TEMPERATURE

Temperature

The operational temperature of the process is a very crucial factor since methanogenic bacteria are highly sensitive to temperature [Gujar *et al*., 1983]. Granulation can occur in mesophilic as well as thermophilic temperature range for both acidified and nonacidified wastewaters [Hulshoff *et al*., 1983c, Hulshoff and Letting, 1986, Wiegant *et al*., 1985a,b].

However, operation in the thermophilic range is more attractive [Wiegant *et al*., 1986]. UASB lab-scale reactor operated in thermophilic range was reported to have a capacity of loading more than 100 kg COD/m^3.d [Ohtsuki *et al*., 1992]. Other advantage of thermophilic operation over mesophilic is associated with the higher specific decay rates at thermophilic temperature conditions. Hence, the quantity of sludge produced at thermophilic temperature is less than mesophilic temperature [Garber *et al*., 1982]. Also, the pathogen reduction is better in thermophilic conditions.

Experiments that achieved granular sludge were operated at 30 to 35^o under mesophilic conditions [Lettinga *et al*., 1980b, Hulshoff *et al*., 1983a,b, Wu *et al*., 1987, Zeeuw, 1983, Dold *et al*., 1987] and at 55^{o}C under thermophilic conditions [Wiegant *et al*., 1983, 1985, 1986]. The methanogen playing major role in granule formation under both temperature condition is *Methanothrix*. Thermophilic *Methanothrix* and mesophilic *Methanothrix* look much alike but filaments in thermophilic are shorter. The activity for thermophilic *Methanothrix* granules is 4.2 - 7.3 kg CH_4-COD/ kg VSS.d, higher than that reported for mesophilic *Methanothrix* granules at 30^{o}C as 2.2 - 2.4 kg CH_4-COD/ kg VSS.d [wiegant *et al*., 1986]. At both thermophilic and mesophilic temperature granules consisting of *Methanosarcina Sp*. can develop under specific conditions. Although, granulation is faster under thermophilic conditions, the mechanism underlying the granulation process is similar for both the temperature conditions.

It is reported that at the application of one step UASB system at low temperature eliminates (5-20^{O}C). The hydrolysis of COD becomes limited in winter resulting in a decrease of the mathanogenic activity of the sludge and therefore deterioration of the treatment process, unless long HRT's are applied (deMan, *et.al.*1990). The treatment of sewage at temperature of 13^{O}C

was investigated in three reactor each 3.84 L [are UASB and two anaerobic hybrid (AH) reactors] with small sludge granules. Although the anaerobic treatment of domestic sewage has been application a large scale in several tropical counties (Hulshoff pol *et.al.,* 1997), the process is short not applied on a full scale in countries with lower temperature mainly as a result of lower removal efficiencies. It was also observed that at low temperature, a longer HRT (>12hr) is needed and accumulated SS increases with decreasing temperature. The removal and degradation of colloidal particles which represent 20-30% of total COD for domestic sewage appear to become limiting in UASB reactors at lower temperature [Elmitwalli Tarck A., Lettinga Gatze. e*t.al.*, 1999]. It is reported that, the reduction in methanogenic activity at lower temperature was observed. The methanogenic activity at 30^{O}C was observed to be reduced by 56 to 77% at 25^{O}C [Ghangrekar 1997].

The UASB reactor can also be operated at psycrophilic temperature range, around 10^{o}C [Maat and Habets, 1987, Collivignarelli *et al*., 1990], but temperature from 15 to 55^{o}C are most common. The production of VFA increases when temperature rise above 8^{o}C but, methanogenic activity increases from 12^{o}C onwards. In experience with domestic wastewater [Bogte *et al*., 1993], it was reported that below 12^{o}C the purification was predominantly based on settling. Complete transformation of VFA in to biogas was achieved when temperature was above 15^{o}C. However, short period of low temperature does not negatively affect the overall performance of UASB reactor [Schellinkhout, 1993].

At low temperatures, the growth of the active biomass may be so low that it is very difficult and time consuming to accomplish the granulation process. Also, there is vast difference in the specific activity of the sludge at different temperature. It has been reported that the specific activity of sludge at 35^{o}C is more than twice of that at 20^{o}C, and about six times of that at 10^{o}C [Lettinga *et al*., 1980b, Zeeuw *et al*., 1983]. Hence, the loading capacity of the reactor increases appreciably when the temperature is increased from 20 to 30^{o}C for the same COD removal [Bhatti *et al*., 1995]. For this reason, process start-up should be done in mesophilic conditions even for the reactors designed to be operated at low temperature [Brunetti *et al*., 1983]. In all circumstances, a sharp temperature change is detrimental to microorganisms and should be avoided [Souza, 1986].