

Fuzzy approach for risk assessment of brominated flame retardants in aquatic ecosystems

E. Pujolassus¹, S. Betrò¹, X. Seguí¹, A. Àgueda¹, J. Casal¹, W. Ocampo-Duque², I. Rudolph³, R. Barra³, M. Páez⁴, E. Barón⁵, G. Santín⁵, E. Eljarrat⁵, D. Barceló⁵ and R.M. Darbra¹

¹CERTEC, Dept. Chemical Engineering, Universitat Politècnica de Catalunya, ETSEIB, Diagonal 647. 08028 Barcelona, Catalonia, Spain

²Facultad de Ingeniería, Pontificia Universidad Javeriana (PUJ) Calle 18, 118-250, Cali, Colombia

³Aquatic systems research unit, Environmental Science Center EULA-Chile, University of Concepción, Concepción, Chile

⁴Dep. of Chemistry, Universidad del Valle, Cali, Colombia

⁵Dept. Environmental Chemistry, IDAEA-CSIC, Jordi Girona 18-26. 08034 Barcelona, Spain

E-mail contact: rm.darbra@upc.edu

1. Introduction

Brominated flame retardants (BFR) are pollutants that represent a threat to both human health and environment due to their industrial use, their persistence and their ability to bioaccumulate and biomagnify in food chains, especially in the aquatic one. For the last ten years contamination levels for this type of compounds have been reported for European, North American and Asian human tissue, sediments and biota samples [1-3]. However, monitoring efforts into the assessment of BFRs contamination levels in Latin America are scarce.

In this study, a model for the evaluation of the environmental risk of BFRs in the aquatic ecosystems has been developed. It has been based on a technical application of the Fuzzy Theory [4]. In particular, three interconnected Fuzzy Inference Systems (FIS) have been created through the use of the Fuzzy Toolbox in Matlab. In order to improve and make the model scientifically robust, several international experts have been questioned about different information required to build the fuzzy system. Information from 38 questionnaires have been collected and statistically treated.

The model has been tested in two case studies: Ebro River basin (Spain) and Latin America (Chile and Colombia). The data gathered for each one of the two case studies correspond to two different international projects. The first one is the EU funded AQUATERRA project (2004-2009): Integrated modelling of the river-sediment-soil-groundwater system. It provided to this study data from four samples campaigns in two Ebro tributaries in north east of the Spain, the Cinca River (2002 and 2004) [5] and the Vero River (2004 and 2005) [6].

The second project is the BROMACUA funded by the BBVA Foundation. Contamination levels, bioaccumulation and biomagnification in the aquatic trophic chain are being evaluated in two ecosystems, one from Chile (San Vicente bay and Lengua estuary) and another one from Colombia (delta-estuary of the Magdalena river).

Concentrations in biota and sediments obtained in the sample campaigns of both projects have been used directly as input for the model. In this paper, the characteristics of the developed methodology as well as the main results of the risk of BFRs in these two case studies are presented.

2. Methodology

The methodology followed for this study is based on the following steps:

- Identification of the relevant input and output factors of the system, and detection of their dependencies and relative importance. As it can be seen in Figure 1 (left), the proposed approach consists of three levels or Fuzzy Inference Systems (FIS)
- Selection of indicator variables representing each factor of the system (see Figure 1 (right))
- Establishment of ranges and linguistic descriptors for each factor (e.g. low, medium or high persistence)
- Setting up fuzzy propositions (rules) to connect the inputs of each level (antecedents) with the corresponding output (consequent)

The implementation of the proposed methodology requires information about the fuzzy sets and the inferring rules that must be established, this comes from the expert's questionnaires.

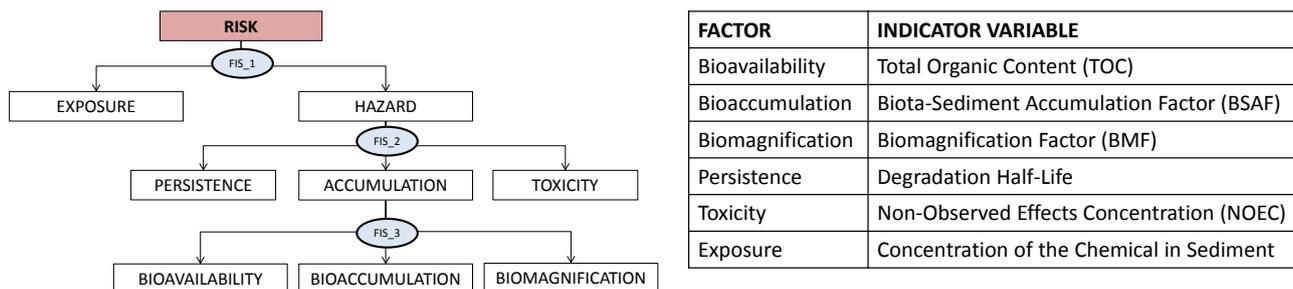


Figure 1: Left: diagram of the variables included in the proposed model; right: table of indicator variables.

3. Results

A total number of 38 experts have contributed to this study. Experts' opinions have been used to define the ranges associated to the fuzzy sets describing the different factors of the system. Concerning the variables' weight, one output from the experts is that toxicity is more important than persistence and, at the same time, the latter is more important than accumulation. As a particular example of the results obtained, the risk assessment for the Cinca River in Spain is presented in Fig 2. As it can be seen, the risk increases after the industrial site, being the effects of pollution still persistent more than 30km downstream.

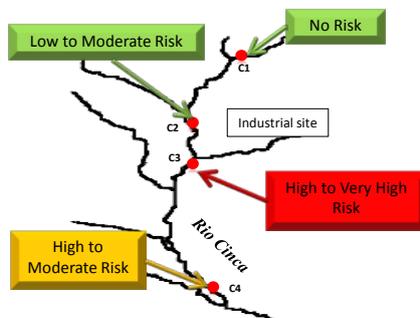


Figure 2: Results of the risk BFRs at the Cinca River

4. Conclusions

Quantitative risk assessments associated to BFRs have been performed in several hot spots of Latin American and Spanish aquatic ecosystems. For this purpose, a methodology based on fuzzy logic has been used, providing results that are very useful in the decision making processes. The applied methodology has been proved to be adequate for this type of analysis, although, a significant effort had to be made in order to gather all the information required. The sites in Spain present higher risk that the ones analyzed in Latin America. This model can be applicable to different ecosystems and to other POP contaminants, besides BFRs.

5. References

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