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Ibuprofen removal from a medicinal effluent: A review on the various techniques for medicinal effluents treatment

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HIGHLIGHTS

- There is IBU as a pharmaceutical sample in the medicinal effluents.
- It can be fed to the natural environment through pharmaceutical industry wastes.
- IBU in the nature can have traumatic effects on living organisms.
- Several techniques for removing/reducing IBU from the environment were studied.

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ABSTRACT

Ibuprofen (IBU) is a non-steroidal anti-inflammatory drug that is used for medical treatment in human and animals. Since IBU is not entirely absorbed in the body, a portion of it is obviously defecated and entered into the aqueous environment. Besides, IBU can be fed to the natural environment through pharmaceutical industry wastes. The existence of IBU in the nature can have traumatic effects on living organisms. In fact, it can widely endanger human life and the health of the natural habitat. Therefore, researchers have intended to discover methods to remove IBU from the environment or reduce its existence down to minimum. Finally they applied several different methods for doing. So, in this paper, we examine quite a few procedures to discover the advantages and disadvantages of each.

Contents

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1. Introduction

Several types of pharmaceuticals and personal care products exist in the sewer systems in addition to surface and underground streams (Verlicchi et al., 2010). The concentrations of these pollutants are normally in the range of ng/L or μg/L (Suárez et al., 2012). In the last two decades, the existence of these pharmaceuticals in the aqua environment has turned into a concern (Daneshvar et al., 2010) and the amount of some pharmaceutical products exceeds 1000 μg/L in the wastewater of pharmaceutical companies (Kumar and Xagoraraki, 2010).

The pharmaceuticals that human consumes are not thoroughly absorbed by the body, as a result, they enter the aqua-environment in the form of wastewater, many of these are not bio-degradable and are not completely removed at wastewater treatment facilities, hence they probably exist in drinking water (Cabrita et al., 2010). One of the negative effects of the presence of pharmaceuticals in the nature is that the fish develop both male and female features (Sanchez et al., 2011) Besides they damage digestive glands and the health of male reproductive muscles (Gonzalez-Rey and Bebianno, 2012) In addition, they change the DNA of clams (Milan et al., 2013).

PHACs are a type of pharmaceutical that are used for medical treatment in human and animals but they have not been considered as pollutants until recently, although their existence in the aqueous environments and running water has lately turned into a great concern (Buser et al., 1999; Heberer, 2002; Andreozzi et al., 2003).

The toxic effects of PHACs on the fish, crustaceans, coral and bacteria, even in concentrations less than 1 mg/L, have been reported (Ferrari et al., 2003; Nassef et al., 2010; Lee et al., 2011; Zhang et al., 2012).

Non-steroidal Anti-Inflammatory drugs (NSAIDs) are a type of pain reliever used worldwide (Takagi et al., 2006) besides the annual production of NSAIDs can be up to tons (Cleuvers, 2004).

NSAIDs exist in the human and animal waste, and so in wastewater, in addition to unused drugs (Bound and Voulvoulis, 2004) besides in the last decade, their remains in water are on the rise (Kolpin et al., 2002; Boyd et al., 2003; Kolpin et al., 2004). Recently, NSAIDs can be found in μg/L and ng/L concentrations in the natural environment (Cleuvers, 2004; Kosjek et al., 2005) moreover, they have toxic effects on the bacteria (Daughton and Ternes, 1999; Ferrer et al., 2001).

Ibuprofen (IBU) is considered as an acidic drug and is classified in NSAIDs (Larsson et al., 2009) and its chemical formula is 2-[4-(2-methylpropyl) phenyl] propanoic acid (Fig. 1) which is a popular pain reliever in many countries like Finland, Spain and Sweden (Ternes et al., 2004). IBU has second rank in the drugs production between the other ones [15000 tones/yr Myers, 2007]. The structure and properties of IBU is shown in Fig. 1 and Table 1 (Baccar et al., 2012).

However IBU is used for the therapy of rheumatoid arthritis and osteoarthritis but, it can also be applied for the alleviation of mild to moderate pain, inflammation and fever. 1000 tones/yr of IBU is consumed in some countries such as UK and Germany (USGS U.S. Geological Survey: FY2003 MT Annual Report). Furthermore, concentration of IBU above 10 $\mu g\ L^{-1}$ is detected in the Europe (Vieno et al., 2005), Japan (Nakada et al., 2006) and US (Brun et al., 2006) rivers water. The presence of these pharmaceuticals in the environment endangers the human health (Ziylan and Ince, 2011). Table 2 shows IBU consumption rate in some countries.

IBU has been identified to exist in sewer wastewater in considerable amounts, up to 10 ng/L and 169 μg/L (Santos et al., 2007; Miège et al., 2008).

Besides, in England and Wales, IBU exists in surface and drinking water in the range of 0.025 to 0.475 mg/L (Boxall et al., 2014).

Some of the risks caused by IBU in the environment are listed as follows: combination of IBU with other drugs may stop cell reproduction in human embryo (Estevez et al., 2014) Moreover, some reports indicate that contacts with IBU can negatively affect reproduction of aquatic vertebrates (Collado et al., 2012) furthermore, IBU has toxic effects on the algae (Cleuvers, 2003). Unfortunately, sewage treatment plants (STPs) are not really effective in treatment of such wastewater since they are not designed to remove pharmaceuticals (Carballa et al., 2007).

There are several methods for the removal of IBU such as absorption, adsorption, filtration, advanced oxidation, biological treatment etc. In this study we analyze many methods and their advantages and disadvantages so that we can choose the most appropriate method which can help with designing wastewater treatment systems.

2. Methods

2.1. Biological works

IBU is biodegradable and in case of using active sludge, IBU not only will not be absorbed by the sludge, but it will also be degraded by that, which is an important technique to prevent the accumulation of IBU (Ternes et al., 2004). The biodegradation rate constant (K_{biol}) indicates the rate of IBU biodegradation and is classified as follows:

1 — If $K_{biol} > 5\ L/g_{ss}$, the biodegradation rate is very high
2 — If $1 < K_{biol} < 5$, the biodegradation rate is high
3 — If $0.5 < K_{biol} < 1$, IBU degradation is moderately
4 — If $K_{biol} < 0.5$, IBU degradation is barely.

IBU is highly degradable and in many researches is reported to have a K_{biol} of 21–35 and a biodegradation percentage of up to 99% in a temperature range between 16 and 26 °C (Joss et al., 2006; Suarez et al., 2010).

The biodegradation of IBU can be affected by the operational conditions at the wastewater treatment plant (WWTP) such as:

— the sludge retention time (SRT)
— the system's being aerobic or anaerobic