1. **Approach to get the elementary flows of COD and nutrients**

The steps are the following:

1. We execute the design according to Metcalf&Eddy equations
2. Some extra calculations and inputs needed after executing the design to prepare for the elementary flows factors
3. Calculation of the elementary flows factors following the equations in Table 1.
4. **Extra calculations and new inputs needed**

Inputs needed:

* TSSef: Average effluent TSS concentration (from 5 to 35 mg/L); 35 mg/L is the limit established by the directive 91/271 EU. This will be imposed in the desing exercise; and from this one we will estimate VSSe.

Extra calculations:

**Table 1. Extra calculations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Id** | **Description** | **Equation/Value** | **Source** |
| VSSe | WWTP Effluent volatile suspended solids (g/m3) | = TSSef · 0.85 | Metcalf % Eddy |
| Qwas | Wastage flow rate (m3/d | V in m3, MLSS in g/m3, SRT in days, TSS in g/m3, Q in m3/d | Typical equation of SRT calculation (see metcalf and eddy) |
| Qin | Influent flow (m3/d) |  |  |
| Qe | Effluent flow (m3/d) |  |  |

1. **COD Influent fractionation (in red what is an input ; in green what is calculated)**

**Table 2. COD influent fractionation;**

|  |  |  |  |
| --- | --- | --- | --- |
| **Inputs** | **Fractions** |  | **Equation/Value** |
| TCOD | COD total (g/m3) |  |  |
| sCOD | COD soluble (g/m3) |  |  |
| BOD | This is the BOD5 (g/m3) |  |  |
|  | bCOD (g/m3) |  | bCOD = 1.6(BOD) |
|  | nbCOD (g/m3) |  | nbCOD = TCOD - bCOD |
|  | nbsCODe (g/m3) |  | nbsCODe = sCOD - 1.6·sBOD (a check in here is needed to make sure that nbsCODe is not negative !... if this is the case I would fix nbsCODe at 20 g/m3 and recalculate sCOD) |
|  | nbpCOD (g/m3) | To calculate nbVSS | nbpCOD = TCOD - bCOD - nbsCODe |
|  | VSSCOD (g/m3) | To calculate nbVSS | VSSCOD = (TCOD-sCOD)/VSS |
|  | nbVSS (g/m3) | To calculate sludge production (non biodegr from the influent) | nbVSS = nbpCOD / VSSCOD |
|  | rbCOD (g/m3) | Readily biodegradable COD | We assume that rbCOD = bCOD ; |
| TSS | Total suspended solids (g/m3) |  |  |
| VSS | Volatile suspended solids (g/m3) |  |  |
|  | iTSS (g/m3) | To calculate sludge production (inerts from the influent) | iTSS = TSS – VSS |
|  | Px,bio (g/d) |  |  |
|  | Px,vss (g/d) |  | PX,VSS = PX,bio + Q·nbVSS |
|  | Px,TSS (g/d) |  |  |

1. **Nitrogen influent fractionation (in red what is an input ; in green what is calculated)**

**Table 3. N influent fractionation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Inputs** | **Fractions** |  | **Equation/Value** |
| TKN  (g/m3) |  |  |  |
|  | nbpON (g/m3) |  | nbpON = fN(nbVSS) ; fN=0.064 ; |
|  | nbsON (g/m3) |  | = 1 g/m3 ; |
|  | TKN\_N2O (g/m3) |  | TKN\_N2O = fN2O X TKN; fN2O= 0.001 gN-N2O/gN-TKN |
|  | bTKN  (g/m3) | Biodegradable TKN available for nitrification; this is the fraction of N used for nitrification. We assume 100% of bTKN is hydrolyzed to Ammonia. | bTKN = TKN - nbpON – nbsON – TKN\_N2O |
| Ne (g/m3) |  | Imposed ammonia concentration in the effluent |  |
| NOx,e (g/m3) |  | This is the imposed NOX concentration at the effluent |  |
|  | NOx\_nitri (g/m3) | Amount of nitrogen oxidized to nitrate | NOx\_nitri = bTKN – Ne – 0.12·Px,bio/Q (g/m3) |

1. **Phosphorus influent fractionation (in red what is an input ; in green what is calculated)**

**Table 4. Influent P fractionation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Inputs** | **Fractions** |  | **Equation/Value** |
| TP (g/m3) |  |  |  |
|  | nbpP (g/m3) |  | nbpP = fP·(nbVSS) ; fP=0.025 gP/gnbpVSS; |
|  | nbsP (g/m3) |  | = 0 gP/m3 |
|  | aP (g/m3) | Available phosphorus to be accumulated in organisms ; this corresponds to the P in Metcalf and Eddy design exercise. | aP = TP – nbpP – nbs = PO4in |
|  | aPchem (g/m3) | Available phosphorus for chemical P removal (we first use P for biomass growth and the remaining is going to be precipitated with chemicals) | aPchem = aP – (0.015 · Px,bio)/Qin |

1. **Elementary flows factors**

**Table 5. Elementary flows factors**

For organic matter we provide the elementary flow based on COD; just one C balance based on COD. The BOD is included within the balance, but will not have a separate balance. The lower case “e” means effluent. All flows in m3/d; concentrations are in g/m3.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Water (effluent) (g/d)** | **Air (g/d)** | **Sludge (g/d)** |
| COD | CODwater = sCODe + biomass CODe | (negative COD goes to air in the form of oxygen; but this is accounted as oxygen demand, estimated from metcalf and Eddy equations;) | CODsludge = A + B |
| CO2 | - | CO2 from BOD oxidation (includes COD removal under aerobic and under anoxic conditions, with the assumption that yield in aerobic is same as anoxic) + CO2 from endogenous decay –CO2 consumed by nitrifiers    About 10% of this CO2 should be accounted as is non-biogenic!  Should we account as well CO2 consumed by nitrifiers and the CO2 produced in the denitrification? |  |
| TKN | TKNe = sTKNe + biomass N  )  Ne is imposed by design input | - | Nsludge = A + B |
| NOx | - For technology BOD removal only; and BOD removal + nitrification:  - For the technology BOD removal + nitrification + denitrification:  NOx is Imposed by design input | - |  |
| N2 | - | Only for the technology that includes denitrification (= the technology that is named Nremoval). For the others N2 equals 0.  ) | - |
| N2O | - | This applies to all technologies (even BOD removal only?) | - |
| TP | (in g/d)  For non BioP and non ChemP🡪  For BioP 🡪 PO4e is Imposed by design input    For chemP 🡪 PO4e is Imposed by design input | - | (in g/d)  **A+B**  For non BioP🡪  For BioP 🡪  For chemP 🡪 |
| S |  |  |  |
| CH4 | - |  | - |