Influence of hydrologic processes on spatial patterns of nitrogen in an arid stream of Southeast Spain

García García V, Gómez RM, Vidal-Abarca MR, Suárez ML

Department of Ecology and Hidrology. Murcia University. Spain.

Introduction

Spatial variability in nutrient concentration has often been observed according to the extremely heterogeneity of streams. However, most work has focused on temporal variation. As interest in the causes and consequences of spatial variation in streams increases, there is growing recognition of the need for more spatially explicit data sets and for quantitative analyses of these data.

Nitrogen is the focus of our study because its high natural content in sedimentary watersheds of Murcia Province.

Our objectives are:

- To determine the nitrogen content in the surface water of Chícamo stream over different hydrological conditions (base flow, rainfalls, low flow).
- To analyze the nitrogen spatial variation patterns at different spatial scales (watershed, reach -permanent and temporal-, sub-reach).
- To know the degree of spatial dependence between sampling sites.
- To analyze the hydrology effect over nitrogen spatial variability.

Study site

The Chícamo stream in located in the Murcia province, south-east of Spain (figure 1). It drains a sedimentary watershed of 502 km2 with limestone and conglomerates close to the stream source and marls downstream. Stream length is 13.5 km, with a permanent (5.8 km) and temporal (7.7 km) reaches. Climate is semi-arid mediterranean (mean annual temperature higher than 18 ºC and annual precipitation of less than 250 mm). The natural cover of the watershed is open mediterranean scrub. Agricultural and urban activities are located downstream, close to the stream mouth, affecting to the stations located under 28 (figure 3).

Permanent and intermittent reaches are very different as it is summary in table 1.

Figure 1. Map of Chícamo stream location.

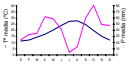

Figure 2. Ombroclimatic diagram of study site (mean values for period 1953-2003).

	Permanent reach	Intermittent reach
Channel morphology	Narrow and strait meanders	Wide and meandering
Bedrock geology	Limestones and conglomerates	Marls
Riparian vegetation	Diverse and dense	Scarce and sparce
Water salinity	Low (1,4 – 1,5 g/l)	High (5,5 – 10,6 g/l)

Table 1. Environmental characteristics of permanent and intermittent reaches.

Results

Watershed scale	DIN (mg/l)	N-NO3- (mg/l)	N-NO2- (mg/l)	N-NH4+ (mg/l)
Base flow (n=30)	8,9	8,8	0,04	0,03
Rainfalls (n=14)	3,3	3,2	0,1	0,1
Low flow (n=15)	5,8	5,8	0,01	0,005
Rainfalls (n=8)	3,2	2,8	0,0001	0,4
Base flow (n=30)	9,3	9,1	0,07	0,03

Permanent reach	DIN (mg/l)	N-NO3- (mg/l)	N-NO2- (mg/l)	N-NH4+ (mg/l)
Base flow (n=13)	3,5	3,5	0,005	0,01
Rainfalls (n=5)	3,7	3,6	0,01	0,01
Low flow (n=12)	3,7	3,7	0,01	0,01
Rainfalls (n=4)	3,9	3,9	0,0001	0,02
Base flow (n=13)	4,7	4,7	0,005	0,04

Intermittenti reach	DIN (mg/l)	N-NO3- (mg/l)	N-NO2- (mg/l)	N-NH4+ (mg/l)
Base flow (n=13)	13	12,9	0,1	0,04
Rainfalls (n=6)	3,1	2,9	0,1	0,1
Low flow (n=3)	14,3	14,3	0,02	0
Rainfalls (n=4)	2,5	1,7	0,0002	0,8
Base flow (n=27)	12,7	0,03	0,1	0,04

Table 2. Nitrogen concentrations at watershed scale (A), permanent reach scale (B), intermittent reach scale (C).

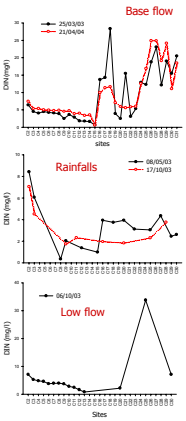

Figure 5. DIN spatial variability at watershed scale under different hydrological conditions.

