Monod Growth: Specific Rate, Doubling Time and Chemostat Washout

Specific growth rate by Monod with Levenspiel product inhibition, doubling time, and the steady state, washout dilution rate and productivity of a chemostat.

Method: Doran; Bioprocess Engineering Principles; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Maximum specific growth rate	0.40000	1/h
Saturation constant	0.20000	g/L
Substrate concentration	5.0000	g/L
Inhibiting product concentration	0	g/L
Product concentration that stops growth	90.000	g/L
Inhibition exponent	1.0000	
Feed substrate concentration (chemostat)	20.000	g/L
Biomass yield on substrate	0.50000	kg/kg
Dilution rate	0.20000	1/h

Calculated results

Parameter	Value	Unit
Specific growth rate at S and P	0.38462	1/h
Doubling time	1.8022	h
Washout dilution rate	0.39604	1/h
Steady-state substrate at D	0.20000	g/L
Steady-state biomass at D	9.9000	g/L
Biomass productivity	1.9800	kg/(m³·h)

Formula and method

The formula is shown on the calculator page: https://calc.firecad.com/chemical/bioprocess/monod-growth-washout

Variables

μ_{max}	Maximum specific growth rate	1/s
K_s	Saturation constant	kg/m³
S	Substrate concentration	kg/m³
P	Inhibiting product concentration	kg/m³
P_m	Product concentration that stops growth	kg/m³
n	Inhibition exponent	-
S_0	Feed substrate concentration (chemostat)	kg/m³
$Y_{X/S}$	Biomass yield on substrate	kg/kg
D	Dilution rate	1/s
μ	Specific growth rate at S and P	1/s
t_d	Doubling time	s
D_{crit}	Washout dilution rate	1/s
S_{ss}	Steady-state substrate at D	kg/m³

X_{ss}	Steady-state biomass at D	kg/m³
DX	Biomass productivity	kg/(m³·s)

Method and standards

Monod with Levenspiel inhibition (product concentration taken as fixed).

Assumptions and limits

- Single limiting substrate; no maintenance or death terms.
- In a real chemostat the product concentration depends on D; holding P fixed while finding S_ss and X_ss is an approximation.
- With no growth (S = 0 or P at or above P_m) the doubling time is infinite and is not shown.

References

• Doran
• Bioprocess Engineering Principles
• 2nd ed. (Academic Press, 2013)
• ch. 12 (Monod kinetics, chemostat steady state and washout)
• Levenspiel (1980)
• Biotechnol. Bioeng. 22: 1671 (product inhibition (1 − P/P_m)ⁿ)

Report details

Report reference	FCC-QB06-2XRZ (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/bioprocess/monod-growth-washout

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.