Spectrophotometric characterization of human impacted surface waters in the Moselle watershed

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ABSTRACT

In order to characterize the pollution discharged into the Moselle River and some of its tributaries, spectroscopic techniques, namely UV–vis spectroscopy and synchronous fluorescence spectroscopy, have been combined. UV–visible spectra were analysed using the maximum of the second derivative at 225 nm (related to nitrates), the SUVA254 and E2/E3 indices (related to the nature of organic matter). Synchronous fluorescence spectra ($\Delta \lambda = 50$ nm) presented different shapes depending upon the type of pollution. The pollution results from anthropogenic activities: untreated domestic sewage due to misconnections in a periurban river, effluent from urban WWTPs, agricultural runoff (nitrates) in several streams, discharge from a paper mill (humic-like substances due to wood processing) and from steel mills (PAHs).

Key words | nitrate, paper mill, steel mill, synchronous fluorescence, UV–visible spectroscopy

INTRODUCTION

In 2000 the European Union established a general framework for the protection and management of water bodies (directive 2000/60/EC). In a watershed, river pollution results from the various uses of water. In order to achieve the final goal of good ecological and chemical status, river pollution sources should be identified and reduced.

Recently spectrophotometric methods have been proposed to characterize water pollution features. Turbidity, UV–visible and fluorescence spectroscopy are rapid and environment-friendly techniques. UV–visible spectroscopy, which provides information on molecules with unsaturated bonds, has been used as a surrogate method for COD estimation on wastewater, based on absorbance at 254 nm (Mrkva 1983). The region of the spectrum around 215 nm is related to nitrates (Ferree & Shannon 2001). Many compounds such as proteins, steroids, phenols, oils, surfactants, vitamins, humic and fulvic acids, etc. emit fluorescence after excitation by visible or near-UV light. Thus the fluorescence spectrum of a water sample can bring information relative to the chromophoric substances it contains (Hudson et al. 2007), such as natural and anthropogenic organic matter. Fluorescence spectroscopy has been suggested to detect pollution related to discharges of untreated sewage in water bodies (Nam & Amy 2008; Kusakabe et al. 2008) or to cross-connections in water reuse systems (Hambly et al. 2010a, b), based on tryptophan-like fluorescence ($\lambda_{exc} \approx 280$ nm and $\lambda_{em} \approx 340$ nm) (Baker et al. 2003). Two other fluorescence centres are in general examined to compare water samples: fulvic-like fluorescence (around $\lambda_{exc} = 320–340$ nm/$\lambda_{em} = 410–430$ nm) and humic-like fluorescence (around $\lambda_{exc} = 370–380$ nm/$\lambda_{em} = 460–480$ nm) (Baker 2003). Although modern devices can provide excitation–emission matrices in a relative short time (~1 min according to Baker 2001), synchronous fluorescence (SF), with a constant difference between excitation and emission wavelengths have also been promoted (Miano & Senesi 1992; Ahmad & Reynolds 1995; Sierra et al. 2005): the SF spectra are better resolved than emission or excitation spectra and are fast to collect.

The goal of this contribution is to show the potentialities of the combination of UV–visible and fluorescence spectroscopy to detect different types of anthropogenic pollution, related to domestic, agricultural and industrial water use in a watershed. Examples are taken in the Moselle watershed, in the northeastern part of France (Figure 1(a)). From its source in the Vosges Mountains at the Bussang Pass, the Moselle River, as well as its tributaries, crosses areas of various anthropogenic activities: forestry, agriculture (crops such as wheat and rapeseed, cattle), industries (textile, paper and steel mills, salt extraction, power plants, etc.) as...