Global Water Research Coalition

Endocrine Disrupting Compounds

Occurrence of EDC in Water Systems

IWA affiliate

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Global Water Research Coalition: Cooperation for worldwide water knowledge, innovation and progress

GWRC is a non-profit organization that serves as the collaborative mechanism for water research. The product the GWRC offers its members is water research information and knowledge. The Coalition will focus on water supply and wastewater issues and renewable water resources: the urban water cycle.

The members of the GWRC are: the Awwa Research Foundation (US), CRC Water Quality and Treatment (Australia), Kiwa (Netherlands), Sues Environment - CIRSEE (France), Stowa - Foundation for Applied Water Research (Netherlands), DVGW – TZW Water Technology Center (Germany), UK Water Industry Research (UK), Veolia - Anjou Recherché (France), Water Environment Research Foundation (US), Water Research Commission (South Africa), WaterReuse Foundation and the Water Services Association of Australia.
These organizations are all in charge of a national research program addressing the different parts of the water cycle. They have provided the impetus, credibility, and initial funding for the GWRC. Each brings a unique set of skills and knowledge to the Coalition. Through its member organisations GWRC represents the interests and needs of 500 million consumers.

The Global Water Research Coalition is affiliated with the International Water Association (IWA). The GWRC was officially formed in April 2002 with the signing of the partnership agreement at the International Water Association 3rd World Water Congress in Melbourne. With the US Environmental Protection Agency a partnership agreement was signed in July 2003.

Endocrine Disrupting Compounds

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September 2003

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Disclaimer

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Acknowledgements

The project team wishes to express their gratitude to all the members of the GWRC, to team members and to the participants who made a contribution to this project.

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GLOSSARY OF DEFINITIONS

Endocrine Disrupting Compound: (WHO definition)
An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an organism, or its progeny, or (sub) populations.

Source water:
Source water is defined as water coming from a natural source i.e. water from rivers, dams, streams and fountains. Borehole water is also included in this category.

Drinking Water:
Under the term drinking water is understood water which is treated and intended for human consumption.

Tap Water:
This is water taken at the consumer point of the treated water distribution system.

Receiving water: This is water in a river or other body of water into which an effluent is discharged.

Surface water: This refers to river water from the source through to the drinking water intake.

Waste Water:
This is defined as:
1. Untreated wastewater: Water used and/or polluted by humans by agricultural or industrial activity.
2. Treated wastewater: Water at the exit of a purification plant.

Raw Water:
Untreated water.

NOEL:
Acronym for 'No observed effect level'.

ELISA:
Acronym for 'Enzyme-linked Immunosorbant analysis'.

Summary

There has been increasing concern regarding substances in the environment that could impact on the endocrine systems of wildlife and man. The data that initiated the concern relate to fish, amphibians, reptiles and, to a lesser extent, birds exposed to anthropogenic chemicals through the aquatic environment. Significant changes were observed in the reproductive organs of alligators and turtles exposed to a mixture of persistent pesticides in a Florida Lake while changes in the reproductive organs of male fish exposed to treated sewage effluent were also observed. The changes were shown to be mediated through effects on the endocrine system, which is a complex hormonal mechanism for control of the development and physiological status of animals, particularly vertebrates. These findings also resulted in concern for possible impacts on humans through exposure to endocrine disrupting substances from drinking water derived from primarily from surface sources.

In order to collect the data available within the GWRC membership on the occurrence of EDCs in water systems, questionnaires about monitoring/analytical data for EDCs in ground- and surface water, wastewater influent, effluent and sludge, as well as drinking water, and the use of industrial chemicals considered to possess ED activity and the analytical methods available were distributed to the members. Nine GWRC members, representing seven countries, returned the completed questionnaires.

This inventory of the GWRC data concerning the occurrence of EDCs in water systems clearly indicates that EDCs are found in surface water as well as in the influent and effluent from wastewater treatment. Concentrations of the different classes of EDCs vary from ng/l up to µg/l.
The limited data regarding drinking water supports the proposition that uptake of EDCs by humans from treated drinking water is relatively low in comparison to other sources such as food. However, the presence of EDCs in surface water is an indication that the use of untreated surface water, as drinking water, which is often the case in rural areas and informal settlements in urban areas of developing countries, is not without risk.

