Lab Report # 1

This exercise will help you *practice R loops* while working with *realistic environmental science models*.

Let's do this clearly and systematically:
We'll cover **5 models for `while` loop** and **5 models for `for` loop**, each with —
1️⃣ Model name and purpose
2️⃣ Equation(s)
3️⃣ Input data required
4️⃣ Hint on how to use it in R loops

🌿 A. Five Environmental Models for `while` Loop in R

These are situations where you **don't know beforehand** how many iterations are needed — ideal for a `while` loop.

1️⃣ BOD (Biochemical Oxygen Demand) Decay Model

Equation:

$$L_t = L_0 e^{-kt}$$

Where:

- L_t = remaining oxygen demand at time t
- L_0 = ultimate BOD
- k = deoxygenation rate constant day^{-1}

Input data:
`L0 = 250 mg/L`, `k = 0.23 day⁻¹`, `threshold = 5 mg/L`

Loop logic:
Continue computing L_t daily until $L_t < threshold$.

2️⃣ Newton's Law of Cooling (Environmental Temperature Model)

Equation:

$$T(t) = T_s + (T_0 - T_s)e^{-kt}$$

Where:

- T_0 = initial temperature
- T_s = surrounding temperature

- k = cooling constant

Input data:

`T0 = 80°C`, `Ts = 25°C`, `k = 0.1 min⁻¹`, stop when `T < 30°C`

Loop logic:
Simulate minute by minute cooling until temperature is below 30°C.

3️⃣ Population Growth with Carrying Capacity

(Logistic growth – until equilibrium reached)

$$P_{t+1} = P_t + rP_t\left(1 - \frac{P_t}{K}\right)$$

Where:

- P_t = population at time t
- K = carrying capacity
- r = intrinsic growth rate

Input data:

`P0 = 100`, `K = 1000`, `r = 0.2`
Stop when `|P_t - P_{t-1}| < 0.1`

4️⃣ Groundwater Drawdown Model (Theis Equation – simplified iterative)

$$s = \frac{Q}{4\pi T} \cdot W(u)$$

and

$$u = \frac{r^2 S}{4Tt}$$

Approximate $W(u) \approx -0.5772 - \ln(u) + u - \frac{u^2}{2\times 2!} + \dots$

Input data:

`Q = 1000 m³/day`, `T = 500 m²/day`, `S = 0.0001`, `r = 50 m`
Increase `t` until drawdown `s` converges.

5️⃣ Soil Moisture Balance (Daily Update until Equilibrium)

$$SM_{t+1} = SM_t + P - ET - R$$

Stop when daily change is < 0.01 mm

Input data:
`SM0 = 100 mm`, `P = 3 mm/day`, `ET = 2 mm/day`, `R = 0.5 mm/day`

🌎 B. Five Environmental Models for `for` Loop in R

Use these when the **number of iterations (days, months, years, etc.) is known in advance.**

1️⃣ Carbon Dioxide Accumulation Model

$$C_{t+1} = C_t + E_t - A_t$$

Where:

- E_t = emission $Gt/year$
- A_t = absorption $Gt/year$

Input data:
`years = 1:10`, `C0 = 400 ppm`, `E = c(5,6,6.5,7,7.2,7.5,8,8.5,9,9.5)`, `A = 4 each year`

2️⃣ Air Pollutant Dispersion (Gaussian Plume over fixed distances)

$$C(x) = \frac{Q}{2\pi u \sigma_y \sigma_z} e^{-\frac{y^2}{2\sigma_y^2}} e^{-\frac{H^2}{2\sigma_z^2}}$$

Compute for several `x` values.

Input data:
`Q = 100 g/s`, `u = 5 m/s`, `σy = 20, σz = 10`, `H = 50`, `x = seq(100, 1000, 100)`

3️⃣ Water Quality Index (WQI) for Multiple Parameters

$$WQI = \frac{\sum w_i q_i}{\sum w_i}$$

Loop through parameters to calculate `q_i * w_i`.

Input data:
Parameters: `DO, pH, BOD, NO3, Temp`, weights `w`, and quality scores `q`.

4️⃣ Daily Evapotranspiration (Penman-Monteith simplified)

$$ET_0 = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5} R_a$$

Compute for multiple days.

Input data:
Vectors: `Tmax`, `Tmin`, `Ra` for 7 days.

5️⃣ Annual Soil Carbon Loss under Different Land Uses

$$C_{t+1} = C_t - d_t C_t$$

Where d_t = decomposition rate (varies each year).

Input data:
`C0 = 50 ton/ha`, `d = c(0.02,0.025,0.03,0.028,0.027)` for 5 years.
