Particulate contaminant fluxes in the Upper Rhône River

Flux de contaminants particulaires sur le Haut Rhône

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RÉSUMÉ

Les contaminants hydrophobes sont majoritairement transportés par les matières en suspension (MES). L'évaluation des flux de contaminants particulaires représente donc un enjeu important pour les gestionnaires du fleuve afin d'identifier les sources, le transport et le devenir de ces contaminants à l'échelle du bassin versant, et de mettre en place des politiques environnementales adaptées. Le flux d'un contaminant particulaire à travers une section du fleuve est le produit du débit, de la concentration en MES et de la teneur en contaminant adsorbé sur les particules. Afin de calculer les flux de PCB et de mercure avec une incertitude minimale et d'étudier la variabilité spatio-temporelle de ces flux, un réseau de surveillance dédié a été mis en place en septembre 2011 sur le Haut-Rhône (France) et à l'exutoire de ses principaux affluents. La stratégie de suivi repose sur des prélèvements bimensuels de MES et sur une fréquence de prélèvement renforcée pendant les crues. Une centrifugeuse et un système de filtration adaptés sont utilisés pour collecter suffisamment de MES pour permettre l'analyse des contaminants en laboratoire. Cette étude a montré que, pour les PCB et le mercure, le suivi de la concentration en MES lors des crues est essentiel pour éviter une sous-estimation des flux. En effet, la concentration en MES apparaît comme le paramètre influençant le plus le calcul de flux, puisqu'il varie de 1 à 1000 mg/L entre le régime de base et les périodes de crue. Cependant, les données collectées ont montré que les teneurs en contaminants dans les MES varient également au cours des événement hydrologiques mobilisant d'importantes concentrations en MES. Un suivi de ces teneurs en régime de base et en crue est donc nécessaire pour quantifier ces variations.

ABSTRACT

Suspended particulate matters (SPM) have been recognized as the main way of transport for the hydrophobic contaminants. Estimating particulate contaminant fluxes is thus of huge interest for water-quality managers in order to identify sources, transport and fate of contaminants at the river basin scale, and to plan remediation measures. The particulate contaminant flux across a river section is the product of the water discharge, the SPM concentration and the contaminant content adsorbed on particles. In order to evaluate particulate fluxes of PCBs and Hg with minimal uncertainty and to investigate the spatio-temporal variability of these fluxes, a dedicated monitoring network was set up in September 2011 on the Upper Rhône River (France), and on the outlets of its main tributaries. The monitoring strategy relies on fortnightly measurements of contaminant concentrations and a specific monitoring of flood events. In order to collect a sufficient amount of SPM to allow for contaminant analysis (PCBs, Hg), appropriate centrifugation and filtration devices were deployed. This study highlighted that for PCBs and Hg, SPM concentration monitoring is essential during flood events to avoid an underestimation of fluxes. Indeed, SPM concentration appeared to be the most influencing parameter of the flux assessment, as it varied from 1 to 1000 mg/L between base-flow and flood periods. Nevertheless, contaminant concentrations should be accurately studied during hydrological events as they appeared to vary between base-flow and sediment-laden events.

KEYWORDS

Mercury (Hg), Particulate contaminant flux, PCBs, Rhône river, Suspended particulate matters (SPM).

1 INTRODUCTION

The European Water Framework Directive came into force in 2000, taking the 1976 Barcelona Convention into account and thus encouraging the contracting parties to evaluate pollution discharge to the Mediterranean Sea. As suspended particulate matters (SPM) have been recognized as the main way of transport for the hydrophobic contaminants (Lick, 2009), efforts were focused on the estimation of particulate contaminant fluxes, which is of huge interest for water-quality managers in order to identify sources, transport and fate of contaminants at the river basin scale, and to plan remediation measures. The particulate contaminant flux across a river section is the product of the water discharge, the SPM concentration and the contaminant content adsorbed on the particles. Therefore, calculating a particulate contaminant flux with minimal uncertainty requires information on the spatial and temporal variability of those three terms. Under the umbrella of the Rhône Sediment Observatory, a dedicated monitoring network was set up in September 2011 on the Upper Rhône River (France), and on the outlets of its main tributaries, amongst which, the Arve, Bourbre and Ain rivers (Fig. 1). Data are collected in order to evaluate particulate fluxes of polychlorinated biphenyls (PCBs) and mercury (Hg) and to investigate the spatio-temporal variability of these fluxes.

2 MATERIAL AND METHODS

The monitoring network primarily relies on the Jons station located on the Rhône river, at the outlet of the area of interest. At this station, we conducted fortnightly measurements of contaminant concentrations, along with a specific monitoring of flood events. In addition, several measurement campaigns have been conducted on the main tributaries in order to document contaminant concentrations at a regional scale during base-flow and flood periods, including during dam flushing operations. At each monitoring station, discharge recordings are available and at some stations, continuous time series of SPM concentration were obtained from turbidity measurements calibrated against manual sampling and SPM concentration laboratory analysis. In order to collect a sufficient amount of SPM to allow for contaminant analysis (PCBs, Hg), appropriate centrifugation and filtration devices were deployed, along with a sediment trap and an automatic sampler.

