HELMINTH OVA REMOVAL USING UASB REACTORS AT 4°C

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Abstract

Research was conducted to elucidate the pathogen removal capacity of UASB reactors with a focus on Helminth eggs. The removal capacity applying different hydraulic conditions was estimated by using artificial latex beads, simulating Helminth eggs. Additionally, the Helminth eggs removal is assessed in a UASB reactor treating domestic wastewater located in Lima (Peru).

The most common Helminth eggs found in the studied wastewater were *Ascaris, Trichuris and Strongyloides*. The study demonstrated that with upflow velocities less than 1.5 $m.h^{-1}$ a Helminth egg removal efficiency exceeding 80% is feasible. Total and faecal coliforms removal varied from 0 to 82.60%. Results show that when pathogen removal is targeted, the UASB reactor must be followed by an adequate post treatment system for treating the remainder of Helminth eggs and faecal coliforms.

Keywords

Pathogens, UASB reactor, sludge, helminths ova.

Introduction

Particularly when treated wastewaters are used for agricultural purposes, the presence of pathogenic organisms may limit the its application potential. Within the group of pathogenic organisms, helminth ova are microscopic and range in size from 10μm to more than 100μm (Metcalf & Eddy, 2003). Using recycled water also reduces the pressures on the environment by reducing the uncontrolled discharge of polluted waters in the environment (Shuval 1990; Van Lier & Huibers, 2004; Toze 2005; Rose 2007). The UASB reactor technology has been selected for the current research as the optimization of its parameters are promising in terms of helminth ova removal efficiency, and it is relatively cheap, compact and it can provide public health protection, environmental protection, and resource recovery in a sustainable way. It can remove helminth ova through sedimentation and filtration in the sludge bed (Jimenez et al, 2007). However, there are not much details known about helminth ova removal in general and especially on effect of operational conditions when using a sludge bed system reactor. The current research is focused on helminth ova removal from domestic sewage using a UASB reactor operated under different hydraulic conditions.

Methodology

Experiments using latex beads (Exp.1) was conducted using latex beads particles and the experiments using helminth ova (Exp.2) was conducted using wastewater containing helminth ova. In addition, properties of the sludge from a UASB reactor was also characterised since helminth ova are interacting with it inside the reactor. Inoculum for Exp. 1 anaerobic dispersed sludge consisted of primary sludge digester of the domestic wastewater treatment plant (WWTP) of Ede (The Netherlands), the total solids and volatile solids concentration was 52 and 33 $g.L^{-1}$respectively. Inoculum for Exp. 2 consisted of anaerobic flocculent sludge taken from the pilot-scale UASB reactor located at UNITRAR the WWTP from the National University of Engineering (Lima, Peru). The inoculum was taken from 1.5m height , the total solids and volatile solids concentration was 283 and 254 $g.L^{-1}$ respectively. The density of this sludge was 1096 $g.L^{-1}$.

Exp 1 was done using wastewater from the WWTP of Bennekom (The Netherlands) as influent. It was pumped in a 100L tank, where it was settled for approximately a day. Hereafter, the supernatant (70L) was pumped into a second tank where it was mixed with the latex beads with a mechanical stirrer. Four identical acrylic lab-scale UASB reactors with a height of 0.40m and a diameter of 0.09m were used. They were located in the experimental hall on the ground floor from the Sub-Department of Environmental Technology, from December 2008 to February 2009. Two types of particles were used: Latex beads Coulter® CC Size standard L20: Ø=20 µm and L90: Ø =90 µm with a density of 1.05 mg/L (Miami, USA). Four up flow velocities were tested, i.e. 0.3, 0.5, 1, 1.5 h^{-1}. Experiments were done in triplicate. The four reactors were fed with exactly the same influent (average wastewater temperature: 4°C) by means of four peristaltic pumps (2 Masterflex, UK, and 2 Watson Marlow, USA). The effluent was collected separately for each reactor in order to be able to take separate samples.

Exp 2 was done using wastewater from the WWTP located at Lima (Peru) as influent. Two identical lab-scale UASB reactor made of Pyrex were used (Figure 1). Reactor height was 1.25 m and diameter 0.04m. Both reactors were inoculated with 0.140 litres of sludge (average wastewater temperature was maintained at 4°C). They were located in the research lab of UNITRAR, in the period between December 2009 to February 2010. Experiments were done by duplicate. Wastewater was placed in a vessel with permanent mixing using a stirrer, then it was pumped to the UASB lab-scale reactors by using 2 peristaltic pumps (Masterflex, USA). Before each experiment a washing phase for the sludge was applied: the volume of the collected effluent during the washing step equalized the reactor volume. This group of experiments were done in order to compare previous experiments. Five up flow velocities were tested, i.e. 0.39, 1.58, 2.83, 3.16 and 4.12 $m.h^{-1}$..

