Phosphorous losses in flood events in a Mediterranean agroforestry catchment: effects of rainfall characteristics and land use

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OBJECTIVE

The aim of this research was to evaluate the phosphorus delivery and transport after flood events in an agroforestry catchment, in which forestland and cropland are the dominant land uses.

MATERIAL AND METHODS

The analysis was carried out in an agroforestry catchment located in the central part of the Ebro Basin (NE Spain). Sediments were collected in five trap MATs distributed across the catchment in 20 campaigns during five years, in which rainfall events of different characteristics (total precipitation and intensity) were recorded.

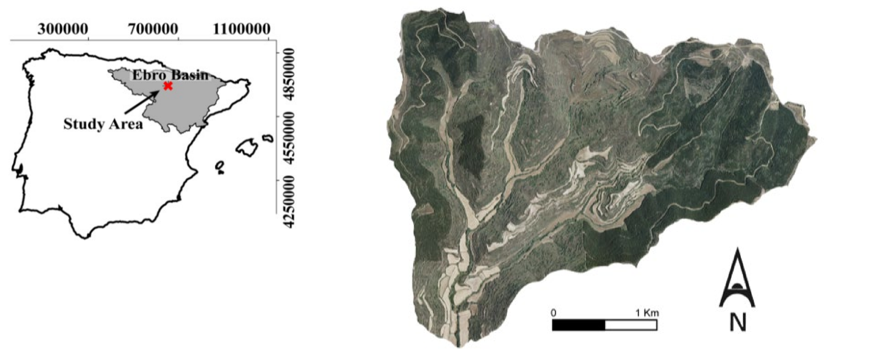

Figure 1. Location of the study area and distribution of land uses/ land covers in the Cenera catchment

The characteristics of the sediment sources in the catchment and their variability were assessed taking surface samples (0-2 cm) under each land use/land cover (cropland, forest, scrubland, afforestation, streambank and, barren land, 35 points covering all LU/LC).In the sediments trapped in the MATs, P concentration, particle size and other properties such as soil organic matter (SOM), low frequency magnetic susceptibility (χLF) and Ti concentrations were analysed to relate to the provenance of sediments. The relationships between different properties in the sources and in the sediments were evaluated using a multivariate analysis (correlation matrix).The rainfall events recorded in each campaign were analysed and the campaigns were grouped using a cluster analysis taken into account the characteristics of the collected sediments.

Figure 2. View of MATs used to collect sediment: a) during a high water episode of a low energy event; b) after a high-intensity rainfall and flood event

Table1. Properties of the sediment sources

Land use/ land cover	Clay (%)	Silt (%)	Sand (%)	χLF (10^{-8} m^3/kg)	P (mg/kg)	Ti (mg/kg)	SOM (%)
Cropland	13.3 ± 2.9 a	71.5 ± 2.9 a	15.6 ± 3.1 ab	37.6 ± 18.4 ab	381 ± 83 a	2972 ± 393 a	2.8 ± 1.4 a
Forest	14.5 ±2.0 ab	70.9 ± 3.2 a	16.4 ± 2.5ab	43.0 ± 21.8 a	267 ± 74 b	2999 ± 474 ab	7.8 ± 3.3 b
Scrubland	13.7 ± 4.6 ab	69.2 ± 4.7 a	17.1 ± 4.2 ab	36.5 ± 30.0 a	258 ± 117 b	2952 ± 497 ab	8.0 ± 4.9 b
Afforest.	16.3 ± 4.9 b	69.0 ± 5.9 a	14.7 ± 5.8 ab	42.9 ± 21.4 ab	266 ± 33 b	3164 ± 489 a	5.0 ± 2.7 c
Streambank	13.8 ± 2.5 ab	73.3 ± 4.3 b	12.9 ± 5.8 b	26.4 ± 15.1 b	291 ± 35 b	3318 ± 310 b	2.3 ± 0.7 ad

Different letters indicate significant differences between land use/land cover.

