

DIFFERENT APPROACH TO ANAEROBIC SEWAGE TREATMENT PROCESSES

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INTRODUCTION

Anaerobic technology have been successful applied for industrial waste water treatment. High reaction rate per unit volume by retaining the biomass in the reactor independently of the incoming waste water flow and concentration. Often high volumetric loading rates in the order of 10 to 40 kg COD/m³.d are used. High rate anaerobic biological reactors may be classified into three broad groups depending on the mechanism used to achieve biomass detention. These are – **fixed film, suspended growth, and hybrid.**

The most popular are suspended growth reactors – Upflow Anaerobic Sludge Blanket reactors - (UASB). Less popular are hybrid reactor among whose Anaerobic Baffled Reactors (ABR) are to be mentioned. The most significant advantage of the ABR is its ability to separate acidogenesis and methanogenesis longitudinally down the reactor, allowing the reactor to behave as a two-phase system without the associated control problems and high costs (Weiland and Rozzi, 1991). Two-phase operation can increase acidogenic and methanogenic activity by a factor of up to four as acidogenic bacteria accumulate within the first stage (Cohen et al. , 1980, 1982), and different bacterial groups can develop under more favourable conditions. The advantages and disadvantages of ABR's have been discussed by Barber and Stuckey (1999).

Application of anaerobic systems for municipal sewage treatment is so far very limited. The predominant reason given for is, that municipal sewage is too weak (to low BOD or COD) to maintain high biomass (in the form of granules suspended solids or fixed film) content in reactors. There are however, some successful examples in pilot and full scale. Orozo (1997), investigated a full scale anaerobic baffled reactor (ABR) to treat municipal sewage with an average BOD of 314 mg O₂/l . For a hydraulic retention time of 10.3 hours, (organic loading rate 0.85 kg/m³.d) he achieved a 70 % removal efficiency. It has to be stressed that the process was run at very low temperature between 13 and 15 °C.

Much better effects were reported by Garuti et al. (1992). Treating municipal sewage of COD between 264 and 906 mg O₂/l and an organic loading rate of 2.17 kg/m³.d, a 90 % effect of COD was achieved. The HRT (Hydraulic Retention Time) varied between 4.8 to 15 hours.

Mahmoud et al. (2004) with a higher OLR (Organic Loading Rate) of 2.88 kg/m³.d obtained a COD reduction of only 44 %. The high OLR rate was the effect of high COD value of the inflowing sewage , which was 741 mg O₂/l. The HRT in the UASB reactor was 6 hours.

The relatively low removal efficiency is not unexpected. It has to be made clear that for anaerobic sewage treatment there is a balance between possible to achieve efficiency and possibly to retain biomass in the reactor. That repeated often opinion, giving high preference for anaerobic treatment of highly loaded industrial effluents, should be revised in the light of results presented by Aiyuk et al. (2004). They have operated an UASB reactor for pre-treated municipal sewage having a COD of only 141 mg O₂, and a BOD₅ of 70 mg O₂/l. (UASB effluent was respectively 45 and 25 mgO₂/l). Probable fixed film bioreactors are able to retain large amounts of biomass, and thus permit high COD removal effects. Relatively high COD removal effects on an anaerobic fixed bed reactor have been reported by Pozo and Diaz (2003). They achieved a 65 % COD removal effect at an organic load of about 0.4 kg COD/m³.d. It is hard however, to have confidence in results obtained in a very small laboratory reactor of a volume of 2.44 litres.

The existing so far technology does not allow to expect in average much higher than 70 % COD, or 80 % BOD removal effects. Obviously a second treatment step has to be added. Orozo (1997) mentioned about an aerated lagoon for anaerobically treated sewage effluent polishing. It could be any other process, from which activated sludge should be given preference.