The detection limits reported by the various countries vary significantly. Future GWRC activities should aim to harmonize analytical methods, optimise detection limits for the various EDCs and develop appropriate quality assurance for analysis.

1 Introduction

The presence and effects of Endocrine Disrupting Compounds (EDCs) in the environment has become an important issue [Keith, 1997]. The endocrine system is a complex physiological process by which the body can respond to a range of internal and external signals and stresses. Hormones are the chemical messengers of the body that are secreted from the endocrine glands directly into the blood and are involved in regulating the growth, development and functions of the body, particularly in higher animals. For example, estrogens in females and androgens in males play a key role in reproductive health. There are frequently cascades of hormones with complex feedback mechanisms to regulate the process.

The presence of low concentrations of some industrial chemicals and natural and synthetic hormones in water could affect or damage the functioning of the endocrine system. EDCs can mimic hormones or block hormonal activity such as anti-estrogens or anti-androgens. There is concern, and some evidence from aquatic populations that EDCs could give rise to changes that could lead to disruption of wild populations. The data that initiated the concern relate to fish, amphibians, reptiles and, to a lesser extent, birds exposed to anthropogenic chemicals through the aquatic environment. Significant changes were observed in the reproductive organs of alligators and turtles exposed to a mixture of persistent pesticides in a Florida Lake, while changes in the reproductive organs of male fish exposed to treated sewage effluent were also observed. Since some of the chemicals responsible may be discharged to waters used as a source of drinking water, concern. Has also been raised about EDCs in drinking water and their possible effect on man.

A range of substances have been shown to exhibit ED activity, usually in in vitro assays, but some in whole animals. These include:

- natural and synthetic hormones,
- phyto-estrogens,
- pesticides,
- organic solvents,
- pharmaceuticals (contraceptives and steroids),
- alkylphenols and alkylphenol-polyethoxylates,
- phthalates,
- organo-halogen compounds (like polychlorinated- and brominatedbiphenyls, diphenyl-ethers and dioxins),
- some heavy metals [Colborn, 1996; WWF, 1996; EPA, 1996].

In the case of natural and synthetic hormones, this refers to disruption of the endocrine system of other organisms such as fish affected by exogenous estrogens from other species, including man.

Many chemicals have not yet been investigated for ED activity. Screening for activity by means of bioassays or biomarkers is needed so that these chemicals can be assessed for potential risks. This may be particularly relevant for water since the total EDC activity measured in bioassays of water or water extracts, cannot always be completely explained by the measured concentrations of natural EDC compounds in water [Lévi et al., 2002, Vethaak et al., 2002].

As indicated above, a number of circumstances have been reported where effects on wild populations have been attributed to natural and synthetic EDCs [Mukerjee et al., 2002]. These include reproductive problems in animal populations, such as alligators and fish-eating birds, feminisation of male birds, fish and alligators, the presence of the female specific egg yolk precursor protein, vitellogenin in male oviparous animals and ovotestis in male fish, sexual developmental defects known as intersex, and disturbance of sex ratio's in exposed populations [Vethaak et al., 2002]). The conclusion that anthropogenic chemicals can act as EDs and can impact on wild populations was also drawn in a recent IPCS review [IPCS 2002].

It has been suggested that certain EDCs may induce or promote breast cancer although there is considerable controversy in this area [Keith, 1997]. However, with regard to human health, there is, to date, no firm evidence for, or causal association demonstrated between low-level exposure to EDCs and adverse health outcomes [IPCS, 2002].

Humans and wildlife are exposed to chemicals via different pathways. Water appears to be an important component in the distribution of EDCs in the environment and is one of the pathways of exposure. This is particularly the case with aquatic organisms that can be permanently in contact with a waterborne ED.

The occurrence and activity of EDCs in water systems has been investigated in a number of studies. These studies show that a range of EDCs can be present in drinking water sources, particularly surface water (river), as well as in wastewater effluent [AWWA, 2002, Rhodes Trussell, 2002].

As a consequence of the concerns relating the above, the Board of the Global Water Research Coalition (GWRC) selected EDCs as the first priority issue for their collaborative research programme. As part of this programme, GWRC commissioned a 'State-of-the-Science' report on EDCs in the water cycle with particular reference to the experience of member organisations. This, in turn, would be used to help identify the gaps in present knowledge with a view to formulating further research proposals to address these knowledge gaps (GWRC, 2002).

