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Water analysis of the Poncia stream (Gembloux, Belgium)

Gilles Olive

The Poncia is a 1,600-meter-long stream between its source area and its confluence with the Orneau River, which is a tributary of the Sambre River (therefore sub-tributary of the Meuse River) (Fig. 1). The entire course of Poncia is located in the district of Grand-Manil at Gembloux city, in the Namur province, in Belgium. According to the elders, until the mid-1960s, the water quality of the Poncia was excellent, as it was possible to fish for crayfish and now they consider the water degraded and no longer catch crayfish. Crayfish is known to be an indicator of the water quality of a river.[1-3] In the years 2010, the Plan Communal de Développement de la Nature (PCDN, Communal Plan for the Development of Nature) envisaged the rehabilitation of the Poncia. To this end, as part of its activities, the PCDN wished to initiate a collaboration with the Ecole Industrielle et Commerciale de la Ville de Namur (EICVN, Industrial and Commercial School of the City of Namur) in order to carry out long-term (at least one year) and regular (monthly) water analyzes. For this purpose, three sampling points (Fig. 2) were determined. Sampling point 1 (50° 33' 26" N ; 4° 40' 06" E) is located at the source of the Poncia stream. Sampling point 2 (50° 33' 30" N ; 4° 40' 24" E) is located in a cow grazing area. Sampling point 3 (50° 33' 21" N ; 4° 41' 00" E) is located at the end of a highly urbanized area and in this part most of its course is underground (this can be important for stream metabolism if it affects air exchange, hyporheic exchange and photosynthesis), and it is near point 3 that it emerges from the ground before reaching the Orneau a few meters further on. Each point has its importance, the first serves as a reference point, the second takes into account the agricultural pollution linked to cattle and, to a lesser extent, to the surrounding agricultural context. The last point should be considered as representing the pollution of human origin via wastewater discharges and other waste deposits directly into the watercourse.

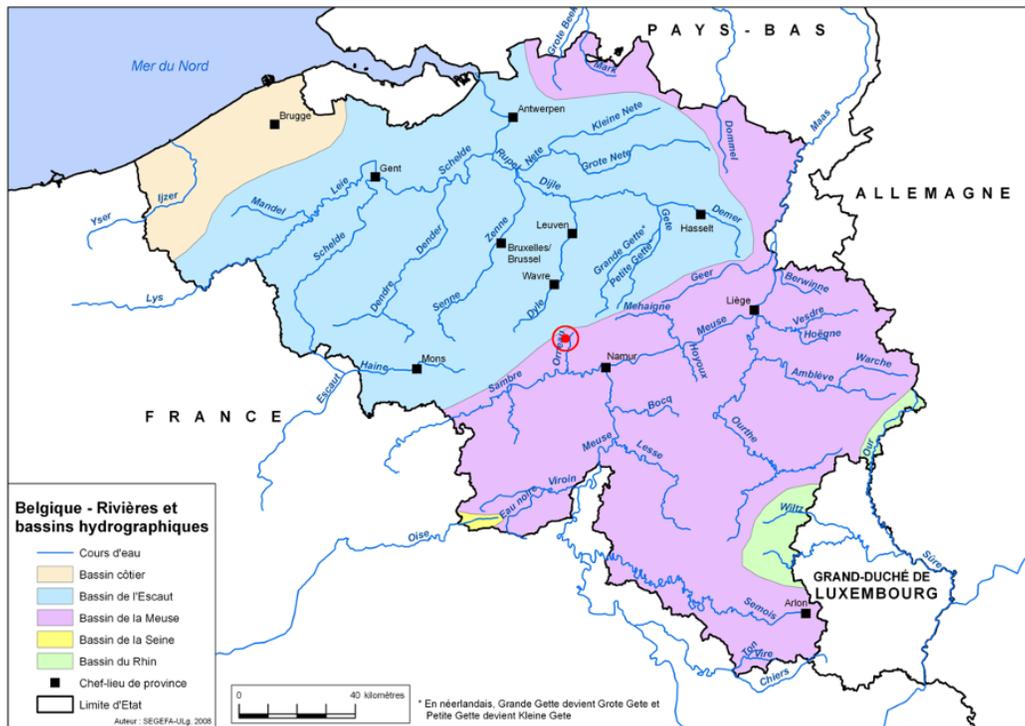


Figure 1. Location of the study area.

Eight parameters were monitored over 20 months. The study measured physical parameters such as temperature, electrical conductivity and dissolved oxygen concentration of the water at all three points, as well as the pH, the ammonium ion concentration, the nitrite and nitrate ions concentration and the phosphate ion concentration as chemical parameters. Table 1 shows the analysis of the results achieved during this study.

