

INOCULUM SLUDGE SOURCE

Type of Seed Sludge

The presence of bacterial culture and carrier materials for bacterial attachment is essential for the initiation and stimulation of sludge aggregation [Hulshoff and Lettinga, 1986]. Digested sewage sludge is most commonly used as the seed for granulation. Relatively easy and fast reactor start-up is possible with this type of seed sludge. The good inoculum digested sludge is characterized by low residual methanogenic activity ($< 0.6 \text{ kg CH}_4\text{-COD/m}^3\cdot\text{d}$) as well as good settleability (SVI, 50 mL/g VSS) after wash out of the colloidal fraction [Zeeuw and Lettinga, 1983]. With this type of sludge a long enough biomass retention time is possible to enable development of granular sludge devoid of support particles.

The digested sewage sludge with total solids less than 40 kg TS/m^3 usually has higher methanogenic activity than thicker types with total solids greater than 60 kg TS/m^3 . Sludge with concentration of 30 to 40 kg TS/m^3 exhibit the highest methanogenic activity [Zeeuw and Lettinga, 1983]. However, the thicker types are more preferred, since a longer sludge retention time could be maintained [Hulshoff and Lettinga, 1986]. With thinner types of sludges, excessive expansion of sludge bed may result in washout of sludge, and a longer time may be required for sludge granulation. Inoculated digested sludge concentrations of 10 to 20 g VSS/L in the reactor region is recommended for thicker sludge type [Hickey *et al.*, 1991b], and about 6 g VSS/L for thinner type of digested sludge.

Start-up without any seed material is possible for raw sewage [Barbosa *et al.*, 1989, Lettinga *et al.*, 1993b]. Long start-up is necessary in this case. The start-up time required in this case was reported to be 6 to 12 weeks. Start-up and granulation is possible with inoculum sludge other than digested sewage sludge. Activated sludge also has enough methanogenic bacteria and can be used as an alternative to digested sewage sludge [Wu *et al.*, 1987, Guyot *et al.*, 1990]. Successful cultivation of granules using digested sludges, activated sludge, cow manure have been reported for variety of wastewater over a wide temperature range from 20 to 55°C [Hulshoff *et al.*, 1983a, Wiegant and Man, 1986, Wu *et al.*, 1987, Manjunath *et al.*, 1989, Campos *et al.*, 1986, Peng and Jin, 1993].

Facultative waste stabilization pond sludge was also reported to be a suitable inoculum source for the UASB reactors treating a low strength domestic wastewater [Gnanadipathy *et al.*, 1993]. Flocculent sludge from an anaerobic rotating biological contactor reactor can also be used for successful start-up of the reactor [Yan *et al.*, 1993]. Bottom sediments of polluted ditch and sludge from septic tanks may also be used as seed material [Grin *et al.*, 1983]. Even raw sewage and fresh cow manure are among the options [Wiegant *et al.*, 1985a,b, Wiegant *et al.*, 1986, Souza, 1986].

If granular sludge from existing UASB reactor is used as seed material, it is superior to digested sewage sludge. The start-up process with granular sludge may be faster, depending on the nature of the wastewater and characteristics of the sludge [Hulshoff *et al.*, 1983a, Maat and Habets, 1987, Cao *et al.*, 1992, Hajipakkos, 1992, Goodwin *et al.*, 1992]. If the UASB reactor is seeded with

granular sludge adapted from other full scale plants with similar wastewater composition, the full organic load can be injected very quickly [Hacks, 1985] or even from the start depending on the volume of inoculum granular sludge used. Thus, the start-up time can be reduced from several months to less than a day [Maat and Habets, 1987]. But when, the granular sludge is not available for similar characteristics of the wastewater, and even if available the cost of granular sludge is much higher, then it is necessary to go for primary start-up procedure, which may be cheaper than adopting granular sludge.

Problem may arise when the granular sludge is exposed to wastewater that has a very different composition and strength from that on which the granular sludge was originally cultivated [Hall and Jovanovic, 1982, Kudo *et al.*, 1991]. The characteristics of the sludge may be expected to change in this case and secondary start-up becomes necessary [Peng and Jin, 1993].

Addition of small amount of crushed granular sludge in to the digested sludge seed can significantly enhance the development of granular sludge [Hulshoff *et al.*, 1983a,b, Hulshoff and Lettinga, 1986]. It can sharply increase the methanogenic activity. However, too large an amount of crushed granular sludge, greater than 15 % of the total seed material, will have no obvious beneficial effect although a smaller amount (less than 8 %) clearly enhances granulation. Addition of granular activated carbon to the basic non-granular seed sludge also found to have enhancing effect on granulation process and the reactor performance [Morgan *et al.*, 1991b]. It is reported that the supplementation of commercial charcoal (75-180 μ) at 50 mg/L of reactor volume in inoculum sludge improves characteristics of sludge developed in reactor. This phenomenon could be very useful for the wastewater where granulation proceeds slowly and dense sludge is unable to be formed [Ghangrekar, 1997].