The Role of Emerging Environmental Contaminants in Future Impact Assessments of Wastewater Treatment Plants in Europe

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Summary

Pharmaceuticals and personal care products represent the biggest single group of emerging environmental contaminants. Owing to growing awareness about their potential environmental impacts and vastly improved analytical procedure, they have been increasingly detected in recent times in wastewater effluent, surface waters and even portable water albeit in much lower quantities. This review paper explores the likely role of emerging environmental contaminants in the future environmental impact assessment of wastewater treatment plants in Europe. Relevant empirical research data from two European countries (Finland and Germany) examined show that there is an urgent need to take into account the environmental impacts of trace emerging contaminants in future EIA process especially with respect to water quality, ecological health and regulatory framework.

Keywords: Impact assessment, Trace organics, Emerging contaminants, Ecotoxicology

Introduction

The increased production and use of synthetic chemicals for various domestic, medical and agricultural purposes has recently been a point of interest for environmental scientists and researchers. Many of these chemical compounds produced nowadays and at an ever increasing quantities are widely used in households, agriculture and healthcare facilities. While it offers several benefits such as significant increase in agricultural output and marked improvement in human and animal health. However, their quantity, complexity and fate in the ambient environment is fast becoming a source of environmental concern.

This group of persistent organic compounds found in pharmaceuticals, pesticides and personal care products are collectively referred to as "emerging environmental contaminants". They have been increasingly detected in recent times in various environmental matrices although in trace quantities usually within micro and nano range (Chevre et al., 2008, Oulton et al., 2010, Vieno et al., 2007, Diaz-Cruz et al., 2009) partly due to advanced analytical procedures and growing awareness about their potential impacts. In fact, the presence or absence of trace contaminants in any environmental receptor is widely believed to be a function of the analytical process. Therefore in assessing the fate and impacts of micropollutants, it is pertinent to understand their sources and final sinks as well as their fate in the environment.

Sources and impacts of micropollutants

Micropollutants or trace organics emanates and are concentrated in the resulting wastewater flow diverse sources. They are produced and released into the environment mainly as a result of domestic, industrial and agricultural activities (Bhandari et al., 2009). The sources, fate and final sinks of micropollutants is very vital to the understanding of the complex interaction that occur from the source where they emanates to the various environmental receptors that act as their sinks as shown in Fig. 1.

In assessing the roles of micropollutants in environmental impact assessment process, a knowledge of EIA process with respect to water quality impacts of wastewater treatment is highly indispensable. The fate of micropollutants during wastewater treatment to a large extent determines their residual content in the discharge effluent and any subsequent risk assessment. Therefore, it is easy to understand why wastewater treatment plants are very important in the control of micropollutants as their degradation, transformation as well as information on their metabolites during wastewater treatment process are directly related to the efficiency of the treatment technologies (Ternes, 2004). In addition, the intrinsic properties of the contaminants is also an important factor that affects their degree of removal during the wastewater treatment. Vieno (2007) and more recently Gerrity & Snyder (2011) published some important physicochemical properties of selected trace contaminants.

