Revista de Gestão Costeira Integrada - Journal of Integrated Coastal Zone Management

E-ISSN: 1646-8872

rgci.editor@gmail.com

Associação Portuguesa dos Recursos Hídricos

Cotrim, Gabriel; Fahning, Cristiane S.; da Rocha, Gisele O.; Hatje, Vanessa

Endocrine disruptors: strategies for determination and occurrence in marine environments

Revista de Gestão Costeira Integrada - Journal of Integrated Coastal Zone Management, vol. 16, núm. 3, septiembre, 2016, pp. 299-326

Associação Portuguesa dos Recursos Hídricos

Lisboa, Portugal

Journal of Integrated Coastal Zone Management
Revista de Gestão Costeira Integrada

http://www.aprh.pt/rgci/pdf/rgci-669_Cotrim.pdf | DOI:10.5894/rgci669

Endocrine disruptors: strategies for determination and occurrence in marine environments *

Gabriel Cotrim[a, @], Cristiane S. Fahning[b], Gisele O. da Rocha[a,b,c,d], Vanessa Hatje[a,b,c,d]

ABSTRACT

Research examining the occurrence of endocrine disruptors (ED) in the marine environment has substantially increased. These contaminants have been observed in several environmental compartments and matrices, and they may cause severe adverse effects in humans and ecosystems. In this study more than 240 papers investigating the analytical developments regarding the analysis on ED in environmental matrices and the occurrence of these compounds were critically evaluated. Modern sample preparation procedures aiming the use of minimal sample manipulation, minimal amount of solvents and energy according to the Green Chemistry principles are widely used. The ED in marine environments occurs in trace concentrations and their quantification still represents a challenge. The effects of these contaminants in marine ecosystems are poorly understood. However, due to their large use, it is predicted that new analytical developments to deal with ED contamination will promote a large increase in the number of scientific publications in the near future. Regulations and mitigation measures for the presence of these contaminants in the environment are still scarce and need to be quickly implemented to reduce potential future adverse effects on ecosystem services of coastal environments.

Keywords: Emerging contaminants; Endocrine disrupters; Contamination; Sample preparation; Environmental analysis

[@] Corresponding author: gabriel.cotrim.souza@gmail.com
[a] Centro Interdisciplinar em Energia e Ambiente – CIEnAm, UFBA, 40170-290, Salvador-BA, Brazil
[b] Instituto de Química, Universidade Federal da Bahia, 40170290, Salvador-BA, Brazil
[c] INCT de Energia e Ambiente, UFBA, 40170-290, Salvador-BA, Brazil
[d] INCT de Ambientes Marinhos Tropicais, UFBA, 40170-290, Salvador-BA, Brazil

* *Submission: 29 JAN 2016; Peer review: 11 MAR 2016; Revised: 16 JUL 2016; Accepted: 10 AUG 2016; Available on-line: 26 SEP 2016*

RESUMO

Pesquisas que examinam a ocorrência de interferentes endócrinos (IE) no ambiente marinho têm aumentado substancialmente. Estes contaminantes podem causar efeitos adversos em seres humanos e nos ecossistemas e têm sido observados em vários compartimentos e matrizes ambientais. Neste estudo, mais de 240 trabalhos que relataram o desenvolvimento analítico de IE em diversas matrizes e a ocorrência destes compostos no ambiente marinho foram criticamente avaliados. Procedimentos de preparo de amostra, visando a mínima manipulação, a mínima quantidade de solventes e energia de acordo com os princípios de Química Verde estão sendo amplamente utilizados. Os IE em ambientes marinhos ocorrem em concentrações traço e sua quantificação ainda representa um grande desafio. Como resultado, os efeitos desses contaminantes em ecossistemas marinhos ainda são mal compreendidos. No entanto, devido ao amplo uso destes compostos é previsto que novos desenvolvimentos analíticos para a determinação de IE irão promover um grande aumento no número de publicações científicas no futuro. Regulações e medidas mitigadoras para a ocorrência destes contaminantes ainda são bastante reduzida e precisam ser rapidamente implementadas para reduzir os futuros potenciais efeitos adversos nos serviços ecossistêmicos dos ecossistemas costeiros.

1. Introduction

The lifestyle adopted by humans in the modern society has favored the occurrence of continuous physical, chemical and biological changes in the environment. The contamination of water bodies due to the presence of domestic and industrial wastewater, water runoff and agricultural activities stand out among the major human impacts on the coastal zones. Thousands of substances (e.g., pharmaceuticals, personal care products, surfactants, nanomaterials, metals, phthalates, and hydrocarbons, among others), which have allegedly subsidized the improvement of the quality of human life and ensured the growth of activities such as aquaculture and agriculture, are produced and released in the environment.

The development of new analytical techniques of separation, identification and quantification of substances (e.g., high performance liquid chromatography (HPLC) coupled to mass spectroscopy, among others) has allowed the identification of a large number of compounds in samples of water, air, sediments and biological tissues so far unknown (Locatelli *et al*., 2016; Casatta *et al*., 2015; Emnet *et al*., 2015; Benjamin *et al*., 2015; Cai *et al*., 2012a, 2012b; Bartolomé *et al*. 2010; Richardson & Ternes, 2011; Rubio & Pérez-Bendito, 2009). The sensitivity of many analytical techniques has improved, reducing the limits of detection from parts per million to parts per trillion and, in some cases, to parts per quadrillion (Huerta *et al*., 2015; Bhandari *et al*., 2009). As a result, the potential for studying traces of contaminants in the environment, especially in complex matrices, such as seawater, has also increased. The substantial improvement in analytical sensitivity enabled the detection of a series of compounds known, generically, as emerging contaminants (EC). Emerging contaminants can be defined as a class of natural or synthetic chemicals, or any group of microorganisms that are not naturally found in the environment (Richardson & Ternes, 2011; EPA, 1997). In general, the ECs are present unknown toxicity, large industrial production and they are ubiquitous in the environment (Birch *et al*., 2015; De la Cruz *et al*., 2012; Deblonde *et al*., 2011; Bhandari *et al*., 2009). ECs are not necessarily new compounds, they are input in environment for several years. However, the identification and quantification of these compounds was only possible after the development of new analytical techniques that allows detection of trace and ultratrace concentrations.

Among the emerging contaminants, a number of compounds have been receiving special attention from the scientific community, due to their potential capacity of interfering with the functioning of the endocrine system of organisms. The literature uses several names for these compounds: xenobiotics, pseudo-estrogens, pseudo-androgens, endocrine disruptors (ED), and interfering endocrines (Lisboa *et al*., 2013; Menzies *et al*., 2013; Grassi *et al*., 2013; Ghiselli & Jardim, 2007; Lathers, 2002; Kardinaal *et al*., 1997). Many of them are not degraded or broken down by any biochemical and/or natural photochemical pathways and may also undergo bioaccumulation and/or biomagnification (Colin *et al*., 2016). In this paper, this group of compounds will be referred to as endocrine disruptors.

Several contaminants, both organics and inorganics, have their ecotoxicological profiles and modes of action well determined. As a result decision makers can plan accordingly in order to regulate their use, minimize adverse effects for the provision of ecosystems services or even ban some compounds. The literature has already showed examples of the positive effect of such regulations in contamination levels in the environment. For instance, Sutton *et al*. (2014) observed declines in Polybrominated compounds in sediment and biota of San Francisco Bay. However, for most of the EDs dealt in this manuscript it still is necessary a better knowledge and understanding of the environmental cycles and toxicity in order to subsidize the development of regulations and management practices.

2. Importance and relevance of endocrine disruptors

The United States Environmental Protection Agency (U.S. EPA) defines endocrine disruptors as exogenous agents that interfere with the synthesis, secretion, transport, binding, action or elimination of hormones that are responsible for reproduction, development, behavior and maintenance of body homeostasis (EPA, 1997). Although there are multiple mechanisms of action of endocrine disruptors in biota, the vast majority of the observed disturbances are attributed to the functioning of the gonads, responsible for secondary sexual characteristics, and the development and functioning of sexual organs (Gu *et al*., 2016; Gavrilescu *et al*., 2015; Christiansen *et al*., 2012; Boisen *et al*., 2005; Lintelmann *et al*., 2003; Toppari *et al*., 2001; Paulozzi, 1999).

In humans, EDs may cause serious problems such as precocious puberty (Buttke *et al*., 2012), testicular (Huyghe *et al*., 2003), breast (Lee & Choi, 2013; Macon & Fentton, 2013), and prostate cancers (Bedia *et al*., 2015; Prins, 2008), gynecomastia (irregular breast growing in men) (Vandenberg *et al*., 2013), tract disorders in the male reproductive system such as cryptorchidism (irregular descent of the testicles from the abdominal cavity) (Main *et al*., 2010; Toppari *et al*., 2001), hypospadias (congenital malformation of the urinary meatus) (Thorup *et al*., 2014; Main *et al*., 2010; Boisen *et al*., 2005; Toppari *et al*., 2001; Paulozzi, 1999) low count and poor quality semen (Paoli *et al*., 2015; Jouannet *et al*., 2001). It is estimated that more than 87,000 commercialized chemicals need to be tested in order to determine their potential influence on the endocrine system of humans and biota (EPA, 1997).

It has been known that EDs can be either natural and/or synthetic compounds, originated through domestic and industrial uses (Gravilescu *et al*., 2015; Nurulnadia *et al*., 2014; Diamanti-Kandarakis *et al*., 2009; Pojana *et al*., 2004). Natural ED compounds of known effect include steroidal hormones such as estrogen, progesterone and testosterone, produced by both humans and animals. In addition, there are also the phytosterols, which are natural substances present in several plants that also possess hormonal activity. In turn, synthetic compounds include artificial hormones (contraceptives or additives used in animal food) as well as the xenosteroids, substances produced for use in the industry, agriculture and in the manufacture of several products (Li *et al*., 2014; Kinani *et al*., 2008; Ghiselli & Jardim, 2007; Birkett & Lester, 2003).

The most commonly known or classified as ED xenosteroids are the alkylphenols polyethoxylated (APEOs), organotin compounds, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phthalates, polybrominated flame retardants (PBFRs), dioxins, furans, pesticides, and pharmaceutical and personal care products (PPCPs), among others (Richardson & Ternes, 2014; Tan *et al*., 2007b; Lintelmann *et al*., 2003). The EDs can be grouped according to their chemical characteristics and utilization (Table 1).

Phytosterols are substances with estrogenic and androgenic activities (Hwang *et al*., 2006) found in plants such as soybean, wheat, rice, carrots, beans, potatoes, cherries and apples (Richardson & Ternes, 2014; Richardson, 2002). The main representatives of this class of EDs are isoflavones (genistein, daidzein, biochanin A, formononetin, equol, and demetilangolensine, among others), lignans (enterodiol, enterolactone, secoisolariciresinol, and metairesinol, among others), and coumestans (coumestrol) (Clapauch *et al*., 2002). Although the capacity of the endocrine interference of phytosterols is low, between one and two orders of magnitude smaller than estradiol (Bovee *et al*., 2004), some studies have reported the presence of these compounds in water bodies at levels that may cause endocrine disruption (Ribeiro *et al*., 2009; Kuster *et al*., 2009).

Pesticides belong to a class of EDs with a several representatives. Although the use of various pesticides has been prohibited in different countries, residues of these compounds are still present in the environment, as in the case of DDT and its metabolites. This reflects the high persistence and lipophilic properties of these substances (Garcia-Jares *et al*., 2009). The main compounds used as pesticides that can behave as EDs are DDT, DDT metabolites (i.e., DDE and DDD), methoxychlor, chlorinated cyclodiene, vinclozolin, linuron and diuron, among others (Mnif *et al*., 2011; Čeh & Majdič, 2010; Lintelmann *et al*., 2003). Each of these compounds has distinct effects on the endocrine systems of organisms. For instance, the herbicide diuron is capable of inhibiting the androgens (Thibaut & Porte, 2004) while the DDT metabolites mimic the action of estrogens (Bulayeva & Watson, 2004). However the possibilities and pathways of pesticides may cause disturbance in endocrine systems as well as their endpoints in individuals still is not well understood (Ventura *et al*., 2016; Monteagudo *et al*., 2016; Marx-Stoelting *et al*., 2014).

PAHs are generated in the processes of incomplete combustion or pyrolysis of organic matter (e.g., coal, oil, gas and wood) and traditionally have been used as tracers of burning fuels (Santos *et al*., 2016; Sun *et al*., 2013; Da Rocha, *et al*., 2009) and oil refineries (Bayat *et al*., 2015; Zrafi-nouira *et al*., 2010). Antiestrogenic effects of PAHs have been reported in the literature for mollusks from contaminated areas (Gagné *et al*., 2002). Weiss *et al*. (2009) suggested that the PAHs contribute to the anti-androgenic activity of sediments in rivers.

Another group of EDs that has received attention is the PCBs, which are compounds resulted from the addition

Table 1. Main classes of endocrine disruptors and use.

Group	*Main Species*	*Application and/or source*
Estrogen hormones[a,b]	Estrone (E1) 17β-estradiol (E2) Estriol (E3)	Natural estrogens (human or animal production)
	17α-ethynylestradiol (EE2)	Synthetic estrogen (contraceptives)
Phthalates[b,c]	Dimethyl phtalate (DMP), Diethyl phthalate (DEP), Di-n-buthyl phthalate (DnBP), Diisobuthyl phthalate (DiBP), Di(2-ethylhexyl) phthalate (DEHP) Di-n-octhyl phthalate (DnOP)	Plasticizers in polymers. Additives in pesticides, paints, cosmetics, floor coverings, ceilings, or insulators in electrical devices, among others
Alkylphenols (APs)[b]	APEO 4-n-nonylphenol (4-n-NP) 4-tert-nonylphenol (4-t-NP) 4-n-octhylphenol (4-n-OP) 4-tert-octhylphenol (4-t-OP) Bisphenol A (BPA)	Detergents, paints, propellants in pesticides, personal care products, plasticizers, elastomers, polymerization of acrylic and vinyl acetate
Phytosterols (phytoestrogens and fitoandrogens)[b]	Isoflavones (Genistein) Lignans (Metairesinol)	Soybean Linseed and wheat
Pesticides[b]	dichloro-diphenyl-dichloroethane (DDD) dichloro-diphenyl-trichloroethane (DDT) dichloro-diphenyl-dichloroethene (DDE)	Insecticides. Use banned in most countries
	Methoxychlorine	Insecticide DDT substitute
	Linuron Diuron	Herbicides
PAHs[b]	Anthracene Benzo(a)pyrene Phenantrene Fluoranthene Naphthalene Pyrene	Incomplete combustion of organic matter (coal, oil, petroleum, wood) Burning of fossil fuels
PCBs[b,d]	Addition of chlorine atoms to phenylbenzene or biphenyl. Several species	Plasticizers, pesticides, disinfectants, capacitor and transformer fluid, among other
PBFRs[b,e]	Several species	For Avoiding the easy fire ignition in electrical and electronic equipment
Organotin compounds[f]	Monobutyltin Dibutyltin Tributyltin	Antifouling used on boats, buoys, refrigeration system, dock, etc.; wood preservatives; disinfectant.
Dioxins[b,g]	2,3,7,8- tetrachlorodibenzo-p-dioxin	Byproducts of reactions: Synthesis of chlorine, Production of hydrocarbons
Furans[b,g]	2,3,7,8-tetrachlorodibenzofuran	Pyrolysis and incomplete combustion of organic material in the presence of chlorine

[a]Beausse, 2004; [b]Birkett *et al*., 2003; [c]Gómez-Hens & Aguilar-Caballos, 2003; [d]Carpenter, 2006; [e]Eriksson *et al*., 2001; [f]Lintelmann *et al*., 2003; [g]Assunção & Pesquero, 1999.

of chlorine atoms to the byphenyl molecule. PCBs were used as dielectric fluids in large transformers and capacitors, plasticizers, heat fluids, hydraulic lubricants, paints, and adhesives, among other applications (Anezaki & Nakano, 2015; Liu *et al*., 2015; Pocar *et al*., 2003). Although many countries have banned the production of PCBs in the 1970s and 1980s, it is believed that about 10^8 kg of PCBs are still spread out in the environment, mainly due to their persistent characteristics (Anezaki & Nakano, 2015; Scheringer *et al*., 2009; Boyle *et al*., 1992). There are evidences that PCBs inhibit estrogen activity, effectively increasing the bioavailability of estrogen in the body (Kester *et al*., 2000) and, therefore, disturbing the functions controlled by this hormone. Together with PCBs, PBFRs are part of the halogenated organic compounds group, which are considered or accepted to be EDs. Although some studies have reported the endocrine disrupting potential of these compounds, there are no restrictions regarding their production and/or use (Richardson & Ternes, 2015; Kabir *et al*., 2015; Mankidy *et al*., 2013a; Gereckea *et al*., 2008; Trachsel, 2008; Darnerud, 2008; Vos *et al*., 2003; Legle & Brouwer, 2003). Besides those EDs already described, estrogenic hormones, alkylphenols (APs), bisphenol A (BPA) and phthalates are noteworthy for having high capacity of endocrine interference, yet they are of concern due to the large industrial production, and consumption on a global scale. Thus, these groups of substances will be discussed in more detail in this text.

2.1. Estrogenic Hormones

Estrogens are hormones that take part of a larger group of substances, the steroids. Figure 1 illustrates the structure of these substances which have an arrangement derived from the cyclepent[α]phenanthrene molecule (Moss, 1989). Estrogens are liposoluble, and this characteristic allows them to pass through the cell membranes, thus transmiting information by coupling themselves to intracellular receptors (Tata, 2005). Natural estrogens are responsible for female secondary characteristics, for the development of the male reproductive system, for processes associated with growth, metabolism, reproduction, development, besides acting in the maintenance of bones, cardiovascular and central nervous systems (Hampl *et al*., 2016; Tata, 2005; Shimada *et al*., 2001).

Estrogens have a tetracyclic structure arranged in a phenol, two cyclohexanes, and a cyclopentane condensed ring. Estrogens strutuctures are differentiated from each other by the functional groups attached to carbons C16 and C17 (Figure 1) (Moss, 1989). Estrone (E1) and estradiol present a carbonyl group and a hydroxyl group, respectively, bonded to the carbon C17 of the tetracyclic structure (Table 2).

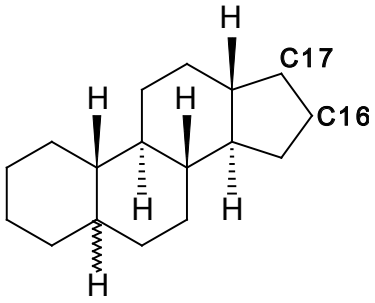


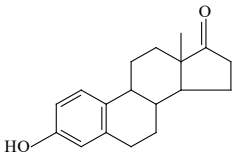
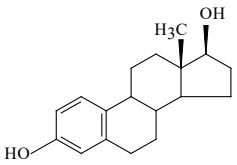
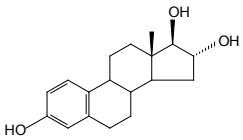
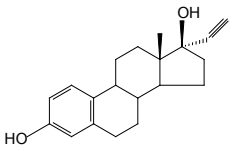
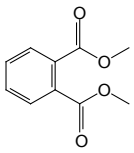
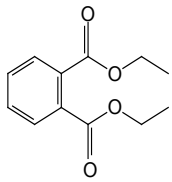
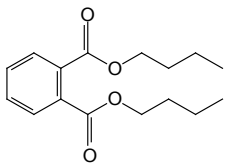
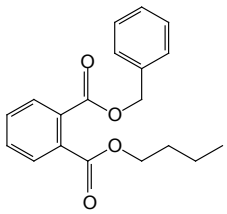
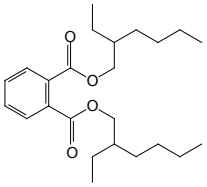
Figure 1. Cyclopent[α]phenathrene.

The three-dimensional arrangement of the hydroxyl group attached to the C17 in the estradiol originates the 17β-estradiol (E2) or the 17α-estradiol. In turn, estriol (E3) presents two hydroxyls, one is connected to the C16 and the other to the C17; while the 17α-ethynylestradiol (EE2), a synthetic estrogen used in many contraceptives and therapeutic agents, presents an ethynyl group bonded to the C17. All these estrogens have very low vapor pressures, ranging between 2.3 x 10^{-10} and 6.7 x 10^{-15} mmHg (Table 2), responsible for the low volatility of these compounds. The partition coefficients of estrogens between octanol and water (Log K_{ow}) are high, ranging between 2.81 and 4.15 (Lu, 2009).

