Raw sewage and its treatment

|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | meaning | equation | default |
| Q | Sewage flow |  | 0.2 |
| SO | Mass of sewage solids |  | 0.09 |
| BOD |  |  | 0.06 |
| FB | Fraction BOD in sewage solids |  | 0.5417 |
| FS | Fraction sewage solids removed by primary settler |  | 0.667 |
| focs | Fraction organic carbon in sewage solids |  | 0.3 |
| ds | Density of sewage solids |  | 1.5 |
| Cso,s | Conc. solids in raw sewage |  | 0.45 |
| CBOD,S | Conc. BOD in raw sewage |  | 0.3 |

Defining the primary clarifier

|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | meaning | equation | default |
| hps | Depth of the PS tank |  | 4 |
| HRTPS | Hydraulic retention time |  | 2 |
| VOLPS | Volume PS per person |  | 1.67∙10-2 |
| AREAPS | Area PS per person |  | 4.167∙10-3 |
| CSO,PS | Conc. suspended solids in PS | (1-FS) ∙ Cso,s | 0.15 |
| FP | Fraction BOD removed by PS | FS∙FB | 0.36 |

Defining the activated sludge process

|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | meaning | equation | default |
| hAS=hSLS | Depth of aeration tank and SLS |  | 3 |
| HRTSLS | Hydraulic retention time SLS |  | 6 |
| CSO,AS | Conc. suspended solids in activated sludge |  | 4 |
| CSO,SLS | Conc. suspended solids in effluent |  | 0.0075 |
| dAS | Density of activated sludge solids |  | 1.3 |
| focAS | Fraction organic carbon activated sludge |  | 0.37 |
| kSLR | Sludge loading rate |  | 0.1 |
| M | Aeration mode: surface (s) or bubble (b) |  | s |
| OxReq | Oxygen requirement |  | 0.192 |
| VOLAS | Volume aerator per person |  | 9.6∙10-2 |
| AREAAS | Area aerator per person |  | 3.2∙10-2 |
| HRTAS | Hydraulic retention time  aerator |  | 11.5 |
| VOLSLS | Volume SLS per person |  | 5.0∙10-2 |
| AREASLS | Area SLS per person |  | 1.67∙10-2 |

|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | meaning | equation | default |
| FBODrem | Fraction BOD removed in activated sludge  process |  | 0.915 |
| YBOD | Sludge growth |  | 0.777 |
| SU | Wasted sludge (surplus sludge) |  | 0.026 |
| SRT | sludge retention time |  | 14.1 |

Definition of the modelled chemical

Equilibrium partitioning constants

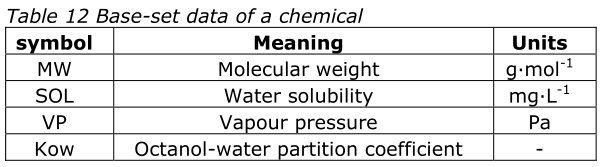
|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | meaning | equation | default |
| SOS | Chemical concentration in sewage solids (raw and settled) |  |  |
| SOAS | Chemical concentration in activated sludge solids |  |  |
| W | Chemical concentration in water |  |  |
| A | Chemical concentration in air |  |  |
| KAW | Air-water equilibrium partition constant |  |  |
| Kps | Sewage solids-water equilibrium partition constant |  |  |
| KpAS | Activated sludge solids-water equilibrium partition  constant |  |  |

Henry’s law constant, H, has dimensions of Pa∙m3∙mol-1. P is the vapour pressure in Pascal (Pa) of the chemical in equilibrium with the aqueous concentration W, MW is the molecular weight of the chemical in g∙mol-1, R is the gas constant (8.314 J∙K-1∙1R -1) and T is the absolute temperature (K). KAW is also known as the dimensionless Henry constant.

Estimation methods for equilibrium partitioning constants

Neutral organic chemicals

From base-set data (Table 12) the air-water equilibrium partition coefficients of organic chemicals is estimated according to:



For the partitioning of the chemical between solids and the aqueous phase, a simple relationship is applied:

With：

Kp: partition coefficients [L∙kg-1] for sewage (KpS) or activated sludge (KpAS)

Koc: partition coefficient for organic [L∙kg-1]

