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CONCENTRATED EFFLUENT TREATMENT BY ATTACHED-GROWTH CULTURES ON GRAVEL AND POZZOLANA: EXPERIMENTAL STUDY

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ABSTRACT

Effluents coming from small food processing industries are mainly characterised by a high concentration (about 10 g.l⁻¹ of COD) and a rather low daily volume. An adaptation of the domestic wastewater treatment process by attached-growth cultures for this type of effluent is under study. Coarser granulometries than those currently used and the recycling of the effluent allow yields better than 95 % in COD. The alternation principle between feeding and rest periods allows to avoid filter clogging and to decrease biofilm release phenomena. A better understanding of the biomass regression during the rest periods is necessary to obtain a long-lasting system and to decrease the suspended solids rejects

KEYWORDS

Attached-growth cultures; pilot; food processing industry; gravel; milk; pozzolana; wastewater treatment.

INTRODUCTION

The effluent of the French small food processing industries will soon be submitted to regulation. Their connection to the collective sewerage network is not always possible due to the specificity of this type of effluent (high concentration) and also to the important relative load they induce in the rural environment (several hundreds of people equivalent). Nowadays treatment systems based on suspended cultures are proposed for these kind of effluents (aerated waste stabilization ponds, sequencing batch reactor (Torrijos et al,1996). But such systems are very costly in investment and operation and do not fit with the economic resources of the agricultural sector. For this reason, and in order to meet an increasing demand, the evaluation and optimisation of rustic systems able to treat highly concentrated effluents are very attractive. The adaptation of attached-growth cultures on fine media process is being studied. The purpose is to apply higher loads on a still limited surface area.

One of the key factors of the wastewater treatment through aerobic attached cultures is the availability of the oxygen necessary to keep up the microorganisms activity (Chachuat, 1998). The alternation between feeding and rest periods is necessary to restore the oxygen stock inside the Infiltration bed (IB). The other key factor for this process is the management of the biological clogging phenomenon. The rest periods do not only ensure the renewal of the oxygen stock, but must also regulate the bacterial growth. A good management of the feeding and rest periods alternation should prevent clogging-up and reduce sludge production.

In order to treat concentrated effluents, the sand (0<Ø<2mm), generally used for domestic wastewater treatment, has been replaced by a coarser material. That should lead to a better ventilation of the IB and decrease the clogging risks. Gravel IB (GIB) and Pozzolana IB (PIB) are presently being tried. A

contact time between biomass and effluent is necessary to make for possible the assimilation of the substrate by the biofilm. In a sand IB the flow speeds are usually low compared to the assimilation speeds (Schmitt, 1989). In a filter with rougher granulometry (gravel, pozzolana) the transport time of the pollutant in the porous medium is shortened. So it seems necessary to increase the contact time in order to keep interesting performances. That's achieved by recycling of the effluent. The proposed treatment system for small daily volumes of concentrated effluents is based on several gravel or pozzolana filters, working alternately, in which the influent re-circulates.

EQUIPMENT AND METHODS

Description of the pilot unit. The pilot is composed of a set of columns in a covered room. To each column corresponds a feeding tank F and a recycling tank R (Figures 1 and 2). The PVC transparent columns have an inside diameter of 360 mm and a height of 1.20 m. The influent feeding is done thanks to a liquid spraying nozzle (output $q = 28 \text{ ml.s}^{-1}$) which ensures an homogenous distribution all over the IB. The output effluent is collected via a recuperation tank and, due to gravity, circulates to tank R. Every 4 hours tank R content is pumped into tank F before being resent on the filter. So the influent is passing 6 times on the filter within 24 hours before being rejected and replaced by a raw influent. The sequence is 3 days feeding, then 4 days rest.