Table 2. Relationship between propeties of the sediment sources

	Clay	Silt	Sand	χLF	P	Ti	SOM
Clay		-0.3248 ***	-0.3509 ***	0.3224 ***	0.2673 **	0.4955 ***	0.3459 ***
Silt			-0.7716 ***	-0.6081 ***	-0.1046 NS	-0.3754 ***	-0.5042 ***
Sand				0.3850 ***	-0.0175 NS	0.0381 NS	0.2664 **
χLF					0.0961 NS	0.4971 ***	0.5482 ***
P						0.2686 **	-0.0270 NS
Ti							0.1703 NS

(p<0.01: significant at 99%; p<0.05: significant at 95%; p<0.1: significant at 90%; NS: not significant)

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RESULTS AND CONCLUSIONS

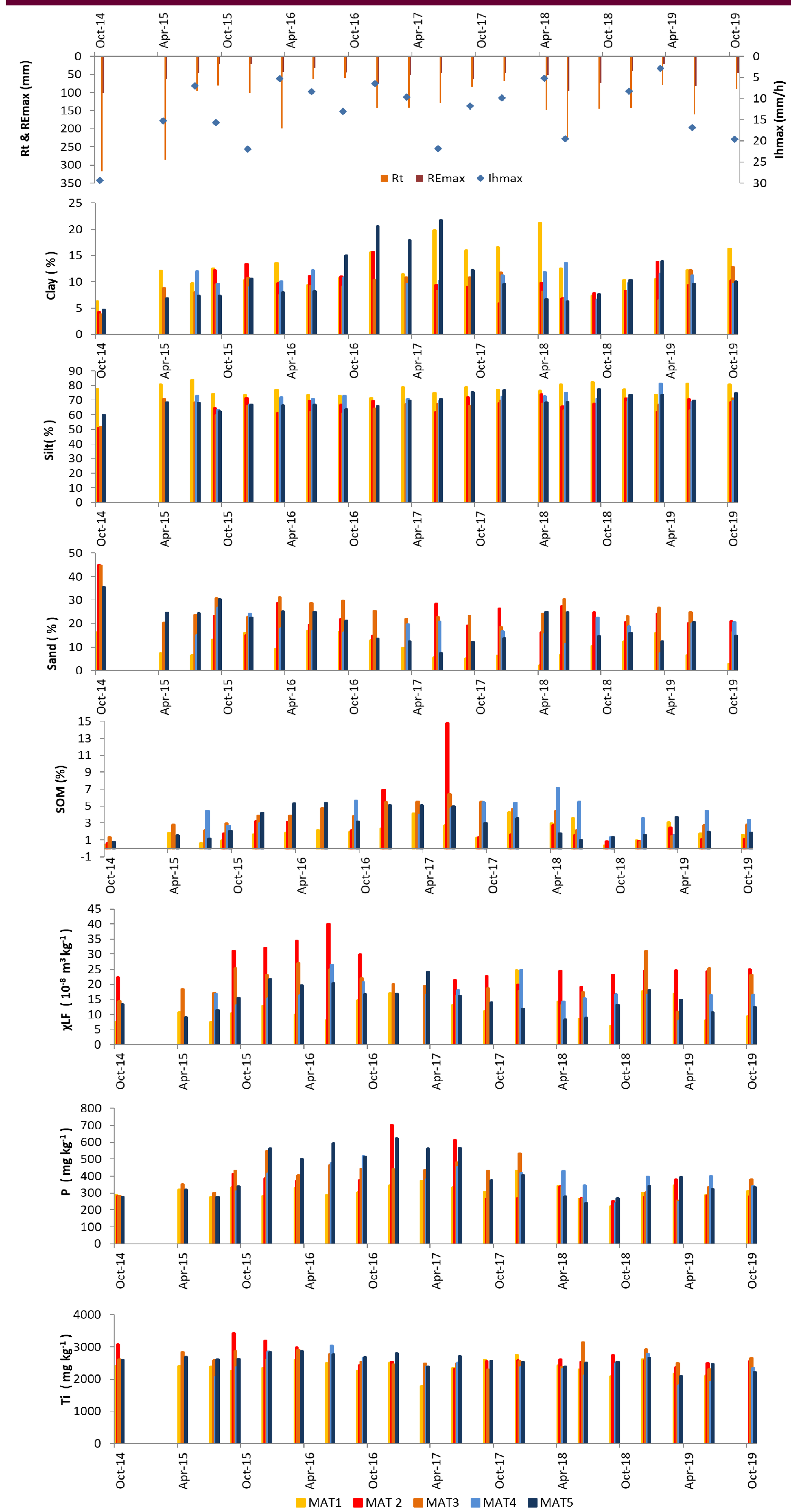
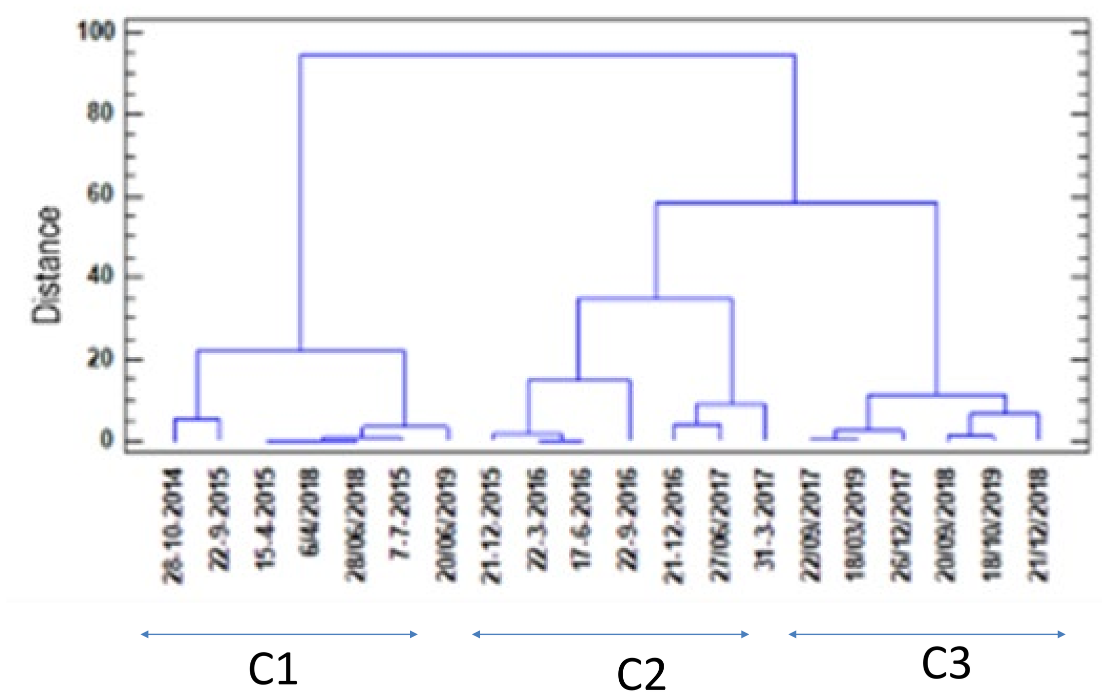


