Overview of operations in unit groups for a generic wastewater biorefinery

Unit Group Numbers	Type	Unit Group Description
0.1-0.2	Separation 0	Separation of raw influent streams, with primary settling and splitting
1.1	Bioreactor	Bacterial bioreactor, preceded by a holding/mixing tank
1.2-1.4	Separation 1	Separation of bacterial product, bacterial biomass and improved effluent (to algal reactor)
2.1	Bioreactor	Algal bioreactor, preceded by a holding/mixing tank
2.2-2.5	Separation 2	Separation of algal products, algal biomass and almost compliant effluent (to macrophyte reactor)
3.1	Bioreactor	Macrophyte bioreactor, preceded by a holding/mixing tank
3.2-3.6	Separation 3	Separation of fibre, cellulosic biomass, sediment and compliant effluent (leaving system) some processes seasonal
4.1	Bioreactor	Solids reactor, preceded by a holding/mixing tank
4.2-4.4	Separation 4	Separation of solids reactor product, separated into crust-associated products, liquor-associated products and cake-associated products, the remainder being compost.

Overview of streams for a generic wastewater biorefinery

Stream number	Stream description	Relation to process units	Relation to other streams (equations refer to mass balance, not volume)
A1-A4	Raw Wastewater	Into Separation 0 (Units 0.1-0.2-3)	Mixed incoming stream
B1	Settled Raw Wastewater	From Separation 0 Into Unit 1: Bacterial Bioreactor	B1 = A1-4 - U1 - D2 Composition same as D2
B2-4	Supplementary Feed	Into Unit 1: Bacterial Bioreactor	Determined by process needs
C1	Bacterial Broth	From Unit 1: Bacterial Bioreactor Into Separation 1	C1 = B1 + B2-4 + C4 + C5 + C6 Composition changed from B1 including increased VFA content
C4	Bacterial Biomass Recycle	From Separation 1 Into Unit 1: Bacterial bioreactor	C4 = C1 - U2 - D1 - V1 Composition changed from C1 Low liquid content
C5	CO_2	From Unit 1: Bacterial Bioreactor To atmosphere	CO_2 only
C6	H_2O	Between Unit 1: Bacterial Bioreactor and atmosphere	H_2O only, rainfall and/or evaporation
D1	Improved Compliance Effluent with VFA content	From Separation 1 Into Unit 2: Algal Bioreactor	D1 = C1 - C4 - U2 - V1 Composition similar to dissolved composition C1
D2	Settled Raw Wastewater, bypass stream	From Separation 1 Into Unit 2: Algal Bioreactor	D2 = A1-4 - B1 - U1 Composition same as B1.
D3-5	Supplementary Feed	Into Unit 2: Algal Bioreactor	Determined by process needs
E1	Algal Broth	From Unit 2: Algal Bioreactor Into Separation 2	E1 = D1 +D2 + D3-5 + E5 + E6 Composition changed from D
E5	CO_2	From atmosphere Into Unit 2: Algal Bioreactor	CO_2 only
E6	H_2O	Between Unit 2: Algal Bioreactor and atmosphere	H_2O only, rainfall and/or evaporation
F1	Almost Compliant Effluent	From Separation 2 Into Unit 3: Macrophyte Bioreactor	F1 = E1 - W1 - W2 - W3 - U3 Composition same as dissolved composition E1
F2-4	Supplementary Feed	Into Unit 3: Macrophyte Bioreactor	Determined by process needs

Stream number	Stream description	Relation to process units	Relation to other streams (equations refer to mass balance, not volume)
G1	Wet Macrophyte Biomass	From Unit 3: Macrophyte Bioreactor Into Separation 3	G1 = F1 + F2-4 + G6 + G7 Composition changed from F1 Combination of liquid, fibre and sediment
G6	CO_2	From atmosphere Into Unit 3: Macrophyte Bioreactor	CO_2 only
G7	H_2O	Between Unit 3: Macrophyte Bioreactor and Atmosphere	H_2O only, Precipitation/Evaporation
H1	Solids Matrix	From Unit 4: Solids Reactor Into Separation 4	H1 = U1 + U2 + U3 + U4&5 + U6-8 – H4 + H5 Composition complex.
H4	CO_2	From Unit 4: Solids Reactor To atmosphere	CO_2 only
H5	H_2O	Between Unit 4: Solids Bioreactor and Atmosphere	H_2O only, Precipitation/Evaporation
U1	Primary Settling Tank Bottoms	From Separation 0 Into Unit 4: Solids Reactor	Volume and composition dependent on incoming streams. U1 = A1-4 - B1 - D2. Dependent on PST efficiency
U2	Bacterial Bottoms	From Separation 1 Into Unit 4: Solids Reactor	U2 = C1 - (D1 + I + C4) Composition based on bacterial biomass
U3	Algal Biomass not to product streams	From Separation 2 Into Unit 4: Solids Reactor	Total algal biomass = U3 + L U3 = E1 – (F1 + W1 + W2 + W3) Composition based on algal biomass
U4&U5	Cellulosic Biomass & N & P Rich Sediment	From Separation 3 Into Unit 4: Solids Reactor	U4+U5 = G1 - (Z + X1 +X2 + X3) U4: Composition based on macrophyte (above ground) biomass, U5: Composition based on sediment accumulation (not directly related to input streams), the same as X3
U6-8	Supplementary Feed	Into Unit 4: Solids Reactor	Determined by process needs
V1	Bacterial Product Stream	From Separation 1 Exit system	V1 = (B1+ B2-4) * Bacterial bioproduct yield coefficient Stream needs further processing for pure product.
W1	Algal Oil Stream	From Separation 2 Exit system	W1 = (D1 + D2 + D3-5 + E5) * Algal oil yield coefficient Stream needs further processing for pure product.
W2	Algal Bioproduct Stream	From Separation 2 Exit system	W2 = (D1 + D2 + D3-5 + E5) * Algal bioproduct yield coefficient. Stream needs further processing for pure product.
W3	Algal Biomass (digestible 'waste')	From Separation 2 Exit system	W3 = (D1 + D2 + D3-5 + E5) - (W1 + W2 + F1) Note U3 can be 0 Composition same as U3
X1	Fibre Stream	From Separation 3 Exit system	X1 = G1 * (1- moisture content fraction) * Fibre compositional fraction
X2	Cellulosic Biomass Stream	From Separation 3 Into further processing and/or leave system	X2 = G1 * (1- moisture content fraction) * Cellulosic compositional fraction
X3	N & P Rich Sediment	From Separation 3 Exit system	Composition based on sediment accumulation (not directly related to input streams)
Y1	Crust/Surface Product Stream	From Separation 4 Exit system	Y1 = (U1 + U2 + U3 + U4&5 + U6-8) * Crust product yield coefficient
Y2	Liquor Associated Product Stream	Separation 4 Exit system	Y2 = (U1 + U2 + U3 + U4&5 + U6-8) * Liquor associated product yield coefficient
Y3	Cake-Related Product Stream	Separation 4 Exit system	Y3 = (U1 + U2 + U3 + U4&5 + U6-8) * Cake-related product yield
Y4	Compost	Separation 5 Exit system	Y4 = H1 - (Y1 + Y2 + Y3)
Z	Compliant Effluent	From Separation 4 Exit system	Composition must comply with discharge standards (either for discharge into natural water body or for irrigation or for re-use)