Release of nutrients into a forested catchment of southern Italy

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SOMMARIO

The mountain catchments are the main source of a good quality water supply. A correct water management suggests policies aimed to the planning, the optimization and, above all, the protection of this valuable natural resource. To date, there are some models, more or less complex, used in the management of water resources or pretending the water supplies and the hydraulic loading of solutes. Some of these patterns disregard the extent of bottom pollution caused by site features and by atmospheric deposition affecting the fixation, volatilization, absorption and release of biogenic substances. This work aims to aid in the knowledge of the relationships between soil and atmosphere systems through the comparative analysis of nutrient depositions and their following release into water outflows in a small experimental catchment located in the Cosenza district of Sila Greca (Calabria, Italy) extending for a surface of 139 ha and without human settlements. The study area, expanded from 975 m. a.s.l. to 1300 m. a.s.l., is forested for about 95% of its surface of which 80 % is covered by Calabrian Pine (*Pinus laricio*, Poiret) with populations differentiated by age, density, tree canopy cover and stand characteristics. Small areas are interested by chestnut (*Castanea sativa*, Miller) reforestations. The remaining basin surface is composed by clearings (2%), sowable lands (1.4%) and catchment ditches (8.2%) colonized, to a large extent, by black alder (*Alnus glutinosa*, Linnaeus) and aspen (*Populus tremuloides*, Linnaeus). The climate data concerning Lake Cecita Station, located at 1.100 m. a.s.l. and ongoing from 1924 to 2010, are deduced from the Annals of Hydrographic Service of Catanzaro Unit. The rainfall regime, belonging to the Mediterranean type, shows an average annual value of 1046.6 mm distributed in 99 rainy days. On a monthly basis, the higher rainfall media data have been recorded in the months of October and November, even though the month with the highest rainfall, in all the measurement period, is January 1945 with 391.7 mm. The lowest values have been recorded in the months of June, July and August. Besides, it is pointed out a great monthly variability in the regarded period. Finally, July is the month lacking in rainfall during many years of the tested time. The average monthly temperature is 9.9 °C with a mean value of 2.0 °C in the coldest month and a mean value of 18.6 °C in the hottest month. The geological structure of the basin consists of a crystalline basement formed by intrusive and plutonic rocks generally fractured except some cutting valleys. The soils, greatly on plutonic rocks, lead to the "Typic Xerumbrepts" association and, in small way, to the "Ultic Haploxeralfs" in the surface layers of pleistocenic sediments (stream terrace).

The catchment is supplied with three stations located in Petrarella (1258 m. a.s.l), Don Bruno (1175 m. a.s.l.) and Bonis (975 m. a.s.l.) resorts, respectively, on the left side and on the right side of Cino river and at the closing section of the basin, to measure some climatic features as temperature, air relative humidity, wind speed and direction, solar radiation and pH depositions. Besides, in this closing section, is located a lock chamber used for hydrological measures with a sharp-crested weir to value hydraulic discharge until 18 m^3 / sec, corresponding to a flow with a return time of 200 years. The variations of hydrometric level have been measured by horizontal hydrometer.
The assessment of atmospheric depositions has been realized in three different stations. In particular, a tower, located at an elevation of 1100 m. a.s.l. in Cozzarella - Don Bruno location, has been supplied for the measurements of CO_2 and H_2O exchanges on plant range. The tower is located in a *Pinus laricio* reforestation plot carried out from 1955 to 1960.
The mean annual value of the discharge coefficient is 0.18 until 1999 year, reaching 0.35 in the following period after a silvicultural management interesting the whole basin. So, this behavior is, directly related to the variations of interception and transpiration processes.
To value the water standard grades, have been detected three measuring and collecting stations of the atmospheric depositions at different heights (min, med, max), three stations located in riverbed and

one station corresponding to Petrarella spring. In particular, the riverbed stations show the following features:

- Station A (St. A): subtended surface 1.82 ha; annual flow 6070 m^3, cleared in summer months (from June to August) and maximum in December; discharge coefficient 0.269; mean flow 0.20 l/s.
- Station B (St. B): subtended surface 12.73 ha; annual flow 42449 m^3, cleared in summer months and maximum in December; discharge coefficient 0.269; mean flow 1.37 l/s.
- Station C (St. C): subtended surface 139 ha corresponding to the closing section; annual flow 504000 m^3 with summer minimum values and winter maximum values; discharge coefficient 0.294; mean flow 17.96 l/s.
- Petrarella spring Station (St. D): subtended surface 2.70 ha; discharge coefficient 0.797 highlighting an apparent feeding basin different from the real catchment, wider and deeper than the apparent one. This last supposition is confirmed by the low variability of recorded temperatures.