Over almost two years of analyses of the Poncia's water, several steps were taken. One of the first difficulties was related to the analyses themselves. The analyses by laboratory techniques took a considerable amount of time (and must be carried out quickly because the water is not stable over time) and, despite more precise results, did not cover a sufficient number of parameters (as some analyses needed to be carry out on site). Therefore, it was decided to carry out these analyses by colorimetric tests, thus allowing an important saving of time and having the advantage of being able to cover the entirety of the parameters wished by the partner. For reasons of simplicity and budget, it was decided to carry out the analyses via ready-to-use colorimetric kits of the Sera brand, which are normally intended for aquarium

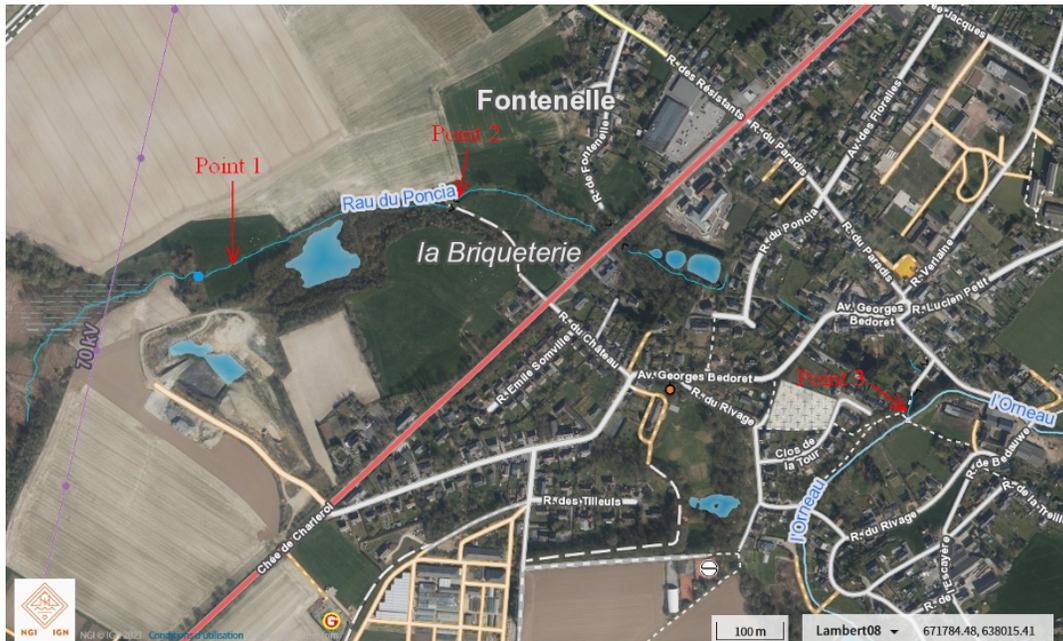


Figure 2. Situation of sampling points.

water analyses, the precision having been judged sufficient for the purpose of this study, after being compared to standard methods (just after the start of this work).

A high water temperature is favorable for the development of bacteria, parasites and microbial germs [4, 5], but also a decrease of the oxygen content [6]. In this study, the temperature follows the rhythm of the seasons, between 7 and 20 °C, with a minimum at 1 °C. The fact that the temperature of point 2 is always two degrees higher in summer than the other two points is due to the fact that point 2 is located in full sunlight in a field (Fig. 2).

The measurement of the electrical conductivity, which is easy, gives an idea of the salinity of the water, as it depends on the concentration of conductive dissolved salts and this is especially useful for monitoring the same water over time, like our case.[7, 8] The increase in electrical conductivity with temperature is related to the concentration of salts in the water [9, 10] and this is also the case of the Poncia. Point 3 always has a higher electrical conductivity that indicates a high pollution due to human activities. The fact that the values in point 2 are lower than those in point 1 can be explained by a strong presence of algae in the creek, algae that can consume part of the ions to grow. In the point of view of the conductivity, the Poncia's water has to be considered as having an accentuated medium to important mineralization [11] with values between 489 and 789 $\mu\text{S}/\text{cm}$.

The dissolved oxygen concentration is one of the most important water quality parameters for aquatic life with the pH.[12] Since the values range between 4 and 6 mg/L, the water of this stream can be considered to be with good quality, even if the solubility is less than 10 mg/L at the considered temperatures.[12] Point 1 is the most oxygenated and point 3 the lowest. It is to be noted that this analysis is rather difficult to carry out.

The pH values of the Poncia's water is rather stable all the time of this study, with values being between 7.1 and 7.7 for point 1 and 2 and between 6.8 and 7.3 for point 3. It is quite clear that pollution of human origin has a great importance on the pH, by acidifying the water. This trend was observed throughout the analyses. No explanation has been found for this lowering of the pH, because normally detergent and soap increase the pH.

Table 1. Statistics of physico-chemical parameters at the three sampling points.

