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A fancy eco-compatible wastewater treatment system: Green Bio-sorption Reactor

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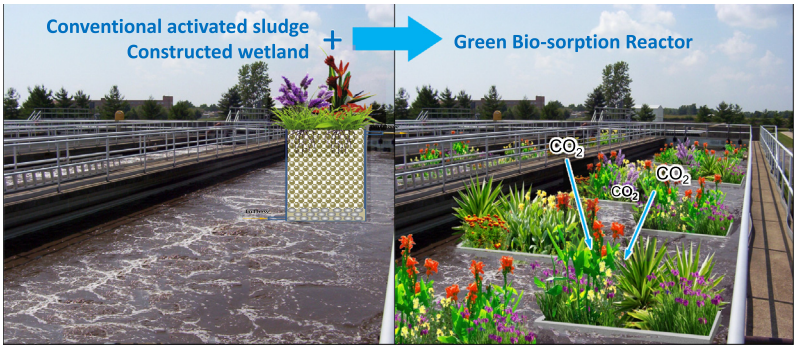
HIGHLIGHTS

- An eco-friendly process of GBR was firstly proposed and examined.
- GBR holds satisfied performance, aesthetic value and potential carbon-sink.
- Alum sludge could probably be a supplement to biological phosphorus removal.
- The present GBR achieved high SND efficiency.

GRAPHICAL ABSTRACT



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ABSTRACT

A novel concept was proposed and preliminarily investigated by embedding alum sludge-based constructed wetland into conventional activated sludge system in terms of Green Bio-sorption Reactor (GBR). This novel GBR inherited the aesthetic value of constructed wetland and owned the robust phosphorus (P) adsorption along with the benefit of carriers' addition (dewatered alum sludge). The preliminary demonstration was conducted in a lab-scale sequencing batch reactor (SBR) system without biological phosphorus removal process. The novel process achieved averagely 96%, 99% and 90% for BOD, TP and TN removal with piggery wastewater as influent, demonstrating for the first time of its promising performance. Moreover, the coexistence of biofilm and suspended sludge also achieved 55–88% simultaneous nitrification and denitrification efficiency, higher than biofilm only. Overall, alum sludge-based GBR could achieve reliable pollutants removal and provides a novel and sustainable pathway to upgrade conventional activated sludge system.

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1. Introduction

Discharges from municipal and industrial wastewater treatment plants (WWTPs) have been identified as one of the major sources of aquatic pollution (e.g. eutrophication) in industrialized countries (Monaghan et al., 2012). Therefore, the treatment performance of WWTPs should be enhanced and upgraded urgently. Moreover, most existed WWTPs are also facing growing connected population and rising quantity of wastewater. It implies that the treatment capacity of wastewater treatment facilities needs to be expanded as well. Compared with construction of new treatment facilities, retrofitting the existing facilities is a more preferential and sustainable solution, which is also the common way currently

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for intensifying the treatment capacity/efficiency (Rosso et al., 2011). So far, many techniques have been proposed and launched in full-scale WWTPs to achieve this purpose, such as fluidized bed reactor (Islam et al., 2014), moving bed biofilm reactor (MBBR) (Javid et al., 2013; Barwal and Chaudhary, 2014), membrane bioreactor (Hazrati and Shayegan, 2011), integrated fixed-film activated sludge system (IFAS) (Veuillet et al., 2014; Malovanyy et al., 2015). Although these processes remarkably intensify the performance of conventional activated sludge system (CAS) by dumping carriers or installing membrane modules etc., they are, however, oriented by single-purpose of intensifying treatment performance and also energy-intensive.

It is highly expected that the new solution for wastewater treatment should consider not only the wastewater treatment technology itself, but also the harmony for the WWTPs and the around residents as the buffer zone is getting smaller (Lintilie et al., 2016). Moreover, facing the climate change, the treatment processes should be more economic and sustainable by reducing energy consumption and greenhouse gas (GHG) emission.

Recently, some state-of-the-art facilities/solutions have emerged within these criteria, such as vegetation-activated sludge process (V-ASP, Fig. 1a) (Yuan et al., 2016), Biomatrix (Fig. 1b) (Biomatrix website), Living Machine® (Fig. 1c) (Morgan and Martin, 2008) and food chain reactor (FCR, Fig. 1d) (Organica website a). All these processes share a common feature of fantastically aesthetic value because of the introduction of vegetation/-plants. Therefore, they could be compatible and versatile in various situations and scales from a community to a city. Among these solutions, FCR from Organica has attracted much attention and has been increasingly employed in full scale practice. The main body of FCR is comprised of a series of reactors arranged in a cascade fashion all with natural (roots of vegetation) and artificial (Bio-Fiber) media which provide the fixed habitat for bacteria. The different level of bacterial culture along the flow direction forms a food chain where the FCR came from.

