8.2.5 Operational parameters of the aerobic digester

Once the optimal configuration of an aerobic sludge digester unit has been determined, it is a relatively simple matter to calculate the main operational parameters. These are:

- Reduction of the volatile sludge concentration;
- Oxygen uptake;
- Increase of the nitrate concentration;
- Alkalinity demand.

All these parameters are directly related to the oxidation of active sludge in the digester. The decrease of the active sludge concentration can be determined from the incoming and outgoing active sludge fractions (f_{ai} and f_{ae}) as follows:

$$f_{ae} = X_{ae}/X_{ve} = (X_{ai} - X_{ad})/(X_{vi} - (1 - f)\cdot X_{ad}) \quad (8.49)$$

Where X_{ad} = digested active sludge concentration (mg VSS.l^{-1})

By rearranging Eq.(8.49) one has:

$$X_{ad} = X_{ai}\cdot(1/f_{ai} - 1/f_{ae})/(1 - f - 1/f_{ae}) \quad (8.50)$$

For any optimised system, the values of f_{ai}, f_{ae} and X_{ai} will be known and the value of X_{ad} can be calculated. The operational parameters can now be linked to X_{ad}. The decrease of the volatile sludge concentration is a fraction (1-f) of the value of X_{ad} (a fraction f remains as endogenous residue), so that:

$$X_{vd} = (1 - f)\cdot X_{ad} \quad (8.51)$$

Where X_{vd} = digested volatile sludge concentration (mg VSS.l^{-1} of sludge)

Similarly, the increase in the nitrate concentration and the alkalinity decrease are determined: knowing that the oxidation of l mg VSS results in the release of f_n mg N, which after nitrification is transformed into nitrate, consuming in these processes an alkalinity of 3.57 mg $CaCO_3$.mg^{-1} N, one has:

$$N_{nd} = f_n\cdot X_{vd} = f_n\cdot(1 - f)\cdot X_{ad} \text{ and} \quad (8.52)$$

$$Alk_d = 3.57\cdot N_{nd} = 3.57\cdot f_n\cdot(1 - f)\cdot X_{ad} \quad (8.53)$$

Where:

N_{nd} = nitrate production in the digester (mg N.l^{-1} of sludge)
Alk_d = alkalinity consumed in the digester (mg $CaCO_3$.l^{-1} of sludge)

The oxygen uptake rate in the digester is calculated from the oxygen demand: the oxidation of one mg VSS requires f_{cv} mg O_2 for the organic matter and $4.57\cdot f_n$ mg O_2 for nitrification of the released organic nitrogen. Hence:

$$V_{da}\cdot O_{tda} = q\cdot(f_{cv} + 4.57\cdot f_n)\cdot X_{vd} \text{ or}$$

$$O_{tda} = (f_{cv} + 4.57\cdot f_n)\cdot(1 - f)\cdot X_{ad}/R_d \quad (8.54)$$