Observation strategy for quantifying particulate contaminant fluxes along the Rhône River: the Rhône Sediment Observatory (OSR)

Stratégie d’observation pour la quantification des flux de contaminants particulaires dans le Rhône : l’Observatoire des Sédiments du Rhône (OSR)

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ABSTRACT

A long-term goal of the Rhône Sediment Observatory is to quantify suspended particles and associated contaminant fluxes along the Rhône River from Lake Geneva to the Mediterranean Sea, from hydrological event to annual scales. Facing the complexity to evaluate these fluxes, an original observation strategy was developed to produce dense datasets regarding liquid discharges, suspended particulate matterloads (from turbidity), particle-size, organic and inorganic contaminant concentrations from centrifuge or sediment trap samples. Eventually, continuous time-series and flux calculation were established and made available in an efficient database (BDOH/FluxOSR).

RÉSUMÉ

L’une des actions de long-terme de l’Observatoire des Sédiments du Rhône (OSR) vise à quantifier les flux de contaminants particulaires en transit dans le Rhône du Léman à la Méditerranée, à des échelles temporelles allant de l’événement hydrologique aux bilans annuels. Face à la complexité de ces estimations, les partenaires de l’OSR ont développé une stratégie originale d’observation pour produire de denses et robustes jeux de données de débits, de matières en suspension (via des mesures de turbidité), de granulométrie, des particules en suspension et de contaminants organiques et inorganiques à partir d’échantillons collectés par centrifugation ou à l'aide de pièges intégratifs. A partir de ces données, des séries temporelles continues et des calculs de flux ont été établis et mis à disposition du public dans une base de données performante (BDOH/FluxOSR).

KEY-WORDS

Metals, monitoring network, particulate flux, polychlorinated biphenyl, suspended particulate matter.

1 INTRODUCTION

Most of the suspended particulate matter (SPM) delivered from continental surfaces to the North Western Mediterranean Sea is carried by the Rhône River, together with numerous organic and inorganic contaminants. However, apart from the SORA station settled at the lower course of the River, available data on SPM and particulate contaminant concentrations are generally incomplete and in many cases do not allow accurate estimations of particle-reactive contaminant fluxes along the River and from its various tributaries and their final exports to the Mediterranean Sea.

In 2009, the Rhône Sediment Observatory (OSR) was established to produce and manage data on sediment stocks and fluxes over the 500 km-long Rhône River from Lake Geneva to the sea. The temporal and hydrological variability of the rivers is complex and fluxes are very difficult to precise; hence, an original observation strategy was developed to quantify both SPM fluxes and their associated contaminants in a robust way, at time-scales ranging from a flood lasting for a few hours to an annual or pluri-annual assessment.

2 METHOD

The SPM contaminant flux is assessed by multiplying water discharge, SPM concentration and contaminant concentration in SPM. In the OSR program, the monitoring of the SPM parameters started in 2010 through a distributed network of permanent and temporary stations (Figure 1).

