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APPLICATION OF THE UASB TECHNOLOGY FOR SEWAGE TREATMENT IN A SMALL COMMUNITY AT SUMARE, SAO PAULO STATE

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ABSTRACT

Sumare City does not have sewage treatment, leading to the deterioration of water resources and public health conditions. There is a sewage treatment plan for the city's urbanized area. However, difficulties of financing delay the plan's implementation. Meanwhile, new small communities of low income population are built surrounding the city. That was not foreseen in the city's plan. So, the sanitation problem is constantly aggravated. The city's Water and Wastewater Department (Departamento de A'guas e Esgotos - DAE), worried by this situation tried out a new scheme to overcome this problem. One of these communities (235 houses) was chosen and a proposal was made to its inhabitants, which was accepted, to use an anaerobic digester to treat the sewage, DAE being the financer agent and the inhabitants reimbursing DAE. The UASB technology was made available by means of an agreement between DAE-Sumare and CETESB for technology transfer. DAE was responsible for the management and plant construction. The plant was started-up in May 1992. This is a successful experience in view of the non-existence of finance for the construction of sewage systems. A 67.5 m^3 UASB reactor was built. The difficulties to establish the real costs for this were extremely high, and lead to cost reduction recommendation. Data collected for performance evaluation, over a period of fourteen months showed a difference compared to the 120 m^3 UASB reactor e perience, at CETESB, in Sao Paulo City. The influent and effluent Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) values, are higher than were experienced at CETESB. The average removal rates of BOD, COD and TSS are also higher, respectively 80%, 74% and 87%.

KEYWORDS

Anaerobic treatment; cost; finance; performance; sewage; UASB reactor.

INTRODUCTION

Sumare City, with 156,000 inhabitants, is 115 km from Sao Paulo, the State's capital. Among other actions, the city's Master Plan foresees the urban area sewage treatment. However, difficulties in obtaining financing, delay its implementation. Meanwhile, new low income small communities, not envisaged in the city's plan, are growing surrounding the city. So, the sanitation problem is constantly aggravated.

Some factors block the expansion of sewage treatment systems in Brazil: lack of financial resources and of political willingness. The sewage treatment technology has evolved during the last few years and is now available (Jordao, 1991).

Looking for compact, modular and appropriate sewage treatment technologies for Brazil, the adaptation of UASB reactor for sewage treatment has been studied at CETESB (Vieira, 1984; Vieira and Souza, 1986; Vieira, 1988) following the technology of the UASB reactor developed in The Netherlands for treatment of industrial wastewater (Lettinga *et al*, 1980). However, this technology is seldom used in Sao Paulo State. Some factors have been identified as the reasons for this situation. The lack of finance for sanitation, the insecurity in applying new technologies and mainly, the non-attainment of the State Legislation of Water Pollution which requires for emission standards, 80% BOD removal in the treatment system or an effluent lower than 60 mg BOD l^{-1}.

Brazilian Federal Legislation for environmental quality has standards for organic matter (BOD) in water quality as high as those for Germany and Japan (CETESB, 1990). These standards are related to the receiving bodies and the aim is to maintain the natural quality of receiving streams. Some Brazilian States, such as Sao Paulo and Minas Gerais also have standards for effluents emission which do not take into account the water quality nor the water flow of receiving streams. There are situations where treated domestic sewage with a BOD slightly higher than 60 mg l^{-1} is discharged at low flows in large rivers, able to degrade the remaining organic matter in short distances.

Keeping in mind the very bad sanitation conditions in Brazil, some situations should be approached in ways such as to favour and stimulate *simple* systems of sewage treatment, even at the cost of an inferior performance, rather than more complex systems. There is a need to consider also the possibility and the economic feasibility of post-treatment which is possible in the case of UASB reactors.

FINANCE

The rapid growth of low income districts surrounding Sumare City demanded a sewage treatment solution. Compact and modular plants with a simple technology were needed to meet the problem. In 1989, technicians of DAE made an agreement with CETESB to transfer the UASB reactor technology for sewage treatment.

The real cost of the sewerage plus emissary was calculated to be US$ 29,200 and the sewage treatment plant US$ 10,900. DAE proposed that the population pay for the investment in 6 instalments, with DAE acting as the financier. The population agreed and the payments were started at once.

A share of a 1,260 m^2 municipal site was reserved for the sewage treatment plant. In this way, a solution for the main problems described (lack of financial resources and of political willingness) was met at Sumare.

