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Release of polycyclic aromatic compounds into a Mediterranean creek (Catalonia, NE Spain) after a forest fire

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ABSTRACT

Wildfires produce polycyclic aromatic compounds (PACs), among which polycyclic aromatic hydrocarbons (PAHs) are of environmental concern. After a fire affecting a Mediterranean creek, we studied the distribution and short-term permanence of PACs and of 16 priority PAH pollutants in the aquatic environment. PACs were traced through absorbance and fluorescence emissions and organic carbon concentrations. PAHs were analysed by gas chromatography. High TOC/DOC concentrations and fluorescence/absorbance values reflected abnormal inputs of fire-induced aromatic compounds. Their concentrations decreased gradually but showed sporadic peaks after precipitation. Fifteen months later, values still surpassed background levels. Initially concentrations of individual and total PAH species of the dissolved, particulate and sediment phases were increased. Then they fluctuated with new PAH inputs related with runoff, leaching and soil erosion following precipitation events. All PAH concentrations approached background levels 15 months after the fire, and never reached values of toxicological concern. However, some bioaccumulation may have occurred.

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1. Introduction

Forest fires occur with a high frequency in the Mediterranean region and have serious environmental consequences (Naveh, 1974; Lavorel et al., 1998), especially because water is scarce and precipitation is irregularly distributed over time and space. Environmental concern is enhanced because fires produce large amounts of deleterious pyrolytic substances.

Among them polycyclic aromatic hydrocarbons (PAHs) are known for their toxicity potential, environmental persistence, ubiquity and tendency to bioaccumulation (Freeman and Catell, 1990; Gabos et al., 2001; Xue and Warshawsky, 2005). Although industrial PAH pollution in streams and estuaries has been extensively examined (Wild and Jones, 1995; Chen et al., 2004; Christensen and Bzdusek, 2005) few studies have addressed post-fire inputs of PAHs to rivers (Olivella et al.,

2006). Further, the input of other aromatic compounds like humic substances (HS) may be enhanced by increased soil leaching and erosion after fire (a.f.). Among other effects, HS can bind PAHs (Haitzer et al., 1999) and are common precursors of trihalomethanes (Imai et al., 2003). Additionally, new pyrolytic humic substances (PHS) can be produced in soils after high-temperature combustion of lignin-like structures (Almendros et al., 1988; González-Pérez et al., 2004), and they may also enter the rivers. Therefore, PAHs, PHS and HS may contribute large amounts of PACs to aquatic systems after a wildfire.

Given that PACs can have deleterious environmental effects and pose health risks, the significance of the release, behaviour, transport and fate of these aromatic compounds in rivers affected by fire should be evaluated. Here we assessed the incorporation, time variation and persistence of PACs in a Mediterranean stream after a wildfire.

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Bulk aromaticity of PACs was traced by fluorescence and light absorption capacity of aromatic rings (Green and Blough, 1994; Renee et al., 1999; Baker and Spencer, 2004). Sixteen PAH priority pollutants listed by the US Environmental Protection Agency (USEPA) and the European Community Directive 80/778/EEC were analysed in water and sediments of the Mediterranean creek. We expected a substantial increase of the stream's organic carbon a.f., thus variations of total, particulate and dissolved organic carbon (TOC, POC, DOC) were measured.

2. Materials and methods

The Gallifa creek is a first-order tributary located in Catalonia, NE Spain (Fig. 1, Table 1). On 11 August 2003, a fire burned 4500 ha of forest affecting the Gallifa streamlet and the riparian zone. Over 80% of the basin was burned by a severe crown fire (Turner et al. 1999). One year a.f., the first regrowth appeared. A research programme was started to assess the impact of fire on the creek, and a reference sampling site was established in the neighbouring Mura creek (Table 1, Fig. 1).

