MethodsX 3 (2016) 459–476

Contents lists available at ScienceDirect

MethodsX

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

Inclusion of emerging organic contaminants in groundwater monitoring plans

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A B S T R A C T

Groundwater is essential for human life and its protection is a goal for the European policies. All the anthropogenic activities could impact on water quality.

- Conventional pollutants and more than 700 emerging pollutants, resulting from point and diffuse source contamination, threat the aquatic ecosystem.
- Policy-makers and scientists will have to cooperate to create an initial groundwater emerging pollutant priority list, to answer at consumer demands for safety and to the lack of conceptual models for emerging pollutants in groundwater.
- Among the emerging contaminants and pollutants this paper focuses on organic wastewater contaminants (OWCs) mainly released into the environment by domestic households, industry, hospitals and agriculture. This paper starts from the current regulatory framework and from the literature overview to explain how the missing conceptual model for OWCs could be developed.
- A full understanding of the mechanisms leading to the contamination and the evidence of the contamination must be the foundation of the conceptual model. In this paper carbamazepine, galaxolide and sulfamethozale, between the OWCs, are proposed as "environmental tracers" to identify sources and pathways ofcontamination/pollution.

A R T I C L E I N F O

Method name: Inclusion of emerging organic contaminants in groundwater monitoring plans

Keywords: Groundwater, Pollution, Monitoring, Priority list, Emerging pollutants, Environmental tracers, Organic wastewater contaminants

Article history: Available online 25 May 2016

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http://dx.doi.org/10.1016/j.mex.2016.05.008

Introduction

Following the prevision of the United Nations by 2050 the world's population will reach 9.6 billion [107]. This population rise will be supported by an increase of the agricultural and industrial activities that will produce a greater water stress due to an increased demand for freshwater and to an increased generation of wastewater. Groundwater pollution by anthropogenic activities is a threat to human and ecosystem health and wellbeing, in fact groundwater is a source of fresh water for human consumption, irrigation and ecosystem needs, and its protection is a key environmental objective. In addition to the known pollutants, new substances with no clear immediate effects are emerging [37]. It is important to be aware of these new pollutants in monitoring programmes and in developing groundwater protection policies, because their effects can affect coming generations [96]. Until now, water quality legislation has not systematically dealt with emerging pollutants in groundwater for several reasons, including a lack of knowledge of contaminant sources and pathways, properties and effects of substances and analytical detection techniques. In the last years the advances in analytical chemistry allowed the detection of chemicals in water bodies at very low concentrations [69]. The use of high resolution mass spectrometers like the QTOF technology, coupled with multiresidues methods help to perform target and non-target screening followed by quantitative determination [85]. Emerging contaminants could be natural or synthetic substances that are not commonly monitored in the environment [102]. They can encompass chemicals not previously included in national or international monitoring programmes but continuously introduced into the environment by anthropogenic activities [90], and well-known contaminants that have gained interest with the revelation of new aspects of their occurrence, fate or effects [22]. Accordingly to Geissen et al. [42] more than 700 emerging pollutants, their metabolites and transformation products are listed as present in the European aquatic environment (www.norman-network.net). The fact that emerging pollutants are present in water bodies as complex mixture has to be considered. The ubiquity and the high number of potentially toxic compounds could lead to synergistic effects [85].

Contaminants, pollutants, indicators and environmental tracers could reach groundwater bodies. Contaminants are substances present in places where they should not be, or at concentrations above background [15]. Pollutants are contaminants that result in, or can result in, adverse biological effects [15]. Indicators are measured or observed substance properties, or values derived from these, which describe the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value [78]. Environmental tracers are detectable material accidentally present or added in small quantities to flowing surface water or groundwater, depicting the pathways or serving in the measurement of flow characteristics.

The identification of sources and pathways of contamination/pollution and the prediction of their impacts on groundwater quality are possible combining indicators and tracers. This is useful for the development or the improvement of new conceptual models. Conceptual models intend to describe and optionally quantify systems, processes and their interactions [36] and are developed to different incremental degrees of complexity. Emerging contaminants and pollutants include any compound for which a conceptual model is missing. A way to develop management strategies without a conceptual model for the emerging pollutants is to consider their sources of contamination. The presence of emerging pollutant in water bodies traditionally could be the result of point (mainly urban and industry) or diffuse (agriculture) pollution. Non-point source pollution usually regards large areas and may cause larger impact on groundwater quality than point-source [52]

In this paper, Organic Wastewater Contaminants (OWCs, Table 1) are used as an example. OWCs can include pharmaceutical products, industrial compounds, pesticides and other emerging pollutants (personal care, life style and cosmetics products etc.). In terms of chemical use and emissions, pesticide use and agriculture sector are one of the main responsible of the diffuse pollution [42]. Anyway the contamination profile is dominated by industrial compounds, followed by pesticides and pharmaceuticals [52]. OWCs are primarily released into the environment by domestic households, industry, hospitals and agriculture (Fig. 1), while secondary contamination of soils and vegetation can occur through utilisation of biosolids, sludge and manure in agriculture [99]. Other specific sources of OWCs in groundwater are sewer leaching and urban storm water recharge, both of which directly affect urban groundwater. Moreover, these contaminants are present in the effluents from wastewater