PLANT FACILITY

Based on previous experience, CETESB provided the UASB reactor basic design. DAE hired an engineering firm to perform the design and the plant construction.

The sewerage and earthwork was accomplished by DAE and municipal workers. The construction took about one year. In May 1992 the system was started-up. Considering the time needed in Brazil to establish sewage treatment systems, this length of time can be viewed as a short one.

PLANT DESCRIPTION

The UASB reactor was designed based on the previous experience obtained by CETESB in the development of technology to treat domestic sewage by UASB reactors. The steps of technology development comprised the design and operation of a lab scale reactor (106 l UASB reactor) and a full scale demonstration reactor (120 m^3 UASB reactor) (Vieira and Souza, 1986; Vieira 1988; Vieira and Garcia, 1992). The design criteria are presented in Table 1.

The plant was built for 1,410 inhabitants with a contribution of 150 l $inhab.^{-1}$ day^{-1}. The system comprises two in-series screens, grit chamber, Sutro weir, grease interceptor, pumping tank, UASB reactor, sludge drying bed, gas meter and gas flare.

TABLE 1. Design Parameters for the 67.5 m^3 UASB Reactor Treating Domestic Sewage

Nominal Flow (m^3 h^{-1})	**9.5**
Maximum Flow (m^3 h^{-1})	**16.6**
Maximum Superficial Velocity in the Settler (m h^{-1})	**1.25**
Average HRT (h)	**7.0**

REACTOR

The reactor was built in concrete and totally closed at the top with fibreglass covers. Figure 1 presents the flow scheme and Figure 2 shows a plant overview.

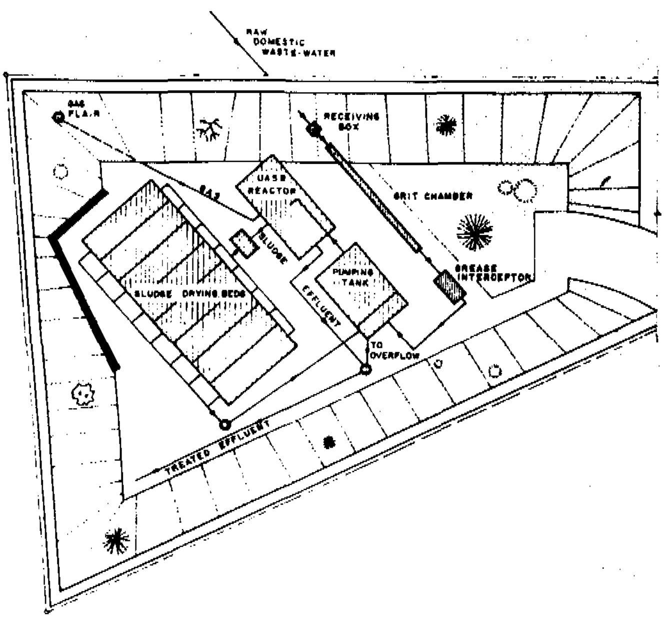

Fig. 1. Flow scheme of the plant

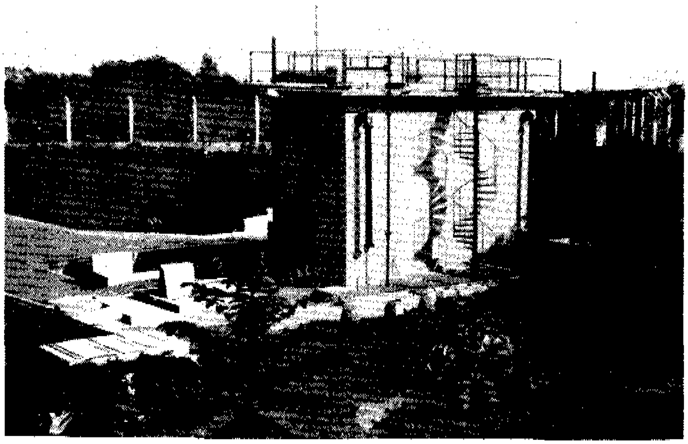

Fig. 2. Overview of the UASB plant.

Removable covers for scum removal were provided at the top of the reactor, over the gas chambers. The settler's covers are also removable. In order to dissipate the scum, sprinklers were installed, as well as a device to remove the scum.

A feed box with 8 distribution points is located at the top of the reactor and the sewage is sent to the bottom of the reactor through flexible pipes. At the bottom, there is one inlet point per 2 m^2.

The gas is collected in the gas chambers and burnt in a flare. Excess sludge is taken to a drying bed for final disposal. Effluent is disposed of to a small tributary stream, 500 m far from the plant.

