# Washing Validation Script

The goal of this document is to validate the application of washing into the Leafy green model, by comparing and adapting the model by Munther et al.

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## Creating FC levels Curve

The first step is to compare the levels of FC in wash steps as a condition of dosing periods and chemical oxygen demand COD.

For this specific creation of FC curve, we used the parameters mentioned in Munther et al. As defined in the following equation

Where FC is the concentration (mg/L) of FC available, is the is the depletion rate of free chlorine in the wash water (L/mg min).is the added rate of free chlorine at the desired dose (mg/ mL min2). is an indicator function, where it is 1 if the time is withing the dosing period time interval , and 0 if the dosing period is off.

The variables defined are below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Chlorine Levels over time | | | | | |
|  | r1 | FC addition rate of dose 1 | **C Wash:** 12.75  No C Wash: 0 | mg/(ml(min)2) |
|  | r2 | FC addition rate of dose 2 | **C Wash:** 7.47  No C Wash: 0 | mg/(ml(min)2) |
|  | r3 | FC addition rate of dose 3-n | **C Wash:** 5.56  No C Wash: 0 | mg/(ml(min)2) |
|  | Ro | Chlorine dosing period | 12 | min |
|  | Ro0 | Chlorine dosing period duration | 2 | min |
|  | K0 | Free Chlorine demand per minute | 32.3 | mg/ (L min) |
|  | ΛFC | Natural decay of FC | 1.7\*10-3 | 1/Min |
|  | Β FC | Depletion rate of FC in wash water | 5.38\*10-4 | L/ (mg min) |
|  | O | Products Initial Oxygen Demand | 301-366 | mg/L |

Using the following equation and applying in the model we can track chlorine over time.

Below you can see he validation of the Fc levels over time

On the left results from our model and on the right results from Munther et al. As observed the curves are properly reproduced as demonstrated in the manuscript of Munther et. al

Chart, histogram

Description automatically generatedHistogram

Description automatically generated with medium confidence

Recreating the same FC depletion tools meant that we had to take the same processing parameters as Munther et al.

This mean having a product flow rate of ~100 lb/min or 45,000 g/min. A wash tank with a volume of 3.2X10^6 mL, and a reciprocal wash time of 2.3/min. Where these processing parameters were adapted by Luo and et al, 2012. And the natural decay of Fc was obtained from Hua and et al 1999.

Conduct the same experiment to validate the model.

The goal of this is to see if the functions that we have adapted for the model are able to reproduce the plots from the experiment by Munther et. Al.

Using the functions and the parameters for the model we were able to obtain the reproduce the plots.

**XL**

Once again, the Left one if the plot produced by our model adaptation, while the one on the right hand is the one by Munther et al.

Chart, line chart

Description automatically generated Chart, line chart

Description automatically generated

**XW**

Chart

Description automatically generated Chart, line chart

Description automatically generated

## Slight Change to XL

Using the same approach as these we did a slight adaptation to the calculation of XL. In the equation by Munther et al for X

The original equation by Munther et al.

Calculates the change in XL as:

Where the first term indicates the rate increase of pathogen transferring from the water to the lettuce, and the second term reflects the inactivation of the pathogen on the lettuce due to FC., where the third term is a factor of dwell time of dwell time.

Since in our model contamination goes from lettuce to lettuce a slight modification was made to the equation to quantify a log reduction of the cell on the lettuce as a factor of FC. The second and third terms were substituted by the first term above, while the second term is still conserved to measure transfer from water to the lettuce. This first term was adapted from Madamba et al.

When running the model with the equation substitution the results look the same as the ones ran with the first validation exercise.

Chart, line chart

Description automatically generated Chart

Description automatically generated

Testing Xs

Xs was also updated, since we have only lettuce going in, we updated the Xs according to Pang et al. When we put the contamination in the lettuce the Xs curves obtained are fairly like the ones we had the contamination coming from the spinach as expected since the contamination going into the water should be the same. Therefore, we can say that the total effect of the updated Xs and Bws terms is validated with new Bws term defined from cross contamination from lettuce.

Chart, line chart

Description automatically generated

Ultimately now that the contamination is in the Lettuce XL is expected to be higher. We run XL and we observe that there are reductions in the number of pathogens in the lettuce due to the chlorine and that in areas is plateaus when FC levels are lower than 0.5. The results do make sense therefore the model is considered validated.

Chart, histogram

Description automatically generated