Mahmoud et al. (2004) have investigated a very interesting combination of a UASB reactor and a sludge digester. The advantage of such combination is primarily a higher methane production and a very low sludge production rate. For the UASB – digester system the sludge production was only 0.185 g TS/g COD_{rem}, or 0.122 g VSS/g COD_{rem}. The excess sludge production from the UASB-Digester system is very well dewaterable and stabilised. Much lower sludge production rate in the order of 0.11 g TS/g COD removed was reported by Ghangrekar and Kahalekar (2003).

The sludge production rate in anaerobic processes can therefore be approximately even 5 times smaller than the sludge production rate in aerobic processes.

EVALUATION OF A QUASI-ANAEROBIC SEWAGE TREATMENT PROCESS.

The treatment plant.

The municipal sewage treatment plant was designed and constructed with the aim of biological treatment including nutrients removal. Sewage in the amount of about 350 m³/d passing medium racks and a simple grit chamber supplied directly to the first anaerobic stage to the dephosphatation chamber. The next stage is a nitrification chamber combined with denitrification. Two vertical secondary settling tanks follows, after which treated sewage is disinfected. There are two recirculation loops; one so called external loop returning activated sludge from the settling tanks to the nitrification stage, and the second - internal loop returning the mixed liquor from the denitrification sector to the dephosphatation chamber.

A simplified scheme is presented below. (Fig. 1)

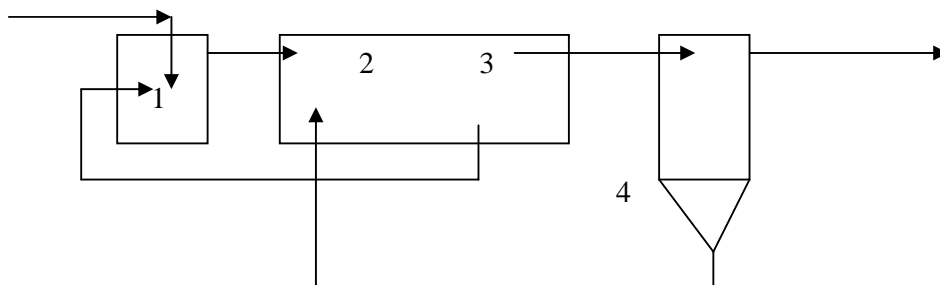


Figure 1. Basic reactors;

1. dephosphatation chamber, 2 nitrification sector, 3 denitrification sector, 4 secondary settling tank

For aeration in the nitrification chamber, tube diffusers were installed.

After ten years of operation the plant is no longer working according to the designed principle. The main reason for is ineffective work of the aeration system, partially devastated. As a consequence the biological treatment process is in fact working under anaerobic condition. Dissolved oxygen is measured only occasionally at a level below 0,5 mgO₂/l.

Operational conditions, and achieved results.

As aforementioned the extremely low concentration of dissolved oxygen, in the nitrification chamber, classify the process as quasi-anaerobic. That statement is supported by measurement of the oxygenation reduction potential (ORP) (Fig. 2).

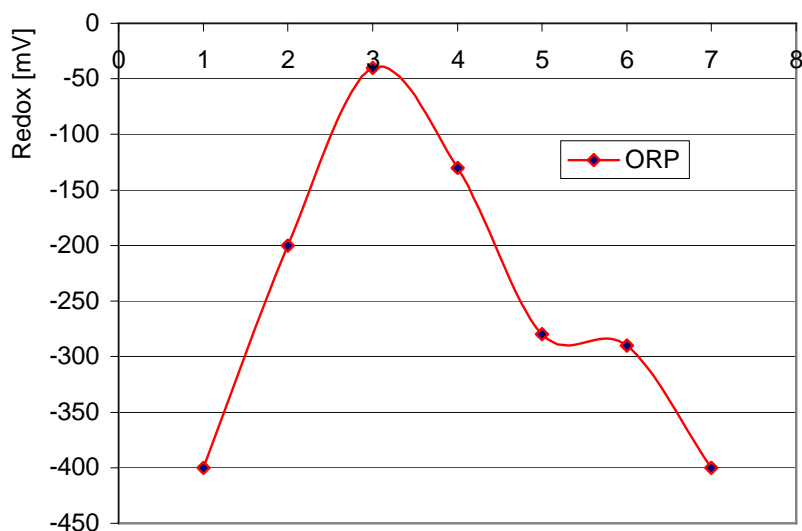


Figure 2. Changes of the oxidation reduction rate in the different stages of sewage treatment;