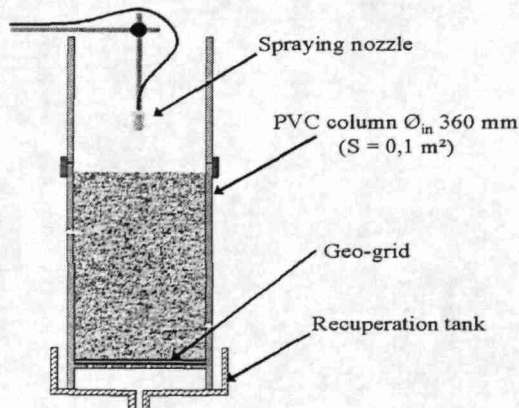


Figure 1 : diagram of a column

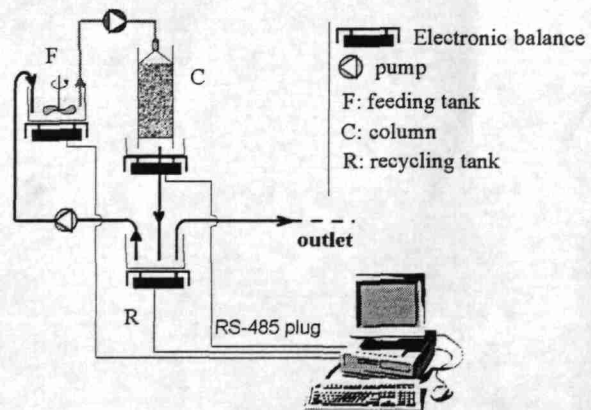


Figure 2 : diagram of the pilot

Two columns have been used this way during 32 weeks. The first one (G) was filled with 60 cm of gravel, the second one (P) with 60 cm of pozzolana. The characteristics of these two materials are shown in Table 1.

Table 1 : physical characteristics of the materials

	d10*	d60*	porosity
gravel	2.6mm	3.7mm	42%
pozzolana	0.6mm	2.3mm	54%

*dx: sieve mesh allowing x% in mass of the material grains to go through.

Applied loads. The influent is daily prepared from milk and powdered serum of milk. Dosing is done to achieve a COD of 10 g/l. Feeding is done by 7 liters batches. A column treats 700 g of gCOD.m^{-2} within one feeding day. On a weekly basis, the treated load is of $300 \text{ gCOD.m}^{-2} \cdot \text{d}^{-1}$.

Analyses. COD measurements are performed on effluents at different treatment steps (on the reconstituted milk and on the effluent after 6 transits). In parallel, measurements on suspended solids are carried out by filtration on glass fiber membranes.

Mass follow-up. One of the columns, together with its tanks F and R are equipped with electronic balances (commercialised by NOBEL). The balances data are collected through "acquisition modules" connected to a PC via a RS-485 plug (Figure 2). The accuracy for the column mass follow-up is of 5g.

Tracer experiments. The hydraulic properties of the different IB are evaluated using NaCl as tracer. Filters are fed with clear water until the steady-state condition is reached, then salt is introduced (10g in 100ml). The tracer output is measured by a conductimeter. Tracer experiments have been performed in clean and used media.

RESULTS AND DISCUSSION

Performances. For an initial concentration of 10g.l^{-1} , the average COD at the exit of the GIB is 0.51g.l^{-1} (standard deviation 0.42). The results of the PIB are better: 0.30g.l^{-1} (standard deviation 0.22). Figure 3 is showing the COD of the effluent out of GIB and PIB each first working day of each week. These results are the worst, they improve the two following feeding days. In fact, mainly at the filters

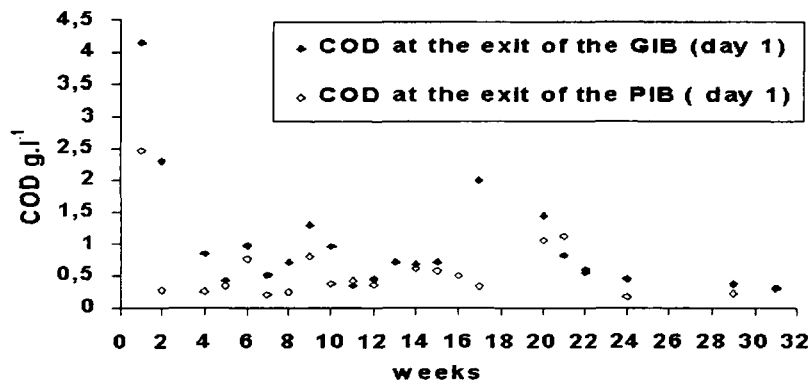


Figure 3: COD of the effluents measured during the first working day of the filters

restart, after a rest, period a sporadic release of a part of the biofilm appears and the suspended solids (SS) concentration increases. This latter reaches 1.8g.l^{-1} for the gravel filter during week 17. SS affect highly the effluent quality, the COD being greater than 2g.l^{-1} during the same week. The better results obtained by the pozzolana are partly explained by a lesser biofilm release. The biomass seems to better stick on the pozzolana because of its microporosity (Show and Tay 1999).