In order to make an assessment of the state of the science with regard to the occurrence of EDCs in various parts of the water cycle it is essential to establish the knowledge that is available. Much of this knowledge is not available through the published literature and is collected and developed by organisations for their own purposes. It is, therefore, particularly important to tap into this "grey" literature in order to develop a good understanding of the current state of scientific knowledge. This is particularly the case with subjects such as EDCs, since much of the data will be generated by water suppliers, wastewater undertakers and related organisations as part of their operations.

2 Approach of the inventory

In order to collect the data available within the GWRC membership on the occurrence of EDCs in water systems, two questionnaires were distributed to the members at the end of May 2002.

The first questionnaire requested monitoring/analytical data for EDCs in ground- and surface water, wastewater influent, effluent and sludge, as well as drinking water. The second questionnaire concerned the use of industrial chemicals considered to possess ED activity within the countries of member organisations and the analytical methods available to them for analysis of EDCs.

Nine GWRC members, representing seven countries, returned the completed questionnaires.

3 Development of the inventory

Members in Europe and the USA reported most of the data received. This was to be expected since these countries have ready access to the necessary infrastructure for sampling and analysis of water samples. In particular there is a requirement for advanced analytical capability to detect and quantify the very low concentrations necessary for many of the suspected EDCs.

However, relatively few data were actually reported on the occurrence of EDCs, particularly in drinking water. The fact that information is limited, may be due to the following:

- Although much data was generated in the past, particularly on pesticides, this was not focussed on ED activity. The very low detection limits needed for meaningful data on some EDCs were not always available.
- There is no specific requirement for routine monitoring of many of the suspected EDCs and the analysis is both difficult and expensive.
- Certain endocrine disrupting chemicals such as phthalates are not regarded as “toxic” and therefore most organizations do not have ongoing analytical monitoring or research programmes for these chemicals.
- Some countries, particularly developing countries, do not have national programmes for monitoring water. Most of the monitoring is undertaken through small research projects, which generate limited data.
- The number of validated analytical methods is limited which might result in some caution in reporting the data.
- Some data, especially for drinking water, may have been be regarded as confidential.

All of the individual data received are presented in Annex A of this report. Annex B reflects a summary of the availability of analytical methods and their use by the GWRC membership. A summary of the information regarding different groups of EDCs on the inventory is given below.

3.1 Natural and synthetic hormones

Five of the GWRC member countries reported data for hormones, namely Netherlands, France, Germany, Great Britain and USA. No positive results were reported in drinking water.

The United Kingdom reported levels of between 0.8 – 7.1 ng/l of estrone in surface water, and The Netherlands reported up to 3.4 ng/l.

The highest values for hormones were found in the influent of wastewater treatment plants. The Netherlands reported 17-150 ng/l for 17ß-estradiol, 2-130 ng/l for estrone, up to 15-ng/l for17a-estradiol and 0.6 ng/l for 17a-ethinylestradiol. The corresponding effluent values were <0.8, <0.4-11, <0.4 and<0.4-2.6 ng/l. France reported the following values on influent: 17ß-estradiol: 10-22; estrone: 8-18; 17a-ethinylestradiol: 5-7; and estriol: 10-15 ng/l. The corresponding effluent values were 5-8, 3-8, 2-4 and 5-8 ng/l. Great Britain reported effluent values for 17ß-estradiol: 4.5-8.0 ng/l and estrone: 2.5-9.4 ng/l. The USA reported effluent values for 17ß-estradiol of 0.2-3.8 ng/l and 17a-ethinylestradiol of <0.1-0.3 ng/l.

3.2 Pesticides

France reported a small number of positive results for pesticides in drinking- and riverbank infiltrated water. These were mostly herbicides of the triazine family namely atrazine, simazine and terbuthylazine. The Netherlands, France, Germany and South Africa reported positive results for pesticides in surface water. These were predominantly persistent organochlorine compounds. In particular, South Africa reported some very high values for aldrin, dieldrin, DDE and lindane, although it is not clear what proportion were adsorbed to particulate matter.