1. dephosphatation chamber, 2 nitrification entrance sector, 3 nitrification middle sector, 4 denitrification sector, 5 denitrification sector outflow, 6 secondary settling tank, 7 effluent

In order to describe better the treatment plant below the average hydraulic retention time HTR for each chamber or sector is given.

Dephosphatation chamber	3 h
Nitrification sector	20 h
Denitrification sector	4 h
Secondary settling tanks (both)	10 h

The quality of raw sewage entering the investigated plant varied in a relatively wide range. However, over a period of two years of analytical determinations an average value of raw sewage BOD was calculated to be about 245 mgO₂/l. The value of BOD for treated sewage varied between 30 and 40 mgO₂/l. Although determinations are done of non-filtered samples (ordinary procedure) a distinct difference was found for homogenised samples. The average values are shown in Fig. 3.

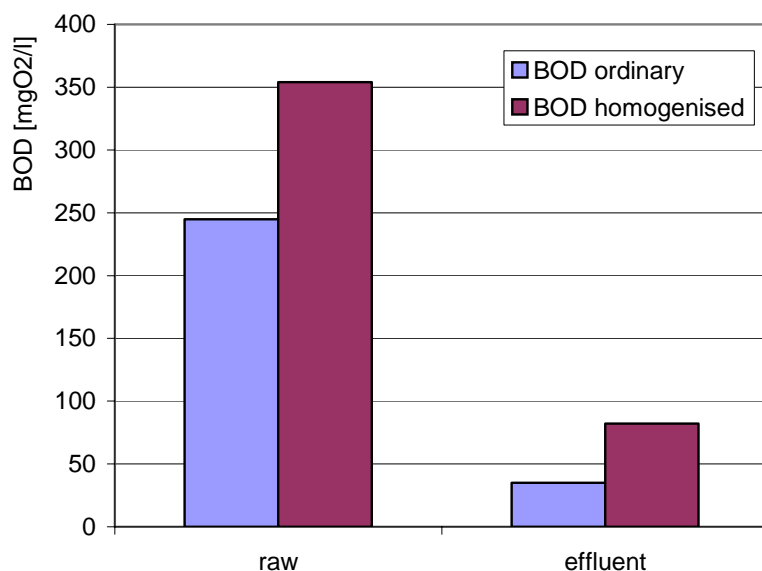


Figure 3. Determined average values of BOD - raw sewage, and effluent

Taking into account only the homogenised samples, the effect of BOD removal was about 77 %. Using as well the BOD value of the homogenised samples the organic load was around 0,4 kg/m³.d. Under such a load the removal of organic compounds can be considered as satisfactory.

In respect to nutrients removal the decrease of phosphates concentration from about 11,5 to 4,2 mgP/l are above expectations. Similarly the decrease of ammonia of 88 % and the total nitrogen in the order of 76 %, with the total nitrogen in treated sewage of 18 mgN/l was relatively high.

Probably the close to aerobic conditions in the nitrification chamber could be claimed to be responsible for the distinct effects of nutrient removal. In another words the quasi-anaerobic conditions can be a clue to a novel approach to efficient low cost, municipal sewage treatment.

CONCLUSIONS.

1. Advanced wastewater treatment processes which include nutrients removal require large areas and are characterised by high power consumption.
2. Anaerobic treatment processes applied successfully for high strength industrial wastewater's should be revised and adopted to municipal sewage treatment.
3. The presented case is giving some insight possible modifications, and have a potential for practical application if followed by further investigations.

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