The E1, E2 and E3 are produced mostly by ovaries and are the main natural estrogens. These estrogens, together with the synthetic hormone EE2, have been detected in domestic wastewater and efluents from wastewater treatment plants (WWTP) (Xu *et al*., 2012; Behera *et al*., 2011; Quednow & Püttmann, 2008; Tan *et* al., 2007a; Tan *et* al., 2007b) that are discharged in superficial water bodies (Lisboa *et al*., 2013; Noppe *et al*., 2007). Although most of the estrogen is excreted in their inactive form, the action of bacteria transforms them into biologically active compounds that are capable of producing adverse effects (Zheng *et al*., 2012; D'Ascenzo *et al*., 2003; Panter *et al*., 1999; Belfroid *et al*., 1999). Many studies have shown that these estrogens, in concentration as low as few ng L^{-1}, may have adverse effects on the reproductive systems of biota and humans (Luzio *et al*., 2016; Palanza *et al*., 2016; Salvador *et al*., 2007; Kuster *et al*., 2004; Grist *et al*., 2003). Human exposure to high concentrations of estrogens can cause various disorders such as gynecomastia, libido decrease, impotence, and sperm counting decrease. In addition to direct effects on the reproductive system, these estrogens and/or their metabolites may cause breast, prostate, and/or ovary cancers (Palanza *et al*., 2016; Frye *et al*., 2011; Xu *et al*., 2007; Xu *et al*., 2005).

The estrogenic hormones are compounds with the highest interference potential in the endocrine system (Ghiselli & Jardim, 2007; Aksglaede *et al*., 2006; Reis Filho *et al*., 2006. Laws *et al*., 2000). Although they have relatively short half-lives, when compared to other

Table 2. Physicochemical properties of steroids and phthalates.

Compound	Molar mass[a]	Solubility[b]	Vapor pressure[c]	Log K_{ow} [d]	Chemical structure
Estrone (E1)	270.4	13	2.3×10^{-10}	3.43	
17β-estradiol (E2)	272.4	13	2.3×10^{-10}	3.94	
Estriol (E3)	288.4	13	6.7×10^{-15}	2.81	
17α-ethynylestradiol (EE2)	296.4	4.8	4.5×10^{-11}	4.15	
Dimethyl phtalate (DMP)	194	7,273	0.258	1.41	
Diethyl phthalate (DEP)	222	808	6.95×10^{-2}	2.35	
Di-n-buthyl phthalate (DnBP)	278	9.9	5.16×10^{-3}	4.22	
Butylbenzyl phthalate (BBP)	312	0.93	1.27×10^{-3}	5.22	
Di(2-ethylhexyl) phthalate (DEHP)	391	2.09×10^{-3}	3.65×10^{-5}	7.7	

Adapted from Lu, 2009. [a]Molar mass (g mol^{-1}); [b]Solubility in water (mg L^{-1} at 20 ° C); [c] Vapor pressure (mmHg); [d] Octanol / water partition coefficient

organic compounds (e.g. pesticides, PCBs and PAHs), estrogens are introduced into the environment in a continuous and large scale way (Johnson & Williams, 2004) and thus becoming a pseudopersistent pollutant. Therefore, estrogens are potential sources of a large number of adverse effects in the environment. For instance, fish cultivated in waters contaminated by estrogenic hormones have shown altered hormone levels and anatomical changes in the reproduction organs (Luzio *et al*., 2016; Volkova *et al*., 2015; Dzieweczynski & Buckman, 2013; Larsson & Förlin, 2002). It was also observed a total reversion of male to female sex in medaka fish (*Oryzias latipes*), when exposed to natural estrogens in concentration of 140 ng L^{-1} (Hirai *et al*., 2006).

2.2. Alkylphenols and Bisphenol A

Alkylphenols (APs) and Bisphenol A (BPA) are the endocrine disrupting substances most intensively studied. The APs are substances formed by a phenol group attached to a carbon chain (Table 3). APs, including nonylphenols (NPs) and octylphenols (OPs) are used directly in the production of a large range of products or can be originated from the degradation of APEO (Funakoshi & Kasuya, 2009). APEOs and APs belong to a class of non-ionic surfactants used in the production of phenolic resins, detergents, adhesives, paper, plastic additives, acrylic, vinyl acetate, emulsifiers, wetting agents, spermicides, among other applications (Hotta *et al*., 2010; David *et al*., 2009; Isidori *et al*., 2006; Tsuda *et al*., 2000).

NPs and OPs are names given to a large number of isomer compounds with structural formulas $C_{15}H_{24}O$ and $C_{14}H_{22}O$, respectively. In the context of endocrine disruptors, the most studied NPs and OPs are the 4-n-nonylphenol (4-n-NP), 4-tert-nonylphenol (4-t-NP), 4-n-octylphenol (4-n-OP), and the 4-tert-octyl-phenol (4-t-OP) (Koniecko *et al*., 2014; Quednow & Püttmann, 2008; Loos *et al*., 2008; Tsuda *et al*., 2000).

The effects of APs in humans are still unknown. However, their endocrine disrupting potential has already been established in laboratory experiments by the high multiplication of breast cancer cells, which are sensitive to estrogens (Kabir *et al*., 2015; Soto *et al*., 1995; Soto *et al*., 1991). Indeed, manipulative experiments with mice have shown an increase in the endometrial mitotic index when single doses of 20 and 50 mg of NP were administred (Soto *et al*., 1991). Kurihara *et al*., (2007) showed that NPs present in sediments of Tokyo Bay induced the production of vitellogenin (VTG) in male and young fish.

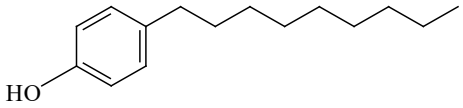
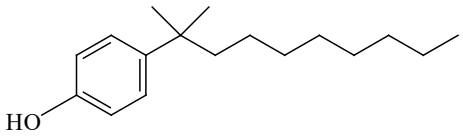
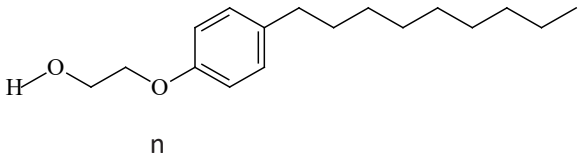
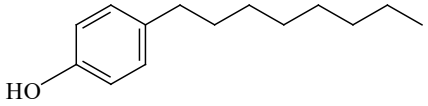
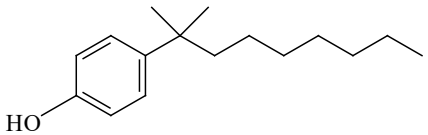
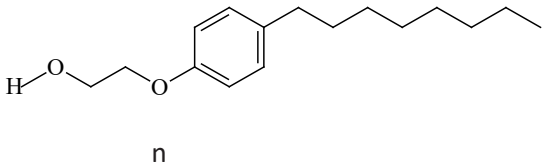
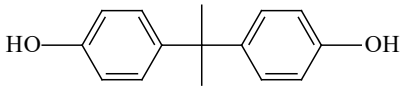
Oehlmann *et al*. (2000) described the enlargement of accessory sex glands, the stimulation of oocytes in females and a reduction in length of penis and prostate in males of the gastropod *Lapillus nucella* exposed to OP. The main sources of APs for the environment are the domestic, industrial and WWTP effluents (Bergé *et al*., 2014; Richardson & Ternes, 2014; Solé *et al*., 2000; EPA, 1997). APs can also be released into the marine environment due to fossil fuel activities, such as the release of water produced in oil rigs (Boitsov *et al*., 2007).

In WWTP and in the environment, APEOs may only be partially degraded microbiologically, which may generate shorter chain APs (e.g., NPs, OPs and mono-, di-, and tri- etoxylated APs) that are more persistent (David *et al*., 2009; Zhang *et al*., 2008; Ying *et al*., 2002a; Renner *et al*., 1997). In general, compounds originated from the degradation of APEOs present higher estrogenic activity, are more insoluble in water and have lower coefficients of octanol/water (K_{OW}) (Table 3). As a result, they are more lipophilic and susceptible to accumulation in fauna and humans (Gu *et al*., 2016; Casatta *et al*., 2015; Nurulnadia *et al*., 2014; Bouzas *et al*., 2011; Basheer *et al*., 2004; Ying *et al*., 2002a).

Bisphenol is a generic name given to a group of hydroxylated diphenylalkanes, being the bisphenol A (BPA) the main substance of this group (Perez *et al*., 1998). BPA is used in various applications, such as the production of polymers (e.g., polyvinyl chloride - PVC), epoxy resins, polyester resins, polycarbonates, fungicides, antioxidants, flame retardants, and resin for dental filling (Frye *et al*., 2011; Yi *et al*., 2010; Lintelmann *et al.,* 2003). Additionally, BPA is used in plastic films and packaging, routinely used into food packages. This is a fact of concern given the known ability of BPA to migrate from the packaging to the food (Gu *et al*., 2016; Casatta *et al*., 2015; Emnet *et al*., 2014; Nurulnadia *et al*., 2014; Fasano *et al*., 2012; Bouzas *et al*., 2011; Basheer *et al*., 2004). In some countries, such as Canada, USA, France, and more recently in Brazil, BPA has been banned from use in children utensils and toys (ANVISA, RDC 41/2011; Lintelmann *et al*., 2003).

The estrogenic potency of BPA is 10^{-3} to 10^{-5} times smaller than that of estradiol (Lintelmann *et al*., 2003; Milligan *et al*., 1998). However, its estrogenic capacity can be amplified due to its wide release and large persistence in the environment. The first evidence of estrogenic activity of BPA was reported in the late 1930s (Dodds & Lawson, 1938; Dodds & Lawson, 1936). Overtime, various toxicological studies confirmed the estrogenic behavior of bisphenol A (Xu *et al*., 2015; Mandich *et al*., 2007). Vandenberg *et al*. (2010) have examined 80 biomonitoring studies of BPA in tissues and fluids of humans, focusing on individuals exposed to BPA through the environment, or by non-occupational exposure. Levels of BPA between 2 to 150 ng L^{-1} were detected in children, teenagers and adults blood and urine samples. Those results suggest that this substance is possibly causing adverse effects in human health.

Table 3. Physicochemical properties of Alkylphenols, alkylphenols polyethoxylated e Bisphenol A.

Compound	Molar mass[a]	Solubility[b]	Log K_{OW}[c]	Chemical structure
4-n-Nonylphenol (4-n-NP)	220	5.43	4.48	
4-t-Nonylphenol (4-t-NP)	220	-	-	
Nonylphenol monoethoxylated	264	3.02	4.17	
Nonylphenol diethoxylated	308	3.38	4.21	
Nonylphenol polyethoxylated	-	-	-	
4-n-Octylphenol (4-n-OP)	206	12.6	4.12	
4-t-Octylphenol (4-t-OP)	206	-	-	
Octylphenol monoethoxylated	250	8.00	4.10	
Octylphenol diethoxylated	294	13.2	4.00	
Octylphenol polyethoxylated	-	-	-	
Bisphenol A	228	120	3.30	

Adapted from Ying *et al*., 2002a. [a]mole mass (g mol^{-1}); [b]Solubility in water (mg L^{-1} at 20 ° C); [c]Coefficient of octanol/water partition.

Experimental tests with biota showed that the action of BPA in mice may be associated to changes in the development of the mammary gland tissues (Lee et al., 2015; Vandenberg *et al*., 2007; Muñoz-de-Toro *et al*., 2005; Markey *et al*., 2001), behavioral disorders and premature sexual maturation (Talsness *et al*., 2009). Ortiz-Zarragoitia & Cajaraville (2005) reported the reabsorption of gametes in both genders of mussel *Mytilus edulis*, also as a result of exposure to BPA. Biological effects such as the increase synthesis of VTG, the inhibition of gonad growth, the increase of liver metabolism and the bioaccumulation of steroidal and phenolic EDs were assessed in high-back crucian carp (*Carassius auratus*) exposed to WWTP effluents (Liu *et al*., 2012).

The presence of BPA as well as APs in the environment are caused by leaching processes of materials with them in the constitution (Wang & Schnute, 2010). These compounds have been detected in several environmental compartments such as air, water, soil, sediment, and biota (Salgueiro-González *et al*., 2015; Nurulnadia *et al*., 2014; Jakimska *et al*., 2013; Maggioni *et al*., 2013; Bach *et al*., 2012). Due to the its higher water solubility when compared to AP and phthalates, and its relatively high log K_{ow} value (Table 3) it may be predicted that BPA has a wide distribution in the aquatic environment (Sun *et al*., 2012; Cunha *et al*., 2012). This hypothesis, however, needs to be further investigated.

2.3. Phthalates

Phthalates or phthalic acid esters are synthetic compounds that have been used in industrial activities since the 1930s. Their application includes plasticizers in polymers and additives for various products such as insecticides, paints, packaging, cosmetics, floor coverings, ceilings, clothing, and/or electrical insulating compounds additives (Net *et al*., 2015; Mankidy *et al*., 2013b; Li *et al*., 2008; Horn *et al*., 2004; Sumpter, 1998). The most commonly used phthalates are dimethyl phthalate (DMP), diethyl phthalate (DEP), di-n-buthyl phthalate (DnBP), diisobuthyl phthalate (DiBP), di(2-ethylhexyl) phthalate (DEHP) and butylbenzyl phthalate (BBP). A quarter of the whole world production of phthalate is represented by DEHPs, which is employed in the production of PVC (Net *et al*., 2015; Dargnat *et al*., 2009).

Although Brazil does not prohibit the use of phthalates in products such as cosmetics and food packaging, the World Health Organization (WHO) warns about the possible health problems caused by these compounds (WHO, 2012). Phthalates, especially DnBP, BBP and DEHP, have high values of log K_{ow} (Table 2), characteristic of lipophilic compounds, which allows the accumulation of these compounds in the organic matter present in soils and sediments (Benjamin *et al*., 2015; Net *et al*., 2015; Gavala *et al*., 2003).

The interfering nature of phthalates has been reported in a number of studies both *in vivo* and *in vitro* (Benjamin *et al*., 2015; Romani *et al*., 2014; Mankidy *et al*., 2013; Hashimoto *et al*., 2003; Picard *et al*., 2001; Körner *et al*., 1999). Phthalates became the subject of much concern once they are suspected to cause premature puberty (Tsai *et al*., 2016; Zhang *et al*., 2015; Fisher & Eugter, 2014; Colón *et al*., 2000).

In humans, phthalates can affect not only the endocrine and reproductive systems, but also may cause respiratory and dermatological problems (Pérez-Feás *et al*., 2011). In rodents, the exposure of males in the intrauterine period to DnBP, BBP and DEHP results in a series of reproductive abnormalities, such as damage to testicles (Foster, 2006; Gray *et al*., 2006; Foster *et al*., 2001). Other studies have shown carcinogenic effects and feminization in mice and fish even at low concentrations of phthalates (Benjamin *et al*., 2015; Valton *et al*., 2014; Martino-Andrade & Chahoud, 2010; Larsen *et al*., 2002).

In the environment, phthalates can suffer natural degradation (Benjamin *et al*., 2015; Liang *et al*., 2008). According to ecotoxicological models for mammals, fish and arthropods the degradation products of DEHP, such as 2-ethylhexanol and 2-ethylhexanal, present more toxicity than the original compound (Benjamin *et al*., 2015; Horn *et al*., 2004; Nalli *et al*., 2002). Therefore, environmental studies should take into account the presence and toxicity of both the original compounds and their metabolites.

The main routes of intake of phthalates in humans are inhalation associated with atmospheric particulate matter, direct contact with materials composed with phthalates and the ingestion of contaminated food (Net *et al*., 2015; Gärtner *et al*., 2009; Rudel *et al*., 2003). The addition of phthalates to food is not common. However, the foof contact to its package or even with plastic utensils used during food processing may generate food contamination. The phthalates, which are used as plasticizers, are not chemically bound to the polymer matrix, so they can be quickly released to the environment during their production, use and disposal (Net *et al*., 2015; Sax, 2010; Heudorf *et al*., 2007; Fromme *et al*., 2002). Considering the relatively high vapor pressures, when compared to other organic compounds (Table 2), phthalates can be volatilized into the atmosphere and be transferred to other environment compartments during their life cycle (Net *et al*., 2015; Xie *et al*., 2007).

3. Analytical techniques employed in the determination of EDs in the environment

Techniques for sample preparation

The development of new procedures for sample preparation should aim for simplification, automation, economy, minimal sample manipulation, minimal use of solvents and energy, according to the principles of the Green Chemistry (Huerta *et al*., 2015; Yan & Wang, 2013; Farré *et al*., 2010).

The determination of organic contaminants such as EDs in environmental samples is always challenging, not only due to the very low concentrations of analites but also due to the complexity and diversity of sample matrices. Matrix effects may have negative impacts to important analytical parameters (e.g., limit of detection (LOD), limit of quantification (LOQ), linearity, accuracy and precision), making the direct analysis of environmental samples very dificult (Farré *et al*., 2012; Wu *et al*., 2010). Therefore, the pretreatment of environmental samples,

especially for matrices such as coastal and ocean waters that have high salinities, is a real necessity. This step, nevertheless, usually takes up to 70-90 % of the analysis time (Zuloaga *et al*., 2012).

Sample preparation for the determination and quantification of organic compounds are based on three main steps: extraction, clean up and pre-concentration. The extraction step is a procedure performed to separate the analytes from the sample matrix. In the clean up step the possible interferences in the analysis, which difficult to identify and quantify the compounds of interest, are removed. EDs in environmental samples are usually present at concentration levels below the LOD of most analytical methods. Consequently, the pre-concentration it is a crucial step to improve detectability and to meet LOD and LOQ of analytical methods.

Sample preparation techniques are specific for each sample type. Solid phase extraction (SPE), for instance, has been the preferred technique in studies of EDs in liquid samples (Anumol e Snyder, 2015; Melo e Brito, 2014; Richardson & Ternes, 2014; Lisboa *et al*., 2013; Zhang *et al*., 2012; Richardson, 2012; Saravanabhavan *et al*., 2009; Fatoki & Noma, 2001). The SPE technique applied to aqueous samples has the advantage of aggregating three steps, i.e., extraction, clean up and preconcentration, in a single stage. In addition, SPE offers a wide variety of solid phases for extraction, resulting in different types of interactions with the analytes and, then, wide applicability. Another advantage of SPE is the possibility of automation, which facilitates its use in environmental studies when it is necessary to process a large number of samples. However, SPE has limitations, such as the blocking of the extraction phase pores by the matrix components, several operational steps, and analytical variations among extraction cartridges (Richardson & Ternes, 2014; Queiroz & Lanças, 2005; Lisboa *et al*., 2013). Even with these limitations, the SPE has been the extraction procedure most used in EDs studies. Shan *et al*. (2014) analyzed BPA, 4-n-OP and 4-n-NP in tap and bottled water using SPE C18 with minimum detectable concentrations of 0.75-1.0 ng L^{-1} and the recoveries ranged from 87.0 % to 106.9%. Zhang *et al*. (2012) used C18 as stationary phase in SPE and found limits of determination for OP, NP, E1, E2, E3, EE2 and BPA in wastewater below 0.8 ng L^{-1}, with recoveries higher than 80%. Ribeiro *et al*. (2009) investigated the presence of estradiol, estrogen, 17α-ethinylestradiol, bisphenol A, 4-octylphenol, 4-nonylphenol in estuarine waters, using Oasis HLB cartridges and found BPA concentrations up to 800 ng L^{-1}.

In the case of solid samples, such as suspended particulate matter, sediment and biota, the most used sample preparation procedures are microwave assisted extraction (MAE) (Vega-Morales *et al.*, 2013; Liu *et al.*, 2012; Dévier *et al.*, 2010), ultrasound assisted extraction (UAE) (Huerta *et al.*, 2015; Yu *et al.*, 2011; Sánchez-Avila *et al.*, 2011) and pressurized liquid extraction (PLE) (Salgueiro-Gonzales *et al.*,2014; Ma *et al.*, 2013; Jakimska *et al.*, 2013). They have been the main alternatives to replace the extractions traditionaly performed by Soxhlet (Bossio *et al*., 2008; Wang *et al*., 2007). Both soxhlet and liquid liquid extraction (LLE) extractions use large amounts of solvents, generate a large amount of organic residues, are time consuming and also difficult to automate. These factors decrease their analytical speed, and make them unattractive for the preparation of a large number of samples, as required in monitoring programs. Due to the large complexity of the solid matrices, such as sediment, soil or animal tissues, it is necessary to perform clean up steps. These procedures are intended to minimize or eliminate the impurities that may cause equipment damage or even interfere with the determination. Additionally, after their first step extraction, those solid sample extracts obtained by MAE, UAE and PLE are further cleaned up using mainly the SPE technique. The main strategy used to perform the clean up in solid samples is the SPE with C18 and/or florisil cartridges (Zhang *et al*., 2012; Arditsoglou & Voutsa, 2008a; Braga *et al*., 2005).

Yu *et al*. (2011) have used the UAE for the extraction of hormones, BPA and personal care products and have quantified them by ultra high performance liquid chromatography coupled with tandem mass spectrometry. The analytes were extracted for 15 minutes with a mixture of acetonitrile/water, centrifuged and cleaned up with C18 cartridges. The method was applied to sludge and sediment samples with recoveries ranging between 63 % and 119 % and LOQs between 0.1 and 3 ng g^{-1}, for the sludge samples, and from 0.02 to 0.5 ng g^{-1}, for sediments. Matějíček (2011) has developed a method for extraction of estrogens in sediments based on MAE. The samples were extracted with a mixture of methanol/water for 10 minutes, filtered and determined by HPLC. Recoveries ranged 99-110 % and limits of detection were 90 ng g^{-1} (E2), 180 ng g^{-1} (E1), and 250 ng g^{-1} (EE2). Ma *et al*. (2013) have optimized a method on GC-MS combined with PLE for the determination of six phthalates in soil samples. The LOQs of the proposed method ranged from 0.02 to 0.29 μg g^{-1} and recoveries varied between 90 and 110%.

