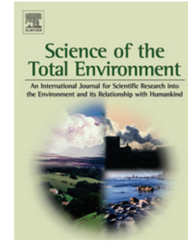
SCIENCE OF THE TOTAL ENVIRONMENT 389 (2008) 503–513

available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/scitotenv



Quantitative multimolecular marker approach to investigate the spatial variability of the transfer of pollution from the Fensch River to the Moselle River (France)

Laurent Jeanneau[a,*], *Pierre Faure*[a], *Emmanuelle Montarges-Pelletier*[b]

[a]*G2R, Nancy-Université, CNRS, BP 239, 54506, Vandoeuvre-les-Nancy, Cedex France*
[b]*LEM, Nancy-Université, CNRS, BP 40, 54501 Vandoeuvre-lès-Nancy Cedex France*

ARTICLE INFO

Article history:
Received 1 August 2007
Received in revised form
12 September 2007
Accepted 17 September 2007
Available online 17 October 2007

Keywords:
Sedimentary organic matter
Multimolecular approach
Quantification
Source apportionment

ABSTRACT

The lipidic fraction from 8 sediments sampled at the confluence between the Fensch River (FR) and the Moselle River (MR) have been analyzed by gas chromatography-mass spectrometry (GC-MS) in order to investigate the transfer of organic micropollutants from the FR to the MR. Molecular markers have been quantified and classified into five categories: natural, petrogenic, pyrogenic and sewage water markers and non-specific molecules. This classification coupled with the quantification of the molecules allows the comparison between anthropogenic and natural inputs and the source apportionment of anthropogenic molecules that are not covalently bound to sedimentary organic macromolecules. The transfer and the fate of organic micropollutants in river sediments seem to be controlled by the water flow. Low water flow conditions induce the settling of fine particles, which could limit the biodegradation. This leads to the preservation of the original anthropogenic fingerprint that is rich in low molecular weight molecules. In high water flow conditions, sediments are mainly composed of coarse particles, limiting the preservation of organic matter, which leads to a persistent anthropogenic fingerprint, mainly composed of high molecular weight compounds.

1. Introduction

The industrial revolution occurring during the last two centuries has induced over-consumption of fossil organic matter as the major source of energy, which has sharply increased the anthropogenic pressure on the biosphere. The most known consequence is the increase in the amount of greenhouse effect gases in the atmosphere, which could play on the Global Warming (Arrhenius, 1896; IPCC, 2001). Since (1) the efficiency of pyrogenic processes is not total and (2) crude oils are used for the production of lubricant and road asphalt, organic pollutants from these sources can be released on continental surfaces and to hydrosystems by water-leaching.

The first industrial revolution has induced intensive steel and coal activities in the North-East of France due to occurrence of coal and iron ores, which has resulted in an increase in the demography. Although the industrial activity has decreased for twenty years, its environmental impact still occurs. The Moselle River is the most important hydrosystem in this area and its quality is strongly affected by past and present industrial activities and by an intense urbanization. The Fensch River (FR) is a tributary of the Moselle River (MR). It drains one of the most industrialized valleys of the Moselle watershed, which results in pyrogenic matter, petrogenic and wastewater treatment inputs. This small hydrosystem has undergone an important anthropogenic process already

* *Corresponding author*. Tel.: +33 3 83 68 47 43; fax: +33 3 83 68 47 01.
E-mail address: laurent.jeanneau@g2r.uhp-nancy.fr (L. Jeanneau).

0048-9697/$ – see front matter
doi:10.1016/j.scitotenv.2007.09.023

described in our preliminary works (Jeanneau et al., 2006; Montarges-Pelletier et al., 2007). The impact of these processes on the quality of the sedimentary organic matter of the Moselle River has been underlined but the spatial variation of this impact in term of organic markers is still unknown.

The impact of fossil organic matter is quantified in environmental samples by the analysis of the sixteen polycyclic aromatic hydrocarbons (PAH) listed by the US-Environmental Protection Agency (US-EPA). Since PAH have several sources (Freeman and Cattell, 1990; Nielsen, 1996; Wang and Fingas, 1997) this quantification allows neither the comparison between anthropogenic and natural inputs nor the differentiation between the different sources of anthropogenic organic matter. Moreover it characterizes a few part of the organic matter that can be analyzed by gas chromatography-mass spectrometry (GC-MS). In order to differentiate between sources of organic matter, the molecular marker approach has been developed based on the potentiality of molecules to be source specific (Takada and Eganhouse, 1998). Such an approach, applied to molecules identified and quantified by GC-MS, allows classifying them by their source and then to differentiate the inputs of organic matter that occurs in environmental samples.

