Science of the Total Environment 542 (2016) 955–964

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Influence of the water quality improvement on fish population in the Seine River (Paris, France) over the 1990–2013 period

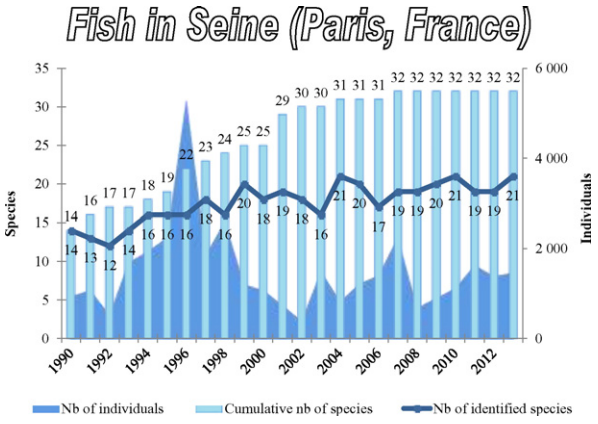
Sam Azimi *, Vincent Rocher

SIAAP–DDP, 82 Avenue Kleber, F 92 700 Colombes, France

HIGHLIGHTS

- In 2013, the dissolved oxygen concentration in the Seine River is slightly modified by the Paris anthropogenic activities.
- An emergence of a more sensitive assemblage of fish is observed over the past decades.
- The overall fish index of the river Seine has the good quality level downstream of Paris.
- Exceedance of the environmental quality standards for mercury and PCBs was evidenced in the fish muscles.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 4 August 2015
Received in revised form 19 October 2015
Accepted 19 October 2015
Available online 9 November 2015

Editor: D. Barcelo

Keywords:
River Seine
Ecological status
Electrofishing
Fish species assemblage
IBI
EROD
Dissolved oxygen

ABSTRACT

Over the past 20 years, rules concerning wastewater treatment and quality of water discharged into the environment have changed considerably. Huge investments have been made in Paris conurbation to improve waste water treatment processes in accordance with the European Water Framework Directive. The interdepartmental association for sewage disposal in Paris conurbation (SIAAP) carried out a monitoring of both fish assemblages and water quality in the Seine River around the Paris conurbation (France) since the early 90's. The main goal of this study was to estimate the influence of the water quality improvement on fish.

On one hand, the study confirmed the improvement of the water quality (dissolved oxygen, ammonia nitrogen, organic matter) in the Seine River, mostly focused downstream of Paris conurbation. On the other hand, an increase of the number of species occurred from 1990 (14) to 2013 (21). Moreover, changes in the river Seine assemblages happened over that 23-year period with emergence of sensitive species (ruffe, scalpin and pikeperch). The improvement of the water quality was also reported with respect to the Index of Biotic Integrity (IBI). However, no variation of pollutant concentrations in roach, eel and chub muscles has been observed. An exceedance of the environmental quality standards have even been reported all over this period as regards mercury and organochlorine.

* Corresponding author.
E-mail address: sam.azimi@siaap.fr (S. Azimi).

http://dx.doi.org/10.1016/j.scitotenv.2015.10.094
0048-9697/

1. Introduction

The management of aquatic environments in Europe is governed by Water Framework Directive (WFD, 2000/60/CE), transposed into French law by the 2006 Act on water and aquatic environment (2006–1772 of 30/12/06). These guidelines, aiming at improving and restoring the good ecological status of water, have been backed by the Grenelle Acts 1 and 2 (2009-967 of 03/08/09 and 2010-788 of 12/07/10). For a long time, the watercourse quality assessment has only relied on the analysis of the physical and chemical composition of water. It is now based also on biological components of the aquatic ecosystems as algae (diatoms), macrophytes, benthic macro-invertebrates and fish (O'Farrell et al., 2002; Hering et al., 2003; Hering et al., 2010). Among all these potential bio-indicators, fish are genuine integrators of water quality and, more broadly, of the functioning of aquatic environments because they are at the top of the food chain, Also they are sensitive to both quality of water and health of the physical habitat, they can live for a long time and they have a very mobile nature (Sanchez et al., 2012; Tales, 2009; Polard, 2010; Couillard, 2009). The use of such sentinel species allows to track environmental variations at variable temporal scales, ranging from weeks (invertebrates) to years (fish). Also, since bio-indicators differ in ecological traits such trophic position, they can inform if pollutants have permeated upwards the food-webs (bio-accumulation and bio-magnification risks) (reviewed in Colin et al., 2016).

Furthermore, over the past 20 years, rules concerning wastewater treatment and quality of water discharged into the environment have changed considerably. In 1991, the implementation of the European Directive on the collection, treatment and discharge of wastewater, has requested the member states of the European Union to identify areas sensitive to eutrophication, in which discharges of phosphorus and nitrogen should be reduced (it was already the case for organic matter). Specifically, the treatment plants of medium and large sizes located in these areas had to develop treatments that respect maximum concentrations of nitrogen and phosphorus. These regulatory requirements have imposed an upgrade of the Parisian urban wastewater plants in order to provide treatment that can effectively remove carbon, nitrogen and phosphorus from wastewater. So, significant efforts have been made in Paris conurbation since early 90's to integrate water treatment units for chemical treatment of phosphorus and biological treatment of nitrogen.