The LOD and recoveries reported in the literature for MAE, PLE and UAE are very variable depending on the sample size, solvent volumes and equipments used. However, these techniques offer several benefits compared to traditional Soxhlet technique, for instance relatively fast extraction, reduced solvent consumption, and a smaller amount of sample handling.

Methods for ED analysis

The HPLC and gas chromatography (GC) are the most commonly analytical techniques used for the determination of persistent organic pollutants (POP), EDs, and ECs in environmental samples. GC and liquid chromatography (LC) are powerful separation techniques and should be combined with highly sensitivity detectors for enabling the analytes determination. EDs are analyzed mainly by liquid chromatography with ultraviolet, fluorescence, and/or mass spectrometry detectors or by GC with mass spectrometry detector (Huerta *et al*., 2016; Birch *et al*., 2015; Emnet *et al*., 2015; Zhang *et al*., 2014; Selvaraj *et al*., 2014; Melo & Brito, 2014; Lisboa *et al*., 2013; Villar-Navarro *et al*., 2013; Ribeiro *et al*., 2009; Bossio *et al*., 2008; Xie *et al*., 2007; Fatoki & Noma, 2001; Khim *et al*., 1999). The coupling of a chromatograph with mass spectrometer combines the advantages of the chromatography technique (which are high selectivity and separation efficiency) with the advantages of mass spectrometry (*e.g.* structural information and high selectivity) (Vekey, 2001).

GC is a relatively inexpensive, rapid and reproductible technique for a large number of compounds in environmental samples. The GC presents high resolution and the possibility to be coupled to selective and sensitive detectors such as mass spectrometry (MS) and electron capture detector (ECD), among other possibilities. However, GC is a technique that mainly requires analytes to be volatile or semi-volatile, thermally stable and non-polar in order to facilitate the maximum number of successive interactions between the analyte and the stationary phase, reducing the height and increasing the number of theoretical plates (*H* and *N*, respectively). Although polar-bonded phase columns are commercially available, in general, studies mostly use DB-1 (100% polysiloxane) or DB-5 (95% polysiloxane and 5% phenyl) columns since they present higher robustness and better reproductibility and repeatability. For the analyses of PAHs, several pesticides, phthalates and PCBs, among others, the GC can be used without the need of analyte modification. However, the determination of hormones, antibiotics and other drugs, APs and bisphenol A, among other EDs by GC requires the use of a derivatization step (Farajzadeh *et al*., 2014; Wu *et al*., 2010) in order to prevent those analyte adsorption and decomposition in the column or in the injector, resulting in non-reproducible peak areas or heights and shapes. Moreover, the purpose of derivatization is also the improvement of LOD and selectivity (Farajzadeh *et al*., 2014). Derivatization is a transformation the chemical compound into a specific product with caraceristicas with features that allow its determination.

On the other hand, a growing number of studies has been done using LC, coupled to diode array detectors (DAD), with fluorescence detectors (FLD) and/or of mass spectrometer detectors (Huerta *et al.,* 2015; Torres *et al.,* 2015; Valdés *et al.,* 2015; Anumol e Snyder, 2015; Salgueiro-Gonzales *et al.,* 2014; Melo e Brito, 2014; Ammann *et al*., 2014; Lisboa *et al*., 2013; Zhang *et al*., 2012; Jardim *et al*., 2012; Matějíček, 2011; Labadie & Hill, 2007; Ferguson *et al*., 2000; Khim *et al*., 1999). A good advantage of the liquid chromatography is that derivatization is mostly unnecessary. In this way, a relatively complicated and time-consuming derivatization procedure, which may lead to an underestimation of ED concentrations and possibly contamination of samples, is then eliminated. Another interesting LC advantage is its applicability for the determination of polar organic pollutants, thermolabile substances and/or those easily decomposed, and, hence cannot be analyzable by GC systems.

The best technique (GC or LC) and the best detector (DAD, FLD, flame ionization (FID), ECD or MS) for the determination of EDs in environmental samples will depend on the study goals, the type of matrix to be studied, and the physicochemical characteristics of the analytes. It also should be taken into account the following parameters: sensitivity, number of samples, availability of instrumentation, costs and the analyst skills. Liquid and gas chromatography are complementary techniques, and both have interesting innovations in order to achieve LOD in the range of few ng L^{-1}.

The recent advances in LC, GC, types of columns, detectors (especially for mass spectrometers), the interface chromatograph-detector and their speed of data acquisition have been providing significant improvements in the separation of complex samples in short analyses, with little use of solvent and good selectivity and sensitivity. With this, the current and future trend is to find EDs and ECs at even lower concentrations levels in an increasing number of matrices and places around the world. It is also expected that studies are likely to switch focus, *i.e*., from descriptive studies of EDs occurrence in several environmental compartments towards processes studies. These changes will subsidize a better understanding in the processes controlling transformations, transport, fate and interactions between environmental compartiments. Ecological, (eco)toxicological and human health risk assessments will contribute even further for the evaluation of behavior and possible adverse effects of ED inputs into the ecosystems.

4. Occurrence of EDs in marine environment

The origins of EDs in the aquatic environment are highly variable and are often attributed to human activity. In general, coastal environments, such as estuaries, bays and mangroves, serve as major receptors of domestic, industrial, hospital, agricultural, and aquiculture

effluents. Submarine outfalls, port and ship activities, surface runoffs are also important sources of EDs. The relative inefficiency of conventional WWTP in the complete removal of EDs makes them one of the most important sources of these compounds to water bodies (Deblonde *et al*. 2011; Pal *et al*., 2010; Santos *et al*., 2010; Kuster *et al*., 2009).

Once in the environment, EDs may undertake different pathways: *(i)* distribution between environmental compartments, such as water, air, soil, sediment, suspended particulate matter and biota, *(ii)* degradation and subsequent transport and distribution of their metabolites in the environment, *(iii)* bioaccumulation and/or biomagnification (Lintelmann, 2003).

The presence, behavior, ecotoxicity and the interfering effects of EDs have been reported for riverine environments (Gu *et al*., 2016; Esteban *et al*., 2016; Kabir *et al*., 2015; Li *et al*., 2014; Fu *et al*., 2007; Fatoki & Noma, 2001,) while the effects and fate of EDs in the marine environments is still unknown. Coastal regions, in special estuaries, are dilution zones, where river water mixes with marine waters. In general, coastal waters have lower levels of contaminants than freshwaters, either due to distance from sources or to the occurrence of attenuation processes (i.e., dilution, sorption, precipitation and photooxidation). Tables 4, 5 and 6 shows a review of the occurrence of EDs studies in coastal environments, which will be discussed below.

Among the EDs discussed here, APs and BPA are the most studied EDs in marine environments. As previously discussed, APEOs, their degradation products (e.g., NPs and OPs), and BPA are synthetic and their presence in the environment is a result of human activity. Industrial and domestic effluents, WWTPs (effluents and sludge) as well as the application of pesticides are the main sources of APs, APEOs and BPA to the marine environment (Kabir *et al*., 2015; Gravilescu *et al*., 2015; Quednow & Püttmann, 2008; Soares *et al*., 2008; Ying e*t al*., 2002a).

The high partition coefficients of NP, OP and BPA, according to log K_{OW} values of 4.48, 4.12, and 3.30, respectively, suggest that these compounds, when entering the aquatic environment they are sorbed in suspended particulate matter and sediments.

NP concentrations in saline waters (Table 4) range from 0.002 ng L^{-1}, in the sea of Japan (Kannan *et al*., 1998), to 4100 ng L^{-1}, in the coast of Spain (Petrovic *et al*., 2002). In turn, OP concentrations in water ranged from 0.013 ng L^{-1}, in the North Sea (Xie *et al*., 2006), to 800 ng L^{-1}, in Singapore (Basheer *et al*., 2004). The concentrations of NP are up to an order of magnitude above the concentrations of OP, probably due to the highest use of polyethoxylated nonylphenol (Isobe *et al*., 2001). In general, the most contaminated areas are estuaries and coastal regions under the influence of industrial and domestic effluents and WWTP. In the ocean, concentrations decrease abruptly with distance from the coast. In the North Sea waters, however, the concentrations of OP (0.013 to 3 ng L^{-1}) and NP (0.09 to 1.40 ng L^{-1}) increased with the distance from the coast (Xie *et al*., 2006). The authors have suggested that atmospheric deposition of OP and NP, from the burning of aircraft fuels, was the main source.

In general, there is a negative correlation between the concentrations of OP and NP with salinity. This relationship is primarily due to dilution (physical mixing processes) with distance from the source. Studies also showed the influence of salinity on the distribution of AP and APEO (Li *et al*., 2005; Ferguson *et al.*, 2001). Nevertheless, according to these studies the increase of salinity favors the removal and degradation processes of AP and PEA in the water column. This is the result of the salting out. This process results from the decrease in the solubility of organic compounds in water due to the effect of ionic strength on their activity coefficients but also represents these substances are going to be preferentially absorbed in environmental matrices with less polar nature as well as higher content of organic matter, such as SPM, sediments and biota. Furthermore, as a result of the reduced solubility, and high affinity for organic matter, it is expected that these compounds participate in processes of aggregation, flocculation and and the fate is usualy the accumulation in sediments.

In sediments, concentrations of NPs (Table 5) ranged from 0.01 ng g^{-1}, in Morro Bay, California (Diehl *et al*., 2012) to 32000 ng g^{-1}, in Auckland, New Zealand (Stewart *et al*., 2014), while the concentrations of OPs ranged from 0.01 ng g^{-1}, in the estuary Urdaibai in Spain (Puy-Azurmendi *et al*., 2010), to 179 ng g^{-1}, in Masan Bay, South Korea (Khim *et al*., 1999). Similarly to the processes that occur in the water column, the concentration of APs in sediments decreases with increase distance from the coast, due to dilution processes.

The presence of organic matter is the main factor influencing on the accumulation of APs in sediments, mainly due to lipophilic characteristics of these compounds. Jonkers *et al*. (2003), found high correlations between organic carbon and concentrations of NP in sediments from Scheldt and Rhine estuaries. The accumulation and persistency of AP in estuarine sediments (Shang *et al*., 1999) suggests that benthic macrofauna may be subject to long term exposition to these contaminants, potentially causing chronic effects in biota. The presence of AP in marine organisms (e.g. fish, oysters, squid, mussels, prawns, etc.) has been reported in several regions around the world (e.g., USA, Italy, Taiwan, Greece, Singapore and Japan) (Colin *et al*., 2016; Casatta *et al*., 2015; Emnet *et al*., 2015; Lee *et al*., 2015; Arditsoglou & Voutsa, 2012; Bouzas *et al*., 2011; Bartolomé *et al*., 2010; Wang *et al*., 2010; Kumar *et al*., 2008; Ferrara *et al*., 2008; Isobe *et al*., 2007; Pojana

Table 4. Endocrine disruptors (BPA, AP and estrogens) in seawater (ng L^{-1}) around the world.

Site	BPA	E1	E2	E3	EE2	OP	NP
Todos os Santos Bay, Brazil[a]	<LOD-48.2	<LOD	<LOD-18.2	<LOD-37.9	<LOD	<LOD-134	<LOD
Morro Bay, United States[b]	-	-	-	-	-	-	100-900
La Coruña Beach, Spain[c]	35	-	-	-	-	175	70-199
Biscay Bay, Spain[d]	60-130	-	-	-	-	50-100	1110-1460
Southeast Coast of California, United States[e]	-	-	-	-	-	<LOD-42	<LOD-230
Thermaikos Gulf, Greece[f]	10.6-52.3	<LOD	<LOD	<LOD	<LOD	1.7-18.2	22-201
Northeast Coast, Spain[g]	7.1-35	-	-	-	-	3.8-39	29-712
Aveiro Coast, Portugal[h]	2.6-13	<LOD-0.5	<LOD-1.1	-	<LOD	-	15-98
Mondego Estuary, Portugal[i]	178-589	<LOD	<LOD	-	<LOD	<LOD	-
Halifax and St. John Port, Canada[j]	-	1.4-7.5	1.8	-	<LOD	-	-
Thessaloniki Coast, Greece[k]	25-59	-	-	-	-	8-29	181-915
Laguna Venice, Italy[l]	3.4-145	3.2-6.7	3.0-175	-	4.6-28	-	4.0-211
Scheldt Estuary, the Netherlands[m]	-	0.37-10	<LOD	<LOD	<LOD	-	-
Suruga Bay, Japan[n]	3.6-1070	<LOD-9.2	<LOD	-	<LOD	<LOD	28.2-276
Acushnet Estuary in Buzzards Bay, United States[o]	-	0.78-1.2	0.56-0.83	-	3.01-4.67	-	-
North Sea, German Creek[p]	-	-	-	-	-	0.013-3	0.09-1.4
North Sea[q]	-	-	-	-	-	0.013-0.3	0.09-1.4
Taiwan Coast[r]	-	-	-	-	-	61-66	290-370
Baltic Sea, German[s]	0.1-5.7	0.13-0.54	<LOD	<LOD	1.6-17.9	0.1-1.1	1.3-7.5
Singapore coast[t]	2-2470	-	-	-	-	10-800	290-370
Rhine Estuary, the Netherlands[u]	-	-	-	-	-	-	31-147
Scheldt Estuary, the Netherlands[u]	-	-	-	-	-	-	35-934
Coast of Spain, Mediterranean and Atlantic[v]	-	-	-	-	-	300	300-4100
North Sea, German Creek[w]	1.6-6	-	-	-	-	0.02-1.6	0.8-63
Jamaica Bay[x]	-	-	-	-	-	1.56-8.3	77.4-416
Jamaica Bay[y]	-	-	-	-	-	3.3	201
Japan Sea[z]	-	-	-	-	-	-	0.002-0.093
Pearl River Delta and coastal[aa]	10-227	<LOD-3,1	-	-	<LOD-1,56	-	11-234
Cape D'Aguilar Marine Reserve, Hong Kong[ab]	14,1-206,5	-	-	-	-	-	91.7- 473.9
Gulf of Gdansk, Southern Baltic[ac]	<LOD-713.9	-	-	-	-	<LOD - 834.8	<LOD-3659.6
Yangtze River Estuary, China[ad]	0.98–43.8	<LOD-1.43	<LOD	-	<LOD-0.11	-	-

[a]Lisboa *et al*., 2013; [b]Diehl *et al*., 2012; [c]Salgueiro-González *et al*., 2012; [d]de los Ríos *et al*., 2012; [e]Vidal-Dorsch *et al*., 2012; [f]Arditsoglou & Voutsa, 2012; [g]Sánchez-Avila *et al*., 2011; [h]Jonkers *et al*., 2010; [i]Ribeiro *et al*., 2009; [j]Saravanabhavan *et al*., 2009; [k]Arditsoglou & Voutsa, 2008b; [l]Pojana *et al*., 2007; [m]Noppe *et al*., 2007; [n]Hashimoto *et al*., 2007; [o]Zuo *et al*., 2006; [p]Xie *et al*., 2006; [q]Ebinghaus & Xie, 2006; [r]Cheng *et al*., 2006; [s]Beck *et al*., 2005; [t]Basheer *et al*., 2004; [u]Jonkers *et al*., 2003; [v]Petrovic *et al*., 2002; [w]Heemken *et al*., 2001; [x]Ferguson *et al.,* 2001; [y]Ferguson *et al*., 2000; [z]Kannan *et al*.,1998; [aa]Xu *et al*., 2014; [ab]Xu *et al*., 2015; [ac] Staniszewska *et al*., 2015; [ad]Shi *et al*., 2014.

Table 5. Endocrine disruptors (BPA, AP and estrogens) in marine sediments (ng g^{-1}).

Site	BPA	E1	E2	E3	EE2	OP	NP
Abra and Urdaibai Estuary, Spain[a]	<LOD-0.04	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD-0.2
Morro Bay, United States[b]	-	-	-	-	-	-	0.01-157
Biscay Bay, Santander Coast, Spain[c]	4-59	-	-	-	-	9-14	150-210
Thermaikos Golf, Greece[d]	7.2-39	<LOD	<LOD	<LOD	<LOD	6.0-25	223-2695
Northeast Coast, Spain[e]	-	-	-	-	-	38-39	79-521
South-central Coast, Chile[f]	-	0.06-4.61	0.06-16.81	0.01-53.21	4.18-48.14	-	-
Urdaibai Estuary, Spain[g]	0.01-43	<LOD	<LOD	<LOD	<LOD	0.01-0.03	154-264
Northeast Coast, China[h]	-	-	-	-	-	-	8.8-1000
Yangtze Estuary, China[i]	0.72-13.2	-	-	-	-	-	1.56-35.8
Xiamen Bay, China[j]	1.7-121.9	1.1-7.4	1.0-2.4	<LOD	0.9-2.2	1.4-24.0	12.9-1160.0
Thessaloniki, Greece[k]	17	<LOD	<LOD	<LOD	<LOD	8	266
Masan Bay, Japan[l]	-	-	-	-	-	-	92-557
Savannah Estuary, United States[m]	-	-	-	-	-	0.86-6.9	4.1-18
Laguna Venice, Italy[n]	3.4-145	<LOD	<LOD	-	12-41	-	47-192
Tóquio Bay, Japan[o]	-	0.05-3.6	<LOD-0.59	-	-	-	-
Taiwan Coast[p]	-	-	-	-	-	27-49	130-190
Yeongil Bay, Korea[q]	<LOD-191	-	-	-	-	<LOD-24.3	<LOD-1430
East Coast of Sidney, Australia[r]	-	0.16-1.17	0.22-2.48	-	0.05-0.5	-	-
Califórnia Coast, United States[s]	-	<LOD-0.6	0.16-0.45	-	-	1.9-8.2	122-3200
Rhine Estuary, the Netherlands[t]	-	-	-	-	-	-	1.5-92.2
Scheldt Estuary, the Netherlands[t]	-	-	-	-	-	-	0.4-1080
Spain Coast, Mediteranean and Atlantic Ocean[u]	-	-	-	-	-	17-145	18-1050
Tóquio Bay, Japan[v]	-	-	-	-	-	6-10	120-640
Jamaica Bay[w]	-	-	-	-	-	<LOD-45	6.99-13700
Jamaica Bay[x]	-	-	-	-	-	8.1	846
Masan Bay, South Korea[y]	2.7-50.3	-	-	-	-	4-179	113-3890
Auckland, New Zealand[z]	<LOD-145	<LOD-2.2	<LOD-1.0	-	<LOD	<LOD-135	<LOD-32000
Gulf of Gdansk (Baltic Sea)[aa]	-	-	-	-	-	<LOD-48.88	<LOD-249.08
Yellow Sea[ab]	-	-	-	-	-	0.8-9.3	349.5-1642.8
East China Sea[ab]	-	-	-	-	-	0.7–11.1	31.3-1423.7
Cape D'Aguilar Marine Reserve, Hong Kong[ac]	60,8-265,9	-	-	-	-	-	527,3-800,0
Yangtze River Estuary, China[ad]	<LOD-7.87	<LOD-1.92	<LOD-0.30	-	<LOD-0.72	-	-

LOD=linit of detection. [a]Puy-Azurmendi *et al*., 2013; [b]Diehl *et al*., 2012; [c]de los Ríos *et al*., 2012; [d]Arditsoglou & Voutsa, 2012; [e]Sánchez-Avila *et al*., 2011; [f]Bertin *et al*., 2011; [g]Puy-Azurmendi *et al*., 2010; [h]Wang *et al*., 2010; [i]Bian *et al*., 2010; [j]Zhang *et al*., 2009; [k]Arditsoglou & Voutsa, 2008b; [l]Li *et al*., 2008; [m]Kumar *et al*., 2008; [n]Pojana *et al*., 2007; [o]Isobe *et al*., 2006; [p]Cheng *et al*., 2006; [q]Koh *et al*., 2006; [r]Braga *et al*., 2005; [s]Schlenk *et al*., 2005; [t]Jonkers *et al*., 2003; [u]Petrovic *et al*., 2002; [v]Isobe *et al*., 2001; [w]Ferguson *et al.*, 2001; [x]Ferguson *et al*., 2000; [y]Khim *et al.,*1999; [z] Stewart *et al*., 2014; [aa]Koniecko *et al*., 2014; [ab]Duan *et al*., 2014; [ac]Xu *et al*., 2015; [ad]Shi *et al*., 2014

Table 6. Phthalates in sediments (ng g^{-1}) and water (ng L^{-1})

Site	Sample	DMP	DEP	DBP	DEHP	BBP	DnOP
Abra and Urdaibai Estuary, Spain[a]	Sediment	<LOD	<LOD-6218	<LOD-1010	688-2530	-	-
Biscay Bay, Santander Coast, Spain[b]	Water	<LOD	3330-37360	4450-5960	7080-85360	-	-
	Sediment	<LOD	170-7670	630-1040	1120-15190	-	-
Southeastern California Coast, United States[c]	Water	-	-	-	-	-	<LOD-85
Northeastern Coast, Spain[d]	Water	9.4-21	43-4482	-	4.6-138	2.6-658	-
	Sediment	12-26	22-4317	-	1.9-107	12-3297	-
Urdaibai Estuary, Spain[e]	Sediment	<LOD	908-6377	466-1168	346-4376	-	-
Cantábria Coast, Spain[f]	Sediment	<LOD	<LOD	<LOD	190-2800	<LOD	
Kavala Coast, Greece[g]	Water	-	-	370-700	600-1300	300-6000	-
Arctic Sea, Norway[h]	Water	0.013-0.312	0.008-0.795	0.0002-0.048	0.024-3.330	-	-
North Sea[i]	Water	<LOD-0.68	0.03-4.0	0.45-6.6	<LOD-5.3	<LOD-0.26	-
Elizabeth Port and East London, South Africa[j]	Water	500-350800	4400-398300	700-1028100	2100-2306800	-	-
Auckland, New Zealand[k]	Sediment	<LOD	<LOD	<LOD	<LOD-11500	<LOD -1600	<LOD
Anzali wetlands, Iran[l]	Sediment	-	-	0.12-19.02	0.25-43.12	-	-

LOD – Detection limit. [a]Puy-Azurmendi *et al*., 2013; [b]de los Ríos *et al*., 2012; [c]Vidal-Dorsch *et al*., 2012; [d]Sánchez-Avila *et al*., 2011; [e]Puy-Azurmendi *et al*., 2010; [f]Antizar-Ladislao, 2009; [g]Grigoriadou *et al*., 2008; [h]Xie *et al*., 2007; [i]Ebinghaus & Xie, 2006; [j]Fatoki & Noma, 2001; [k]Stewart *et al*., 2014; [l]Hassanzadeh *et al*., 2014

et al., 2007; Cheng *et al*., 2006; Basheer *et al*., 2004). NPs concentrations ranged from 1.2 ng g^{-1} in oysters, at Savannah, USA (Kumar *et al*., 2008), to 7600 ng g^{-1} in mussels and oysters from the northeastern coast of China (Wang *et al*., 2010a). Concentrations of OPs ranged from 0.2 ng g^{-1}, in anchovies in the Tyrrhenian Sea (Ferrara *et al*., 2008), to 1460 ng g^{-1}, in oysters collected on the coast of Taiwan (Cheng *et al*., 2006). In many studies a significant relationship between the concentrations of NP and OP in biota and in the water column was not observed (Tsuda *et al*., 2000). The absence of this correlation is not only associated with the high water dynamics, but also to the fact that the concentration of biological tissues reflects the contamination exposure integrated over the animal lifetime.