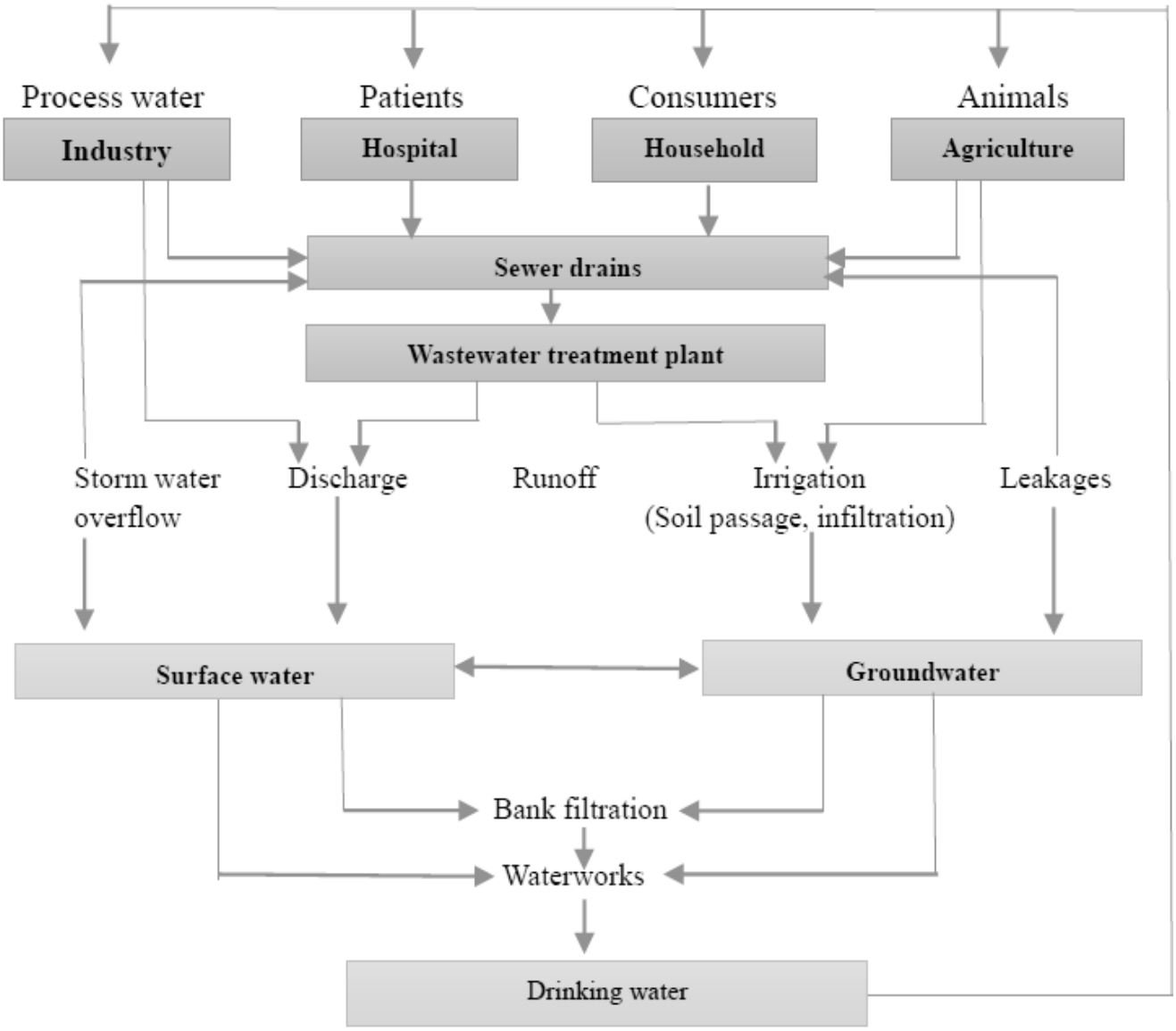

Fig. 1. Sources and sinks of micropollutants

Rys. 1. Źródła i ujścia mikrozanieczyszczeń

Fate of micropollutants in wastewater treatment process

Having established wastewater treatment as an important entry point for micropollutants into the ambient environment through effluent discharge, it is also quite logical to have an understanding of the fate of these contaminants during wastewater treatment process. Vieno et al. (2007) in their study of the fate of pharmaceuticals in twelve Finnish wastewater treatment plants identified degradation and sorption as the main elimination routes for pharmaceuticals during the treatment process.

While the primary target of wastewater treatment process is the removal of dissolved organics, heavy metals, nutrients and pathogenic organisms, substantial amount of micropollutants are also removed as the wastewater passes through the various unit operations.

