Ecological Engineering 71 (2014) 206–214

Contents lists available at ScienceDirect

Ecological Engineering

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

Overall performance evaluation of shallow maturation ponds in series treating UASB reactor effluent: Ten years of intensive monitoring of a system in Brazil

Daniel F.C. Dias, Thiago E. Possmoser-Nascimento, Valéria A.J. Rodrigues, Marcos von Sperling*

Department of Sanitary and Environmental Engineering, Federal University of Minas Gerais Av. Antonio Carlos 6627, Escola de Engenharia, Belo Horizonte, MG, Brazil

ARTICLE INFO

Article history:
Received 8 December 2013
Received in revised form 12 May 2014
Accepted 11 July 2014
Available online 7 August 2014

Keywords:
Domestic sewage
Maturation ponds
UASB reactors
Developing countries

ABSTRACT

Maturation (polishing) ponds operating after UASB (upflow anaerobic sludge blanket) reactors are considered a highly suitable system for treating domestic sewage for small to medium communities in warm-climate developing countries. Important attributes are operational simplicity, good organic matter and nitrogen removal, excellent pathogen removal and lower land requirements compared to traditional pond systems. However, most papers in the literature focus on single studies investigating one particular aspect of this system. The objective of the current paper is to present a broad evaluation of one particular system (UASB reactor, three shallow ponds and a coarse rock filter in series) in Brazil treating sewage from 250 inhabitants over a period of 10 years. The study covers in an integrated manner the removal and behaviour of several variables, such as organic matter (BOD and COD), solids, nitrogen fractions, phosphorus, coliforms, pathogenic bacteria, helminth eggs, sulphides, surfactants and organic micropollutants (diethylphthalate, bis(2ethylhexyl)phthalate and bisphenol A). Even with short hydraulic retention times in each pond (2 to 6 days), the results endorse the good capacity for organic matter and ammonia removal and excellent removal of coliforms, helminth eggs and sulphides. Removal of phosphorus, surfactants and selected micropollutants was limited.

1. Introduction

Stabilization ponds are widely used in many temperate and warm-climate countries. In the latter, operating conditions can be optimal due to higher temperatures and stronger sunlight radiation. The conventional pond system is traditionally composed of anaerobic ponds, facultative ponds and maturation ponds in series. Maturation ponds are generally included when pathogen removal is required, but impose a large increase in the already substantial land requirements of pond systems. An anaerobic (such as the UASB—upflow anaerobic sludge blanket) reactor followed directly by shallow maturation ponds in series represents another possible and less known configuration, which occupies a smaller area and is still capable of providing a similar effluent quality. Another improvement in the final effluent quality can be obtained by the inclusion of a coarse rock filter as the last stage in the treatment line.

This paper presents an extensive evaluation of one full-scale system (250 population equivalents) with this configuration operating in southeast Brazil over a period of 10 years (2002 to 2012). The work consolidates results presented by Assunção and von Sperling (2013), Chiatti and von Sperling (2012), Oliveira and von Sperling (2010), Chernicharo et al. (2010), von Sperling et al. (2010), Godinho et al. (2011a,b), Araujo et al. (2010), von Sperling et al. (2008), von Sperling and Andrada (2006), von Sperling and Mascarenhas (2005), von Sperling et al. (2005) and Possmoser-Nascimento et al. (2014). No new data have been collected for this particular work, but rather its approach was to compile all the existing data and results obtained in this system by the research group of the Federal University of Minas Gerais over this long monitoring period. The main driver for such a consolidation is the fact that most publications in the literature cover single studies over a limited period of time, and there are very few reports that encompass together several performance variables over a long period. Another objective is to compare the performance during dry/cool

* Corresponding author. Tel.: +55 3133350565.
E-mail addresses: marcos@desa.ufmg.br, sperling.bhz@terra.com.br (M. von Sperling).

http://dx.doi.org/10.1016/j.ecoleng.2014.07.044
0925-8574/

and wet/warm periods, so that the results can be compared with those from other regions in the world. Still of relevance are the facts that maturation ponds treating UASB reactor effluents are not widely covered in the literature and that these ponds operated with shallower depths compared to usual maturation ponds. Because the literature on waste stabilization ponds is very vast, due to space limitations it is not possible in this paper to compare the performance of the investigated system with other pond configurations. Therefore, citation of general references on pond systems are purposely limited here. Discussion on removal mechanisms is expanded here only for nitrogen and coliforms, because these have shown to be largely influenced by the shallow depths adopted for the maturation ponds.

2. Methods

The experiments were undertaken at the Centre for Research and Training in Sanitation UFMG-Copasa, which receives sanitary sewage from the city of Belo Horizonte, Brazil (latitude 19°53′S). Belo Horizonte is located in Cfa or Cwa humid subtropical climate according to Köppen classification, with a mean annual temperature of 22.1 °C and mean annual rainfall of 1540 mm/year. There are basically two seasons in the region: April to September (dry and cool, with mean temperatures of 20.9 °C and mean rainfall of 33 mm/month), and October to March (wet and warm, with mean temperatures of 23.4 °C and mean rainfall of 254 mm/month).