The monitoring of the chemical composition of the river Seine (dissolved oxygen, organic matter, nitrogen, phosphorus, etc.) is done since the beginning of the 20th century (Rocher et al., 2015). In order to collect biological data for the monitoring of watercourse quality, as of 1990, the interdepartmental association for sewage disposal in Paris conurbation (SIAAP) has enlisted support from National Fisheries Board (whose responsibilities were subsequently rolled into those of French National Agency for Water and Aquatic Environments called ONEMA) for carrying out a monitoring of fish assemblages in the river Seine across the Paris conurbation (France). Since the 2000s, that monitoring has been supplemented with analyses of various pollutants (heavy metals, PCBs, pesticides) in the muscles of some species, as well as the EROD activity (7-ethoxyresorufin-O-deethylase) in the chub livers.

Both approaches (physico-chemical analysis and bio-indicator species) are complementary for the purpose of aquatic environment monitoring. The former is based on the chemical analysis of a number of pollutants in the environmental matrices and enables the assessment of the contamination of habitats. This approach, however, provides no data about the impact of the chemical molecules and on how natural factors (temperature, hydrological regime) modulate their effects, on the living organisms. The latter combines the occurrence and abundance of bio-indicator species in order to diagnose the quality of water and biocenoses, a posteriori a disturbance, through an examination of the biological effects of the pollutants on the organisms.

The aim of this study is to provide information about the possible influence of the improvement of the water quality in the Seine River, with respect to the WFD, on fish population. The first section deals with the estimates of fish assemblage in 8 localities from upstream to downstream of the Paris conurbation. The results describe both counting and ecotype of the various identified species. The full dataset was used for calculating the Index of Biotic Integrity (IBI), a suitable indicator for the biological quality of water bodies. The second section of the survey presents the micropollutant contents (metals, PCBs and pesticides) in the muscles of eel, chub and roach and the description of the EROD index as determined in the chub livers. Before studying those topics, a first paragraph will focus on the water quality improvement of the Seine River.

2. Material and methods

2.1. Survey sites

Fishing sites have been selected and distributed from upstream to downstream of Paris conurbation, so that the SIAAP's intervention range can be encompassed. They have been chosen to provide a representativeness of aquatic habitats in urban areas (Fig. 1).

Until 1999, the monitoring network comprised 4 sampling stations lying along the river Seine in Villeneuve-Saint-Georges, Paris, Levallois/Asnières and Epinay sur Seine. The network was extended to 7 stations in 2000 to include Le Pecq, Poissy and Triel-sur-Seine stations. In 2013, the Choisy-le-Roi station was added to the network to encompass all 4 Paris conurbation wastewater treatment plants that directly discharge treated water into the river Seine. The surveys are conducted in partnership with ONEMA. These stations are intended to allow keeping a close look at the potential impact of releases from most significant structures in urban environments.

Specific fishing campaigns have been set up for the purpose of micropollutant analysis at the Villeneuve-St.-Georges, Levallois/Asnières and Triel-sur-Seine sites. These sites encompass areas lying upstream, near downstream and far downstream of the capital, respectively.

2.2. Applied protocols

The sampling protocol was not uniformly applied throughout the survey period, since the national protocol was amended in 2005. From 1990 to 2004, the sampling was conducted using the per-habitats fishing method. That method consists in discretely identifying and exploring some fifteen key habitats that are both typical to the locality and very attractive to fish. The caught fish are classified per habitat, the final result being the sum of caught fish in relation to the sum of acreages of the explored habitats. Hence, it is not an assessment of assemblage densities, but a catch per unit effort (CPUE). That method is considered as very reliable for catching the various species occurring at the station, and relatively reliable for assessing the proportion of the different species occurring there (Benejam et al., 2012).

The sampling method per Abundance Grab Sampling (AGS) was applied from 2005 onwards. This method, based on the partial exploration of the stations allows to provide a representative sample of the population with respect to richness, composition and abundance in large watercourses (Tales, 2009; Le Pichon et al., 2012). Thus, the fishing was performed on one hundred points within each sampling station, representing nearly a coverage area of 1250 m^2 per station. Although the observed species richness in a single pass generally underestimated the species present in a specific stream reach, richness and composition metrics (such as density of tolerant individuals used in this paper) displayed much less methodological variations (sampling crews, equipment, etc.) and are much easier to estimate precisely than CPUE (Benejam et al., 2012).

It has been shown recently that although CPUE estimates depended on crew (and are likely to be difficult to calibrate), observed species richness and species composition were barely affected (Benejam et al.,