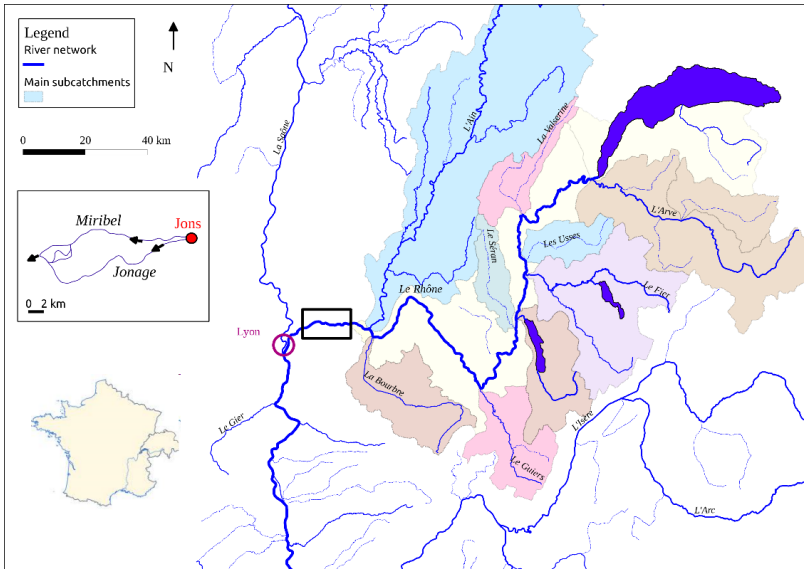

Fig. 1: The Upper Rhône River network and its main subcatchments

3 RESULTS AND DISCUSSION

We first verified that using available continuous measurements, the water budget at the regional scale was well-balanced. From the continuous discharge recordings available for all tributaries and at several points of the Upper Rhône river, we confirmed that the sum of the Upper Rhône River discharge and of the tributaries discharges corresponds to the discharge observed at Jons, at the outlet of the system, over a one year period and over a 10 years period.

Secondly, from turbidity data collected at the Jons station since September 2010, we observed that SPM concentrations fluctuated over time and was highly influenced by the hydrological cycle. The order of magnitude of those variations varied from 1 to 1000 mg/L between base-flow and flood

periods (Fig. 2). Moreover, during this one year period, the flood periods (Q > 500 m^3/s) corresponded to 20% of the time, but the SPM flux due to flood events represented 60% of the total SPM flux. The influence of the SPM concentration on the particulate sediment flux assessment was therefore predominant. To investigate the source of this variability, we set up additional temporary monitoring stations for turbidity recordings at the outlets of the main tributaries during periods of 3 to 4 months. This monitoring was first implemented in September 2011 in the Bourbre River and will be moved to the Ain River in spring 2012. This should allow to obtain a better insight of the tributary contribution to the global SPM flux.

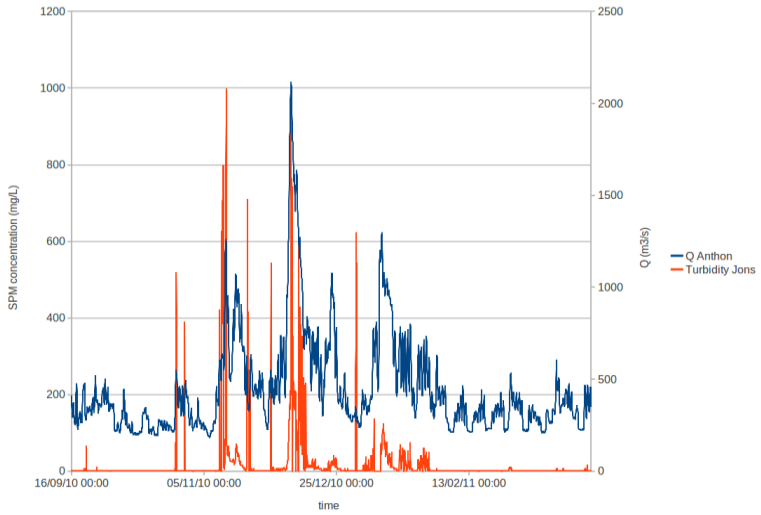

Fig. 2: Turbidity and discharge recordings at the Jons station from September 2010 to March 2011

Thirdly, from particulate contaminant content data collected at the Isère-Campus monitoring station (Grenoble, France) during the May 2008 flood, Minaudo et al. (2011) showed that contamination levels (among which Arsenic and Lead) of SPM varied over low and high SPM load periods. The order of magnitude of the contaminant concentration variation was from 1 to 10 and thus was lower than the SPM load. At the Jons station, one of the monitoring point of the regional water authority, a large data set on SPM content for many contaminants has been collected 4 times per year from 2000 to 2009. Nevertheless, we observed that no samples were collected during flood events, which probably lead to an underestimation of the contaminant contents variations (Launay et al., 2011). Those results highlighted the need of a specific sampling of SPM during floods to handle uncertainties in flux assessment. Indeed, our specific monitoring of flood events at the Jons station, relying on spot and automated sampling, should allow to better characterize the temporal variations of particulate PCBs and mercury concentrations.

4 CONCLUSION AND PERSPECTIVES

As a conclusion, this study highlighted that for hydrophobic organic contaminants such as PCBs and adsorbable metals such as Hg, SPM concentration monitoring is essential during flood events to avoid an underestimation of fluxes. Indeed, SPM concentration appeared to be the most influencing parameter of the flux assessment. Nevertheless, contaminant concentrations should be accurately studied during hydrological events as they appeared to vary between baseflow and sediment-laden events. Therefore, we implemented a robust monitoring network on the Rhône River to allow the assessment of PCBs and Hg fluxes in the Upper Rhône River. The data collected shall also be used in a numerical model, that is being developed in order to represent the particulate contaminant transport throughout the river network.

LIST OF REFERENCES

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