The reactor is covered to avoid offensive odours. The effluent collecting chamber is open and there is some odour only perceived at this point. In general, there is no odour at the plant and there are houses very near it, as near as 10 m.

COSTS

Several reports show the wide variability in the costs of UASB reactor system. In Colombia, Schellinkhout (1992) gives costs of US$ 181 m^{-3} reactor or US$ 17/inhab. for a 160 000 P.E. plant.

In Brazil, the cost has varied around US$ 30/inhab. (Vieira, 1988). Especially in Sao Paulo, the cost of civil building is getting increasingly high. Very often excessive amounts of construction material are seen to be used to build treatment plants. In the case of this plant it was not possible to get the real costs computation, particularly because the plant construction was simultaneous with the municipal water plant construction.

OPERATION

The City of Sumare has the appropriate climate for anaerobic digestion, average temperature being 16°C during the winter and 23°C during the summer.

The operation of the system was started in May 1992. It is a very simple operation, including daily cleaning of the sewage inlet channel, removal of sand and other debris from the screen, and pH, temperature and sewage flow measurements. Sludge, feeding and effluent are sampled weekly.

Feeding

The suction tank receives the sewage, which is then pumped to the biodigestor. A maximum and minimum device turns on the pumps. At present the reactor receives sewage during six hours a day.

Start-up

The start-up of the reactor was carried out with addition of 10% (V/V) digested sludge. The inlet flow increases as long as more houses join the sewerage. The initial inlet flow in May, 1992, was 0.8 m^3 h.

The residences are provided with septic tanks which are simply excavated holes in the soil. Only when these house tanks are filled do the residents look to the joining the sewerage system. Todays district inhabitants are 50% of those expected. Only 39% are joined to the sewerage. Present flow is 1.6 m^3 h.

Water consumption has been lower than the usual standards, about 67 l $inhab.^{-1}$ day^{-1}. About only 62% of the consumed water turns into sewage. All these factors account for the present low inlet flow that is only 17% of the design flow.

SYSTEM EVALUATION

Effluent: Figures 3 and 5 present COD and TSS evolution with time and Figure 4 the COD removal efficiency, since the start-up (May 1992) until now (July 1993).

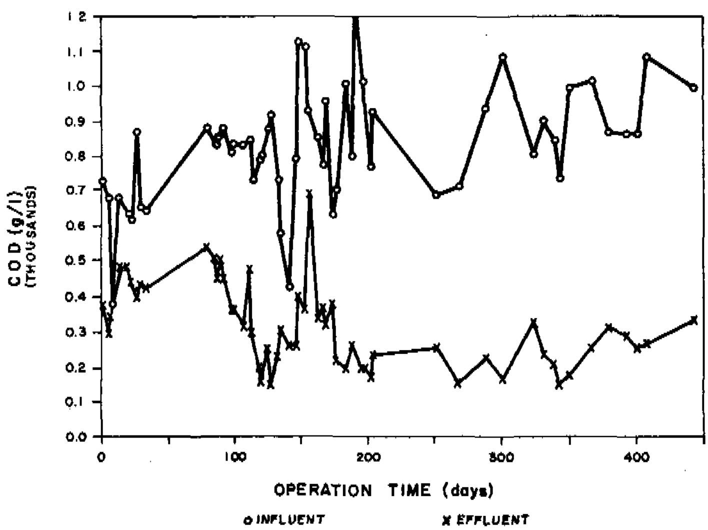

Fig. 3. Influent and effluent COD.

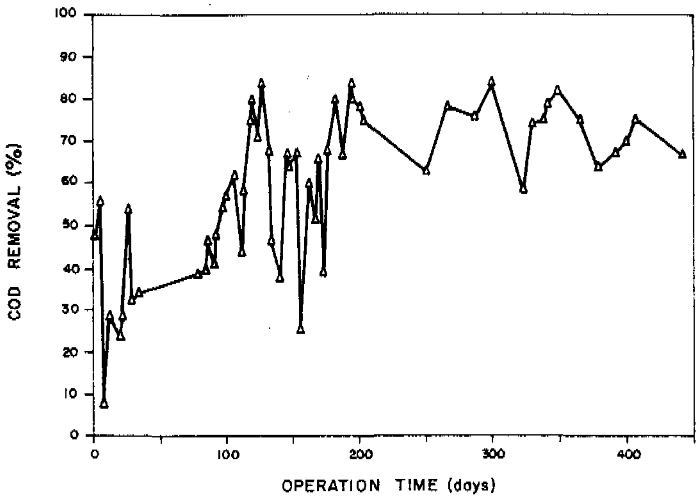

Fig. 4. COD removal.