OP concentrations were positively correlated with NP concentrations in oysters that inhabit the Taiwan Coast. This was similar to that found between OP and NP in the marine gastropod *Thais clavigera*,, which is a predator of oysters *Crassostrea gigas,* from the same region. Cheng *et al*. (2006), by analyzing these two trophic levels, suggested that there was biomagnification of NP and OP.. Studies of biomagnification of EDs, nevertheless, are still scarce and efforts should be made to understand the mechanisms associated to the transfer and accumulation of contaminants trofic levels.

In the studies reviewed, concentrations of NPs in sediments and biota were always higher than the concentrations of OP, similarly to the observed in water. Moreover, NP present higher lipophilicity (log K_{OW} NP > log K_{OW} OP), therefore it is accumulated in higher proportion in sediments and biota when compared to OP.

Concentrations of OP and NP in coastal sediments are much lower than concentrations found in rivers. Fu *et al*. (2007) have reported concentrations of NP up to 31704 ng g^{-1} in rivers that flow into the bay of Jiaozhou, China,. In turn, for marine environments the NP values were below 14000 ng g^{-1} (Gu *et al*., 2016; Isolbe *et al*., 2007; Pojana *et al*., 2007; Ferguson *et al*., 2001;). Attenuation due to dilution and degradation processes is possibly the main reason for the differences in the concentrations observed between riverine and marine environments.

The BPA concentrations (Table 4) in seawater ranged from 0.1 ng L^{-1} in the Eastern Baltic Sea, Germany (Beck *et al*., 2005), to 2470 ng L^{-1} in waters from Singapore coast

(Basheer *et al*., 2004). The BPA concentration is mainly attributed to industrial activity and the WWTP effluents. As a result, it was observed a decreasing gradient of BPA concentration with the distance increase from the sources. This variation in the BPA concentrations has been mainly attributed to dilution and degradation processes. It is estimated that BPA present half-life between 2.5 - 4 days in marine waters (Heemken *et al*., 2001). Thus BPA molecules that are not sorbed and tranferred to sediment may be rapidly degraded.

In sediments, BPA ranged from 0.01 ng g^{-1}, in sediments from Urdaibai estuary, Spain (Puy-Azurmendi *et al*., 2010), to 266 ng g^{-1} in sediments of Cape D'Aguilar Marine Reserve, Hong Kong (Xu *et al*., 2015). There are few studies describing the presence of BPA in marine organisms, among these, a study with mussels reported BPA concentrations ranging from 0.54 ng g^{-1} and 213 ng g^{-1} (Isobe *et al*., 2007). AP and BPA concentrations in mussels are generally higher than those obtained for fish since they feed on suspended material and accumulate large amounts of contaminants (Basheer *et al*., 2004), including trace metals and PHA.

Unlike the AP, the BPA concentrations in sediment and biota were, in many cases, lower than its concentrations in water. This pattern can be explained by the lower lipophilicity of BPA compared to AP, and its high solubility. It seems like that these compounds degrade before reaching the sediments (Gu *et al*., 2016; Casatta *et al*., 2015; Emnet *et al*., 2015; Miège *et al*., 2012; Bouzas *et al*., 2011 Isolbe *et al*., 2007; Pojana *et al*., 2007; Cheng *et al*., 2006; Heemken *et al*., 2001).

E1, E2, E3 and EE2 are the most studied hormones, primarily because of their large inputs in the environment and their high endocrine disruption potential. The concentrations of E1 in water, sediment and mussels range from 0.13 ng L^{-1} (Beck *et al*., 2005) to 52 ng L^{-1} (Noppe *et al*., 2007), 0.05 ng g^{-1} (Isobe *et al*., 2006) to 7.4 ng g^{-1}, (Zhang *et al*., 2009) and 0.2 ng g^{-1} to 0.4 ng g^{-1} (Saravanabhavan *et al*., 2009), respectively. The E2 in water and sediment was found at concentrations ranging from 0.56 ng L^{-1} (Zuo *et al*., 2006) to 175 ng L^{-1} (Pojana *et al*., 2007), and 0.06 ng g^{-1} to 16.8 ng g^{-1} (Bertin *et al*., 2011) respectively, while E2 has not been detected in organisms. Among the studied hormones, the synthetic EE2 is the only one that has exclusively anthropogenic sources. EE2 in water, sediment and biota was found in concentrations ranging from 1.6 ng L^{-1} (Beck *et al*., 2005) to 28 ng L^{-1} (Pojana *et al*., 2007), 0.05 ng g^{-1} (Braga *et al*., 2005) to 48 ng g^{-1} (Bertin *et al*., 2011), and 7.2 ng g^{-1} to 38 ng g^{-1} (Pojana *et al*., 2007), respectively. On the other hand, E3 was only identified in sediments of the south-central coast of Chile (Bertin *et al*., 2011) ranging from 0.01 ng g^{-1} to 53.2 ng g^{-1}.

Estrogenic hormones are released into the environment in their inactive conjugated forms (*i.e.* glucuronic or sulfate acid). However, they are rapidly transformed in their interfering forms through the activity of microorganisms present in environment (Ying *et al*., 2002b). Like other EDs, estrogens are presented in relatively low concentrations in the marine environment, due to dilution and/or attenuation processes.

High concentrations of estrogens were not found in the sediments, possibly due to their relatively fast degradation before the occurrence of other processes such us sorption, flocculation and/or deposition. Bowman *et al*., (2003) reported half-lives from 2.8 to 3 days for E1 and E2. However EE2, with slower degradation rate than natural hormones (Braga *et al*., 2005), has the potential to accumulate and to present high concentrations in sediments. Evaluations of estrogenic hormones in marine biota showed very low concentrations, reflecting the concentrations observed in environment (Gu *et al*., 2016; Emnet *et al*., 2015; Casatta *et al*., 2015; Miège *et al*., 2012; Bouzas *et al*., 2011; Saravanabhavan *et al*., 2009; Pojana *et al*., 2007; Isolbe *et al*., 2007; Cheng *et al*., 2006).

Table 6 presents the occurrence of phthalates in water and sediment from coastal regions. The highest concentrations of phthalates were found in areas near large harbors, quite possibly due to effluents and plastic waste originating from them (Fatoki & Noma, 2001). Urban and industrial effluents from neighboring regions may also have been important sources of phthalates in these regions. As for the other studied EDs, salinity and content of organic matter in the water influence the transfer of phthalates to sediments (Mackintosh *et al*., 2006) or biota (Cheng *et al*., 2013; Bartolomé *et al*., 2010; Dargnat *et al*., 2009). In general, with increasing salinity the balance between the concentrations of phthalates in the sediment and water may be affected. Phthalates can be mobilized and transferred between compartments, besides being degraded through biological processes. The biodegradation processes occur with higher intensity in aerobic conditions. In the anoxic environments biodegradation processes are minimized (Fromme *et al*., 2002). Similarly to other classes of contaminants, phthalates can be stored in anoxic sediments for a long period of time and in medium to large temporal scales sediments may be remobilized and they may act as a source of contaminants.

5. Conclusions

A large variety of emerging contaminants, and among them, those ones which are likely to cause endocrine disruption in some level, are emitted by ever-growing and diverse man-made sources, effectively spreading themselves out to every environmental compartiment throughout the globe. The limited knowledge about the chemistry, transport, toxicity and fate of endocrine disruptors, associated to its wide use in anthropogenic

activities have promoted a growing interest in the development of analytical methods and its applications to study the distribution and behavior of these contaminants in the environment. Yet, problably the quantity of new compounds considered "emerging" or "endocrine disruptors" which has been recently synthetized, developed, and released for use by industrial, farmaceutical, agricultural, and aquicultural sectors are continuously increasing, and faster than analysis systems and analytical methods are possibly progressing. This happens, in part, in order to benefit humanity for increasing its well being conditions, but it also happens for creating substitute molecules for those ones being banned of use because are considered nocive for the environment, biota and/or human beings. However, an important portion of the problem is associated with the accelerated development and registry of new substances without a proper study of their cycle of life (which includes environmental risk evaluation and the development of degradation and removal processes for them), which is time-consuming and cost-effective. So, it is quite possible these new substances are going to be accumulated in the environment soon after they started to be utilized. In spite the recent advances in Analytical Chemistry regarding sample preparation and detection systems for the study of EDs, it is believed that a large amount of micropolutants remain unindentified and undetected in the environment. If they persist unkwown, it is quite possible that identification of sources, transport and fate of these contaminants are underestimated or not existent at all. And, therefore, subsidizing the development of regulatory measures, source control and decision-making to promote the sustainable management of ecosystems and the preservation of the environment and human health is delayed or biased.

Studies around the world indicated that estuaries and coastal regions under the influence of domestic or industrial and WWTP effluents have increasing levels of EDs, and hence this topic needs to be addressed. However, the number of these studies is still very incipient to produce a good diagnosis of the real situation of these contaminants in marine environments. If on one hand this data reflects the relative novelty of this subject, on the other hand the major impediments to the development of this topic is the complexity of marine waters (*i.e.,* high ionic strength, dissolved organic matter and high content of dissolved salts, which are in general the main interfering species in chemical analysis) and the low concentration levels of EDs. These factors represent significant challenges for the coming years. Additionally, it is well accepted conventional water-treatment systems are inefficient to remove EDs from their inffluents, which eventually are realeased to superficial waters and then reaching estuarine and coastal regions. In this way, it becomes necessary the development of new and more efficient water treatment systems, possibly employing advanced oxidative methods or biodegradation by microrganisms (such as bacteria, fungi, enzimes, yeasts, and/or genetically modified organisms) able to break ED molecules down. If new and more adequate WWTP systems are developed, lower levels of residual EDs in the effluents would be reached. In this way, it is possible to a substancial lower amount of EDs could reach coastal areas resulting in the decrease of contamination levels, what could facilitate the management of those areas. In the same direction, the development and application of mitigation and/or remediation of affected areas would alliviate the environmental pressure in regard to EDs to the already impacted regions. New and more studies are needed in these research areas.

It is also urgent the acquisition of robust databases through long-term investigations about EDs behavior and distribution in different compartments and how they participate in food chain in order to access their possible bioaccumulation and/or biomagnification among different trophic levels. The real understanding of ED effects in the aquatic environment is far from understood. In addition, studies about the possible adverse human health effects of endocrine disruptors are scarce. Until robust analytical procedures, with high selectivity and sensitivity could be developed to the analysis of a large number of samples, as it is required in monitoring studies, the behavior of these contaminants in the environment as well as their fate and effects in biota may not be fully understood. Indeed, cause-effect manipulative studies and ecotoxicology tests are still in an embrionary stage of development, and represent a major challenge.

References

Agência Nacional de Vigilância Sanitária (ANVISA); Resolução RE nº 41, 2011.

Aksglaede, L.; Juul, A.; Leffers, H.; Skakkebaek, N. E.; Andersson, A. M. (2006) - The sensitivity of the child to sex steroids: possible impact of exogenous estrogens. *Human Reproduction Update*, 12(4):341-349. DOI:10.1093/humupd/dml018

Ammann, A. A.; Macikova, P.; Groh, K. J.; Schirmer, K.; Suter, M. J. F. (2014) - LC-MS/MS determination of potential endocrine disruptors of cortico signalling in rivers and wastewaters. *Analytical and Bioanalytical Chemistry*, 406(29):7653–7665. DOI: 10.1007/s00216-014-8206-9

Anezaki, K.; Nakano, T. (2015) - Unintentional PCB in chlorophenylsilanes as a source of contamination in environmental samples. *Journal of Hazardous Materials*, *287*:111–7. DOI:10.1016/j.jhazmat.2015.01.026

Antizar-Ladislao, B. (2009) - Polycyclic aromatic hydrocarbons, polychlorinated biphenyls, phthalates and organotins in northern Atlantic Spain's coastal marine sediments. *Journal of Environmental Monitoring*, 11(1):85-91. DOI: 10.1039/b808668k

Anumol, T.; Snyder, S. A. (2015) - Rapid analysis of trace organic compounds in water by automated online solid-phase extraction coupled to liquid chromatography–tandem mass spectrometry. *Talanta*, 132: 77–86. DOI:10.1016/j.talanta.2014.08.011

Arditsoglou, A.; Voutsa, D. (2008a) - Determination of Phenolic and Steroid Endocrine Disrupting Compounds in Environmental Matrices. *Environmental Science and Pollution Research*, 15(3):228-236. DOI: 10.1065/espr2007.12.459

Arditsoglou, A., Voutsa, D. (2008b) - Passive sampling of selected endocrine disrupting compounds using polar organic chemical integrative samplers. *Environmental Pollution*, 156:316–324. DOI:10.1016/j.envpol.2008.02.007

Arditsoglou, A.; Voutsa, D. (2012) - Occurrence and partitioning of endocrine-disrupting compounds in the marine environment of Thermaikos Gulf, Northern Aegean Sea, Greece. *Marine Pollution Bulletin*, 64(11):2443-2452. DOI: 10.1016/j.marpolbul.2012.07.048

Assunção, J. V. de; Pesquero, C. R. (1999) - Dioxinas e furanos: origens e riscos. *Revista de Saúde Pública*, 33(5):523-530. DOI: 10.1590/S0034-89101999000500014

Bach, C.; Dauchy, X.; Chagnon, M.-C.; Etienne, S. (2012) - Chemical compounds and toxicological assessments of drinking water stored in polyethylene terephthalate (PET) bottles: A source of controversy reviewed. *Water Research*, 46(3):571-583. DOI:10.1016/j.watres.2011.11.062

Bartolomé, L.; Etxebarria, N.; Martínez-Arkarazo, I.; Raposo, J. C.; Usobiaga, A.; Zuloaga, O.; Raingerard, D.; Ortiz-Zarragoitia, M.; Cajaraville, M. P. (2010) - Distribution of organic microcontaminants, butyltins, amd metals in mussels from the estuary of Bilbao. *Archives of Environmental Contamination and Toxicology,* 59:244-254. DOI: 10.1007/s00244-009-9458-9

Basheer, C.; Lee, H. K.; Tan, K. S. (2004) - Endocrine disrupting alkylphenols and bisphenol-A in coastal waters and supermarket seafood from Singapore. *Marine Pollution Bulletin*, 48 (11-12):1161-1167. DOI: 10.1016/j.marpolbul.2004.04.009

Bayat, J.; Hashemi, S. H.; Khoshbakht, K.; Deihimfard, R.; Shahbazi, A.; Momeni-Vesalian, R. (2015). Monitoring of polycyclic aromatic hydrocarbons on agricultural lands surrounding Tehran oil refinery. *Environmental Monitoring and Assessment*, *187*(7):451. DOI:10.1007/s10661-015-4646-8

Beausse, J. (2004) - Selected drugs in solid matrices: A review of environmental determination, occurrence and properties of principal substances. *Trends in Analytical Chemistry*, 23:753-761. DOI:10.1016/j.trac.2004.08.005

Beck, I.-C.; Bruhn, R.; Gandrass, J.; Ruck, W. (2005) - Liquid chromatography–tandem mass spectrometry analysis of estrogenic compounds in coastal surface water of the Baltic Sea. *Journal of Chromatography A*, 1090(1-2):98-106. DOI: 10.1016/j.chroma.2005.07.013

Bedia, C.; Dalmau, N.; Jaumot, J.; Tauler, R. (2015) - Phenotypic malignant changes and untargeted lipidomic analysis of long-term exposed prostate cancer cells to endocrine disruptors. *Environmental Research*, 140:18–31. DOI:10.1016/j.envres.2015.03.014

Behera, S. K.; Kim, H. W.; Oh, J.-E.; Park, H.-S. (2011) - Occurrence and removal of antibiotics, hormones and several other pharmaceuticals in wastewater treatment plants of the largest industrial city of Korea. *Science of the Total Environment*, 409(20):4351-4360. DOI:10.1016/j.scitotenv.2011.07.015

Belfroid, A. C.; Van der Horst, A.; Vethaak, A. D.; Schäfer, A. J.; Rijs, G. B.; Wegener, J.; Cofino, W. P. (1999) - Analysis and occurrence of estrogenic hormones and their glucuronides in surface water and waste water in The Netherlands. *Science of the Total Environment*, 225(1-2):101-108. DOI: 10.1016/S0048-9697(98)00336-2

Benjamin, S.; Pradeep, S.; Josh, M. S.; Kumar, S. (2015) - A monograph on the remediation of hazardous phthalates. *Journal of Hazardous Materials,* 298:58-72. DOI: 10.1016/j.jhazmat.2015.05.004

Bergé, A.; Gasperi, J.; Rocher, V.; Gras, L.; Coursimault, A.; Moilleron, R. (2014). Phthalates and alkylphenols in industrial and domestic effluents: case of Paris conurbation (France). *The Science of the Total Environment*, *488-489*(2014):26–35. DOI:10.1016/j.scitotenv.2014.04.081

Bertin, A.; Inostroza, P. A.; Quiñones, R. A. (2011) - Estrogen pollution in a highly productive ecosystem off central-south Chile. *Marine Pollution Bulletin*, 62 (7):1530-1537. DOI:10.1016/j.marpolbul.2011.04.002

Bhandari, A.; Surampalli, R. Y.; Adams, C. D.; Champagne, P.; Ong, S. K.; Tyagi, R. D.; Zhang, T. C. (2009) - Contaminants of Emerging Environmental Concern. 496p., American Society of Civil Engineers; Reston: Virginia, USA. ISBN: 0784472661, 9780784472668.