Water (2 L) and sediment (250 mL) samples were taken in a depositional pond located at the downstream limit of the burned area. Samples were taken 12 and 45 days a.f., after the first autumn rainfall. Samples for TSS, DOC, TOC,

absorption coefficients and fluorescence determinations were collected fortnightly or monthly for 22 months. Collection of reference samples began 3 months a.f. and continued simultaneously in both streams. Samples for PAH analysis from Gallifa were collected during the first four months a.f. and at the end of sampling, and background PAH samples were collected only 445 and 662 days a.f. Sediments (5 cm deep) were scooped out from five deposition zones in the same pond and then mixed in a composite sample. All samples were frozen (-18°C) and stored in the dark until analysis (Ainsworth et al., 2006). Water velocity was recorded with a mini-air flow meter.

Total suspended solids (TSS) were isolated by filtering 0.5 L water through pre-combusted GF/F Whatman glass fiber filters, which were then combusted (450°C , 3 h) to differentiate organic (OSS) from inorganic (ISS) suspended solids.

TOC and DOC analyses were performed with a Shimadzu TOC-5000 analyzer (EPA 9060A, USEPA, 1996).

Samples for optical properties analysis were previously filtered and thermostatted to $23 \pm 2^{\circ}\text{C}$. Absorption coefficients at 300 nm (a_{300}) were measured with a Perkin-Elmer double-beam spectrophotometer with 1 cm quartz cells. Absorption coefficients (a) were calculated from absorbance values (A) using: $a(\lambda) = 2.303A(\lambda)/r$, where r is the curvette path length (Green and Blough, 1994; Baker and Spencer, 2004). For fluorescence determination, samples were excited at 370 nm and emission intensities (f_{450} , f_{500}) were measured at 450

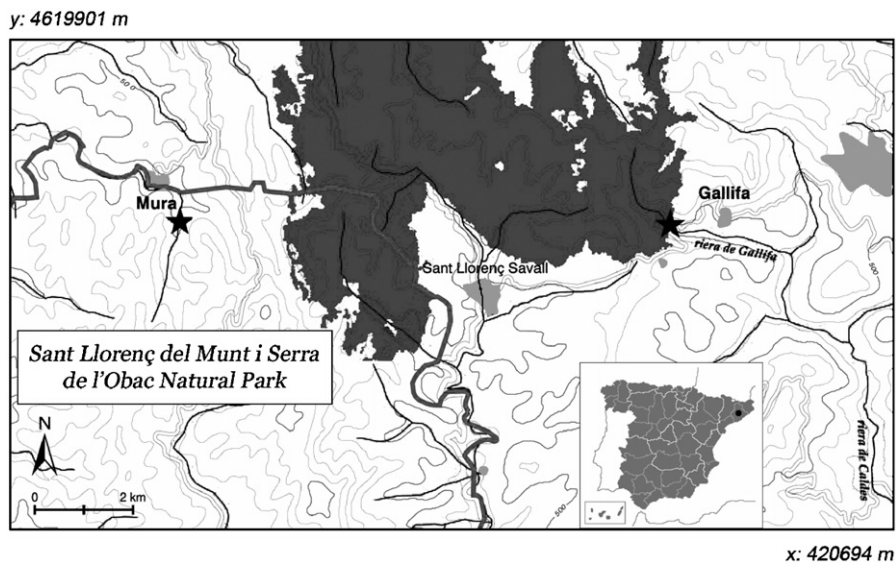


Fig. 1 – Location of the burnt area and sampling sites.

Table 1 – Main characteristics of the Gallifa and Mura creeks

Creek	Burnt	River basin	Order	Basin (Km ²)	Orientation	Altitude (m)	Discharge (L s ⁻¹) ^a	Hydrological regime
Gallifa	Yes	Besòs	1	2.90	S	560	9.48 ± 20	Intermittent
Mura	No	Llobregat	1	2.58	W	540	44.65 ± 41	Intermittent

^a Average discharge (spring and summer 1999–2003)

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