In addition, operational parameters such as the hydraulic retention time (HRT), solids retention time (SRT), temperature as well as the specific method of treatment adopted by the WWTP have been reported to influence the removal rate of certain pharmaceuticals (Jelic at al, 2012).

Environmental impact assessment of WWTPs

Environmental impact assessment has evolved over the years to become an important environmental management tool. An impact assessment is required to identify and collect information on the environmental aspects of a project and such information are taken into account by competent authorities in granting approval for the project (Glasson et al., 2005).

A typical EIA process starts with the identification of a project and continues until the final permit is granted followed by continued monitoring and

evaluation of agreed mitigation measures. The specific aspects of EIA that is important as far as discussion of micropollutants is concerned especially their water quality impacts are the scoping, baseline studies and monitoring phases. The EIA process and its practical applications are discussed in details elsewhere.

Existing regulatory framework in Europe

Environmental regulations in European Union consists of directives which are implemented by EU member states. Such regulations which covers a wide range of environmental matrices such as surface water, groundwater, soil, sediments, drinking water, mineral water, etc. are geared towards protection of the environment from contamination and to safeguard public health.

The impact assessment directive along with other water quality directives are very important with respect to micropollutants and their water quality impacts. Environmental quality objectives and standards are developed for different water quality criteria. In addition, discharge limits are set for identified parameters in wastewater effluents for point sources of contamination (Morris et al., 2009).

In assessing the impacts of wastewater treatment plants according to the current EIA directive, the impacts of micropollutants are not fully considered. There are no emission discharge limits for micropollutants in the present wastewater directive and wastewater treatment plants are not obliged to ensure specific removal efficiency of micropollutants. In other words, as far as Europe is concerned, there is currently no regulatory framework for micropollutants. However, few micropollutants are currently being considered by the European Commission as candidates for the priority pollutants' list.

Review of literature data

This study did not involve any experiments on humans or animals or any laboratory analysis for the micropollutants discussed in this paper and was entirely based on published data from literature. The data presented here which are published elsewhere are by no means exhaustive and readers are referred to other publications for a more comprehensive data on trace organic contaminants in European drinking water, surface water, wastewater, and sewage sludge.

Numerical data on wastewater trace contaminants in the countries studied are available in some scientific literature. This paper reviews relevant data from the target countries an example of which is presented in Tab. 1-2. While it is quite important to point out that the experiments were carried out independently and therefore might be difficult to compare directly as some of the data are site-specific.

Micropollutants in Finnish wastewaters

Vieno carried out a survey on trace organic contaminants in twelve wastewater treatment plants in Finland. The levels of micropollutants in Finnish wastewaters from the study are quite comparable to the ones reported elsewhere. The removal efficiency

Table 1. Elimination of selected pharmaceuticals in Finnish WWTPs

Tabela 1. Usuwanie wybranych środków farmaceutycznych w fińskich oczyszczalniach ścieków

Compound	Sample size	Elimination % *)
Ciprofloxacin	21	84
Norfloxacin	21	81
Ofloxacin	21	92
Carbamazepine	21	-121
Diclofenac	13	17
Ibuprofen	13	95
Ketoprofen	13	82
Naproxen	13	85
Acebutolol	21	47
Atenolol	21	51
Metoprolol	21	17
Sotalol	21	65
Bezafibrate	13	58

*) *Mean values for all WWTPs*

clearly shows that the existing treatment methods cannot efficiently remove all micropollutants from treated wastewater. This is particularly true for antiphlogistic (*diclofenac*), betablockers (*acebutolol, metoprolol*) and lipid regulator (*benzafibrate*) as they are all partially removed during the treatment process.

Micropollutants in German wastewaters

Ternes (1998) in his study on the occurrence of pharmaceuticals in sewage treatment plants and surface waters (*streams & rivers*) in Germany published extensive data on selected trace organics. The results from the study which are comparable to those reported elsewhere, clearly shows that trace organics were detected in the wastewater effluents and were not completely removed by the treatment process. This is particularly true for antiphlogistic (*phenazone, dimethylamino-phenazone*), as well as antiepileptic drug (*carbamazepine*) which exhibited low removal rate.

