

水文学基礎 Fundamentals of Hydrology (浸透 Infiltration) Quiz

毎時 $20 \text{ mm}\cdot\text{h}^{-1}$ の降雨が 6 時間降り続いたとする。土層への浸透強度は、Horton 式

$$f(t) = f_c + (f_0 - f_c)e^{-kt}$$

を用いて表されるとする。雨が降り始めてから 6 時間の間に土層に浸透しきれず、地表面を流れる雨水の総量を求めよ。ここで初期浸透能 $f_0 = 15 \text{ mm/hr}$ 、最終浸透能 $f_c = 10 \text{ mm/hr}$ 、 $k = 1.0 \text{ h}^{-1}$ とする。

Suppose that rainfall happens with the same intensity of $20 \text{ mm}\cdot\text{h}^{-1}$ for six hours. Using the Horton equation,

$$f(t) = f_c + (f_0 - f_c)e^{-kt}$$

calculate the total amount of rainwater that can not infiltrate into a soil layer for 6 hours. The initial infiltration capacity $f_0 = 15 \text{ mm}\cdot\text{h}^{-1}$, the final infiltration capacity $f_c = 10 \text{ mm}\cdot\text{h}^{-1}$, and $k = 1.0 \text{ h}^{-1}$.

(Answer) Total amount of infiltration from $t = 0$ to $t = T$ is

$$\begin{aligned}\int_0^T f(t)dt &= \left[f_c t - \frac{1}{k}(f_0 - f_c)e^{-kt} \right]_0^T \\ &= f_c T - \frac{1}{k}(f_0 - f_c)e^{-kT} + \frac{1}{k}(f_0 - f_c) \\ &\approx f_c T + \frac{1}{k}(f_0 - f_c) \\ &= 10 \text{ mm/hr} \times 6 \text{ hr} + (15 - 10)/1.0 \text{ mm} \\ &= 65 \text{ mm}\end{aligned}$$

Therefore, total amount of rainfall that cannot infiltrate is 55 mm ($= 120 - 65$) mm .