Risk assessment of water effluents in Catalan (NE Spain) waste-water treatment plants based on E-PRTR data

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1. Introduction

The *Regulation 166/2006* [1] concerning the establishment of a European Pollutant Release and Transfer Register (amending *Council Directives 91/689/EEC and 96/61/EC*) aims at establishing a Community level register of integrated pollutant release and transfer (known as 'the European PRTR' or 'E-PRTR'). Its application domain affects certain types of manufacturing and production facilities, among them waste-water treatment plants (WWTPs) with a capacity of more than 100,000 equivalent inhabitants.

Data gathered under the E-PRTR regulation provide a valuable source of information regarding the emission of pollutants to air, water and waste from the assessed installations.

The scenario of the present study covered the 22 WWTP's located in Catalonia (NE Spain) affected by the E-PRTR regulation. 41 micropollutants belonging to different families (heavy metals, anions, volatile organochlorine compounds (VOX), semivolatile organochlorine compounds, volatile aromatic hydrocarbons, policyclic aromatic hydrocarbons, herbicides, endocrine disruptors, phenols and organotins) were determined on the water effluent.

The resulting concentrations were subsequently evaluated using two different risk assessment methods, namely, the COMMPs procedure developed by the Fraunhofer Institut [2] and a method based on fuzzy logic. From the results gathered it has been possible:

(a) To characterize and compare the different sites (WWTPs) according to the associated risk.

(b) To prioritize the compounds studied according to their relative contribution to the total risk.

(c) To compare the two risk-assessment methods tested

2. Data recollection

24 h integrated water effluent samples were collected in the 22 WWTP under concern, along the years 2008-2010 (one per year for every WWTP). Samples were kept below 4ºC until analysis, and analyzed using appropriate referenced analytical methods.

3. Risk assessment methodologies

3.1. COMMPS (Combined Modelling Based and Monitoring Based Priority Setting Procedure)

The COMMPS procedure establishes a ranking of chemical substances according to a risk priority index. For a particular substance *i* it is obtained as the product of a substance's exposure index $\mathrm{I\_exp}$, and its corresponding effect index $\mathrm{I\_eff}$ (Equation 1).

$$\mathrm{I\_prio_i} = \mathrm{I\_exp_i} * \mathrm{I\_eff_i} \qquad \textit{Equation } 1$$

The exposure index of a chemical substance *i*, $\mathrm{I\_exp_i}$, is calculated using all their measured concentration values in every sampling site, whereas in the effect index $\mathrm{I\_eff_i}$ calculation, direct and indirect effects on aquatic organisms are considered (toxicity and potential bioaccumulation) as well as indirect effects on humans (carcinogenicity, mutagenicity, adverse effects on reproduction and chronic effects)[2]. Furthermore,

a site pollution risk index based on the COMMPS procedure developed by us elsewhere [3] has been used to evaluate the potential risk associated to every specific sampling site (WWTP) studied. It is computed on the basis of the different substances present, according to the following equation (Equation 2):

$$I\_site_j = \frac{\sum_{i=1}^{n} I\_exp_{i,j} I\_eff_i}{n} \qquad \textit{Equation 2}$$

Where I_site_j is the site pollution risk index assigned to site j, I_exp_{ij} the exposure index of substance i in sampling site j, and I_eff_i the effect index (direct and indirect effects) of substance i; n being the number of substances (organic compounds) included in the calculation.

3.2. Fuzzy logic

Fuzzy logic represents a significant change in both the approach to and the outcome of environmental evaluations. The key advantage of fuzzy logic methods is how they reflect the human mind in its remarkable ability to store and to process information that is consistently imprecise, uncertain, and resistant to classification [4].

Whereas for the classic logic one fact is true or not true, for the fuzzy logic an affirmation is not never totally true or false, instead of that it will be true or false with a certain degree of membership.

Fuzzy logic has successfully been used in the enviromental field to model non-linear functions, to establish inference systems on top of the experience of experts and to deal with imprecise data [5].

A methodology based on fuzzy logic has been developed to assess the risk of the WWTP's. The experimental data on the concentrations of pollutants have been used to test the method. The main components of the method are:

- Identification of the variables of the system (e.g. concentration of the pollutant, toxicity)
- Establishment of fuzzy sets (e.g. high, medium, low) and ranges for each variable
- Establishment of the fuzzy propositions used to connect the inputs of the problem with the output
- Environmental risk assessment of the WWTP's

4. Conclusions

Within the framework of the *Regulation 166/2006*, a ranking of the risk associated to the 22 WWTP's has been established and a relative risk based prioritization of the compounds analyzed achieved . This information can be considered valuable for management purposes and will be therefore delivered to the responsible water authority (Catalan Water Agency) in order to provide them with scientific criteria to take decisions on the potential sources of risk related to WWTP's.

5. References

[1] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC.

[2] CEC 1999. Revised Proposal for a List of Priority Substances in the Context of the Water Framework Directive (COMMPS Procedure). Fraunhofer-Institut Umweltchemie und Ökotoxicologie. 98/788/3040/DEB/E1

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Acknowledgement - This work has been supported by the Catalan Water Agency and the Coordination Action (CA) Risk-based management of chemicals in a circular economy at a global scale (RISKCYCLE) [FP7, Contract Number: 226552].