Bian, H.; Li, Z.; Liu, P.; Pan, J. (2010) - Spatial distribution and deposition history of nonylphenol and bisphenol A in sediments from the Changjiang River (Yangtze River) Estuary and its adjacent East China Sea. *Acta Oceanologica Sinica*, 29(5):44-51. DOI: 10.1007/s13131-010-0062-7

Birch, G. F.; Drage, D. S.; Thompson, K.; Eaglesham, G.; Mueller, J. F. (2015). Emerging contaminants (pharmaceuticals, personal care products, a food additive and pesticides) in waters of Sydney estuary, Australia. Marine Pollution Bulletin, 97(1-2):56–66. DOI: 10.1016/j.marpolbul.2015.06.038

Birkett, J. W.; Lester, J. N. (2003) - Endocrine Disrupters in Wastewater and Sludge Treatment Processes. 285p., CRC Press LLC: Londres, Inglaterra. ISBN: 9781566706018 - CAT# L1601

Boisen, K. A.; Chellakooty, M.; Schmidt, I. M.; Kai, C. M.; Damgaard, I. N.; Suomi, A.-M.; Toppari, J.; Skakkebaek, N. E.; Main, K. M. (2005) - Hypospadias in a Cohort of 1072 Danish Newborn Boys: Prevalence and Relationship to Placental Weight, Anthropometrical Measurements at Birth, and Reproductive Hormone Levels at Three Months of Age. *The Journal of Clinical Endocrinology & Metabolism*, 90(7):4041-4046. DOI: 10.1210/jc.2005-0302

Boitsov, S.; Mjøs, S. A.; Meier, S. (2007) - Identification of estrogen-like alkylphenols in produced water from offshore oil installations. *Marine Environmental Research*, 64(5):651-665. DOI:10.1016/j.marenvres.2007.07.001

Bossio, J. P.; Harry, J.; Kinney, C. (2008) - Application of ultrasonic assisted extraction of chemically diverse organic compounds from soils and sediments. *Chemosphere*, 70(5):858-864. DOI:10.1016/j.chemosphere.2007.06.088

Bouzas, A.; Aguado, D.; Martí, N.; Pastor, J. M.; Herráez, R.; Campins, P.; Seco, A. (2011) - Alkylphenols and polycyclic aromatic hydrocarbons in eastern Mediterranean Spanish coastal marine bivalves. *Environmental Monitoring and Assessment,* 176:169-181. DOI: 10.1007/s10661-010-1574-5

Bovee, T. F. H.; Helsdingen, R. J. R.; Rietjens, I. M. C. M.; Keijer, J.; Hoogenboom, R. L. A. P. (2004) - Rapid yeast estrogen bioassays stably expressing human estrogen receptors α and β, and green fluorescent protein: a comparison of different compounds with both receptor types. *Journal of Steroid Biochemistry & Molecular Biology*, 91(3):99-109. DOI: 10.1016/j.jsbmb.2004.03.118

Bowman, J. C.; Readman, J. W.; Zhou, J. L. (2003) - Sorptionof the natural endocrine disruptors, oestrone and 17β-oestradiol in the

aquatic environment. *Environmental Geochemistry and Health,* 2, 25(1):63-67. DOI: 10.1023/A:1021296831175

Boyle, A. W.; Silvin, C. J.; Hassett, J. P.; Nakas, J. P.; Tanenbaum, S. W. (1992) - Bacterial PCB biodegradation. *Biodegradation*, 3(2):285-298. DOI: 10.1007/BF00129089

Braga, O.; Smythe, G.; Schäfer, I.; Feitz, J. (2005) - Steroid estrogens in ocean sediments. *Chemosphere*, 61(6) 827-833. DOI: 10.1016/j.chemosphere.2005.04.053

Bulayeva, N. N.; Watson, C. S. (2004) - Xenoestrogen-Induced ERK-1 and ERK-2 Activation via Multiple Membrane-Initiated Signaling Pathways. *Environmental Health Perspectives*, 112(15):1481-1487. DOI: 10.1289/ehp.7175

Buttke, D. E.; Sircar, K.; Martin, C. (2012) - Exposures to Endocrine-Disrupting Chemicals and Age of Menarche in Adolescent Girls in NHANES (2003 – 2008). *Environmental Health Perspectives*, 120(11):1613. DOI: 10.1289/ehp.1104748

Cai, M.; Yang, H.; Xie, Z.; Zhao, Z.; Wang, F.; Lu, Z.; Sturm, R.; Ebinghaus, R. (2012a) - Per- and polyfluoroalkyl substances in snow, lake, surface runoff water and coastal seawater in Fildes Peninsula, King George Island, Antarctica. *Journal of Hazardous Materials,* 209-210:335–342. DOI:10.1016/j.jhazmat.2012.01.030

Cai, M.; Zhao, Z.; Yang, H.; Yin, Z.; Hong, Q.; Sturm, R.; Ebinghaus, R.; Ahrens, L.; Cai, M.; He, J.; Xie, Z. (2012b) - Spatial distribution of per- and polyfluoroalkyl compounds in coastal waters from the East to South China Sea. *Environmental Pollution,* 161:162–169. DOI:10.1016/j.envpol.2011.09.045

Carpenter, D. O. (2006) - Polychlorinated Biphenyls (PCBs): Routes of Exposure and Effects on Human Health. *Reviews on Environmental Health*, 21(1):1-23. DOI: 10.1515/REVEH.2006.21.1.1

Casatta, N.; Mascolo, G.; Roscioli, C.; Vigano, L. (2015) - Tracing endocrine disrupting chemicals in a coastal lagoon (Sacca di Goro, Italy): Sediment contamination and bioaccumulation in Manila clams. *Science of the Total Environment,* 511:214-222. DOI: 10.1016/j.scitotenv.2014.12.051

Čeh, K.; Majdič, G. (2010) - Pesticides as endocrine disruptors. Slovenian Veterinary Research, 47, 163. ISSN 1580-4003. Ljubljana, Slovenia. Available: http://www.slovetres.si/index.php/SVR/issue/viewIssue/24/20

Cheng, C.-Y.; Liu, L.-L.; Ding, W.-H. (2006) - Occurrence and seasonal variation of alkylphenols in marine organisms from the coast of Taiwan. *Chemosphere*, 65(11):2152-2159. DOI:10.1016/j.chemosphere.2006.06.017

Cheng, Z.; Nie, X.P.; Wang, H. P.; Wong, M. H. (2013) - Risk assessments of human exposure to bioaccessible phthalate esters through market fish consumption. *Environment International*, 57-58, 75-80. DOI: 10.1016/j.envint.2013.04.005.

Christiansen, S.; Kortenkamp, A.; Axelstad, M.; Boberg, J.; Scholze, M.; Jacobsen, P. R.; Faust, M.; Lichtensteiger, W.; Schlumpf, M.; Burdorf, A.; Hass, U. (2012) - Mixtures of endocrine disrupting contaminants modelled on human high end exposures: an exploratory study in rats. *International journal of andrology*, 35(3):303-316. DOI: 10.1111/j.1365-2605.2011.01242.x

Clapauch, R.; Meirelles, R. M. R.; Julião, M. A. S. G.; Loureiro, C. K. C.; Giarodoli, P. B.; Pinheiro, S. A.; Harrigan, A. R.; Spritzer, P. M.; Pardini, D. P.; Weiss, R. V.; Athayde, A.; Russo, L. A.; Póvoa, L. C. (2002) - Fitoestrogênios: Posicionamento do departamento de endocrinologia feminina da sociedade brasileira de endocrinologia e metabologia (SBEM). *Arquivos Brasileiros de Endocrinologia e Metabologia*, 46(6):679-695. DOI: 10.1590/S0004-27302002000600013

Colin, N.; Porte, C.; Fernandes, D.; Barata, C.; Padrós, F.; Carrassón. M.; Monroy, M.; Cano-Rocabayera, O.; Sostoa, A.; Piña, B.; Maceda-Veiga, A. (2016) - Ecological relevance of biomarkers in monitoring studies of macro-vertebrates and fish in Mediterranean rivers. *Science of the Total Environment*, 540:307-323. DOI: 10.1016/j.scitotenv.2015.06.099

Colón, I.; Doris, C.; Bourdony, C. J.; Rosario, O. (2000) - Identification of pthalate esters in girls with premature breast development. *Environmental Health Perspectives*, 108(9):895-900. DOI: 10.1289/ehp.00108895

Cunha, B. B.; Botero, W. G.; Oliveira, L. C.; Carlos, V. M.; Pompêo, M. L. M.; Fraceto, L. F.; Rosa, A. H. (2012) - Kinetics and Adsorption Isotherms of Bisphenol A, Estrone, 17β-Estradiol, and 17α-Ethinylestradiol in Tropical Sediment Samples. Water, Air, & Soil Pollution, 223(1):329-336. DOI: 10.1007/s11270-011-0861-2

D'Ascenzo, G.; Di Corcia, A.; Gentili, A.; Mancini, R.; Mastropasqua, R.; Nazzari, M.; Samperi, R. (2003) - Fate of natural estrogen conjugates in municipal sewage transport and treatment facilities. Science of the Total Environment, 302(1-3):199-209. DOI: 10.1016/S0048-9697(02)00342-X

Da Rocha, G. O.; Lopes, W. A.; Pereira, P. A. D. P.; Vasconcellos, P. de C.; Oliveira, F. S.; Carvalho, L. S.; Conceição, L. dos S.; Andrade, J. B. D. (2009) - Quantification and Source Identification of Atmospheric Particulate Polycyclic Aromatic Hydrocarbons and their Dry Deposition Fluxes at Three Sites in Salvador Basin, Brazil, Impacted by Mobile and Stationary Sources. *Journal of the Brazilian Chemical Society*, 20(4):680-692. DOI: 10.1590/S0103-50532009000400012

Dargnat, C.; Teil, M.-J.; Chevreuil, M.; Blanchard, M. (2009) - Phthalate removal throughout wastewater treatment plant Case study of Marne Aval station (France). *Science of the Total Environment*, 407(4):1235-1244. DOI: 10.1016/j.scitotenv.2008.10.027.

Darnerud, P. O. (2008) - Brominated flame retardants as possible endocrine disrupters. International journal of andrology, 31(2):152-160. DOI: 10.1111/j.1365-2605.2008.00869.x.

David, A.; Fenet, H.; Gomez, E. (2009) - Alkylphenols in marine environments: Distribution monitoring strategies and detection considerations. Marine Pollution Bulletin, 58(7):953-960. DOI:10.1016/j.marpolbul.2009.04.021

De la Cruz, N.; Giménez, J.; Esplugas, S.; Grandjean, D.; de Alencastro, L. F.; Pulgarín, C. (2012) - Degradation of 32 emergent contaminants by UV and neutral photo-fenton in domestic wastewater effluent previously treated by activated sludge. *Water research*, 46(6):1947-1957. DOI: 10.1016/j.watres.2012.01.014

De los Ríos, A.; Juanes, J.; Ortiz-Zarragoitia, M.; López de Alda, M.; Barceló, D.; Cajaraville, M. P. (2012) - Assessment of the effects of a marine urban outfall discharge on caged mussels using chemical and biomarker analysis. *Marine Pollution Bulletin*, 64(3):563-573. DOI:10.1016/j.marpolbul.2011.12.018

Deblonde, T.; Cossu-leguille, C.; Hartemann, P. (2011) - Emerging pollutants in wastewater : A review of the literature. *The International Journal of Hygiene and Environmental Health*, 214:442–448. DOI:10.1016/j.ijheh.2011.08.002

Dévier, M.-H., Labadie, P., Togola, A., Budzinski, H. (2010). Simple methodology coupling microwave-assisted extraction to SPE/GC/MS for the analysis of natural steroids in biological tissues:

application to the monitoring of endogenous steroids in marine mussels Mytilus sp. Analytica Chimica Acta, 657(1):28–35. DOI: 10.1016/j.aca.2009.10.023

Diamanti-Kandarakis, E.; Bourguignon, J.-P.; Giudice, L. C.; Hauser, R.; Prins, G. S.; Soto, A. M.; Zoeller, R. T.; Gore, A. C. (2009) - Endocrine-Disrupting Chemicals: An Endocrine Society Scientific Statement. *Endocrine Reviews*, 30(4): 293-342. DOI: 10.1210/er.2009-0002

Diehl, J.; Johnson, S. E.; Xia, K.; West, A.; Tomanek, L. (2012) - The distribution of 4-nonylphenol in marine organisms of North American Pacific Coast estuaries. *Chemosphere*, 87(5):490-497. DOI:10.1016/j.chemosphere.2011.12.040

Dodds, E. C.; Lawson, W. (1936) - Synthetic OEstrogenic Agents without the Phenanthrene Nucleus. *Nature*, 137(3476): 996. DOI: 10.1038/137996a0

Dodds, E. C.; Lawson, W. (1938) - Molecular Structure in Relation to Oestrogenic Activity. Compounds without a Phenanthrene Nucleus. *Proceedings of the Royal Society B*, 125(839):222-232. DOI: 10.1098/rspb.1938.0023

Duan, X.; Li, Y.; Li, X.; Zhang, D.; Gao, Y. (2014) - Alkylphenols in surface sediments of the Yellow Sea and East China Sea inner shelf: Occurrence, distribution and fate. *Chemosphere*, 107: 265–273. DOI: 10.1016/j.chemosphere.2013.12.054

Dzieweczynski, T. L.; Buckman, M. C. (2013) - Acute exposure to 17α-ethinylestradiol disrupts audience effects on male–male interactions in Siamese fighting fish, Betta splendens. *Hormones and Behavior*, 63(3):497-502. DOI: 10.1016/j.yhbeh.2013.01.002

Ebinghaus, R.; Xie, Z. (2006) - Occurrence and air sea-exchange of novel organic pollutants in the marine environment. *Journal de Physique IV*, 139:211-237 DOI: 10.1051/jp4:2006139016

Emnet, P., Gaw, S., Northcott, G., Storey, B., Graham, L. (2015). Personal care products and steroid hormones in the Antarctic coastal environment associated with two Antarctic research stations, McMurdo Station and Scott Base. Environmental Research, 136:331–342. http://doi.org/10.1016/j.envres.2014.10.019

EPA (1997) - Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis. Environmental Protection Agency, US EPA/630/R-96/012, February 1997.

Eriksson, P.; Jakobsson, E.; Fredriksson, A. (2001) - Brominated Flame Retardants: A Novel Class of Developmental Neurotoxicants in Our Environment? *Environmental Health Perspectives*, 109(9):903-908. DOI: 10.1289/ehp.01109903

Esteban, S.; Moreno-Merino, L.; Matellanes, R.; Catalá, M.; Gorga, M.; Petrovic, M.; Lopez de Alda, M.; Barceló, D.; Silva, A.; Duran, J. J.;Lopez-Martinez, J.; Valcarcel, Y. (2016) - Presence of endocrine disruptors in freshwater in the northern Antarctic Peninsula region. *Environmental Research*, 147:179-192. DOI: 10.1016/j.envres.2016.01.034.

Farajzadeh, M. A.; Nouri, N.; Khorram, P. (2014) - Derivatization and microextraction methods for determination of organic compounds by gas chromatography. *Trends in Analytical Chemistry*, 55:14-23. DOI: 10.1016/j.trac.2013.11.006

Farré, M.; Kantiani, L.; Petrovic, M.; Pérez, S.; Barceló, D. (2012) - Achievements and future trends in the analysis of emerging organic contaminants in environmental samples by mass spectrometry and bioanalytical techniques. *Journal of Chromatography A*, 1259:86-99. DOI: 10.1016/j.chroma.2012.07.024

Farré, M.; Pérez, S.; Gonçalves, C.; Alpendurada, M. F.; Barceló, D. (2010) - Green analytical chemistry in the determination of organic pollutants in the aquatic environment. *Trends in Analytical Chemistry*, 29(11):1347-1362. DOI: 10.1016/j.trac.2010.07.016

Fasano, E.; Bono-Blay, F.; Cirillo, T.; Montuori, P.; Lacorte, S. (2012) - Migration of phthalates, alkylphenols, bisphenol A and di(2-ethylhexyl)adipate from food packaging. *Food Control*, 27(1): 132-138. DOI: 10.1016/j.foodcont.2012.03.005

Fatoki, O. S.; Noma, A. (2001) - Determination of Phthalate Esters in the Aquatic Environment. *South African Journal of Chemistry*, 54: 69-83. ISSN: 0379-4350, South African. Available: http://reference.sabinet.co.za/webx/access/electronic_journals/chem/chem_v54_a4.pdf

Ferguson, P. L.; Iden, C. R.; Brownawell, B. J. (2000) - Analysis of alkylphenol ethoxylate metabolites in the aquatic environment using liquid chromatography-electrospray mass spectrometry. *Analytical Chemistry*, 72(18):4322–4330. DOI: 10.1021/ac000342n

Ferguson, P. L.; Iden, C. R.; Brownawell, B. J. (2001) - Distribution and Fate of Neutral Alkylphenol Ethoxylate Metabolites in a Sewage-Impacted Urban Estuary. *Environmental Science & Technology*, 35(12):2428-2435. DOI: 10.1021/es001871b

Ferrara, F.; Ademollo, N.; Delise, M.; Fabietti, F.; Funari, E. (2008) - Alkylphenols and their ethoxylates in seafood from the Tyrrhenian Sea. *Chemosphere*, 72(9):1279–1285. DOI: 10.1016/j.chemosphere.2008.04.060

Fisher, M. M.; Eugster, E. A. (2014) - What is in our environment that effects puberty? *Reproductive Toxicology*, 44:7-14. DOI: 10.1016/j.reprotox.2013.03.012.

Foster, P. M. D. (2006) - Disruption of reproductive development in male rat offspring following in utero exposure to phthalate esters. *International Journal of Andrology*, 29(1):140–147. DOI:10.1111/j.1365-2605.2005.00563.x

Foster, P. M.; Mylchreest, E.; Gaido, K. W.; Sar, M. (2001) - Effects of phthalate esters on the developing reproductive tract of male rats. *Human Reproduction Update*, 7:231–235. DOI: 10.1093/humupd/7.3.231

Fromme, H.; Teitelbaum, S. L.; Pinney, S. M.; Windham, G.; Liao, L.; Biro, F.; Kushi, L. H.; Erdmann, C.; Hiatt, R. A.; Rybak, M. E.; Calafat, A. M. (2002) - Occurrence of phthalates and bisphenol A and F in the environment. *Water Research*, 36(6):1429–1438. DOI: 10.1016/S0043-1354(01)00367-0

Frye, C. A.; Bo, E.; Calamandrei, G.; Calzà, L.; Dessì-fulgheri, F.; Fernández, M.; Fusani, L.; Kah, O.; Kajta, M.; Le Page, Y.; Patisaul, H. B.; Venerosi, A.; Wojtowicz, A. K.; Panzica, G. C. (2011) -Endocrine disrupters: a review of some sources, effects, and mechanisms of actions on behaviour and neuroendocrine systems. *Journal of Neuroendocrinology*, 24(1):144–159. DOI: 10.1111/j.1365-2826.2011.02229.x

Fu, M.; Li, Z.; Gao, H. (2007) - Distribution characteristics of nonylphenol in Jiaozhou Bay of Qingdao and its adjacent rivers. *Chemosphere*, 69(7):1009–1016. DOI: 10.1016/j.chemosphere.2007.04.061

Funakoshi, G.; Kasuya, S. (2009) - Influence of an estuary dam on the dynamics of bisphenol A and alkylphenols. *Chemosphere*, 75(4):491–497. DOI: 10.1016/j.chemosphere.2008.12.050.

Gagné, F.; Blaise, C.; Pellerin, J.; Gauthier-Clerc, S. (2002) - Alteration of the biochemical properties of female gonads and vitellins in the clam Mya arenaria at contaminated sites in the Saguenay Fjord. *Marine Environmental Research*, 53(3):295–310. DOI: 10.1016/S0141-1136(01)00122-2

Garcia-Jares, C.; Regueiro, J.; Barro, R.; Dagnac, T.; Llompart,

M. (2009) - Analysis of industrial contaminants in indoor air. Part 2. Emergent contaminants and pesticides. *Journal of Chromatography A*,1216(3):567–597. DOI: 10.1016/j.chroma.2008.10.020

Gärtner, S.; Balski, M.; Koch, M.; Nehls, I. (2009) - Analysis and migration of phthalates in infant food packed in recycled paperboard. *Journal of Agricultural and Food Chemistry*, 57(22):10675–10681. DOI: 10.1021/jf902683m

Gavala, H. N.; Alatriste-Mondragon, F.; Iranpour, R.; Ahring, B. K. (2003) - Biodegradation of phthalate esters during the mesophilic anaerobic digestion of sludge. *Chemosphere*, 52(10):673–682. DOI: 10.1016/S0045-6535(03)00126-7

Gavrilescu, M.; Demnerová, K.; Aamand, J.; Agathos, S.; Fava, F. (2015) - Emerging pollutants in the environment: Present and future challenges in biomonitoring, ecological risks and bioremediation. *New Biotechnology*, 32:147–156. DOI:10.1016/j.nbt.2014.01.001

Gereckea, A. C.; Schmid, P.; Bogdal, C.; Kohler, M.; Zennegg, M.; Heeb, N. V. (2008) - Brominated Flame Retardants – Endocrine-Disrupting Chemicals in the Swiss Environment. *Chimia*, 62(6):352-357. DOI: 10.2533/chimia.2008.352

Ghiselli, G.; Jardim, W. F. (2007) - Interferentes endócrinos no ambiente. *Quimíca Nova*, 30(3):695-706. DOI: 10.1590/S0100-40422007000300032

Gómez-Hens, A.; Aguilar-Caballos, M. (2003) - Social and economic interest in the control of phthalic acid esters. *Trends in Analytical Chemistry*, 22(11):847–857. DOI: 10.1016/S0165-9936(03)01201-9

Grassi, M.; Rizzo, L.; Farina, A. (2013) - Endocrine disruptors compounds, pharmaceuticals and personal care products in urban wastewater: implications for agricultural reuse and their removal by adsorption process. *Environmental Science and Pollution Research*, 20(6):3616- 3628. DOI: 10.1007/s11356-013-1636-7.