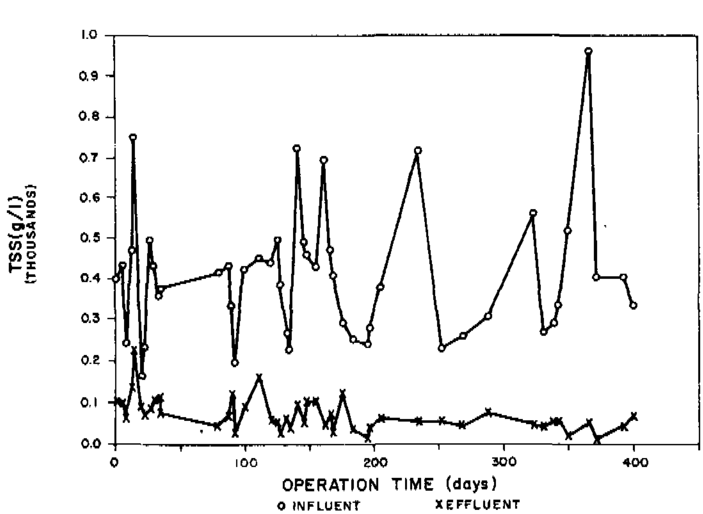

Fig. 5. Influent and effluent TSS.

Table 2 presents the BOD, COD and TSS average with the system in steady-state, reached after 5 months from start-up.

In terms of BOD, COD and TSS removal, the reactor efficiency is good. CETESB previous experience with a UASB reactor treating domestic sewage presented different results due to differences in the sewage strength. A 120 m^3 UASB reactor, in operation since 1987, treats weak domestic sewage coming from high income districts with a high water consumption. In this reactor, the influent has 100 to 250 mg BOD l^{-1}, the effluent 40 to 80 mg BOD l^{-1} and the average BOD removal is 70% (Vieira, 1988; Vieira and Garcia, 1992).

In the case of the low income community at Sumare, the sewage is stronger, presenting a BOD value of about 540 mg l^{-1}. The effluent quality is poorer (102 mg l^{-1}) but the BOD removal is higher, about 80%.

TABLE 2. Average Operating Results During Eight Months in Steady-state

	BOD_T	BOD_S	COD_T	COD_S	TSS
Influent (mg l^{-1})	515	209	402	436	379
Effluent (mg l^{-1})	102	85	232	185	50
Removal (%)	80	60	74	57	87

Sludge. Until now after 14 months of reactor operation and with 17% of the designed flow, there is no excess sludge to be discharged. Sludge characterization presented good results for sedimentation, with SVI always lower than 10 ml g^{-1}. The specific methanogenic activity is also low, about 0.04 g DQO-CH_4 g SV^{-1} day^{-1}.

The sludge has been analysed microscopically since start-up. During start-up, *Methanosarcina*-like organisms and thin filaments similar to *Methanospirillum* spp were observed. These thin filaments sometimes predominated over the *Methanothrix*-like organisms. After 6 months of operation, granules of about 0.8mm diameter, fragile and fluffy were observed.

There was no alteration in the granules' structure after the start-up. *Methanothrix* spp was observed at the 10th day of operation and after 2 months they predominated over the other organisms.

EFFLUENT DISPOSAL

Currently, the treated sewage flow is still low, so the effluent does not damage the receiving body of water. In the future, effluent polishing may be needed. A post-treatment through gravel rapid filtration is foreseen.

Studies of this system in pilot-scale are being run to obtain the optimal load and the gravel size to be used. Another possibility of effluent disposal is irrigation, since the effluent discharge point is located at a small farm.

CONCLUSIONS

The direct participation of the benefiting population in the drawing of financial resources, contributed to the installation of this sewage treatment system in Sumare.

In order to lower costs it is necessary:

- to review the data of water consumption and sewage contribution to differentiate them according to community size and income;

- to search for more efficiency in building, related to the type and quantity of construction material;

- to search for lower unitary prices of construction through more openness in submissions.

This strong sewage (515 mg BOD l^{-1}), typical of low income small communities and treated by a UASB reactor, produced an effluent of about 102 mg BOD l^{-1} with on average 80% BOD removal. Its polishing is needed to meet the legislation, in accordance with the receiving water quality.

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