Parameters	SP	Min.	Max.	Mean	SD	Median
Temperature (°C)	1	1.1	15.9	10.4	4.4	10.8
	2	1.3	20.0	12.3	5.1	12.8
	3	4.8	17.2	11.9	3.5	11.8
Electrical conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	1	301	717	585	113	607
	2	535	674	603	43	601
	3	598	789	713	60	740
Dissolved oxygen concentration (mg/L)	1	5.0	6.0	5.8	0.4	6.0
	2	5.0	6.0	5.8	0.4	6.0
	3	4.0	6.0	5.4	0.8	6.0
pH	1	7.13	7.67	7.40	0.15	7.42
	2	7.07	7.66	7.37	0.17	7.35
	3	6.76	7.32	7.04	0.15	7.03
Ammonium (mg/L)	1	0.000	0.009	0.004	0.004	0.0015
	2	0.003	0.009	0.008	0.002	0.009
	3	0.003	0.030	0.007	0.006	0.006
Nitrite (mg/L)	1	0.00	0.25	0.02	0.06	0.00
	2	0.00	0.75	0.12	0.19	0.00
	3	0.00	1.50	0.48	0.28	0.50
Nitrate (mg/L)	1	0.0	23.7	2.6	6.5	0.0
	2	0.0	38.9	11.6	13.3	10.0
	3	10.0	75.4	28.5	16.1	25.0
Phosphate (mg/L)	1	0.00	1.25	0.29	0.26	0.25
	2	0.10	2.00	0.48	0.40	0.50
	3	0.50	3.00	0.85	0.58	0.75

SP: Sampling point number; SD: Standard deviation

The presence of large amounts of ammonia nitrogen usually indicates recent contamination by decaying organic matter. This ammoniacal nitrogen is transformed by the passage of water through the soil and under the influence of certain bacteria into nitrous nitrogen, and then into nitric nitrogen.[7, 12] But under anaerobic conditions, nitrates can be transformed into ammonia or ammonium.[12] As the concentration of ammonium ion is really lower than

the value of 0.1 mg/L [12], a value retained as a problem, because the values are between 0 and 0.03 mg/L, this point will not be a problem for a future rehabilitation. Point 2, with the cows, have the highest concentration, indicating small pollution from agricultural origin.

As mentioned above, nitrite ions result of ammonia oxidation [7, 12, 13] but also from reduction of nitrate [13]. Nitrite is toxic for fish.[13] Nitrite levels above 1 mg/L are suspect.[11] Point 1 contains no nitrite, except twice at 0.12 and 0.25 mg/L in the first fall and once in April respectively, while point 2 has some at the beginning of this study (around 0.3 mg/L) and then no more. Point 3 is the most polluted with concentrations varying between 0.3 up to 1.5 mg/L.

Agriculture is the main emission source of nitrates, but this pollution can also come from mineral nitrogen fertilizers, livestock effluents, domestic or industrial wastewater and of course from the mineralization of organic nitrogen.[7, 12-14] In Europe, water is considered polluted if nitrate ion concentration levels exceed 50 mg/L [14, 15], but it is normally below 2 mg/L for groundwater under natural grasslands in temperate regions [16] and below 22 mg/L for surface waters [15]. In the Poncia stream, regarding this ion, point 1 contains up to 24 mg/L at the very beginning of those analyses and then none. The concentrations of this nitrate decrease between 39 and 10 mg/L in the first eight months at point 2 and later become nil. And finally, point 3 is the most polluted, as these levels vary from 10 to 75 mg/L, without ever becoming zero. By analyzing the values of nitrite and nitrate ions, it is clear that human activity has a strong influence on the nitrogen pollution of this stream.

Phosphate pollution in water comes from agricultural runoff, domestic and industrial wastewater.[17] This pollution leads to the eutrophication of lakes and thus to the depletion of dissolved oxygen levels.[17] A concentration of 0.1 mg/L of phosphate ions is advisable for surface waters in the USA.[18] According to the results, point 3 is more polluted than point 2, which has higher values than point 1. Indeed, the values of point 1 are around 0.25 mg/L with a minimum at 0 and a maximum at 1.25 mg/L. Point 2 is around 0.5 mg/L, with 0.25 and 2 mg/L as extremum. Point 3 is always above 0.50 mg/L with 3 mg/L as maximum value. The three maxima were recorded on the same day.

In conclusion, it is clear that the pollution of agricultural origin (mainly due to cattle), measured at point 2, is relatively limited and has a low impact (except for the ammonium ion). This is not the case for the pollution of human origin (point 3) which has a strong impact on the pH, the quantity of dissolved ions, of nitrite ions, of nitrate ions and of phosphate ions, leading to a strong decrease in the dissolved oxygen content, which makes aquatic life difficult. Moreover, it is still possible to observe gammarids (*Gammarus pulex*, L., 1758) and odonate larvae, notably Damselflies (*Zygoptera*, Selys, 1854), at point 2 whereas this is no longer the case at point 3.

Thanks to these analyses, it is now possible to know in which areas to propose remedial measures.

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