Gray, L. E.; Wilson, V. S.; Stoker, T.; Lambright, C.; Furr, J.; Noriega, N.; Howdeshell, K.; Ankley, G. T.; Guillette, L. (2006) - Adverse effects of environmental antiandrogens and androgens on reproductive development in mammals. *International Journal of Andrology*, 29(1):96-104. DOI: 10.1111/j.1365-2605.2005.00636.x

Grigoriadou, A.; Schwarzbauer, J.; Georgakopoulos, A. (2008) - Molecular indicators for pollution source identification in marine and terrestrial water of the industrial area of Kavala city, North Greece. *Environmental Pollution*, 151(1):231–242. DOI: 10.1016/j.envpol.2007.01.053

Grist, E. P. M.; Wells, N. C.; Whitehouse, P.; Brighty, G.; Crane, M. (2003) - Estimating the effects of 17alpha-ethinylestradiol on populations of the fathead minnow Pimephales promelas: are conventional toxicological endpoints adequate? *Environmental Science & Technology*, 37(8):1609–1616. DOI: 10.1021/es020086r

Gu, Y.; Yu, J.; Hu, X.; Yin, D. (2016) - Characteristics of the alkylphenol and bisphenol A distributions in marine organisms and implications for human health: A case study of the East China Sea. *Science of the Total Environment*, 539:460-469. DOI: 10.1016/j.scitotenv.2015.09.011.

Hampl, R.; Kubátová, J.; Stárka, L. (2016) - Steroids and endocrine disruptors—History, recent state of art and open questions. *The Journal of Steroid Biochemistry and Molecular Biology*, 155(Part B): 217-223. DOI: 10.1016/j.jsbmb.2014.04.013.

Hashimoto, S.; Ueda, Y.; Kurihara, R.; Shiraishi, F. (2007) - Comparison of the estrogenic activities of seawater extracts from Suruga Bay, Japan, based on chemical analysis or bioassay. *Environmental Toxicology and Chemistry*, 26(2):279–286. DOI: 10.1897/05-689R1.1

Hashimoto, Y.; Kawaguchi, M.; Miyazaki, K.; Nakamura, M. (2003) - Estrogenic activity of tissue conditioners in vitro. *Dental Materials*, 19(4):341-346. DOI:10.1016/S0109-5641(02)00064-7

Hassanzadeh, N.; Esmaili Sari, A.; Khodabandeh, S.; Bahramifar, N. (2014) - Occurrence and distribution of two phthalate esters in the sediments of the Anzali wetlands on the coast of the Caspian Sea (Iran). *Marine Pollution Bulletin*, 89(1-2):128–135. DOI: 10.1016/j.marpolbul.2014.10.017

Heemken, O. P.; Reincke, H.; Stachel, B.; Theobald, N. (2001) - The occurrence of xenoestrogens in the Elbe river and the North Sea. *Chemosphere*, 45(3):245–259. DOI:10.1016/S0045-6535(00)00570-1

Herrera-Herrera, A. V.; Asensio-Ramos, M.; Hernández-Borges, J.; Rodríguez-Delgado, M. Á. (2010) - Dispersive liquid-liquid microextraction for determination of organic analytes. *Trends in Analytical Chemistry*, 29 (7):728-751. DOI: 10.1016/j.trac.2010.03.016

Heudorf, U.; Mersch-Sundermann, V.; Angerer, J. (2007) - Phthalates: toxicology and exposure. *International Journal of Hygiene and Environmental Health*, 210(5):623-634. DOI: 10.1016/j.ijheh.2007.07.011

Hirai, N.; Nanba, A.; Koshio, M.; Kondo, T.; Morita, M.; Tatarazako, N. (2006) - Feminization of Japanese medaka (Oryzias latipes) exposed to 17 beta-estradiol: Effect of exposure period on spawning performance in sex-transformed females. *Aquatic Toxicology*, 79(3):288–295. DOI: 10.1016/j.aquatox.2006.06.018

Horn, O.; Nalli, S.; Cooper, D.; Nicell, J. (2004) - Plasticizer metabolites in the environment. *Water Research*, 38(17):3693–3698. DOI: 10.1016/j.watres.2004.06.012

Hotta, Y.; Hosoda, A.; Sano, F.; Wakayama, M.; Niwa, K.; Yoshikawa, H.; Tamura, H. (2010) - Ecotoxicity by the biodegradation of alkylphenol polyethoxylates depends on the effect of trace elements. Journal of Agricultural and Food Chemistry, 58(2):1062–1067. DOI: 10.1021/jf902772m

Huerta, B., Jakimska, A., Llorca, M., Ruhí, A., Margoutidis, G., Acuña, V., Sabater, S. (2015). Development of an extraction and purification method for the determination of multi-class pharmaceuticals and endocrine disruptors in freshwater invertebrates, Talanta, 132:373–381. DOI: 10.1016/j.talanta.2014.09.017

Huerta, B., Rodriguez-Mozaz, S., Nannou, C., Nakis, L., Ruhí, A., Acuña, V., Sabater, S., Barcelo, D. (2016). Determination of a broad spectrum of pharmaceuticals and endocrine disruptors in biofilm from a waste water treatment plant-impacted river. Science of the Total Environment, 540, 241–249. DOI: 10.1016/j.scitotenv.2015.05.049

Huyghe, E., Matsuda, T.; Thonneau, P. (2003) - Increasing incidence of testicular cancer worldwide: a review. *Journal of Urology*, 170(1):5–11. DOI: 10.1097/01.ju.0000053866.68623.da

Hwang, C. S.; Kwak, H. S.; Lim, H. J.; Lee, S. H.; Kang, Y. S.; Choe, T. B.; Hur, H. G.; Han, K. O. (2006) - Isoflavone metabolites and their in vitro dual functions: they can act as an estrogenic agonist or antagonist depending on the estrogen concentration. *The Journal of Steroid Biochemistry and Molecular Biology*, 101(4-5):246–253. DOI: 10.1016/j.jsbmb.2006.06.020

Isidori, M.; Lavorgna, M.; Nardelli, A.; Parrella, A. (2006) -

Toxicity on crustaceans and endocrine disrupting activity on Saccharomyces cerevisiae of eight alkylphenols. *Chemosphere*, 64(1):135-143. DOI: 10.1016/j.chemosphere.2005.10.047

Isobe, T.; Nishiyama, H.; Nakashima, A.; Takada, H. (2001) - Distribution and behavior of nonylphenol, octylphenol, and nonylphenol monoethoxylate in Tokyo metropolitan area: their association with aquatic particles and sedimentary distributions. *Environmental Science & Technology*, 35(6):1041–1049. DOI: 10.1021/es001250i

Isobe, T.; Serizawa, S.; Horiguchi, T.; Shibata, Y.; Managaki, S.; Takada, H.; Morita, M.; Shiraishi, H. (2006) - Horizontal distribution of steroid estrogens in surface sediments in Tokyo Bay. *Environmental Pollution*, 144(2):632–638. DOI:10.1016/j.envpol.2006.01.030

Isobe, T.; Takada, H.; Kanai, M. (2007) - Distribution of Polycyclic Aromatic Hydrocarbons (PAHs) and phenolic endocrine disrupting chemicals in South and Southeast Asian mussels. *Environmental Monitoring and Assessment*, 135:423–440. DOI 10.1007/s10661-007-9661-y

Isolbe, T.; Takada, H.; Kanai, M.; Tsutsumi, S.; Isolbe, K. O.; Boonyatumanond, R.; Zakaria M. P. (2007) - Distribution of polycyclic aromatic hydrocarbons (PAHs) and phenolic endocrine disrupting chemicals in South and Southeast Asian mussels. *Environmental Monitoring and Assessment*, 135:423-440. DOI: 10.1007/s10661-007-9661-y

Jakimska, A.; Huerta, B.; Barganska, Z.; Kot-Wasik, A.; Rodríguez-Mozaz, S.; Barceló, D. (2013) - Development of a liquid chromatography–tandem mass spectrometry procedure for determination of endocrine disrupting compounds in fish from Mediterranean rivers. *Journal of Chromatography A*, 1306:44–58. DOI:10.1016/j.chroma.2013.07.050

Jardim, W. F.; Montagner, C. C.; Pescara, I. C.; Umbuzeiro, G. a.; Di Dea Bergamasco, A. M.; Eldridge, M. L.; Sodré, F. F. (2012) - An integrated approach to evaluate emerging contaminants in drinking water. *Separation and Purification Technology*, 84:3-8. DOI: 10.1016/j.seppur.2011.06.020

Johnson, A. C.; Williams, R. J. (2004) - A model to estimate influent and effluent concentrations of estradiol, estrone, and ethinylestradiol at sewage treatment works. *Environmental Science & Technology*, 38(13):3649–3658. DOI: 10.1021/es035342u

Jonkers, N.; Laane, R. W. P. M.; De Voogt, P. (2003) - Fate of nonylphenol ethoxylates and their metabolites in two Dutch estuaries: evidence of biodegradation in the field. *Environmental Science & Technology*, 37(2):321–327. DOI: 10.1021/es020121u

Jonkers, N.; Sousa, A.; Galante-Oliveira, S.; Barroso, C. M.; Kohler, H.-P. E.; Giger, W. (2010) - Occurrence and sources of selected phenolic endocrine disruptors in Ria de Aveiro, Portugal. *Environmental Science and Pollution Research*, 17(4):834–843. DOI: 10.1007/s11356-009-0275-5

Jouannet, P.; Wang, C.; Eustache, F.; Kold-Jensen, T.; Auger, J. (2001) - Semen quality and male reproductive health : the controversy about human sperm concentration decline. *Acta Pathologica Microbiologica et Immunologica Scandinavica*, 109(5):333–344. DOI: 10.1111/j.1600-0463.2001.tb05801.x

Kabir, E. R.; Rhamna, M. S.; Rhanman, I. (2015) - A review on endocrine disruptors and their possible impacts on human health. *Environmental Toxicology and Pharmacolog*, 40:241-258. DOI: 10.1016/j.etap.2015.06.009

Kannan, N.; Yamashita, N.; Petrick, G.; Duinker, J. C. (1998) - Polychlorinated Biphenyls and Nonylphenols in the Sea of Japan. *Environmental Science & Technology*, 32(12):1747–1753. DOI: 10.1021/es970713q

Kardinaal, A. F. M.; Walkens-Berendsen, D. H.; Arts, C. J. M. (1997) - Pseudo-oestrogens in the diet : Health benefits and safety concerns. *Trends in Food Science & Technology*, 8(10):327–333. DOI: 10.1016/S0924-2244(97)01070-4

Kester, M. H. A.; Bulduk, S.; Tirboel, D.; Meinl, W.; Glatt, H.; Falany, C. N.; Coughtrie, M. W. H.; Bergman, A.; Safe, S. H.; Kuiper, G. G. J. M.; Schuur, A.G.; Brouwer, A.; Visser, T. J. (2000) - Potent Inhibition of Estrogen Sulfotransferase by Hydroxylated PCB Metabolites: A Novel Pathway Explaining the Estrogenic Activity of PCBs. *Endocrinology*, 141(5):1897–1900. DOI: 10.1210/endo.141.5.7530

Khim, J. S.; Kannan, K.; Villeneuve, D. L.; Koh, C. H.; Giesy, J. P. (1999) - Characterization and Distribution of Trace Organic Contaminants in Sediment from Masan Bay , Korea: 1. Instrumental Analysis. *Environmental Science & Technology*, 33(23):4199–4205. DOI: 10.1021/es9904484

Kinani, S.; Bouchonnet, S.; Bourcier, S.; Creusot, N. (2008) - Extraction and purification procedures for simultaneous quantification of phenolic xenoestrogens and steroid estrogens in river sediment by gas chromatography/ion trap mass spectrometry. *Rapid Communications in Mass Spectrometry*, 22(22):3651–3661. DOI: 10.1002/rcm.3771

Koh, C.-H.; Khim, J. S.; Villeneuve, D. L.; Kannan, K.; Giesy, J. P. (2006) - Characterization of trace organic contaminants in marine sediment from Yeongil Bay, Korea: 1. *Instrumental Analyses. Environmental Pollution*, 142(1):39–47. DOI: 10.1016/j.envpol.2005.09.005

Koniecko, I.; Staniszewska, M.; Falkowska, L.; Burska, D.; Kielczewska, J.; Jasinska, A. (2014) - Alkylphenols in Surface Sediments of the Gulf of Gdansk (Baltic Sea). *Water Air Soil Pollution*, 225:2040. DOI 10.1007/s11270-014-2040-8

Körner, W.; Hanf, V.; Schuller, W.; Kempter, C.; Metzger, J.; Hagenmaier, H. (1999) - Development of a sensitive E-screen assay for quantitative analysis of estrogenic activity in municipal sewage plant effluents. *Science of the Total Environment*, 225(1-2):33–48. DOI: 10.1016/S0048-9697(99)80015-1

Kumar, K. S.; Sajwan, K. S.; Richardson, J. P.; Kannan, K. (2008) - Contamination profiles of heavy metals, organochlorine pesticides, polycyclic aromatic hydrocarbons and alkylphenols in sediment and oyster collected from marsh/estuarine Savannah GA, USA. *Marine Pollution Bulletin*, 56(1):136–149. DOI: 10.1016/j.marpolbul.2007.08.011

Kurihara, R.; Watanabe, E.; Ueda, Y.; Kakuno, A.; Fujii, K.; Shiraishi, F.; Hashimoto, S. (2007) -Estrogenic activity in sediments contaminated by nonylphenol in Tokyo Bay (Japan) evaluated by vitellogenin induction in male mummichogs (Fundulus heteroclitus). *Marine Pollution Bulletin*, 54(9):1315–1320. DOI:10.1016/j.marpolbul.2007.06.007

Kuster, M.; Azevedo, D. A.; López De Alda, M. J.; Aquino Neto, F. R.; Barceló, D. (2009) - Analysis of phytoestrogens, progestogens and estrogens in environmental waters from Rio de Janeiro (Brazil). *Environment International*, 35(7):997–1003. DOI: 10.1016/j.envint.2009.04.006.

Kuster, M.; José López de Alda, M.; Barceló, D. (2004) - Analysis and distribution of estrogens and progestogens in sewage sludge, soils and sediments. *Trends in Analytical Chemistry*, 23(10–11):790-798. DOI:10.1016/j.trac.2004.08.007.

Labadie, P.; Hill, E. M. (2007) - Analysis of estrogens in river sediments by liquid chromatography–electrospray ionisation

mass spectrometry Comparison of tandem mass spectrometry and time-of-flight mass spectrometry. *Journal of Chromatography A*, 1141(2):174-181. DOI: 10.1016/j.chroma.2006.12.045

Larsen, S. T.; Lund, R. M.; Nielsen, G. D.; Thygesen, P.; Poulsen, O. M. (2002) - Adjuvant effect of di-n-butyl-, di-n-octyl-, di-iso-nonyl- and di-iso-decyl phthalate in a subcutaneous injection model using BALB/c mice. *Pharmacology & Toxicology*, 91(5):264–272. DOI: 10.1034/j.1600-0773.2002.910508.x

Larsson, D. G. J.; Förlin, L. (2002) - Male-biased sex ratios of fish embryos near a pulp mill: temporary recovery after a short-term shutdown. Environmental Health Perspectives, 110(8):739-42. DOI: 10.1289/ehp.02110739

Lathers, C. M.; (2002) - Educational Issues in Clinical Pharmacology: Who Are Our Audiences and What Are TheirSpecialized Needs? One Specialized Need: "Understanding the Role of Veterinary Medicine in Public Health". *The Journal of Clinical Pharmacology*, 42:718-730. DOI: 10.1177/009127002401102669

Laws, S. C.; Carey, S. A.; Ferrell, J. M.; Bodman, G. J.; Cooper, R. L. (2000) - Estrogenic activity of octylphenol, nonylphenol, bisphenol A and methoxychlor in rats. *Toxicological Sciences*, 54(1):154–167. DOI: 10.1093/toxsci/54.1.154

Lee, C.-C.; Jiang, L.-Y.; Kuo, Y.-L.; Chen, C.-Y.; Hsieh, C.-Y.; Hung, C.-F.; Tien, C.-J. (2015) - Characteristics of nonylphenol and bisphenol A accumulation by fish and implications for ecological and human health. *Science of the Total Environment*, 502:417-425. DOI: 10.1016/j.scitotenv.2014.09.042.

Lee, H.-R.; Choi, K.-C. (2013) - 4-tert-Octylphenol stimulates the expression of cathepsins in human breast cancer cells and xenografted breast tumors of a mouse model via an estrogen receptor-mediated signaling pathway. *Toxicology*, 304:13–20. DOI: 10.1016/j.tox.2012.10.012

Legler, J.; Brouwer, A. (2003) - Are brominated flame retardants endocrine disruptors? *Environment International*, 29(6):879–885. DOI:10.1016/S0160-4120(03)00104-1

Li, D.; Dong, M.; Shim, W. J.; Hong, S. H.; Oh, J.-R.; Yim, U. H.; Jeung, J. H.; Kanan, N.; Kim, E. S.; Cho, S. R. (2005) - Seasonal and spatial distribution of nonylphenol and IBP in Saemangeum Bay, Korea. *Marine Pollution Bulletin*, 51(8-12):966–974. DOI: 10.1016/j.marpolbul.2004.11.006

Li, D.; Dong, M.; Shim, W. J.; Yim, U. H.; Hong, S. H.; Kannan, N. (2008) - Distribution characteristics of nonylphenolic chemicals in Masan Bay environments, Korea. *Chemosphere*, 71(6):1162–1172. DOI: 10.1016/j.chemosphere.2007.10.023

Li, W.C. (2014) - Occurrence, sources, and fate of pharmaceuticals in aquatic environment and soil. *Environmental Pollution*, 187C:193–201. DOI:10.1016/j.envpol.2014.01.015

Liang, D.-W.; Zhang, T.; Fang, H. H. P.; He, J. (2008) - Phthalates biodegradation in the environment. *Applied Microbiology and Biotechnology*, 80(2):183–198. DOI: 10.1007/s00253-008-1548-5

Lintelmann, J.; Katayama, A.; Kurihara, N.; Shore, L.; Wenzel, A. (2003) - Endocrine disruptors in the environment (IUPAC Technical Report). *Pure and Applied Chemistry*, 75(5):631–681. DOI: 10.1351/pac200375050631

Lisboa, N. S.; Fahning, C. S.; Cotrim, G.; Anjos, J. P.; Andrade, J. B.; Hatje, V.; Da Rocha, G. O. (2013) - A simple and sensitive UFLC-fluorescence method for endocrine disrupters determination in marine waters. Talanta, 117:168–175. DOI: 10.1016/j.talanta.2013.08.006

Liu, C.; Kolarik, B.; Gunnarsen, L.; Zhang, Y. (2015). C-Depth Method to Determine Diffusion Coefficient and Partition Coefficient of PCB in Building Materials. *Environmental Science & Technology*, *49*(20):12112–9. DOI:10.1021/acs.est.5b03352

Liu, J.; Wang, R. ; Huang, B.; Lin, C.; Zhou, J.; Pan, X. (2012) - Biological effects and bioaccumulation of steroidal and phenolic endocrine disrupting chemicals in high-back crucian carp exposed to wastewater treatment plant effluents. *Environmental Pollution*, 162:325-331. DOI:10.1016/j.envpol.2011.11.036

Locatelli, M., Sciascia, F., Cifelli, R., Malatesta, L., Bruni, P., Croce, F. (2016). Analytical methods for the endocrine disruptor compounds determination in environmental water samples. Journal of Chromatography A, 1434:1–18. DOI: 10.1016/j.chroma.2016.01.034

Loos, R.; Wollgast, J.; Castro-Jiménez, J.; Mariani, G.; Huber, T.; Locoro, G.; Hanke, G.; Umlauf, G.; Bidoglio, G.; Hohenblum, P.; Moche, W.; Weiss, S.; Schmid, H.; Leiendecker, F.; Ternes, T.; Ortega, a. N.; Hildebrandt, A.; Barceló, D.; Lepom, P.; Dimitrova, I.; Nitcheva, O.; Polesello, S.; Valsecchi, S.; Boutrup, S.; Sortkjaer, O.; de Boer, R.; Staeb, J. (2008) - Laboratory intercomparison stud for the analysis of nonylphenol and octylphenol in river water. *Trends in Analytical Chemistry*, 27(1):89-95. DOI: 10.1016/j.trac.2007.10.011

Lu, C. (2009) - Prediction of environmental properties in water-soil-air systems for phthalates. Bulletin of Environmental Contamination and Toxicology, 83(2):168–173. DOI: 10.1007/s00128-009-9728-2

Luzio, A.; Monteiro, S. M.; Rocha, E.; Fontainhas-Fernandes, A. A.; Coimbra, A. M. (2016) - Development and recovery of histopathological alterations in the gonads of zebrafish (*Danio rerio*) after single and combined exposure to endocrine disruptors (17α-ethinilestradiol and fadrozole). *Aquatic Toxicology*, 175:90-105. DOI: 10.1016/j.aquatox.2016.03.014.