Mass follow-up of the column. It is possible to follow up the evolution of the stagnant water quantity

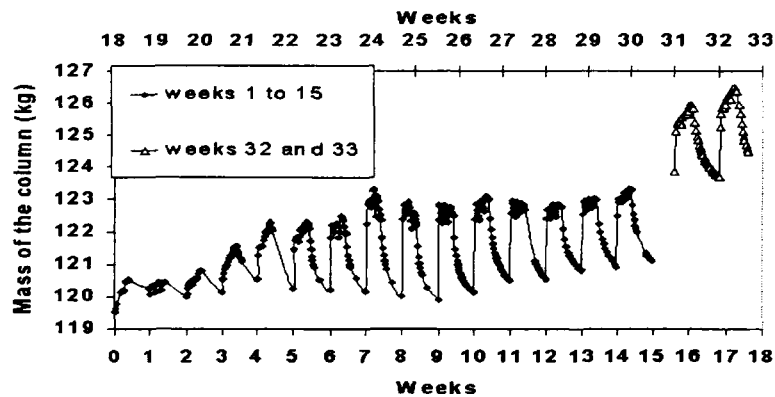


Figure 4: Variation on the mass of column G during the 32 test weeks the column.

into the IB considering that the column has fully been dried up after a 4 hours rest period. The increase of this quantity against the retention capacity of a clean IB reveals biofilm development inside. The mass evolution of column G (as shown on Figure 4) reveals that the expected biological balance has not been reached. The rest periods between two feeding periods do not lead to a sufficient regression of the biofilm. It's possible that, on a long term basis, with such a feeding cycle and such a load, the gravel filter would clog. For the same applied load another feeding cycle is being studied (1 week feeding then 1 week rest). The same study of the pozzolana column couldn't be performed through lack of a second equipment.

Tracer experiments. In clean medium, longer retention times are shown for pozzolana than for gravel (Figure 5). The bacterial development levels off these different hydraulic behaviours. The tracer retention time into the GIB increases together with the colonisation. It decreases in the PIB. The biofilm seems to cover the microporosity of the pozzolana which would therefore loose its hydraulic specificity.

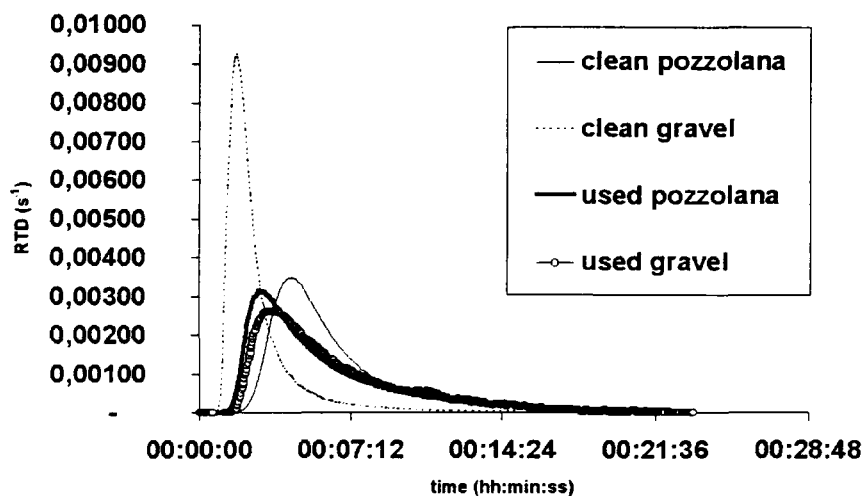


Figure 5: Tracer residence time distribution into the different media

CONCLUSIONS

The adaptation of the attached-growth cultures process for concentrated wastewater treatment (about 10g.l^{-1} of COD), by means of recycling procedure and the use of coarser media, leads to good purifying yields (about 95%). This process, with limited investment costs and simple functioning, can be a realistic solution for effluents problem of small food processing workshops. The efficiency of such a process is pending on a good management of the alternation between feeding and rest periods. Specific measurements of the biomass should lead to a better characterisation of the biological regression and therefore to better cycles definition.

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