TBP01x - 2.7 - banana 2

Welcome to banana 2, which is that volumes are not constant, and the banana is about the consequences when you neglect volume changes. For that I made an example, which is based on batch experiments, which happen to be done on lab scale and full scale. The following measurements are done, at different times, so we have time 10 hours and 13 hours. And in the lab scale we have volume measurements in liters, biomass concentration measurements in gram per liter, and product concentration measurements in gram per liter. The same of course we have also volume measurements in cubic meter on full scale, biomass concentrations in kilograms per cubic meter on full scale, and product concentrations in kilograms per cubic meter. So the following measurements were done: 1.05 L and 0.787L, and you see that on lab scale we have a sizable volume reduction, which might be due to evaporation of water. Biomass concentrations are 5.00 grams per liter and 9.00 grams per liter three hours later. Product concentration is 2.00 grams per liter and 4.407 grams per liter at 13 hours. On the full scale we have a much bigger volume at 10 hours: 5.00 m3, and the volume change is also there, so at 13 hours we have 4.90 m3 . The biomass and the product concentrations in kg/m3 , which is of course the same as grams per liter, on lab and on full scale are exactly the same at 10 hours. But, at 13 hours, things seem to change, because we measure now 6.88 kg biomass per m3, and 3.38 kg product/ m3 which, if you compare it with the lab and the full scale, students come immediately to the conclusion: the organism on full scale performs much less than on lab scale, because the biomass and product concentrations are much lower. And then they come forward with what we call a scale up effect, and make all fancy conclusions, and so is there a scale up effect? Students they say: yes, and I say: nonsense, because you followed the wrong interpretation. When you have to compare the same organism in two different conditions, lab scale and full scale, the only safe way to see if there is a difference in performance is to look at the q-values. In this case we have product and biomass measurements, so what we should do is µ and qp . So what is µ and qp ? We discussed this intensively, that µ and qp come from balances, so µ comes from the biomass balance which we discussed, and I hope you remember that we come to the following conclusion the logarithm of the amount of biomass at in this case 13 hours, divided by the amount of biomass at 10 hours, should equal µ multiplied by the time difference, which is 3 hours. Now the amount of biomass at 13 hours is easily calculated as the product of biomass concentration and volume, and the same for 10 hours. So when you do the calculation you will find for the lab µ = 0.1 h-1. If you do that for the full scale with the same equation, you calculate the amount of biomass at 13h by the product of concentration and volume and the same for 10h, then you find at the full scale µ = 0.1 h-1. Using a fundamental result of the biomass balance, which allows you to calculate µ. qp , we discussed that also before, can be found most conveniently essentially from the product balance but it is more convenient to have the combi-balance and I hope you remember that the combi-balance tells you that qp / µ equals the amount of product produced, which is basically Np(13) minus Np(10), divided by Nx(13) minus Nx(10). So the only thing we have to do is now to calculate for the lab, this ratio because this is the gram product in the lab, so that's the product concentration multiplied by the volume at 13 hours, minus the product concentration multiplied by the volume at 10 hours. You fill it in. So that's the product, and then we have for the biomass 9 multiplied by the volume at 13 hours, minus 5 multiplied by the volume at 10 hours, so that means that you have then the gram of biomass produced. If you fill in all the numbers you find that this ratio is 0.75 grams of product per gram of biomass. For the full scale you find also, from these data with this equation, you also find 0.75 gram product per gram biomass. And because we know already μ, this equation tells you that qp¬¬ equals 0.75 multiplied by μ, and it's the same on full scale as on lab scale. So end of story is: there is no scale-up effect, the organism forms exactly the same on lab scale and full scale, but because volumes are changing, concentrations are changing, but still the rates per organism, so the q-values qp and μ are exactly the same. Thank you very much.