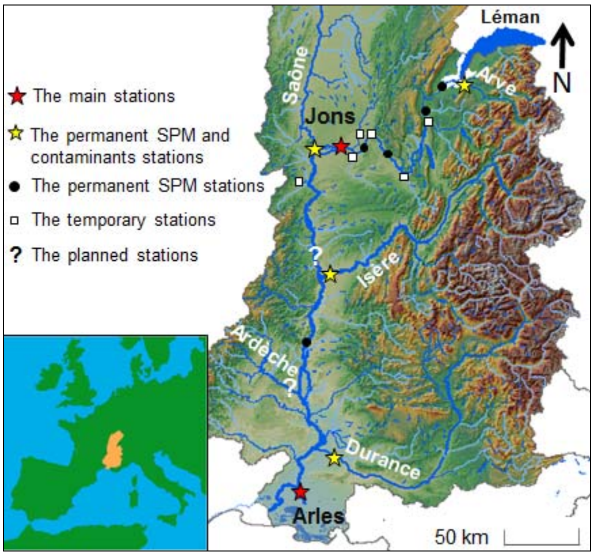

Figure 1: The Rhône River observatory network

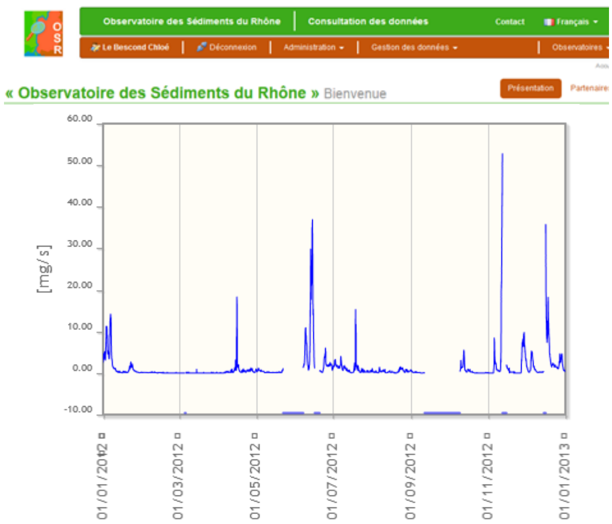

Figure 2: BDOH screenshot with the mercury flux at Jons station in 2012

The water discharge is continuously monitored by CNR, DREAL and OFEV at hydrometric stations with a stage-discharge rating curve and checked by stream gauging. The discharge network is dense and annual water balances showed that the systematic errors are negligible, within 2%-6% typically.

2.1 Suspended particulate matter concentration

The SPM concentration refers to a homogeneous suspension of fine particles (clays and silts). At all stations except the SORA station where SPM concentrations are daily or hourly measured from time-integrative filtered water samples, the SPM concentration is observed by recording continuous turbidity data, with time steps ranging from one to 10 min. An automatic sampler is coupled to the turbidity sensor to collect time-stamped water samples, then SPM concentrations are determined by filtration (porosity filter 0.7 µm). Using these calibration data, the turbidity-SPM concentration calibration curve could be constructed and checked, then used to convert turbidity time series into SPM concentrations time series. As the turbidity response is linearly correlated with the SPM grain-size (Thollet *et al.*, 2013), it is necessary to establish a calibration curve for each observation station and for different periods of time.

2.2 Contaminant concentrations in suspended particulate matter

Multi-contaminant analysis in SPM includes organic and inorganic contaminants and requires up to

100 g of dry matter. The SPM are collected at intervals varying from two weeks to once a month. In case of flood, SPM sampling frequency is increased.

2.2.1 Sampling methods

At Jons and Arles stations, SPM are sampled using a continuous-flow centrifuge. All stations except that of Arles are equipped with an integrative sediment trap (Schulze et al, 2007). This immerged box-shaped device made of marine grade stainless steel has two baffles that slow down the water. The SPM settles down and can be collected in two removable baskets. However, the representativeness of this kind of samples needed to be verified, which was done by comparing their grain-size distributions with those of samples simultaneously collected either manually or with the centrifuge. Unless the trap was exposed to near-bed sand resuspension, the sediment trap samples were found to be representative of the SPM transported by the river (Launay, 2014).

2.2.2 Chemical analysis

Several partners involved in the OSR project analysed the SPM samples: polychlorinated biphenyls (PCBs) and mercury (Hg) were determined by Irstea, metals by Cerege and radioactive isotopes by IRSN. Several PBDEs and organochlorine pesticides were also analyzed by Irstea since 2013.

To interpret spatial and temporal variability, the analysis of particulate organic carbon concentrations in SPM and the grain-size distribution by laser diffraction were also performed as they are necessary to normalize the contaminant concentrations in SPM.

The intensive monitoring at Jons began in September 2011 and major hydrological events have been monitored since then (floods since 2011, dam flushing operations in 2012).

3 RESULTS AND PERSPECTIVES

The results are made available online in a dedicated database: BDOH/FluxOSR (https://bdoh.irstea.fr). Continuous time-series are established and particulate contaminant fluxes are calculated at time scales ranging from hydrological events to annual assessments (Figure 2).

The fluxes of contaminants for each station are mainly governed by those of SPM due to their greater variability (Launay, 2014). Among the different sub-catchments however, the results show a significant spatial variability of particulate contaminant concentrations and grain-size distributions.

The cumulated SPM flux in the Upper Rhône at Jons was estimated to be 0.42 Mt for the hydrological year 2011-2012, 0.5±0,2 Mt/year on average over 2002-2012, and 0.25 Mt during the dam flushing operations of 2012, which is almost 30% of the 2012 annual SPM flux in only two weeks. The calculated annual mercury fluxes were 13 kg in 2011 and 47 kg in 2012, which directly reflects the differences in SPM fluxes. Among the tributaries of the Upper Rhône, the Arve and the Fier Rivers are the main sources of the SPM, mercury and PCBs fluxes.

Finally, a 1-D hydraulic-SPM numerical model of the Rhône River has been developed to understand and predict the propagation and fate of particulate fluxes. It uses the data produced through this observation network but also permits to validate our results.

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