In the present study, the molecular markers identified by GC-MS in the extractable organic matter (EOM) have been quantified and classified by their source into natural, pyrogenic, petrogenic and sewage water (SW) markers, and non-specific molecules. This molecular classification has been developed in order (1) to compare anthropogenic and natural inputs and (2) to differentiate between sources of anthropogenic matter. Since this study is based on the analysis by GC-MS of the molecules that are soluble in organic solvent, the quantification and the source apportionment of the pollution is performed in the compartment of molecules that are not covalently bound to the organic macromolecules of the sediment. This source apportionment has been applied to eight river sediments sampled in the FR and in the MR upstream and downstream the confluence in order to investigate (1) the spatial variability of the impact of the FR on the MR and (2) the fate of organic contaminants in sediments.

2. Materials and methods

2.1. Sampling area

As shown on Fig. 1, the sampling area is the confluence between the Moselle River (MR) and the Fensch River (FR). It is located in the downstream area of the French part of the MR watershed, in the north of the main cities of Nancy and Metz and in the South–West of the borders with Luxembourg and Germany. The FR takes its source in Fontoy. Its water flow, 0.8 m^3/s at lowest water level, is strongly increased by industrial and domestic inputs that have an important impact in terms of flow (0.55 m^3/s), suspended particles (520 kg/day) and hydrocarbons (10 kg/day) (data from the Rhin-Meuse Water Agency). Between the sampling site and the confluence, the FR flows through a pipe located under a channel built to deserve an industrial harbor (Fig. 1). It has been dredged in April 2006 for the first time since the nineteen fifties. The purpose of such a pipe was not only to connect the two rivers, but also to retain the suspended material coming from the Fensch valley. Since no dredging had been performed within the last fifty years, 85% of the pipe was filled with sediments.

Surface sediments were sampled around the junction of MR and FR (Fig. 1) during flood and drought conditions from January 2004 to July 2005 (January and June 2004, February and June 2005) using stainless steel sampling devices. The latitudes, longitudes and altitudes of the sampling sites are shown in Table 1. River sediments from the Fensch River are referred to as “FR” and “pipe” for the sediment accumulated in the pipe. River sediments from the MR are referred to as “MRUp” for upstream area and “MRDo” for downstream area. For the FR and MRUp areas, sediments were sampled at four different times and the results given for those sampling sites are the

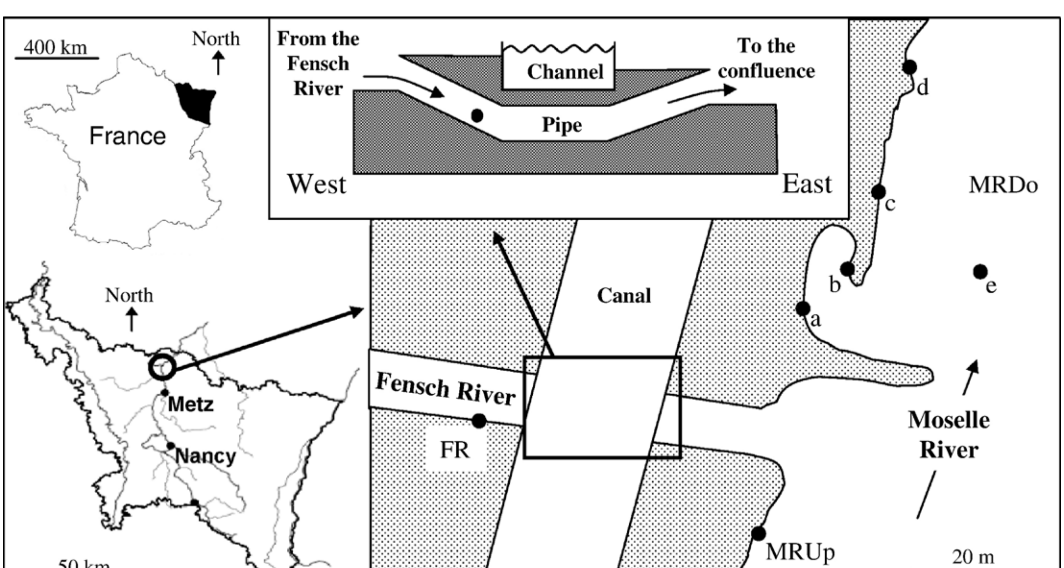


Fig. 1 – Location of the studied area and of the sampling sites.