Ma, T., Teng, Y., Christie, P., Luo, Y., Chen, Y., Ye, M., Huang, Y. (2013). A new procedure combining GC-MS with accelerated solvent extraction for the analysis of phthalic acid esters in contaminated soils. *Frontiers of Environmental Science & Engineering*, 7(1):31–42. DOI: 10.1007/s11783-012-0463-2

Mackintosh, C. E.; Maldonado, J. A.; Ikonomou, M. G.; Gobas, F. A. P. C. (2006) - Sorption of phthalate esters and PCBs in a marine ecosystem. *Environmental Science & Technology*, 40(11):3481–3488. DOI: 10.1021/es0519637

Macon, M. B.; Fenton, S. E. (2013) - Endocrine Disruptors and the Breast: Early Life Effects and Later Life Disease. *Journal Mammary Gland Biology and Neoplasia*, 18(1):43. DOI: 10.1007/s10911-013-9275-7

Maggioni, S.; Balaguer, P.; Chiozzotto, C.; Benfenati, E. (2013) - Screening of endocrine-disrupting phenols, herbicides, steroid estrogens, and estrogenicity in drinking water from the waterworks of 35 Italian cities and from PET-bottled mineral water. *Environmental Science and Pollution Research International*, 20(3):1649–1660. DOI: 10.1007/s11356-012-1075-x

Main, K. M.; Skakkebaek; N. E., Virtanen, H. E.; Toppari, J. (2010) - Genital anomalies in boys and the environment. Best Practice & Research. *Clinical Endocrinology & Metabolism*, 24(2):279–89. DOI:10.1016/j.beem.2009.10.003

Mandich, A.; Bottero, S.; Benfenati, E.; Cevasco, A.; Erratico, C.; Maggioni, S.; Massari, A.; Pedemonte, F.; Viganò, L (2007) - In vivo exposure of carp to graded concentrations of bisphenol A. *General and Comparative Endocrinology*, *153*(1-3):15–24. DOI:10.1016/j.ygcen.2007.01.004

Mankidy, R.; Ranjan, B.; Honaramooz, A.; Giesy, J. P. (2013a) - Effects of novel brominated flame retardants on steroidogenesis in

primary porcine testicular cells. *Toxicology Letters*, 224(13):141–146. DOI: 10.1016/j.toxlet.2013.10.018

Mankidy, R.; Wiseman, S.; Ma, H.; Giesy, J. P. (2013b) - Biological impact of phthalates. *Toxicology Letters*, 217(1):50–58. DOI: 10.1016/j.toxlet.2012.11.025

Markey, C. M.; Luque, E. H.; Munoz De Toro, M.; Sonnenschein, C.; Soto, A. M. (2001) - In utero exposure to bisphenol A alters the development and tissue organization of the mouse mammary gland. *Biology of Reproduction*, 65:1215-1223. DOI: 10.1043/0006-363(2001)065<1215:IUETBA>2.0.CO;2

Martino-Andrade, A. J.; Chahoud, I. (2010) - Reproductive toxicity of phthalate esters. *Molecular Nutrition & Food Research*, 54(1):148–157. DOI: 10.1002/mnfr.200800312

Marx-Stoelting, P'.; Niemann, L.; Ritz, V.; Ulbrich, B.; Gall, A.; Hirsch-Ernst, K. I.; Pfeil, R.; Solecki, R. (2014) - Assessment of three approaches for regulatory decision making on pesticides with endocrine disrupting properties. *Regulatory Toxicology and Pharmacology*, 70(3):590-604. DOI: 10.1016/j.yrtph.2014.09.001.

Matějíček, D. (2011) - On-line two-dimensional liquid chromatography-tandem mass spectrometric determination of estrogens in sediments. *Journal of Chromatography A*, 1218(16):2292–2300. DOI: 10.1016/j.chroma.2011.02.041

Melo, S. M.; Brito, N. M. (2014) - Analysis and Occurrence of Endocrine Disruptors in Brazilian Water by HPLC-Fluorescence Detection. *Water Air Soil Pollution*, 225:1783. DOI: 10.1007/s11270-013-1783-y

Menzies, R.; Quinete, N. S.; Gardinali, P.; Seba, D. (2013) - Baseline occurrence of organochlorine pesticides and other xenobiotics in the marine environment: Caribbean and Pacific collections. *Marine Pollution Bulletin*, 70(1-2):289–295. DOI: 10.1016/j.marpolbul.2013.03.003

Miège, C.; Peretti, A.; Labadie, P.; Budzinski, H.; Le Bizec, B.; Vorkamp, K.; Tronczynski, J.; Persat, H.; Coquery, M.; Babut, M. (2012) - Occurrence of priority and emerging organic compounds in fishes from the Rhone River (France). *Analytical and Bioanalytical Chemistry*, 404:2721-2735. DOI: 10.1007/s00216-012-6187-0.

Milligan, S. R.; Balasubramanian, A. V.; Kalita, J. C. (1998) - Relative potency of xenobiotic estrogens in an acute in vivo mammalian assay. *Environmental Health Perspective*, 106(1): 23–26. DOI: 10.1289/ehp.9810623

Mnif, W.; Hassine, A. I. H.; Bouaziz, A.; Bartegi, A.; Thomas, O.; Roig, B. (2011) - Effect of endocrine disruptor pesticides: A review. *International Journal of Environmental Research and Public Health,* 8(6):2265–2303. DOI: 10.3390/ijerph8062265

Monteagudo, C.; Mariscal-Arcas, M'; Heras-Gonzalez, L.; Ibanez-Peinado, D.; Rivas, A.; Olea-Serrano, F. (2016) - Effects of maternal diet and environmental exposure to organochlorine pesticides on newborn weight in Southern Spain. *Chemosphere*, 156:135-142. DOI: 10.1016/j.chemosphere.2016.04.103.

Moss, G. P. (1989) - Nomenclature of steroids. *Pure and Applied Chemistry*, 61(10):1783–1822. DOI: 10.1351/pac198961101783

Muñoz-de-Toro, M.; Markey, C. M.; Wadia, P. R.; Luque, E. H.; Rubin, B. S.; Sonnenschein, C.; Soto, A. M. (2005) - Perinatal exposure to bisphenol-A alters peripubertal mammary gland development in mice. *Endocrinology*, 146(9):4138-4147. DOI: 10.1210/en.2005-0340

Nalli, S., Cooper, D. G.; Nicell, J. A. (2002) - Biodegradation of plasticizers by Rhodococcus rhodochrous. *Biodegradation*, 13(5):343–352. DOI: 10.1023/A:1022313810852

Net, S.; Sempéré, R.; Delmont, A.; Paluselli, A.; Ouddane, B. (2015) - Occurrence, fate, behavior and ecotoxicological state of phthalates in different environmental matrices. *Environmental Science & Technology*, 49:4019-4035. DOI: 10.1021/es505233b

Noppe, H.; Verslycke, T.; De Wulf, E.; Verheyden, K.; Monteyne, E.; Van Caeter, P.; Janssen, C. R.; De brabanderHubert F. (2007a) - Occurrence of estrogens in the Scheldt estuary: A 2-year survey. *Ecotoxicology and Environmental Safety*, 66(1):1-8. DOI: 10.1016/j.ecoenv.2006.04.005

Nurulnadia, M. Y.; Koyama, J.; Uno, S.; Kito, A.; Kokushi, E.; Bacolod, E. T.; Ito, K.; Chuman, Y. (2014) - Accumulation of endocrine disrupting chemicals (EDCs) in the polychaete Paraprionospio sp. from the Yodo River mouth, Osaka Bay, Japan. *Environmental Monitoring and Assessment*, 186(3):1453-1463. DOI: 10.1007/s10661-013-3466-y

Oehlmann, J.; Schulte-Oehlmann, U.; Tillmann, M.; Markert, B. (2000) - Effects of endocrine disruptors on prosobranch snails (Mollusca: Gastropoda) in the laboratory. Part I: Bisphenol A and octylphenol as xeno-estrogens. *Ecotoxicology*, 9(6):383–397. DOI: 10.1023/A:1008972518019

Ortiz-Zarragoitia, M.; Cajaraville, M. P. (2005) - Effects of selected xenoestrogens on liver peroxisomes, vitellogenin levels and spermatogenic cell proliferation in male zebrafish. *Comparative Biochemistry and Physiology*, 141(2):133–144. DOI: 10.1016/j.cca.2005.05.010

Ortiz-Zarragoitia, M.; Cajaraville, M.P. (2006) - Biomarkers of exposure and reproduction-related effects in mussels exposed to endocrine disrupters. *Archives of Environmental Contamination and Toxicology*, 50:361–369. DOI:10.1007/s00244-005-1082-8

Pal, A.; Gin, K. Y.-H.; Lin, A. Y.-C.; Reinhard, M. (2010) - Impacts of emerging organic contaminants on freshwater resources: review of recent occurrences, sources, fate and effects. *Science of the Total Environment*, 408(24):6062–6069. DOI: 10.1016/j.scitotenv.2010.09.026

Palanza, P.; Nagel, S. C.; Parmigiani, S.; vom Saal, F. S. (2016) - Perinatal exposure to endocrine disruptors: sex, timing and behavioral endpoints. *Current Opinion in Behavioral Sciences*, 7:69-75. DOI: 10.1016/j.cobeha.2015.11.017.

Panter, G. H.; Thompson, R. S.; Beresford, N.; Sumpter, J. P. (1999) - Transformation of a non-oestrogenic steroid metabolite to an oestrogenically active substance by minimal bacterial activity. *Chemosphere*, 38(15):3579-3596. DOI: 10.1016/S0045-6535(98)00572-4

Paoli, D.; Giannandrea, F.; Gallo, M.; Turci, R., Cattaruzza, M. S.; Lombardo, F.; Gandini, L. (2015) - Exposure to polychlorinated biphenyls and hexachlorobenzene, semen quality and testicular cancer risk. *Journal of Endocrinological Investigation*, 38(7):745–752. DOI:10.1007/s40618-015-0251-5

Paulozzi, L. J. (1999) - International trends in rates of hypospadias and cryptorchidism. *Environmental Health Perspectives*, 107(4):297–302. DOI: 10.1289/ehp.99107297

Perez, P.; Pulgar, R.; Olea-Serrano, F.; VillaloboS, M.; Rivas, A.; Metzler, M.; Pedraza, V.; Olea, N. (1998) - The estrogenicity of bisphenol A-related diphenylalkanes with various substituents at the central carbon and the hydroxy groups. *Environmental Health Perspectives*, 106(3):167–174. DOI: 10.1289/ehp.98106167

Pérez-Feás, C.; Barciela-Alonso, M. C.; Bermejo-Barrera, P. (2011)

- Presence of phthalates in contact lens and cleaning solutions. *Microchemical Journal*, 99(1):108-113. DOI: 10.1016/j.microc.2011.04.006

Petrovic, M.; Fernández-Alba, A. R.; Borrull, F.; Marce, R. M.; González, M. E.; Barceló, D. (2002) - Occurrence and distribution of nonionic surfactants, their degradation products, and linear alkylbenzene sulfonates in coastal waters and sediments in Spain. *Environmental Toxicology and Chemistry*, 21(1):37–46. DOI: 10.1002/etc.5620210106

Picard, K.; Lhuguenot, J. C.; Lavier-Canivenc, M. C.; Chagnon, M. C. (2001) - Estrogenic activity and metabolism of n-butyl benzyl phthalate in vitro: identification of the active molecule(s). *Toxicology and Applied Pharmacology*, 172(2):108-118. DOI: 10.1006/taap.2001.9141

Pocar, P.; Brevini, T. A. L.; Fischer, B.; Gandolfi, F. (2003) - The impact of endocrine disruptors on oocyte competence. Reproduction, 125(3):313–325. DOI: 10.1530/rep.0.1250313

Pojana, G.; Bonfà, A.; Busetti, F.; Collarin, A.; Marcomini, A. (2004) - Determination of natural and synthetic estrogenic compounds in coastal lagoon waters by HPLC-electrospray-mass spectrometry. *International Journal of Environmental Analytical Chemistry*, 84(10):717–727. DOI: 10.1080/03067310410001729060

Pojana, G.; Gomiero, A.; Jonkers, N.; Marcomini, A. (2007) - Natural and synthetic endocrine disrupting compounds (EDCs) in water, sediment and biota of a coastal lagoon. *Environment International*, 33(7):929–936. DOI: 10.1016/j.envint.2007.05.003

Porte, C.; Janer, G.; Lorusso, L. C.; Ortiz-Zarragoitia, M.; Cajaraville, M. P.; Fossi, M. C.; Canesi, L. (2006) - Endocrine disruptors in marine organisms: approaches and perspectives. *Comparative Biochemistry and Physiology*, 143(3):303–315. DOI: 10.1016/j.cbpc.2006.03.004

Prins, G. S. (2008) - Endocrine disruptors and prostate cancer risk. *Endocrine Related Cancer*, 15(3):649–656. DOI: 10.1677/ERC-08-0043

Puy-Azurmendi, E.; Ortiz-Zarragoitia, M.; Kuster, M.; Martínez, E.; Guillamón, M.; Domínguez, C.; Serrano, T.; Barbero, Mari C.; De Alda, M. L.; Bayona, J. M.; Barceló, D.; Cajaraville, M. P. (2010) - An integrated study of endocrine disruptors in sediments and reproduction-related parameters in bivalve molluscs from the Biosphere's Reserve of Urdaibai (Bay of Biscay). *Marine Environmental Research*, *69*:S63–S66. DOI:10.1016/j.marenvres.2009.10.003

Puy-Azurmendi, E.; Ortiz-Zarragoitia, M.; Villagrasa, M.; Kuster, M.; Aragón, P.; Atienza, J.; Puchades, R.; Maquieira, A.; Domínguez, C.; López De Alda, M.; Fernandes, D.; Porte, C.; Bayona, J. M.; Barceló, D.; Cajaraville, M. P. (2013) - Endocrine disruption in thicklip grey mullet (Chelon labrosus) from the Urdaibai Biosphere Reserve (Bay of Biscay, Southwestern Europe). *Science of the Total Environment*, 443:233–244. DOI: 10.1016/j.scitotenv.2012.10.078

Quednow, K.; Püttmann, W. (2008) - Endocrine disruptors in freshwater streams of Hesse, Germany: changes in concentration levels in the time span from 2003 to 2005. *Environmental Pollution*, 152(2):476–483. DOI: 10.1016/j.envpol.2007.05.032

Queiroz, M. E. C.; Lanças, F. M. (2005) - Análise de fármacos em material biológico: acoplamento microextração em fase sólida "no tubo" e cromatografia líquida de alta eficiência. *Quimica Nova*, 28(5):880-886. DOI: 10.1590/S0100-40422005000500027

Reis Filho, R. W.; Araújo, J. C. de; Vieira, E. M. (2006) - Hormônios sexuais estrógenos: contaminantes bioativos. Quimica Nova, 29(4):817-822. DOI: 10.1590/S0100-40422006000400032.

Renner, R. (1997) - European Bans on Surfactant Trigger Transatlantic Debate. *Environmental Science & Technology*, 31(7):316–320. DOI: 10.1021/es972366q

Ribeiro, C.; Pardal, M. A.; Martinho, F.; Margalho, R.; Tiritan, M. E.; Rocha, E.; Rocha, M. J. (2009) - Distribution of endocrine disruptors in the Mondego River estuary, Portugal. *Environmental Monitoring and Assessment*, 149(1-4):183–193. DOI: 10.1007/s10661-008-0192-y

Richardson, S. D. (2002) - Environmental mass spectrometry: emerging contaminants and current issues. *Analytical Chemistry*, 74(12):2719–2742. DOI: 10.1021/ac020211h

Richardson, S. D. (2012) - Environmental mass spectrometry: emerging contaminants and current issues. *Analytical Chemistry*, 84(2):747-778. DOI: 10.1021/ac202903d

Richardson, S. D.; Ternes, T. A. (2014) - Water analysis: emerging contaminants and current issues. *Analytical Chemistry*, 86(6):2813–2848. DOI:10.1021/ac500508t

Richardson, S.; Ternes, T. A. (2011) - Water Analysis: Emerging Contaminants and Current Issues. *Analytical Chemistry*, 83(12):4614-4648. DOI: 10.1021/ac200915r

Richardson, S.D.; Ternes, T.A. (2015) - Water Analysis: Emerging Contaminants and Current Issues. Analytical Chemistry, 75:3809–3836. DOI:10.1021/ac500508t

Romani, F.; Tropea, A.; Scarinci, E.; Federico, A.; Russo, C. D.; Lisi, L.; Catino, S.; Lanzone, A.; Apa, R. (2014) - Endocrine disruptors and human reproductive failure: the in vitro effect of phthalates on human luteal cells. *Fertility and Sterility*, 102(3):831-837. DOI: 10.1016/j.fertnstert.2014.05.041

Rubio, S.; Pérez-Bendito, D. (2009) - Recent advances in environmental analysis. *Analytical Chemistry*, 81(12):4601–4622. DOI: 10.1021/ac900738s

Rudel, R. A.; Camann, D. E.; Spengler, J. D.; Korn, L. R.; Brody, J. G. (2003) - Phthalates, Alkylphenols, Pesticides, Polybrominated Diphenyl Ethers, and Other Endocrine-Disrupting Compounds in Indoor Air and Dust. *Environmental Science & Technology*, 37(20):4543–4553. DOI: 10.1021/es0264596

Salgueiro-González, N., Turnes-Carou, I., Muniategui-Lorenzo, S., López-Mahía, P., Prada-Rodríguez, D. (2014). Analysis of endocrine disruptor compounds in marine sediments by in cell clean up-pressurized liquid extraction-liquid chromatography tandem mass spectrometry determination. *Analytica Chimica Acta*, 852:112–120. DOI: 10.1016/j.aca.2014.09.041

Salgueiro-González, N.; Concha-Graña, E.; Turnes-Carou, I.; Muniategui-Lorenzo, S.; López-Mahía, P.; Prada-Rodríguez, D. (2012) - Determination of alkylphenols and bisphenol A in seawater samples by dispersive liquid-liquid microextraction and liquid chromatography tandem mass spectrometry for compliance with environmental quality standards (Directive 2008/105/EC). *Journal of Chromatography A*, 1223:1–8. DOI: 10.1016/j.chroma.2011.12.011

Salgueiro-González, N.; Turnes-Carou, I.; Besada, V.; Muniategui-Lorenzo, S.; López-Mahía, P.; Prada-Rodríguez, D. (2015) - Occurrence, distribution and bioaccumulation of endocrine disrupting compounds in water, sediment and biota samples from a European river basin. *Science of the Total Environment*, 529:121–130. DOI:10.1016/j.scitotenv.2015.05.048

Salvador, A.; Moretton, C.; Piram, A.; Faure, R.; (2007) - On-line solid-phase extraction with on-support derivatization for high-

sensitivity liquid chromatography tandem mass spectrometry of estrogens in influent/effluent of wastewater treatment plants. *Journal of Chromatography A*, 1145(1-2):102-109. DOI: 10.1016/j.chroma.2007.01.055

Sánchez-Avila, J.; Fernandez-Sanjuan, M.; Vicente, J.; Lacorte, S. (2011) - Development of a multi-residue method for the determination of organic micropollutants in water, sediment and mussels using gas chromatography-tandem mass spectrometry. *Journal of Chromatography A*, 1218 (38):6799–6811. DOI: 10.1016/j.chroma.2011.07.056

Santos, A. G.; Regis, A. C. D.; da Rocha, G. O.; Bezerra, M. A.; Jesus, R. M.; de Andrade, J. B. (2016) - A simple, comprehensive, and miniaturized solvent extraction method for determination of particulate-phase polycyclic aromatic compounds in air. *Journal of Chromatography A*, 1435:6-17. DOI: 10.1016/j.chroma.2016.01.018.