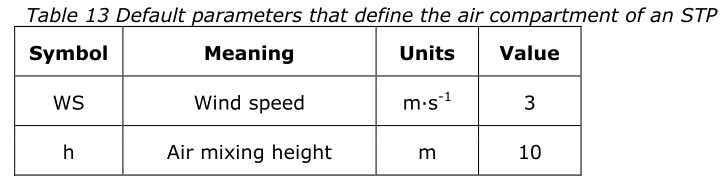
foc: fraction organic carbon solids, focS =0.3 or focAS =0.37[-]

Organic acids and bases

In the case of acids, γ equals 1 and, in the case of bases, γ is -1

Chemical fate processes

Mass balance equations



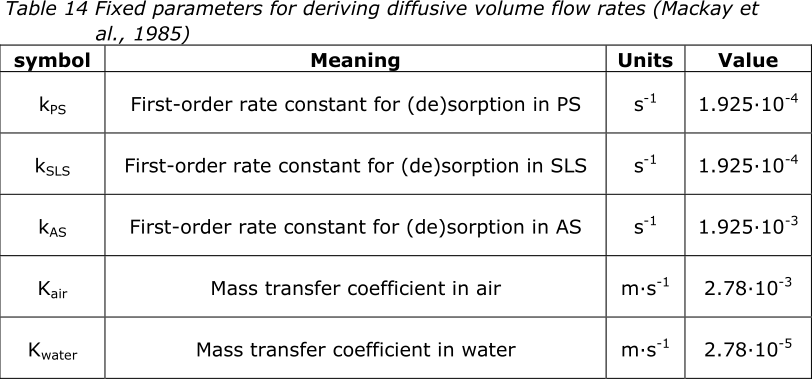


Table A1 Volumes of the nine boxes per inhabitant

|  |  |  |
| --- | --- | --- |
| Vi | Equation | default value  (m3∙PE-1) |
| V1 |  | 0.53 |
| V2 |  | 1.6710-2 |
| V3 |  | 1.67∙10-6 |
| V4 |  | 4.17∙10-5 |
| V5 |  | 9.58∙10-2 |
| V6 |  | 2.95∙10-4 |
| V7 |  | 5.0∙10-2 |
| V8 |  | 2.88∙10-7 |
| V9 |  | 1.67∙10-5 |

|  |  |  |
| --- | --- | --- |
| ADVi,j | Equation | default value |
| ADV0,1 |  | 6.9 m3∙s-1∙PE-½ |
| ADV1,0 |  | 6.9 m3∙s-1∙PE-½ |
| ADV0,2 |  | 2.31∙10-6 m3∙s-1∙PE-1 |
| ADV2,5 |  | 2.31∙10-6 m3∙s-1∙PE-1 |
| ADV5,7 |  | 2.31∙10-6 m3∙s-1∙PE-1 |
| ADV7,0 |  | 2.31∙10-6 m3∙s-1∙PE-1 |
| ADV0,3 |  | 6.94∙10-10 m3∙s-1∙PE-1 |
| ADV3,4 |  | 4.63∙10-10 m3∙s-1∙PE-1 |
| ADV3,6 |  | 2.31∙10-10 m3∙s-1∙PE-1 |
| ADV4,0 |  | 4.63∙10-10 m3∙s-1∙PE-1 |
| ADV6,8 |  | 7.12∙10-9 m3∙s-1∙PE-1 |
| ADV8,0 |  | 1.34∙10-11 m3∙s-1∙PE-1 |
| ADV8,9 |  | 7.11∙10-9 m3∙s-1∙PE-1 |
| ADV9,0 |  | 2.29∙10-10 m3∙s-1∙PE-1 |
| ADV9,6 |  | 6.88∙10-9 m3∙s-1∙PE-1 |
| Sludge decay |  | 2.44∙10-11 m3∙s-1∙PE-1 |

|  |  |
| --- | --- |
| XCHi,j | Equation |
| XCH1,2 |  |
| XCH2,1 |  |
| XCH2,3 |  |
| XCH3,2 |  |
| XCH1,5 |  |
| XCH5,1 |  |
| XCH5,6 |  |
| XCH6,5 |  |
| XCH1,7 |  |
| XCH7,1 |  |
| XCH7,8 |  |
| XCH8,7 |  |

Output

Emission to air

The fraction of the chemical emitted to air (Eair) by an STP of the size of N inhabitants is:

E: Emission rate of the chemical

Emission to water

The total concentration (CT in mg∙L-1) in effluent discharged into the receiving water body is:

The fraction (Eeff) of the chemical input that leaves an STP serving N inhabitants via effluent is:

Emission via combined sludge

The concentration in combined sludge (Ccs in mg/kg dry weight) equals