From the technical point of view, FCR is similar to some previously existed reactors, such as moving bed biofilm reactor and integrated fixed-film activated sludge (Javid et al., 2013; Veuillet et al., 2014). However, FCR is more than a biofilm-alike reactor. The fantastic vegetation/plants and ingenious greenhouse design incorporate treatment, recreation, and education into FCR. Moreover, the reduction of suspended sludge due to biofilm introduction reduces the burden of clarifiers. Meanwhile, the employment of cutting-edge monitor and control technologies considerably save the capital & operation cost (Organica website b). However, pre- or post-chemical phosphorus (P) removal process should be supplementary unit to meet the discharge standard (MANA website).

In recent years, a novel constructed wetland (CW) has been developed in University College Dublin, Ireland, by using dewatered drinking water treatment residue (termed as alum sludge) as wetland substrate. Its reliable performance for pollutants removal has been proven by massive lab- or pilot-scale experiments (Zhao et al., 2010; Hu et al., 2012). The pleasing appearance of CW and robust P adsorption of alum sludge enlightened the idea of embedding this kind of CW into CAS system. This forms the idea of the current study. The proposed novel integrated system seems similar to FCR but holds incomparable P removal ability. Given the special features, the proposed process was named as Green Biosorption Reactor (GBR) (Fig. 1e).

This paper reports on the first study of the GBR. A lab-scale CAS operated in sequencing bath mode (SBR) was retrofitted to a GBR

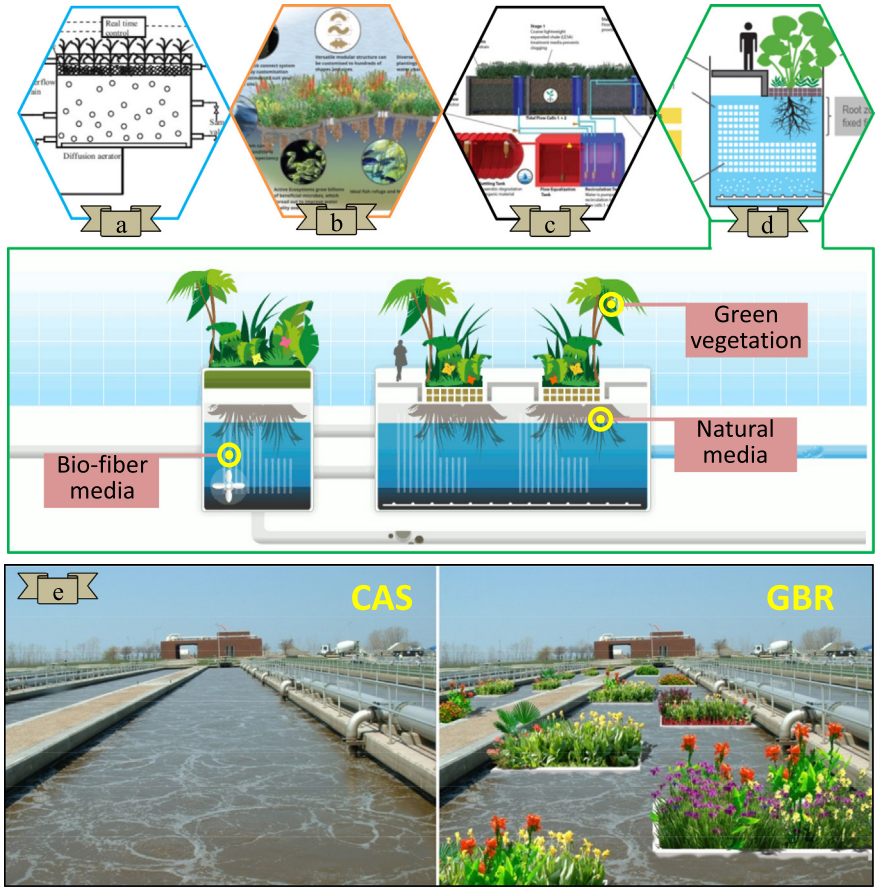

Fig. 1. Emerged wastewater treatment technologies with fantastically aesthetic value (a – V-ASP; b – Biomatrix; c – Living Machine®; d – FCR; e – GBR (present study)).

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