After preliminary treatment (coarse and medium screens followed by grit removal), the influent was directed to a UASB reactor (volume = 14.2 m^3, height = 4.5 m, diameter = 2.0 m). The effluent from the UASB reactor flowed to the pond system, which was initially comprised by four ponds (length = 25.00 m, width = 5.25 m). The ponds started operating in 2002 and had different arrangements, either as four ponds in series, three ponds in series, or two parallel sets of two ponds in series. However, during most of this time (nine years and six months) ponds 1, 2 and 3 operated in series, and the results presented here are for this operational mode (May 2002 to February 2013). In October 2004 the third pond was split in two zones, with the first 2/3 of the area remaining as a pond, and the final 1/3 being converted into a coarse rock filter (grain size between 32 and 150 mm) for algae removal (length = 8.44 m; width = 5.25 m). Fig. 1 presents the flowsheet of the configuration that was used for most of the time. Unless otherwise stated, the results presented here are related to this configuration; however, some results from the other configurations are also presented and, when this is the case, the specific operational conditions are described.

Operational depths in the ponds varied from 0.4 m to 0.8 m, and hydraulic retention times (HRT) were also changed (mean HRT values in each pond ranging from 1.4 days to 6.2 days). Monitoring was undertaken on a weekly or fortnightly basis for traditional parameters (temperature, pH, DO, BOD, COD, solids, nitrogen fractions, phosphorus, coliforms) and occasionally for specific constituents (pathogenic bacteria by molecular methods, algae and chlorophyll-*a*, sulphides, organic micropollutants—diethylphthalate, bis(2ethylhexyl)phthalate and bisphenol A). Data were pooled here as a single time series for the most typical and longer operational period (UASB reactor, three ponds in series, coarse rock filter), and the number of data (n) for each major constituent in each treatment unit varied from 30 to 180.

3. Results and discussion

Table 1 presents the mean and median values of the concentrations of the main constituents in the effluents from each unit, together with the standard deviations. The main results are discussed individually in the subsequent subsections.

Table 2 presents the median concentrations and removal efficiencies in the two main seasons (dry/cool and wet/warm),

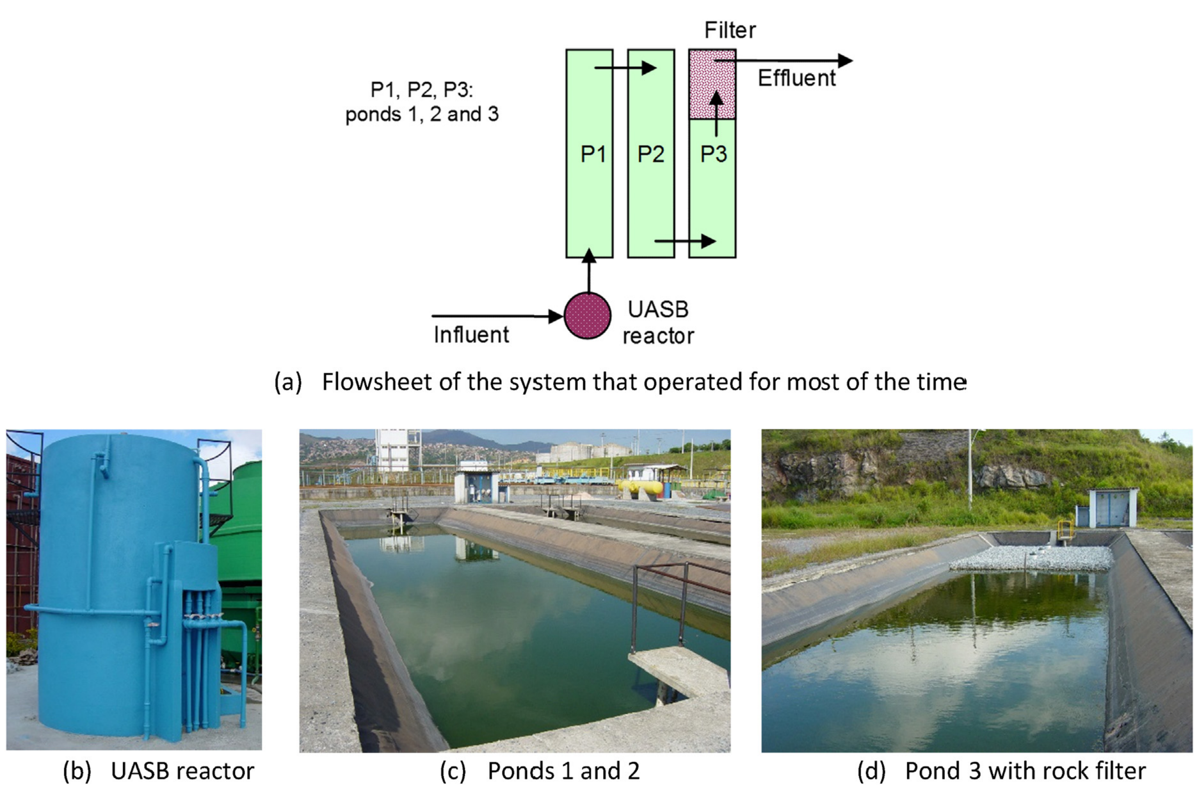

Fig. 1. Flowsheet and view of the units of the treatment system.