MSc Environmental Engineering

Module B3 – Regional Hydrology

Tracer Experiment

Technical Report

Silvia Capponi – 5900557

Dwiva Anbiya Taruna – 5849578

Hang Long – 5743702

Christine Martin – 5603463

Oguzhan Kobya – 4734602

26/05/2023

1 Introduction

The aim of this experiment was to identify and quantify runoff contributions to a headwater stream, with the use of natural tracers. Our group focused on the Mechelback catchment.
Natural tracers are characteristics of water that can be used to determine the origin of water runoff and give information on travel times. To characterize chemical and physical properties, electric conductivity (EC) and temperature can be used respectively. In this experiment, EC and T are used as tracers to identify the contribution of different water sources to the total runoff.
The contribution from a certain source of water can be determined by applying the mass balance for the characteristics' concentrations, like EC, and the mass balance of water.

In our case area tracers are used to estimate the contribution of a lateral inflow. By measuring the discharge and the concentration downstream, and the chemical concentrations upstream, the contributing runoff from the two sources can be estimated.

$$Q_{down} = Q_{up} + Q_{source}$$

$$Q_{down}C_{down=} Q_{up}C_{up} + Q_{source}C_{source}$$

1.1 Locations description

The section of the Mechelback stream analyzed in this report is reported in the following map, with the measurements' location. The confluence of interest is at point 5.
Water quality information can also be related to ecological conditions. For this purpose, at the first location, some information about the stream was also given from biomonitoring, observing the species living in the stream, like stoneflies and caddisflies. A large number of individuals gave information about the good quality of the river at that location.

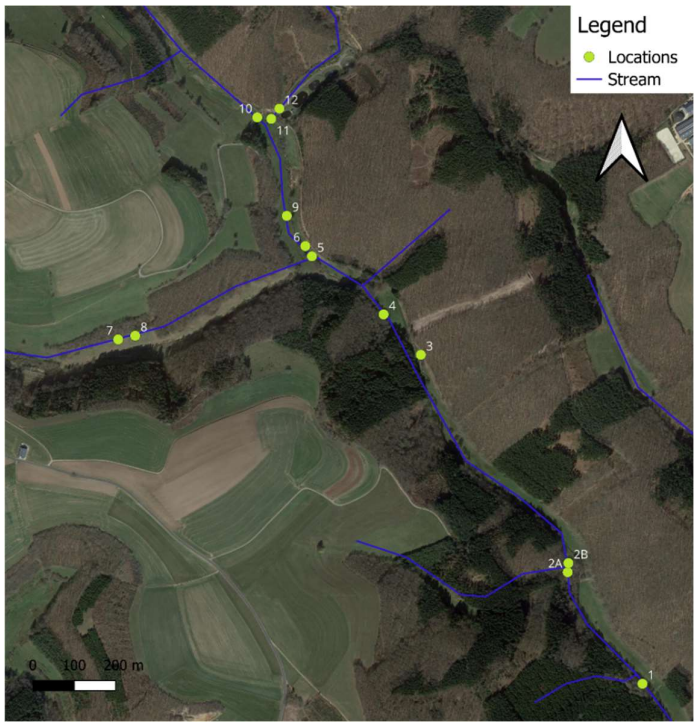

Figure 1 – Mechelback catchment section and location with the measurements

2 Methods

Measurements were taken starting from the downstream location 1 and going upstream.
Discharge measurements were taken at three locations: point 1, 8 and 9. EC was measured also in between, for a total of 12 locations (Table 1). Locations were chosen based on the observation of the landscape features. All measurements were taken in the main river, except for five of them:

- Point 3: puddle on the road across the main river;
- Point 7-8: main tributary;
- Point 11-12: after wastewater treatment plant.

Table 1 – Locations coordinates

Code	Latitude	Longitude
1	49.859744	5.996214
2A	49.862167	5.993694
2B	49.862361	5.993694
3	49.866889	5.98875
4	49.867766	5.987498
5	49.869028	5.985083
6	49.86925	5.984861
7	49.867222	5.978556
8	49.867302	5.979132
9	49.869905	5.984235
10	49.872417	5.983222
11	49.872138	5.983876
12	49.872306	5.983972

2.1 EC measurements

Electric conductivity measurements were taken at different locations, using a Greisinger EC sensor. Readings are taken in µS/cm, after the EC value reaches a constant value. Also, temperature was recorded in °C.
At location 2 there is the confluence with a small tributary, though it resulted to be dry. To investigate a possible seepage from this small tributary, EC was measured also in point 2B.
A puddle with flowing water was noticed walking upstream, thus EC was then measured at point 3, to identify its origin.

2.2 Discharge measurements

The discharge was estimated by measuring with a probe the concentration of a pigment added to water. In this experiment a rhodamine solution was used for this purpose. For a stream with a discharge of about 10-50 l/s volumes around 100-200 ml can be used. The specific values for the three locations are reported in Table 3. After injection of the solution, the rhodamine concentration is measured downstream by the probe.
The probe is connected to a laptop with AquaCal software that registers the data. The results are a breakthrough curve that can be used to determine the discharge.
The discharge can be calculated by the mass balance of the tracer.

$$m_{tracer} = Q \cdot \sum Cdt$$

The first measurement was taken at location 1 downstream. Two measurements were taken with two different tracer volumes.
The second successful measurement was done at point 8 on the main tributary of interest. A third measurement was attempted at point 9.

