# WASTEWATER CHARACTERISTICS

**Effect of Preacidification of Wastewater**

Field experience with UASB reactors have shown that nonacidified wastewater give rise to more abundant granular growth than the wastewater in which carbohydrates are first all fermented to lower volatile fatty acids (VFA) [Vanderhaegen *et al*., 1992, Thaveersri *et al*., 1994, Weigant *et al*., 1983]. More complex soluble substrates such as sugar solutions give rise to very satisfactory granulation of the seed sludge. Also, the granules cultivated on carbohydrates do not deteriorate on feeding it with acidified wastewater [Wiegant *et al*., 1983].

It must be stated that granular sludge can be formed in reactors entirely fed with low-energy COD, such as lower VFA. Yet, in these systems, sludge bed doubling times are of the order of several months and the granules are rather small and fragile. In the treatment of vinasse it was reported that fresh vinasse gave rise to effective sludge bed growth, the granular yield observed was 10 times than preacidified vinasse [Vanderhaegen *et al*., 1992]. Similar observation was made while dealing with tannery wastewater. It was observed that one stage treatment showed better performance than two-stage system [Groenestijn *et al*., 1995]. Physical separation of methanogens and acidogens in two-phase system cannot enhance anaerobic bioconversion rates since; the necessary interspecies hydrogen transfer function is disturbed [Harper and Pholand, 1986].

Jhung and Choi, [1995] have reported that higher COD/VFA ratio favors granulation. For a lab-scale UASB reactor for complex carbohydrate waste treatment no granulation was observed at COD/VFA ratio of one. When the ratio was increased to two the granules of 2 mm size were observed. Also, for the treatment of VFA mixture under thermophilic condition no granulation was reported [VanLier *et al*., 1994]. In the study of biogas generation rate in a two phase UASB reactor treating distillery wastewater, very low biogas developing rate was observed [Shin *et al*., 1992] than the biogas production rate reported for similar wastewater [Wiegant *et al*., 1985]. Granulation was observed in both acidogenic and methanogenic reactor, but the time required for granulation was much more than the single stage system.

All these experiments clearly suggest that to achieve in-reactor granular growth, the feed should contain substantial amount of fermentable sugars. Also, syntrophic association of hydrogen oxidizing bacteria and hydrogen producing bacteria is important for granulation.

**Effect of Suspended Solids**

Finely dispersed and poorly flocculating matter in wastewater can affect the UASB system adversely when present in high concentration [Brunetti *et al*., 1983, Lettinga *et al*., 1980a, Hickey *et al*., 1991b]. It reduces the specific menthanogenic activity of the sludge. The presence of SS in the influent may slow down the growth in the amount of granular sludge. The attachment of newly formed bacteria to the continuously supplied fresh particles will retard or even prevent the development of granules. Also, the prolonged continuous entrapment of voluminous suspended solids in a granular sludge bed may even lead to a spontaneous and sudden washout of almost the complete sludge bed [Lettinga *et al*., 1991].

**Effect of Micro-carrier**

Use of micro-carrier as an initial support material enhances granulation in UASB reactor. The micro-carrier support material is added only initially while starting the reactor and not continuous as suspended solids. In experiments with mesophilic digestion in which hydroanthracite particle (0.25-0.42 mm particle size) were added to inoculum digested sewage sludge, a significant reduction of the time needed for granulation was observed [Wiegant *et al*., 1986]. Such an effect may be the result of better attachment of the filamentous bacteria to the particles, which offer initial nuclei for bacterial adhesion and would lead to a better retention. Once the nuclei have been introduced, the process becomes straightforward, since, this is a mere phenomenon of biofilm growth, and the generated biofilms aggregate each other to make larger granules. This simplifies the generation of UASB granules, and consequently enhances and ensures the start-up of the UASB reactors [Yoda *et al*., 1991].

Similar, results were obtained in a UASB reactor operated at 55$^{o}$C, where, zeolite (100□m) was added as micro-carriers, 15% of the effective reactor volume. Tight granules with a good settleability were obtained in this study with sucrose, and even with VFA as substrate [Ohtsuki *et al*., 1992]. In the different study at mesophilic temperature 30$^{o}$C, Yoda *et al*., [1989] had also reported the transformation of all the micro-carrier in to granular sludge. The micro-carrier used was zeolite with 150 ③m size and 15% of effective reactor volume. This phenomenon is particularly important for the wastes where the granulation process proceeds slowly and also a dense sludge is unable to be formed, and/ or granular seed sludge is getting deteriorated. The use of particulate carriers might be profitable under such circumstances, provided a stable biofilm develops on the carrier [Lettinga *et al*., 1983c].

**Effect of Calcium**

Bivalent cations such as $Ca^{2+}$ exert a positive effect on the flocculation of anaerobic sludge and for granules formation [Hulshoff *et al*., 1983a, Zeeuw and Lettinga, 1980, Habets and Knelissen, 1985a, Fang and Chui, 1993]. Removal of calcium lead to either disintegration or weakening of the structure of granules. Calcium is possibly a constituent of extra cellular polysaccharide and/ or proteins, which are used as linking materials. Bivalent cations have been implicated in the bacterial aggregation process because of their ability to bridge between the electronegative carboxyl and phosphate groups with bacterial surfaces. Calcium and iron salts (calcium carbonate, calcium phosphate and iron sulphide) were also reported to provide natural inert supports for the bacteria.

However, the higher calcium concentration may lead to the serious difficulties because of $CaCO_3$ scaling at the surface of the granules. The higher concentration of bivalent cations $Ca^{2+}$ and $Mg^{2+}$ leads to the chemical precipitation ($CaCO_3$, $CaHPO_4$, $MgNH_4PO_4$) resulting in the formation of granular sludge with high ash content (inorganic matter) [Hulshoff and Lettinga, 1986, Thiele *et al*., 1990]. Even in few cases it leads to very hard gravel like material in sludge bed [Kennedy *et al*., 1988]. While treating completely acidified wastewater with calcium concentration of 1200 mg/L unstable COD removal efficiency (60-90%) was observed due to cementation of sludge bed leading to operational problems [Langerak *et.al*., 1998]. Calcium concentration 780-1560 mg/L favors rapid granule formation with high ash content leading to serious cementation of sludge bed [Langerak *et.al*., 1998]. Calcium concentration of about 450 mg/L increases sludge washout from the reactor. High concentration (800 -1000 mg/L) induces a decline in specific activity of granular sludge [Hickey and Goodwin 1991a]. The concentration 80 to 200 mg/L of calcium appear to be beneficial for granule formation [Lettinga *et al*., 1980a].