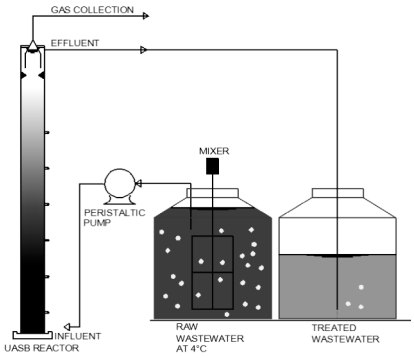

Figure 1 Set up of the experiments

For helminth ova analysis, the flotation method described by Ockert and Teichmann, WHO, IT-778, Geneva, 1989 was used. Total Coliforms were determined according to the Standard Total Coliform Fermentation Technique, Faecal coliforms were analysed according to the Faecal Coliform Procedure, (APHA,2005). Total solids and volatile solids were performed according to Standard Methods (APHA,1998). Density of sludge was measured using a Gay-Lussac-Pycnometer of 24.822 ml (LMS, Germany). Viscosity of the sludge was studied using a viscometer FANN model 32, USA using a speed of 600rpm.

Results and discussion

Exp.1 and Exp2 show a negative relation between the applied upflow velocity and Helminth ova removal efficiency. For upflow velocities less than 1.5 m/h the achieved helminth ova removal will be higher than 80%. It was observed that the density at 4°C of the used sludge of 1096 $g.L^{-1}$ was very close to the density of helminth ova, which varies from 1060 $g.L^{-1}$ to 1150 $g.L^{-1}$ (Jimenez, 2007) therefore, it is possible that helminth ova and sludge stay in the same layer inside the UASB reactor, but the achieved equilibrium can be affected by the upflow velocity, water temperature and the helminth ova's presence in the wastewater. The results of the Exp. 1 indicate a decreased removal efficiency at an increased influent helminth ova (latex beads) concentration. Results from Exp 2. (see **Table 1**) show the predominance of mainly three kinds of Helminth ova in the influent: *Ascaris, Trichuris* and *Strongyloides*. Density and shape of particular helminthes ova and sludge characteristics could also affect the efficiency of this ova UASB reactor's filtration capacity. The presence of extracellular polymeric compounds might be relevant in ova filtration and depends on the applied sludge retention times. (Mahmoud et al, 2006). *Ascaris* was the most common helminth ova present. For Total and Faecal coliforms, no significant removal was shown during Exp. 2. Likely, there is insufficient adsorption of the pathogenic organisms to the sludge and the resulting HRT is simply too short for a significant die-off (Rangeby et al, 1996, Uemura et al, 2002). Analysis using Sludge from the UASB reactor shows that as viscosity is inversely proportional with the temperature. Therefore the sludge viscosity for Exp.2 is expected to be less than 0.0765 $Pa.s^{-1}$.

Table 1 Results of the experiment conducted with helminth ova conducted at UNITRAR.

Flow	UV	Helminth ova		Name	COD		Faecal Coliforms		Total Coliforms	
	(*)	I	E		I	E	I	E	I	E
							MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL
m3/day	m.h-1	Ova.L^{-1}	Ova.L^{-1}		mg.L^{-1}	mg.L^{-1}				
0.0099	0.39	2	0	T, A	748	400	$9.20x10^7$	$1.60 x10^7$	$9.20 x10^8$	$1.60 x10^8$
0.0408	1.58	2	2	T,A	748	510	$9.20 x10^7$	$9.20 x10^7$	$9.20 x10^8$	$9.20 x10^8$
0.0729	2.83	5	2	T,A,S	866	704	$5.40 x10^7$	$3.50 x10^7$	$5.40 x10^7$	$5.40 x10^7$
0.0815	3.16	5	6	A	1016	641	$1.60 x10^7$	$1.60 x10^7$	$1.60 x10^8$	$1.60 x10^8$
0.1064	4.12	5	0	T,A,S	866	585	$5.40 x10^7$	$5.40 x10^7$	$5.40 x10^7$	$5.40 x10^7$

(*): The area of the UASB reactor was $1.075 \times 10^{-3} m^2$

UV: Upflow velocity; I: Influent; E: Effluent; R: Removal efficiency; COD: Chemical Oxygen Demand; T: *Trichuris;* A *Ascaris;* S*: Strongyloides.*

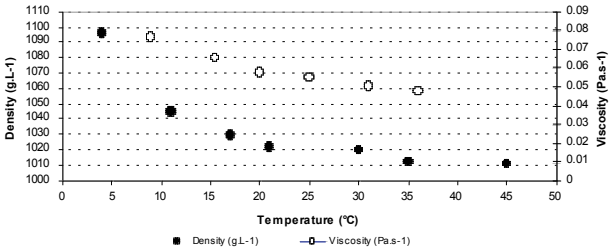

Figure 2 Density and viscosity as a function of the temperature velocity. Tested temperatures: for viscosity were 9, 15.5, 20, 25,31 and 36 °C and for density 4,11,17,21,30, 35 and 45°C. Values are the average of three measurements.

Conclusions

This study demonstrates that the sludge filtration capacity is reciprocally correlated to the upflow velocity and at an increased influent helminth ova concentration a decreased removal efficiency is expected. For the studied domestic wastewater at 4°C, results show that at an upflow velocity less than 0.39 $m.h^{-1}$ about 80% of Helminth eggs will be removed. Removal efficiency of faecal and total coliforms was below 80% in all analysis.

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