Abattoir effluent treatment and protein production: Full-scale application#

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Abstract

A modified sequencing batch reactor (SRB) process was evaluated at full scale for the pretreatment of abattoir effluent and for the production of protein that can be used as an animal feed supplement. Successful pretreatment was achieved with unfiltered COD removal in excess of 90% and filtered COD of less than 200 mg/ℓ. The process adapted readily to variation in effluent volume, flow rate and duration, and was self-regulating. The peak oxygen supply, and therefore power requirements, was reduced by incorporating an anoxic phase during the Fill period. The biomass produced had a crude protein value of c. 40% and was successfully used as a supplement to carcass meal for animal feed. An economic feasibility study showed a net income from protein sales compared to running expenses and a major saving on effluent tariffs, recovering all expenses within the first year of operation. Comparison of the results with those of a previously completed pilot-plant study, showed differences, emphasising the importance and risk involved in scale-up.

Introduction

The abattoir industry in South Africa produces approximately 6×10^6 kℓ effluent per year with a chemical oxygen demand (COD) of 30 000 t/a (WRC, 1990; Cowan, 1994). Most of the effluent ends up in a municipal network resulting in high tariffs payable to the local authority for the receipt and purification thereof. This forces the bigger abattoirs to seek alternatives for effluent treatment and to consider recovery of by-products (Van der Westhuizen and Pretorius, 1996) and the reuse of effluent (Cowan, 1994; Roux and Pretorius, 1997).

Physico-chemical treatment of abattoir effluent for the recovery of high-quality reusable water has successfully been tested on pilot-plant scale (Roux and Pretorius, 1997; WRC, 1998). Biological pretreatment is also possible with the potential of protein as a commercial by-product (Waslien and Steinkraus, 1980; Van Niekerk, 1985; Couillard and Zhu, 1993). De Villiers and Pretorius (2000) reported the successful biological pretreatment of an abattoir effluent in a 60 m^3 pilot plant. The study evaluated a modified sequencing batch reactor process that was easy to operate and adapted readily to changes in raw effluent generation. A biomass was produced with a low sludge volume index (SVI) (50 to 75 mℓ/g) that could be used as a supplement to carcass meal for animal feed. The biomass had a crude protein value (CP) of between 27 and 37% which was cell residence time (θ_c) dependent.

Subsequent to the pilot-plant study the process was implemented at full scale at an abattoir with a slaughter capacity of 2 000 cattle units per day. The evaluation of the full-scale implementation is reported here. The aim of the study was to assess at full scale the modified SBR process for pretreatment of the abattoir effluent and to evaluate the feasibility of the full-scale application.

Revised paper. Originally presented at the WISA Conf., 28 May - 1 Jun 2000, Sun City, South Africa.
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Received 10 December 1999; accepted in revised form 14 July 2000.

Materials and methods

Modified SBR process. The modified sequencing batch reactor (SBR) process (De Villiers and Pretorius, 2000) is defined as an SBR (Irvine and Busch, 1979) with external settler. Flow equalisation takes place within the reactor which is operated as an SBR, except for settlement which takes place in the external settler. Feed to the reactor is intermittent and Idle time is applied. It can also be described as a continuously stirred tank reactor with changing water level and cell recycle (Grady and Lim, 1980).

Full-scale plant. Existing structures were utilised and adapted to suit. A circular reactor, 46 m in diameter and 3.5 m deep, with floating mechanical aerators was used. A single secondary settling tank (SST) was used, 20 m in diameter with the feed pumped (reactor pump) from the reactor and the recycle gravitated back. The recycle flow was controlled with a telescopic valve. The final effluent was stored in a holding tank for overnight release (refer to Fig. 1).

Substrate. Substrate included all the industrial streams: process, offal, lairages and by-products, but excluded sewage. Screening of the different streams (Table 1) and fat removal were implemented as primary treatment. Effluent generation depended on the number of animals slaughtered, with weekends normally being non-slaughter days.

TABLE 1
Screen type and aperture

Effluent stream	Screen type	Aperture (mm)
Process and by-products	Inclined fixed	0.8
Offal	Wine press	3
Lairages	Rotary	1.6