3 Results

3.1 Electric conductivity

Results for EC are reported in Table 2. EC is increasing going upstream, and this is most likely due to the increase of human activity. The value in the main tributary of interest is of about 275 µS/cm. This river comes from the plateau area, which is the most ion rich, most likely due to agriculture and intensive cattle farmers.
The difference in the values between point 2A and 2B is minimal, thus the dry tributary does not contribute to the mainstream.
The EC value at point 3 is very low, thus this water consists of subsurface water coming from the hillslope.
The highest values are those after the wastewater treatment plant. Point 12 was measured exactly at the outlet of the WWTP.

Table 2 – EC results

LOCATION	EC [µS/cm]	T[°C]
1	221	10,2
2A	229	11
2B	230	10,6
3	73	9,6
4	241	10,2
5	246	10,5
6	244	10,6
7	275	9,4
8	-	-
9	255	11
10	209	11
11	265	10,3
12	679	10,2

3.2 Discharge

The measured peaks are higher with higher volumes of the solution, as expected. The second measurement, at location 8, appears to be the most successful, in terms of mixing with the stream water. At point 9, no results were obtained by the probe, meaning that only zero values were recorded, probably due to lack of fully mixing.

Table 3 – Injected tracer volumes and measured concentrations

Location	1	8	9
Tracer volume 1 [ml]	192	28	102 ml
Tracer volume 2 [ml]	250	110	Not done
Max value 1 [µg/L]	66,66	12,58	0 (lack of fully mixing)
Max value 2 [µg /L]	88,85	97,89	Not done

The results obtained through the software are TAB files, which can be analysed on Phyton. The following graphs describe the rhodamine dynamics at location 1 and 8.
At location 1 (Figure 2) the second tracer volume results in two picks.

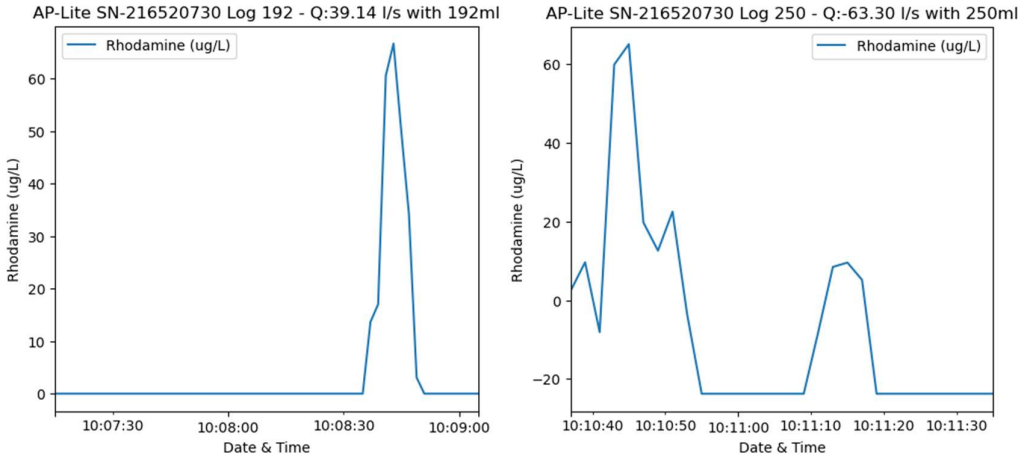

Figure 2 - Location 1

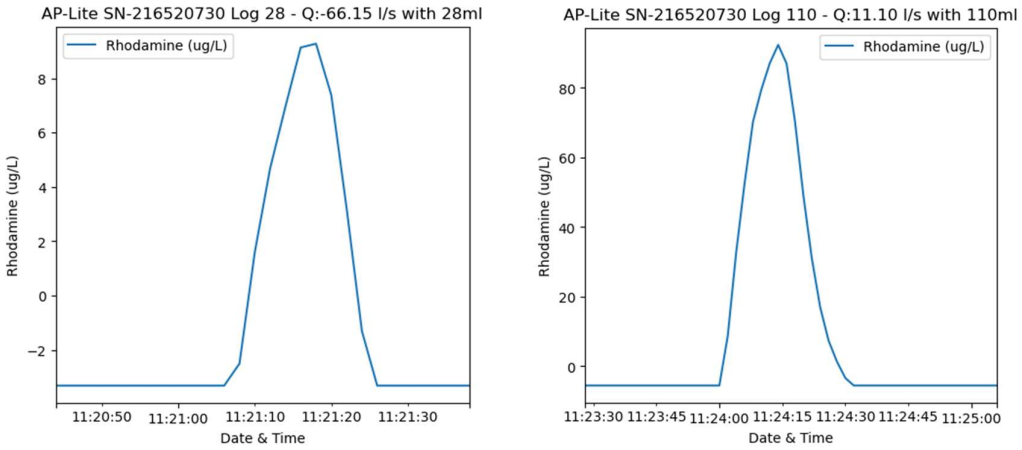

Figure 3 - Location 8