Figure 3. Rainfall characteristics and properties of the sediments collected at five cachtment's locations along the study campaings

The study reveals a P enrichment in the sediments compared to the soils under all land uses, with the greatest P concentration associated to sediment rich in clay and SOM. However, the sediment showed lower χLF than the soils. P losses were up to 1.3 times higher at the catchment outlet than at the headwaters. These results are explained by two main factors: on one hand the higher water volumes accumulated at the outlet and on the other hand the greater contribution of croplands to P losses compared to the other land uses, which occupied a larger surface at the catchment outlet. The differences between monitoring campaigns were attributed to differences in precipitation patterns that influence the hydrological response.

Figure 4. Classification of the campaigns using Ward's hierarchical clustering method, based on the sediment composition obtained at the catchment outlet.



	$Clay_{sed}$ (%)	$Silt_{sed}$ (%)	$Sand_{sed}$ (%)	$χLF_{sed}$ (10^{-8} m^3/kg)	P_{sed} (mg/kg)	Ti_{sed} (mg/kg)	SOM_{sed} (%)
C1	6.9	66.5	26.5	11.0	293	2532	1.47
C2	14.6	66.6	19.7	18.9	531	2632	4.39
C3	10.6	75.4	14.0	14.0	353	2787	2.50

Our findings also confirmed the clear influence of the precipitation concentration on P losses, which suggest that under the increase of events of high intensity projected under climate change scenarios, the mobilisation of P and its loss, in particular from croplands will increase, which could exacerbate water pollution.