Santos, L. H. M. L. M.; Araújo, A. N.; Fachini, A.; Pena, A.; Delerue-Matos, C.; Montenegro, M. C. B. S. M. (2010) - Ecotoxicological aspects related to the presence of pharmaceuticals in the aquatic environment. *Journal of Hazardous Materials*, 175(1-3):45–95. DOI: 10.1016/j.jhazmat.2009.10.100

Saravanabhavan, G., Helleur, R.; Hellou, J. (2009) - GC-MS/MS measurement of natural and synthetic estrogens in receiving waters and mussels close to a raw sewage ocean outfall. *Chemosphere*, 76(8):1156–1162. DOI: 10.1016/j.chemosphere.2009.04.006

Sax, L. (2010) - Polyethylene terephthalate may yield endocrine disruptors. *Environmental Health Perspectives*, 118(4):445–448. DOI: 10.1289/ehp.0901253

Scheringer, M.; Jones, K. C.; Matthies, M.; Simonich, S.; Van De Meent, D. (2009) - Multimedia partitioning, overall persistence, and long-range transport potential in the context of POPs and PBT chemical assessments. *Integrated Environmental Assessment and Management*, 5(4):557–576. DOI: 10.1897/IEAM_2009-007.1

Schlenk, D.; Sapozhnikova, Y.; Irwin, M. A.; Xie, L.; Hwang, W.; Reddy, S.; Brownawell, B. J.; Armstrong, J.; Kelly, M.; Montagne, D. E.; Kolodziej, E. P.; Sedlak, D.; Snyder, S. (2005) - In vivo bioassay-guided fractionation of marine sediment extracts from the southern california bight, USA, for estrogenic activity. *Environmental Toxicology and Chemistry*, 24(11):2820–2826. DOI: 10.1897/05-116R.1

Selvaraj, K. K.; Shanmugam, G.; Sampath, S.; Larsson, D. G. J.; Ramaswamy, B. R. (2014) - GC-MS determination of bisphenol A and alkylphenol ethoxylates in river water from India and their ecotoxicological risk assessment. *Ecotoxicology and Environmental Safety*, 99:13–20. DOI: 10.1016/j.ecoenv.2013.09.006

Shan, X. M.; Shen, D. H.; Wang, B. S.; Lu, B. B.; Huang, F. Y. (2014) - Simultaneous determination of bisphenols and alkylphenols in water by solid phase extraction and ultra performance liquid chromatography-tandem mass spectrometry. *Biomedical and Environmental Sciences*, *27*(6):471–4. DOI:10.3967/bes2014.076

Shang, D. Y.; Macdonald, R. W.; Ikonomou, M. G. (1999) - Persistence of Nonylphenol Ethoxylate Surfactants and Their Primary Degradation Products in Sediments from near a Municipal Outfall in the Strait of Georgia, British Columbia, Canada. *Environmental Science & Technology*, 33(9):1366–1372. DOI: 10.1021/es980966z

Shi, J.; Liu, X.; Chen, Q.; Zhang, H. (2014) - Spatial and seasonal distributions of estrogens and bisphenol A in the Yangtze River Estuary and the adjacent East China Sea. *Chemosphere* 111:336–343. DOI: 10.1016/j.chemosphere.2014.04.046

Shimada, K.; Mitamura, K.; Higashi, T. (2001) - Gas chromatography and high-performance liquid chromatography of natural steroids. *Journal of Chromatography A*, 935(1-2):141–172. DOI: 10.1016/S0021-9673(01)00943-8

Soares, A.; Guieysse, B.; Jefferson, B.; Cartmell, E.; Lester, J. N. (2008) - Nonylphenol in the environment: a critical review on occurrence, fate, toxicity and treatment in wastewaters. *Environment International*, 34(7):1033–1049. DOI: 10.1016/j.envint.2008.01.004

Solé, M.; Alda, M. J. L.; Castillo, M.; Porte, C.; Ladegaard-Pedersen, K.; Barceló, D. (2000) - Estrogenicity Determination in Sewage Treatment Plants and Surface Waters from the Catalonian Area (NE Spain). *Environmental Science & Technology*, 34(24):5076–5083. DOI: 10.1021/es991335n

Soto, A M.; Justicia, H.; Wray, J. W.; Sonnenschein, C. (1991) - p-Nonyl-phenol: an estrogenic xenobiotic released from "modified" polystyrene. *Environ Health Perspect*, 92:167–173. DOI: 10.2307/3431154

Soto, A. M.; Sonnenschein, C.; Chung, K. L.; Fernandez, M. F.; Olea, N.; Serrano, F. O. (1995) - The E-SCREEN assay as a tool to identify estrogens: an update on estrogenic environmental pollutants. *Environmental Health Perspectives*, 103(7):113–122. DOI: 10.2307/3432519

Staniszewska, M.; Koniecko, I.; Falkowska, L.; Krzymyk, E. (2015) - Occurrence and distribution of bisphenol A and alkylphenols in the water of the gulf of Gdansk (Southern Baltic). *Marine Pollution Bulletin*, 91(1):372–379. DOI: 10.1016/j.marpolbul.2014.11.027

Stewart, M.; Olsen, G.; Hickey, C. W.; Ferreira, B.; Jelić, A.; Petrović, M.; Barcelo, D. (2014) - A survey of emerging contaminants in the estuarine receiving environment around Auckland, New Zealand. *Science of the Total Environment*. 468–469:202–210. DOI: 10.1016/j.scitotenv.2013.08.039

Sumpter, J. P. (1998) - Xenoendorine disrupters environmental impacts. *Toxicology Letters*, 102-103:337–342. DOI: 10.1016/S0378-4274(98)00328-2

Sun, K.; Jin, J.; Gao, B.; Zhang, Z.; Wang, Z.; Pan, Z.; Xu, D.; Zhao, Y. (2012) - Sorption of 17α-ethinyl estradiol, bisphenol A and phenanthrene to different size fractions of soil and sediment. *Chemosphere*, 88(5):577–583. DOI: 10.1016/j.chemosphere.2012.03.034

Sun, L.; Zang, S. Y.; Sun, H. J. (2014). Sources and history of PAHs in lake sediments from oil-producing and industrial areas, northeast China. *International Journal of Environmental Science and Technology*, *11*(7):2051–2060. DOI:10.1007/s13762-013-0396-8

Sutton, R.; Sedlak, M. D.; Yee, D.; Davis, A. J.; Crane, D.; Grace, R. (2014) - Declines in Polybrominated Diphenyl Ether Contamination of San Francisco Bay following Production Phase-Outs and Bans. *Environmental Science & Techinology*, 49(2):777-84. DOI:10.1021/es503727b.

Talsness, C. E.; Andrade, A. J. M.; Kuriyama, S. N.; Taylor, J. A.; Vom Saal, F. S. (2009) - Components of plastic: experimental studies in animals and relevance for human health. *Philosophical Transactions of the Royal Society B*, 364(1526):2079–2096. DOI: 10.1098/rstb.2008.0281

Tan, B. L. L.; Hawker, D. W.; Müller, J. F.; Leusch, F. D. L.; Tremblay, L. A.; Chapman, H. F. (2007a) - Modelling of the fate of selected endocrine disruptors in a municipal wastewater treatment plant in South East Queensland, Australia. *Chemosphere*, 69(4):644–654. DOI: 10.1016/j.chemosphere.2007.02.057

Tan, B. L. L.; Hawker, D.W.; Müller, J. F.; Leusch, F. D. L.; Tremblay, L. A.; Chapman, H. F. (2007b) - Comprehensive study of endocrine disrupting compounds using grab and passive sampling at selected wastewater treatment plants in South East Queensland, Australia. *Environment International*, 33(5):654–669. DOI: 10.1016/j.envint.2007.01.008

Tata, J. R. (2005) - One hundred years of hormones. *European Molecular Biology Organization*, 6(6):490–496, 2005. DOI: 10.1038/sj.embor.7400444

Thibaut, R.; Porte, C. (2004) - Effects of endocrine disrupters on sex steroid synthesis and metabolism pathways in fish. *The Journal of Steroid Biochemistry and Molecular Biology*, 92(5):485–494. DOI: 10.1016/j.jsbmb.2004.10.008

Thorup, J.; Nordenskjöld, A.; Hutson, J. M. (2014) - Genetic and environmental origins of hypospadias. Current Opinion in Endocrinology, *Diabetes, and Obesity*, 21(3):227–32. DOI:10.1097/MED.0000000000000063

Toppari, J., Kaleva, M.; Virtanen, H. E. (2001) - Trends in the incidence of cryptorchidism and hypospadias, and methodological limitations of registry-based data. *Human Reproduction Update*, 7(3):282-286. DOI: 10.1093/humupd/7.3.282

Torres, N. H., Aguiar, M. M., Ferreira, L. F. R., Américo, J. H. P., Machado, Â. M., Cavalcanti, E. B., Tornisielo, V. L. (2015). Detection of hormones in surface and drinking water in Brazil by LC-ESI-MS/MS and ecotoxicological assessment with Daphnia magna. *Environmental Monitoring and Assessment*, 187:379. DOI: 10.1007/s10661-015-4626-z

Trachsel, M. (2008) - Results of the Consensus Platforms: Positions and Recommendations Derived from Scientific Findings in a Joint Effort of Academics, Industry, and Authorities. *Chimia*, 62(5):432-438. DOI: 10.2533/chimia.2008.432

Tsai, Y.-A.; Lin, C;-L.; Hou, J.-W.; Huang, P.-C.; Lee, M.-C.; Chen, B.-H.; Wu, M.-T.; Chen, C.-C.; Wang, S.-L.; Lee, C.-C.; Hsiung, C. A.; Chen, M.-L. (2016) - Effects of high di(2-ethylhexyl)phthalate (DEHP) exposure due to tainted food intake on pre-pubertal growth characteristics in a Taiwanese population. *Environmental Research*, 149:197-205. DOI: 10.1016/j.envres.2016.05.005.

Tsuda, T.; Takino, A.; Kojima, M.; Harada, H.; Muraki, K.; Tsuji, M. (2000) - 4-Nonylphenols and 4-tert-octylphenol in water and fish from rivers flowing into Lake Biwa. *Chemosphere*, 41(5):757–762. DOI: 10.1016/S0045-6535(99)00465-8

Valdés, M. E., Marino, D. J., Wunderlin, D. A. Somoza, G. M. Ronco, A. E. Carriquiriborde, P. (2015). Screening concentration of E1, E2 and EE2 in sewage effluents and surface waters of the "Pampas" region and the "Rio de la Plata" estuary (Argentina). Bulletin of Environmental Contamination and Toxicology, 94(1):29–33. DOI: 10.1007/s00128-014-1417-0

Valton, A. S.; Serre-Dargnat, C.; Blanchard, M.; Alliot, F.; Chevreuil, M.; Teil, M. J. (2014) - Determination of Phthalates and Their by-Products in Tissues of Roach (Rutilus Rutilus) from the Orge River (France). *Environmental Science and Pollution Research*, 21:12723–12730. DOI: 10.1007/s11356-014-3213-0

Vandenberg, L. N.; Chahoud, I.; Heindel, J. J.; Padmanabhan, V.; Paumgartten, F. J. R.; Schoenfelder, G. (2010) - Urinary, circulating, and tissue biomonitoring studies indicate widespread exposure to bisphenol A. *Environmental Health Perspectives,* 118(8):1055–1070. DOI: 10.1289/ehp.0901716

Vandenberg, L. N.; Maffini, M. V.; Wadia, P. R.; Sonnenschein, C.; Rubin, B. S.; Soto, A. M. (2007) - Exposure to environmentally relevant doses of the xenoestrogen bisphenol-A alters development of the fetal mouse mammary gland. *Endocrinology*, 148(1):116–127. DOI: 10.1210/en.2006-0561

Vandenberg, L. N.; Schaeberle, C. M.; Rubin, B. S.; Sonnenschein, C.; Soto, A. M. (2013) - The male mammary gland: a target for the xenoestrogen bisphenol A. *Reproductive Toxicology*, 37:15–23. DOI: 10.1016/j.reprotox.2013.01.002

Vega-Morales, T.; Sosa-Ferrera, Z.; Santana-Rodríguez, J. J. (2013). Evaluation of the presence of endocrine-disrupting compounds in dissolved and solid wastewater treatment plant samples of Gran Canaria Island (Spain). *BioMed Research International*, 2013:1-15. DOI: 10.1155/2013/790570

Vekey, K. (2001) - Mass spectrometry and mass-selective detection in chromatography. *Journal of Chromatography A*, 921(2):227-236. DOI: 10.1016/S0021-9673(01)00825-1

Ventura, C.; Nieto, M. R. R.; Bourguignon, N.; Lux-Santos, V.; Rodriguez, H.; Cao, G.; Randi, A.; Nuñez, M. (2016) - Pesticides chlorpyrifos acts as an endocrine disruptor in adult rats causing changes in mammary glands and hormonal balance. *The Journal of Steroid Biochemistry and Molecular Biology*, 156:1-9. DOI: 10.1016/j.jsbmb.2015.10.010.

Vidal-Dorsch, D. E.; Bay, S. M.; Maruya, K.; Snyder, S. A.; Trenholm, R. A.; Vanderford, B. J. (2012) - Contaminants of emerging concern in municipal wastewater effluents and marine receiving water. *Environmental Toxicology and Chemistry*, 31(12):2674–2682. DOI: 10.1002/etc.2004

Villar-Navarro, M.; Ramos-Payán, M.; Fernández-Torres, R.; Callejón-Mochón, M.; Bello-López, M. Á. (2013) - A novel application of three phase hollow fiber based liquid phase microextraction (HF-LPME) for the HPLC determination of two endocrine disrupting compounds (EDCs), n-octylphenol and n-nonylphenol, in environmental waters. *Science of The Total Environment,* 443:1-6. DOI: 10.1016/j.scitotenv.2012.10.071

Volkova, K., Caspillo, N. R., Porseryd, T., Hallgren, S., DinnÉtz, P., Porsch-Hällström, I. (2015). Developmental exposure of zebrafish (Danio rerio) to 17α-ethinylestradiol affects non-reproductive behavior and fertility as adults, and increases anxiety in unexposed progeny. Hormones and Behavior, 73:30–38. DOI: 10.1016/j.yhbeh.2015.05.014

Vos, J. G.; Becher, G.; van den Berg, M.; de Boer, J.; Leonards, P. E. G. (2003) - Brominated flame retardants and endocrine disruption. *Pure and Applied Chemistry*, 75(11-12):2039-2046. DOI: 10.1351/pac200375112039

Wang, J.; Shim, W.; Yim, U.; Kannan, N.; Li, D. (2010) - Nonylphenol in bivalves and sediments in the northeast coast of China. *Journal of Environmental Sciences*, 22(11):1735–1740. DOI: 10.1016/S1001-0742(09)60313-2

Wang, W.; Meng, B.; Lu, X.; Liu, Y.; Tao, S. (2007) - Extraction of polycyclic aromatic hydrocarbons and organochlorine pesticides from soils: a comparison between Soxhlet extraction, microwave-assisted extraction and accelerated solvent extraction techniques. *Analytica Chimica Acta*, 602(2):211-222. DOI: 10.1016/j.aca.2007.09.023

Weiss, J. M.; Hamers, T.; Thomas, K. V.; Van Der Linden, S.; Leonards, P. E. G.; Lamoree, M. H. (2009) - Masking effect of anti-androgens on androgenic activity in European river sediment unveiled by effect-directed analysis. *Analytical and Bioanalytical Chemistry*, 394(5):1385–1397.DOI: 10.1007/s00216-009-2807-8

WHO. State of the Science of Endocrine Disrupting Chemicals. (United Nations Environment Programme), 2012, 30p.

Wu, J.; Zhang, L.; Yang, Z. (2010) - A Review on the Analysis of Emerging Contaminants in Aquatic Environment. *Critical Reviews in Analytical Chemistry*, 40(4):234-245. DOI: 10.1080/10408347.2010.515467

Xie, Z.; Ebinghaus, R.; Temme, C.; Lohmann, R.; Caba, A.; Ruck, W. (2007) - Occurrence and air-sea exchange of phthalates in the Arctic. *Environmental Science & Technology*, 41(13):4555–4560. DOI: 10.1021/es0630240

Xie, Z.; Lakaschus, S.; Ebinghaus, R.; Caba, A.; Ruck, W. (2006) - Atmospheric concentrations and airesea exchanges of nonylphenol , tertiary octylphenol and nonylphenol monoethoxylate in the North Sea. *Environmental Pollution*, 142(1):170–180. DOI: 10.1016/j.envpol.2005.08.073

Xu, E. G. B.; Morton, B.; Lee, J. H.W.; Leung, K. M.Y. (2015) - Environmental fate and ecological risks of nonylphenols and bisphenol A in the Cape D'Aguilar Marine Reserve, Hong Kong. *Marine Pollution Bulletin*, 91(1):128–138. DOI: 10.1016/j.marpolbul.2014.12.017

Xu, N.; Xu, Y.-F.; Xu, S.; Li, J.; Tao, H.-C. (2012) - Removal of estrogens in municipal wastewater treatment plants: a Chinese perspective. *Environmental Pollution*, 165:215–224. DOI: 10.1016/j.envpol.2011.12.025

Xu, W.; Yan, W.; Huang,W.; Miao, L.; Zhong, L. (2014) - Endocrine-disrupting chemicals in the Pearl River Delta and coastal environment: sources, transfer, and implications. *Environmental Geochemistry and Health*, 36(6):1095–1104. DOI: 10.1007/s10653-014-9618-3

Xu, X.; Roman, J. M.; Issaq, H. J.; Keefer, L. K.; Veenstra, T. D.; Ziegler, R. G. (2007) - Quantitative Measurement of Endogenous Estrogens and Estrogen Metabolites in Human Serum by Liquid Chromatography-Tandem Mass Spectrometry. *Analytical Chemistry*, 79(20):7813-7821. DOI: 10.1021/ac070494j

Xu, X.; Veenstra, T. D.; Fox, S. D.; Roman, J. M.; Issaq, H. J.; Falk, R.; Saavedra, J. E.; Keefer, L. K.; Ziegler, R. G. (2005) - Measuring Fifteen Endogenous Estrogens Simultaneously in Human Urine by High-Performance Liquid Chromatography-Mass Spectrometry. *Analytical Chemistry*, 77 (20):6646-6654. DOI: 10.1021/ac050697c

Yan, H.; Wang, H. (2013) - Recent development and applications of dispersive liquid–liquid microextraction. *Journal of Chromatography A*, 1295:1-15. DOI: 10.1016/j.chroma.2013.04.053

Yi, B.; Kim, C.; Yang, M. (2010) - Biological monitoring of bisphenol A with HLPC/FLD and LC/MS/MS assays. *Journal of Chromatography B*, 878(27):2606–2610. DOI: 10.1016/j.jchromb.2010.02.008

Ying, G.-G., Williams, B.; Kookana, R. (2002a) - Environmental fate of alkylphenols and alkylphenol ethoxylates--a review. *Environment International*, 28(3):215–226. DOI:10.1016/S0160-4120(02)00017-X

Ying, G.-G.; Kookana, R. S.; Ru, Y.-J. (2002b) - Occurrence and fate of hormone steroids in the environment. *Environment International*, 28(6):545–551. DOI: 10.1016/S0160-4120(02)00075-2

Yu, Y.; Huang, Q.; Cui, J.; Zhang, K.; Tang, C.; Peng, X. (2011) - Determination of pharmaceuticals, steroid hormones, and endocrine-disrupting personal care products in sewage sludge by ultra-high-performance liquid chromatography – tandem mass spectrometry. *Analytical and Bioanalytical Chemistry*, 399(2):891–902. DOI: 10.1007/s00216-010-4295-2

Zhang, J.; Yang, M.; Zhang, Y.; Chen, M. (2008) - Biotransformation of nonylphenol ethoxylates during sewage treatment under anaerobic and aerobic conditions. *Journal of Environmental Sciences*, 20(2):135–141. DOI: 10.1016/S1001-0742(08)60021-2

Zhang, S.; You, J.; Sun, Z.; Song, C.; Ning, S.; Zhao, C.; Suo, Y. (2012) - A sensitive method for extraction and determination of endocrine-disrupting compounds from wastewater using 10-ethyl-acridone-2-sulfonyl chloride as pre-column labeling reagent by high-performance liquid chromatography with fluorescence detection. *Microchemical Journal*, 103:90–96, 2012. DOI: 10.1016/j.microc.2012.01.009

Zhang, X.; Li, Q.; Li, G.; Wang, Z.; Yan, C. (2009) - Levels of estrogenic compounds in Xiamen Bay sediment, China. *Marine Pollution Bulletin*, 58(8):1210–1216. DOI: 10.1016/j.marpolbul.2009.03.011.

Zhang, Y.; Cao, Y.; Jiang, X.; Zhao, Y.; Fang, X., Xie, C. (2015) - Could exposure to phthalates speed up or delay pubertal onset and development? A 1.5-year follow-up of a school-base population. *Environment International*, 83:41-49. DOI: 10.1016/j.envint.2015.06.005.

Zhang, Z.; Ren, N.; Kannan, K.; Nan, J.; Liu, L.; Ma, W.; Qi, H.; Li, Y. (2014) - Occurrence of Endocrine-Disrupting Phenols and Estrogens in Water and Sediment of the Songhua River, Northeastern China. *Archives of Environmental Contamination and Toxicology*, 66(3):361-369. DOI: 10.1007/s00244-014-9998-5

Zheng, W.; Li, X.; Yates, S. R.; Bradford, S. A. (2012) - Anaerobic transformation kinetics and mechanism of steroid estrogenic hormones in dairy lagoon water. *Environmental Science & Technology*, 46:5471–5478. DOI: 10.1021/es301551h

Zrafi-Nouira, I.; Safi, N. M. D.; Bahri, R.; Mzoughi, N.; Aissi, A.; Abdennebi, H. B. E. N.; Saidane-Mosbahi, D. (2010) - Distribution and Sources of Polycyclic Aromatic Hydrocarbons Around a Petroleum Refinery Rejection Area in Jarzouna-Bizerte (Coastal Tunisia). *Soil and Sediment Contamination*, 19(3):292–306. DOI: 10.1080/15320381003695223

Zuloaga, O.; Nvarro, P.; Bizkarguenaga, E.; Iparraguirre, A.; Vallejo, A.; Olivares, M.; Prieto, A. (2012) - Overview of extraction, clean-up and detection techniques for the determination of organic pollutants in sewage sludge: A review. *Analytica Chimica Acta*, 736:7-29. DOI: 10.1080/15320381003695223

Zuo, Y.; Zhang, K.; Deng, Y. (2006) - Occurrence and photochemical degradation of 17alpha-ethinylestradiol in Acushnet River Estuary. *Chemosphere*, 63(9):1583–1590. DOI: 10.1016/j.chemosphere.2005.08.063

Zuo, Y.; Zhang, K.; Lin, Y. (2007) - Microwave-accelerated derivatization for the simultaneous gas chromatographic-mass spectrometric analysis of natural and synthetic estrogenic steroids. *Journal of Chromatography A*, 1148(2):211–218. DOI: 10.1016/j.chroma.2007.03.037