Methodology on post-flood pond model for pathogen

The post-flood pond model for pathogen was developed in Matlab/Simulink (Figure) and it was divided into two different components: hydrological processes for the water level and the decay rate of pathogens, described in the following chapters.

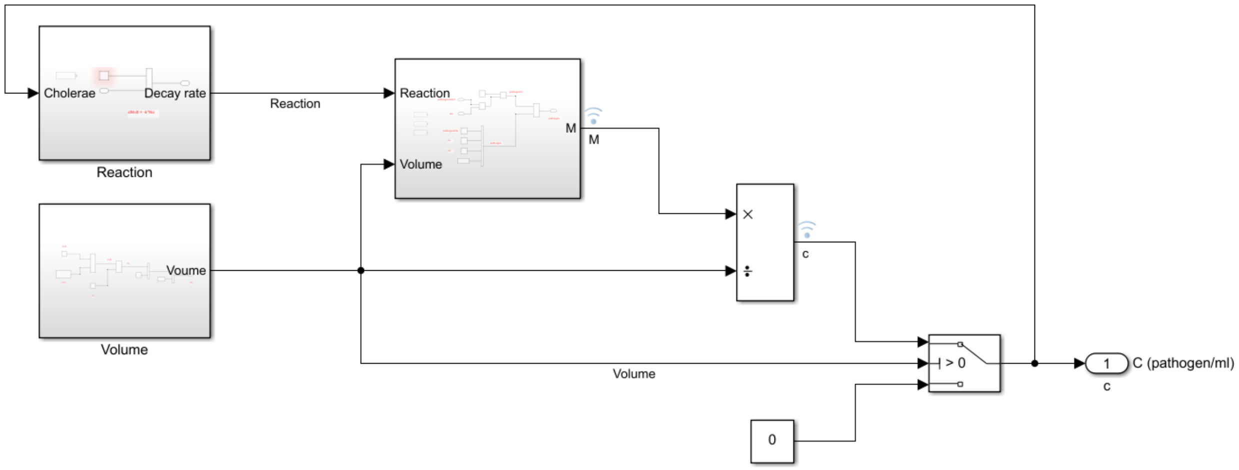

Figure 1 Post-flood pond model developed in Matlab/Simulink.

1 *Hydrological processes*

The water level in a pond is controlled by the balance between input and output (Eq. 1):

$$Q_{in} - Q_{out} = A\frac{dD}{dt} \quad \text{(Eq. 1)}$$

where Q_{in} [L^3 T^{-1}] is the sum of all water inputs, Q_{out} [L^3 T^{-1}] is the sum of all outputs, A [L^2] is the surface area of the pond, and $\frac{dD}{dt}$ [L T^{-1}] is the rate of water-depth (D) change.

The water level changes overtime are determined by the seasonal and interannual variability of the difference between inputs and outputs. The inputs include perennial and intermittent streams, groundwater inflow, precipitation, diffuse runoff from the shoreline, and snowdrift. The outputs include streams, groundwater outflow, and evaporation (Hayashi & Kamp, 2007). Due to data scarcity, the processes considered in this project were infiltration and evaporation as outputs. The first one was calculated with the Horton equation (Eq. 2), that has been widely used to simulate infiltration under ponding conditions (Wang & Chu, 2020).

$$f_p = f_c + (f_0 + f_c)e^{-kt} \quad \text{(Eq. 2)}$$

where f_p is the infiltration capacity [depth/time] at some time t; k is a constant representing the rate of decrease in f capacity; f_c is a final or equilibrium capacity; and f_0 is the initial infiltration capacity (Viessman & Lewis, 1997). Based on Tholin & Kiefer (1959), the equation used in this project was:

$$f = 0.53 + 2.47e^{-0.0697t} \quad \text{(Eq. 3)}$$

Additionally, the Hargreaves and the Samani method (Eq. 4) was used to compute evaporation, as it only requires one input variable: the air temperature.

$$ET_o = 0.0023 * H_0 * (T_{mx} - T_{mn})^{0.5} * (\bar{T}_{av} + 17.8) \quad \text{(Eq. 4)}$$

where ET_o is the potential evapotranspiration [mm d^{-1}]; H_0 is the extraterrestrial radiation [MJ m^{-2} d^{-1}]; T_{mx} is the maximum air temperature for a given day [°C]; T_{mn} is the minimum air temperature for a given day [°C]; $\bar{T}_{av}$ is the mean air temperature for a given day [°C] (Hargreaves & Samani, 1985).

The period analyzed was the first rainy season from May to mid-July, so the mean minimum temperature used was 24.2°C, the maximum was 29.2°C and the average was 25.7°C (climate-data.org, n.d.). Also, the extraterrestrial radiation value was based on the results of Wussah (2014), that calculated the radiation of selected station throughout Ghana for the period of 2000 to 2010.

2 Decay rate of pathogen

In order to determine how long *V. cholerae* could survive in the ponds, the number of pathogens was calculated from the first-order kinetics equation (Eq. 5):

$$N_t = N_0 e^{-kt} \quad \text{(Eq. 5)}$$

Where N_t and N_0 are the pathogen concentrations at time t and the initial concentration (time zero), respectively; and k is the decay rate expressed in hourly terms. Considering the mean average temperature of the first rainy season, k was interpolated from the results of Mezrioui, Oufdou, & Baleux (1995), as shown in Figure Fehler**! Kein Text mit angegebener Formatvorlage im Dokument.**. The initial concentration used was taken from the last step of the flood modelling.

	Unfiltered outflow water		Filtered outflow water	
	E. coli	*V. cholerae*	*E. coli*	*V. cholerae*
pH tested				
6.6	0.0132	0.0197	nr	nr
7. 3	0.0124	0.0195	nr	nr
8	0.0195	0.0164	nr	nr
8.8	0.0232	0.0170	nr	nr
Temperature tested (°C)				
8	0.0020	0.0090	0.0033	0.0083
15	0.0030	0.0120	0.0088	0.0170
23	0.0222	0.0180	0.0130	0.0200
30	0.0271	0.0280	0.0175	0.0275
Sunlight effect				
Control	0.0360	0.0440	0.0249	0.0104
Exposed sample	0.0674	0.0526	0.0936	0.0112

Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.** Decay rate (k, h^{-1}) for E. coli and non-O1 *V. cholerae* in unfiltered and filtered outflow water, under different experimental conditions (Mezrioui, Oufdou, & Baleux, 1995).