Future regulatory framework in Europe

It is quite obvious that in the light of recent research findings on the presence of micropollutants in wastewater effluent, surface water, groundwater, and even sometimes in portable water, future regulatory framework must take this into account. Research in the field wastewater and sludge management should also focus on technologies that offers a higher removal efficiency at a reasonable cost.

In conducting impact assessment in future for wastewater treatment plants, emphasis should also be placed on the likely impacts of micropollutants on environmental receptors (*surface water, groundwater, soil, sediment etc.*) during the scoping and baseline studies' phase of impact assessment with respect to the quality of the treatment plant's effluent. Gerrity & Snyder have also suggested that consideration should be given to trace organic contaminants in the design of wastewater treatment plants because of the interrelatedness of wastewater discharge and drinking water sources most especially in the case of indirect portable water reuse.

It is also expected that as more is known about the long term effects of these trace contaminants, environmental quality standards will be developed for them and an acceptable emission limits will be set. This is still a long way off as most scientific studies up till date do not indicate any acute toxicity to humans and aquatic organisms.

A more rigorous risk-assessment may be needed for instance in the case of a wastewater treatment plant cited close to a medical facility or meant for the treatment of raw sewage from a large hospital or medical facility. In addition, due to the limited knowledge of the long term impacts of micropollutants, a more pragmatic application of the precautionary principle of EIA is needed in future assessments of wastewater treatment plants.

Conclusion

Numerous research works conducted in the past decade have confirmed the presence of pharmaceuticals and personal care products in many environmental matrices. Municipal wastewater treatment plants represent the biggest primary source of these contaminants and while studies have shown that the conventional wastewater treatment methods do not completely eliminate these contaminants, there is no scientific evidence so far that suggests any acute toxicity from trace organic contaminants. However, their long-term impacts both on humans and aquatic organisms remains largely unknown.

Wastewater treatment plants represent the biggest single point source of trace environmental contamination as Numerical data from recent studies have shown that they are not fully eliminated during the wastewater treatment as they have been detected in WWTPs effluents. Existing EIA regulation in Europe presently do not take into account the impacts trace environmental contamination as the WWTP's operators are not obliged to ensure their full elimination during the wastewater treatment process.

It is envisaged that in conducting the impact assessments of new wastewater treatments plants as well as the upgrading of old treatment plants in the future, point source contamination from trace organics and their potential impacts will be given a serious consideration. There is also a need for a review of the existing regulatory framework with respect to the prevention and control of trace environmental pollution until there is a clear understanding of their long-term impacts.

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Znaczenie niebezpiecznych dla środowiska zanieczyszczeń na przyszłą ocenę oddziaływania oczyszczalni ścieków w Europie

Środki farmaceutyczne i produkty do pielęgnacji stanowią największą grupę zanieczyszczeń środowiska. Dzięki rosnącej świadomości o ich potencjalnym wpływie na środowisko oraz znacznie ulepszonym procedurom analitycznym stały się one w ostatnich czasach wykrywalne w wodach odpływowych, wodach powierzchniowych jak również w wodzie pitnej, lecz w znacznie mniejszych ilościach. Referat poświęcony jest prawdopodobnej roli powstających zanieczyszczeń środowiska w przyszłości pod kątem oczyszczalni ścieków w Europie. Zbadano dane empiryczne z dwóch krajów europejskich (Finlandii i Niemiec) i pokazano, że istnieje pilna potrzeba wzięcia pod uwagę wpływu na środowisko zanieczyszczeń w odniesieniu do jakości wody, ekologicznego zdrowia oraz struktur ustawodawczych.

Słowa kluczowe: ocena wpływu, śladowe składniki organiczne, zanieczyszczenia niebezpieczne, ekotoksykologia