3.3 Industrial chemicals

<u>Alkyl phenols and their ethoxylates</u>
Polyethoxylates are broken down in wastewater treatment and in surface waters to produce lower molecular weight ethoxylates, carboxylic acids and the parent alkyl phenol. The high molecular weight polyethoxxylates show no estrogenic activity but the lower molecular weight compounds increase in activity in inverse proportion to the size. These were not detected in ground or riverbank infiltrated water. Only The Netherlands reported values for octylphenol ethoxylates (0.19-0.3 µg/l) and nonylphenol ethoxylates (0.1-1.5 µg/l) in drinking water. The Netherlands and Germany reported values 0.71 and 3.3 µg/l for nonylphenol in surface water. The Netherlands also reported values between 0.14 µg/l and 0.92 µg/l for octylphenol ethoxylates and 0.15-.2.6 µg/l for nonylphenol ethoxylates in surface water. Values of the same order were reported by the Netherlands and Germany in wastewater effluent.

<u>Phthalates</u>
Most of the data received has been generated in the Netherlands, with less data from Great Britain and Germany. Some data had also been contributed by South Africa.

Significant values for phthalates have been detected in wastewater (influent and effluent) and surface water. In surface water the most commonly found phthalates are diethyl phthalate (DEP), dimethylpropylphthalate (DMPP), butylbenzylphthalate (BBP) and di(2-ethylhexyl)phthalate (DEHP). The Netherlands reported values for these four phthalates of 0.01-2.6, 0.01-2.8, 0.01-2.0 and 0.97-200 µg/l in surface water. Germany reported values of <0.04-14 µg/l for BBP and <0.01-10 µg/l for DEP in surface water. Great Britain reported values of 2.2-4.9 µg/l for DEHP.

The Netherlands and Great Britain also reported that DEP and DEHP were the dominant phthalates occurring in drinking water. The Netherlands reported <0.02-2.1 µg/l (DEP) and <0.01-0.65 µg/l (DEHP) and Great Britain reported 1.3-2.5 µg/l for DEHP. These values were substantially lower than those reported for surface water.

Bisphenol A:
Only the Netherlands reported a value of <0.04-4.1µg/l in wastewater effluent.

Polychlorinated Biphenyls (PCBs) and Polynuclear Aromatic Hydrocarbons (PAHs): These are generally highly lipophilic compounds and adsorb readily to particulate matter in water. Only the Netherlands reported a value of <0.01-0.02µg/l for PCBs in surface water. The Netherlands also reported values for PAH's in surface water ranging from <0.01 to 0.1µg/l.

3.4 Toxic heavy metals

Arsenic, cadmium, lead, mercury were reported in the entire water cycle, with lower values in drinking water and higher values in surface and ground water. Very high values of toxic heavy metals in sewage sludge were reported by Australia, Netherlands and France.

3.5 EDC-monitoring studies in Japan

During the period 1998 – 2000, the Japanese Ministry of the Environment studied EDCs in surface water on a national scale. Samples were taken from large and middle sized rivers of Japan, at 100 – 130 sites. Analyses were conducted at each site for between 29 and 34 chemicals that were considered to showed activity. Table 2.1 provides an indication of chemicals that were detected in 10% or more of the samples [Kobuke, Tanaka and Magara, IWA Workshop Endocrine Disruptors, Melbourne, 2002.]

Table 3.1 Occurrence of EDCs in Japan 1998 – 2000				
Endocrine Disrupting	**Winter 1999**		**Winter 2000**	
Compounds	**Rate (%)**	**Range (µg/l)**	**Rate (%)**	**Range (µg/l)**
PCB	88	<0.00001-0.04	78	<0.00001 – 0.15
4-t-octylphenol	22	<0.01 = 0.61	26	<0.01 – 0.72
Nonylphenol	32	<0.1 – 4.6	31	<0.1 – 7.1
Bisphenol A	52	<0.01 – 0.71	54	<0.01 – 0.72
Di – (2-ethylhexyl) phthalate	35	<0.3 – 6.6	35	<0.3 – 6.9
Benzophenone	21	<0.01 – 0.17	14	<0.01 – 0.12
17ß - Estradiol	65	<0.001 – 0.011	90	<0.001 – 0.28

(Rate (%) = occurrence)

The reported concentrations are comparable to the data reported by the GWRC members.

4 Conclusions

This inventory of the GWRC data concerning the occurrence of EDCs in water systems clearly indicates that EDCs are found in surface water as well as in the influent and effluent from wastewater treatment. Concentrations of the different classes of EDCs vary from ng/l up to µg/l.