In all the stations, have been performed collections of water samples on a fortnightly basis and have been detected the main chemical and physical parameters as nitrates, ammonia, phosphates, chlorides, sulfates, pH and conductivity. Besides, the knowledge of rainfall and outflow discharges has permitted the assessment of their weighted averages.

The results have highlighted that nitrogen, in its own three forms of $N\text{-}NH_4$, $N\text{-}NO_3$ and $N\text{-}NO_2$, is, for the different stations, equal to: St. A = 0.1485 mg/l., St. B = 0.1210 mg/l. and St. C = 0.2384 mg/l. In the watercourse, the nitrogen occurs mainly in $N\text{-}NO_3$ form (St. A = 0.0454 mg/l, St. B = 0.119 mg/l, St. C = 0.2316 mg/l) while the $N\text{-}NH_4$ and $N\text{-}NO_2$ forms are in slight concentrations. In particular, in Petrarella spring waters the nitrogen mean concentrations are, rather, scanty but the ammoniac form occurs in higher proportions (8.98%) than the other nitric forms. The annual weighed average concentrations in the watercourse increase with the raising of subtended basin surface, appearing lower than that of atmospheric depositions (0.376 mg/l). Regarding the discharge coefficients related to Station C, the leaks, caused by de-nitrification, by living organisms absorption or by infiltration, are valuable as 77% of those of atmospheric depositions. The $P\text{-}PO_4$ annual weighed concentrations, in atmospheric depositions, are scanty with values of 0.009 mg/l close to those detected in the watercourse stations. Indeed, from the analysis of discharge coefficients, it is pointed out that about 57% of this element is retained inside the basin from increasing biomasses and its total content depends on age, structure and forest management. The chlorides annual weighed concentrations in the watercourse are, yearly, little changeable, including from 8.88 mg/l to 10.21 mg/l except Station P with a greater value of 12.73 mg/l. So, the chlorides and the phosphates concentrations are much higher than those of atmospheric depositions (about 2 mg/l), attesting a process of enrichment of spring waters caused by the time contact with rocky substrata and contiguous soils. The sulfates annual weighed concentrations (St. A = 3.9333 mg/l, St. B = 4.0691 mg/l and St. C = 3.4485 mg/l) are quite steady along the watercourse and a little higher than those of atmospheric depositions (2.5836 mg/l). The spring water of Station P shows higher concentrations (5.8895 mg/l) than those of watercourse, with a uniform trend in time. The conductivity values (St. A = 149.3 μS/cm, St. B = 182.1 μS/cm and St. C = 152.7 μS/cm) highlight that the waters, draining in the catchment, are characterized by a low salty content, while the relative values are unchangeable during all the year, showing an increasing trend on the outflow and A decreasing one in the closing section (St. C) during the dry period.

The watercourse pH feels the effects of depositional trend since crossed soils show a low buffering power. In fact, the pH values, checked in the depositions, are just lower than those of acid rains in the summer period (pH 5.65). These occurrences accord with the minimum values of watercourse while pH values of spring water (St. P) are, usually, little variable.

The tested catchment is an interesting analytical pattern of the effects of a widespread pollution while the punctual one is absent. The reported study highlights that biogenic cycles result from hydrological loop, deposition extents and biotic environment. The periods of minimum flow, in depositional absence, affect the concentrations of analyzed elements in surface waters, while spring waters perform a rolling action on flow discharges and ionic concentrations. These last ones are more regular than the external and are affected, in a greater way, by the lithological composition crossed by waters in their underground run. The concentrations of analyzed substances are all below the national thresholds for supporting life aquatic salmons. The presence of a particular kind of bottom pollution in these mountain areas, which waters are in a good quality level and according to the ranking fixed by 152/2006 decree, decreases according to the altitude and to the distance from pollution sources. So, it is necessary to study and to protect the mountain catchments that, nowadays, are barely monitored while, instead, could supply useful data on the global changes of atmospheric chemistry.