Spatial CV (%)-N-NO3-	Watershed scale	Permanent reach scale	Intermittent reach scale	Sub-reach scale
Base flow	85,5 n=30	39,3 n=13	60,7 n=17	-
Rainfalls	67,9 n=14	94,8 n=5	40 n=9	-
Low flow	135,7 n=15	45,2 n=12	118,6 n=3	-
Rainfalls	70,9 n=8	62,3 n=4	24 n=4	-
Base flow	74,6 n=30	21,8 n=13	59,2 n=17	-
Mean	86,9	52,7	60,5	41,4 (n=12)

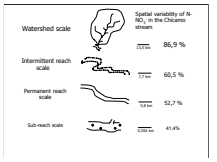

Table 3 and figure 7. N-nitrate spatial variability (CV%) at different spatial scales and hydrological conditions.

Spatial dependence of N-NO_3^- at the watershed scale

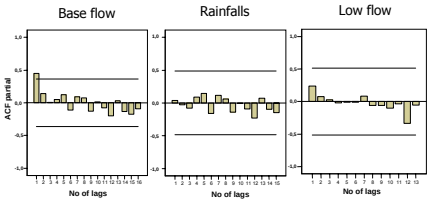

Figure 6. Results of the N-nitrate partial autocorrelation analysis under different hydrological conditions (SPSS, 12.0 version). Partial autocorrelations are only significant for lag=1 at base flow. It means spatial dependence between adjacent stations, 473 m apart.

Seasonal CV (%) N-NO_3^-	
Watershed scale	50,4
Permanent reach scale	12,2
Intermittent reach scale	68,1
Sub-reach scale	37,9

Table 4. N-nitrate seasonal variability (CV%) at diferent spatial scales.

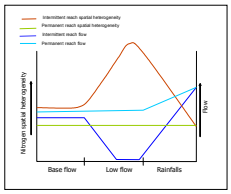

Figure 8. Conceptual model of nitrogen spatial heterogeneity in temporal and permanent reaches in relation to flow.

Methods

A sampling survey was carried out along Chícamo stream, in a total of 30 samples station located 473 m apart as mean distance.

Water samples were taken during 2003-2004 under different hydrological conditions, (base flow: permanent reach= 18 l/s, intermittent reach= 0-0,3 l/s; rainfalls: permanent and intermittent reach= 74 l/s; low flow: permanent reach= 17 l/s, intermittent reach= 0 l/s), by triplicate and analyses were conducted according to Standard Methods.

For the study at sub-reach scale, we used data from 1994.

To analyze spatial and seasonal variability we used the variation coefficient (CV%) as an indicator of overall variation. To determine spatial dependence, we used the partial autocorrelation function (ACF partial) (SPSS ver. 12.0).

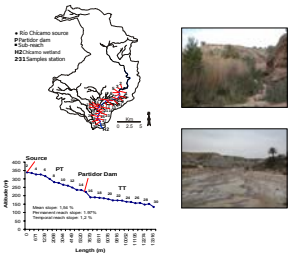

Figure 3. Samples sites location in the Chícamo stream (TP= permanent reach, TT= intermittent reach).

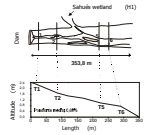

Figure 4. Samples sites location in the sub-reach.

Conclusions

We hypothesized that high nitrogen content in upstream reaches Chícamo stream can be related with geology bedrock. Water nitrogen content in the intermittent reach was higher than in the permanent , under any hydrological condition, with the exception of rainfalls. N-nitrate was the dominant fraction.

As nitrogen concentration was very high at base flow, rainfalls produced a decrease of nitrogen content in surface waters (dilution effect), while the dry period produced an increase.

Nitrogen spatial variability increased as water flow decreased. This was specially true for the intermittent reach, whereas rainfalls had an opposite homogenizing effect, decreasing nitrogen spatial variability.

Nitrogen spatial variability at watershed scale was higher than at intermittent reach scale > permanet reach scale > sub-reach scale (figure 7).

N-nitrate showed spatial dependence at base flow between two adjacent sampling points (473 m), but not after rainfalls or low flow (figure 6).

At seasonal scale the highest nitrogen variability was found in the intermittent reach (table 4).

In summary:

- watershed scale: spatial variability > seasonal variability
- permanent reach: spatial variability > seasonal variability
- intermittent reach: seasonal variability > spatial variability
- sub-reach scale: spatial variability> seasonal variability