Chemosphere 189 (2017) 340–348

Contents lists available at ScienceDirect

Chemosphere

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

Identification, assessment and prioritization of ecotoxicological risks on the scale of a territory: Application to WWTP discharges in a geographical area located in northeast Lyon, France

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HIGHLIGHTS

- Emerging pollutants from WWTP are hazardous for watercourses.
- Their management, on the scale of a territory, requires a specific methodology.
- An innovative ecotoxicological risk assessment methodology has been developed.
- It has been applied on a pilot territory near to Lyon in France.
- Prioritization of the risks on the territory studied will be useful for managers.

ARTICLE INFO

Article history:
Received 30 June 2017
Received in revised form
26 August 2017
Accepted 12 September 2017
Available online 13 September 2017

Handling Editor: Jian-Ying Hu

Keywords:
Wastewater
WWTP
Emerging pollutants
Watercourses
Territory
Ecotoxicological risks
Ranking

ABSTRACT

The ecotoxicological risk assessment methodologies developed up to now mainly focus on local pollution and do not incorporate an evaluation and prioritization of the different risk situations present in the same territory. This article presents the different phases of formulating an innovative methodology developed to fill this gap, and its application to all the 18 WasteWater Treatment Plants (WWTP) of a geographical area located northeast of Lyon, France. The aim was also take into account emerging pollutants that are very often "forgotten" in ecotoxicological risk assessments. The results of the study show the extreme diversity of the ecotoxicity of the pollutants present in discharges, with "minimum" PNEC values in the region of a millionth of a microgram (10^{-6} µg/l) and "maximum" PNEC values in the region of several tens of micrograms. They also show very considerable diversity of the flows of the receiving watercourses in the territory concerned (from several m^3/s to 600 m^3/s). The Risk Quotients (RQ) resulting from these 2 datasets, calculated for each WWTP and for each of the 10 pollutants most implicated in ecotoxicological risks (Diclofenac, Amoxicillin, Trimethoprim, Roxithromycin, 17β-estradiol, 17α-Ethynylestradiol, Estrone, Nonylphenol, Octylphenol, Nickel, et NH_4^+), vary from 0.000002 to 187.7 when using the median concentration values of these pollutants, and from 0.000007 to 3750 when using their maximum concentration values. Globally, they show that: (1) the risks are higher for small streams that receive WWTP discharges of average size, (2) the risks are low to very low for discharges into watercourses with high flow rates.

1. Introduction

1.1. The problem of assessing ecological risks on the scale of a territory

Characterising the ecotoxicity of different sources of pollution (urban and industrial discharges, polluted soils, etc.) located in the same territory provides information useful for their management (Muna et al., 1995; Fairey et al., 1998; Bakopoulou et al., 2011;

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http://dx.doi.org/10.1016/j.chemosphere.2017.09.054
0045-6535/

Giorgetti et al., 2011; Stark et al., 2015). However, it does not take into account the level of exposure of target organisms to these sources of pollution, which limits its usefulness when focusing on risk assessment and management. To overcome this shortcoming, the advantage of using an ecotoxicological risk assessment methodology is that it takes into account both the ecotoxicity of the pollution source, and the real exposure of the target ecosystems concerned (Suter, 1993; US EPA, 1998; Babut et al., 2002; ECB, 2003; Emmanuel et al., 2005; Perrodin et al., 2011). Nonetheless, this type of method is most often used for a localised pollution source and does not take into account all the risks present in a territory. Consequently, we decided it would be useful and innovative to develop a methodology for assessing and ranking all the ecotoxicological risks present in the same geographical area. We have initially chosen to apply this methodology to WWTPs installed in the same territory. This work was done by placing emphasis on emerging pollutants such as drug residues, nonylphenols and plasticizers, given their ecotoxicity and their strong presence in this type of effluent (Deblonde et al., 2011; Miège et al., 2009; Luo et al., 2014). The general approach developed at the end of this work could be used in particular by the different organisations responsible for territorial development in view to identifying the risk situations that should be given priority treatment.

1.2. Objective of the project and presentation of the article

The aim of this article is to present an innovative methodological approach developed to identify, assess and prioritize ecotoxicological risks present on the scale of a territory, and to describe its application for managing different WWTPs of a pilot site near the city of Lyon, in France.

It is composed of five successive parts: (1) the presentation of the territory studied, (2) the development of the methodology, (3) the results obtained from applying the methodology to the territory studied, (4) the discussion of the results, and (5) the presentation of the perspectives for developing the methodology.

2. Presentation of the territory studied

The territory studied is situated northeast of the city of Lyon, in France (Fig. 1). It was chosen for several reasons: (1) the diversity of the WWTPs installed in the territory, (2) the diversity of the receiving watercourses concerned, (3) the wealth of the data and information available in the territory (Dethier and Castella, 2002), (4) the participation of this territory in a research project larger than the present study (Projet PlurisQ), and which encompasses other facets of risk assessments in the same area (natural risks, health risks, economic risks, risk perception, etc.).

Regarding this territory, we identified 18 WWTPs (Fig. 2) with effluent discharges varying from 14 m^3/d (WWTP of Labalme-les-Grottes) to 40007 m^3/d (WWTP of Villeurbanne-la-Feyssine). The low flow rates of the watercourses into which the WWTP effluents are discharged vary from several tenths of a m^3/s (Pomaret, Cottey) to 600 m^3/s (the Rhone at its entry in Lyon). It is noteworthy that one of the watercourses listed (Ruisseau des Echets) is practically dry during low flow periods, with the presence of residual pockets of water. The municipalities in the territory, the average flow rates of the WWTP discharges, and the low flows of the watercourses into which the WWTP discharge effluents, are presented in Table 1.

3. Development of the methodology

3.1. Assessment of pollutant concentrations in effluents

Ideally, a detailed chemical analysis is required (including of emerging pollutants) of each effluent discharged. Unfortunately, these data are rarely all available for the WWTPs of a territory, in particular for that studied. Furthermore, it is known that the concentration of these effluents is variable through time (Lacaze et al., 2017), which requires having repeated analyses to ensure robust assessments of the corresponding concentrations. We initially decided to work with “minimum”, “median” and “maximum” concentrations identified in the literature for WWTP discharges. The disadvantage of this approach is that it does not take into account the specificities of the terrain regarding atypical concentrations of certain pollutants within certain discharges in the territory considered. However, it does have the advantage of taking into account emerging pollutants such as nonylphenols, plasticizers, fire retardants and drug residues, which are frequently omitted in discharge monitoring plans. It is nonetheless important to monitor these substances since some of them are very ecotoxic and undergo very little treatment in WWTPs, so they can be heavily involved in the ecotoxicity of the effluents, and eventually contribute considerably to the ecotoxicological risks generated by them. Lastly, as a function of the results obtained, it will always be possible later to perform detailed analyses of the effluents of the plants that, *a priori,*

Fig. 1. Location of the territory studied. Data SIO, NOAA, U.S. Navy, NGA, GEBCO, © 2017 Google. © 2009 GeoBasis DE/BKG.