The limited data regarding drinking water supports the proposition that uptake of EDCs by humans from treated drinking water is relatively low in comparison to other sources such as food. However, the presence of EDCs in surface water is an indication that the use of untreated surface water, as drinking water, which is often the case in rural areas and informal settlements in urban areas of developing countries, is not without risk.

The detection limits reported by the various countries vary significantly. Future GWRC activities should aim to harmonize analytical methods, optimise detection limits for the various EDCs and develop appropriate quality assurance for analysis.

There remains uncertainty over the appropriate detection limits for a number of EDCs since there are limited data as to the concentrations that would be of interest in relation to risk assessment. This remains an issue for future research.
The data reported was limited and may not reflect the overall situation concerning the levels of occurrence and exposure. They are, therefore, inappropriate for use in risk assessment at this stage.

Very few data were submitted on the use of bioassays for monitoring EDCs and so these were not included in this summary.

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Annex A: Responses to questionnaire on occurrence of EDC in the water cycle

DRINKING WATER - Natural and synthetic hormones

concentrations in ng/L

EDC name	NL	F	GB	GER	AUS	US	SA
bolasteron	<0.4						
a-boldenon	<0.4						
b-boldenon	<0.4						
diethylstilbestrol	<0.4						
dienoestrol	<0.4						
17a-estradiol	<0.4						
17b-estradiol	<0.4		<0.3	<1			
Estron	<0.4		<0.3	<1			
17a-ethinylestradiol	<0.4		<0.3	<1			
estriol				<1			
fluoxymestreron	<0.4						
hexestrol	<0.4						
methylboldenon	<0.4						
methyltesteron	<0.4						
norethandrolon	<0.4						
norethynodrel	<0.4						
normethandron	<0.4						
17b-nortestosteron	<0.4						
taleranol	<0.4						
17b-testosteron	<0.4						
zeranol	<0.4						
norethisteron				<1			
mestranol				<1			

DRINKING WATER - Industrial chemicals

Concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Alkylphenol(ethoxylates):							
pentyl-phenol	<0.05						
octyl-phenol	<0.05			<0.1			
octylphenol-ethoxylates	0.19-0.3						
nonylphenol	<0.1		<0.2	<0.1			
nonylphenol-ethoxylates	0.1-1.5						
Phthalates:		<0.02-10					
dimethyl phthalate	<0.01-0.13						
diethyl phthalate	<0.2-2.1		<0.2				
dipropyl phthalate	<0.025						
dimethylpropyl phthalate	<0.01-1.3						
di-n-butyl phthalate	<0.01-1.1		<0.2				
butylbenzylphthalate	<0.01-0.49		<0.2				
dicyclohexyl phthalate	<0.01-0.02						
di(2-ethylhexyl) phthalate	<0.1-0.65		1.3-2.5				
di-n-octyl phthalate	<0.04-0.01						
diisononyl phthalate			<0.2				
diisodecyl phthalate			<0.2				
diphenylphthalate			<0.2				

DRINKING WATER - PCB and PAH

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Polychlorinated biphenyls:	<0.01		<0.01	<0.01			
Polynuclear aromatic hydrocarbons:							
acenaphthene	<0.01						
anthracene	<0.01						
benz(a)anthracene	<0.01						
benzo(a)pyrene	<0.01						
benzo(b)fluoranthene	<0.01						
benzo(k)fluoranthene	<0.01						
chrysene	<0.01						
indeno[1,2,3-c,d]pyrene	<0.01						
phenanthrene	<0.01						
pyrene	<0.01						

DRINKING WATER - Organic compounds and Metals

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Different organic compounds:							
bisphenol A	<0.01		<5.1	<0.005			
bisphenol F			<6	<0.005			
butylbenzene	<0.01						
hexachlorobenzene	<0.01						
styrene	<0.01	<0.1-0.2					
toluene		<0.1-0.2					
Metals:							
arsenic	<1-4						
cadmium	<0.1						
lead	<1						
mercury	<0.1						

DRINKING WATER - Pesticides

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
alachlor	<0.01						
amitrol							
atrazin	<0.01-0.03	<0.02-0.3	<0.02-2		<0.1		
carbendazim	<0.02						
2,4-D	<0.02		<0.02-2		<0.1		
DDD	<0.01		<0.02		<0.01		
DDE	<0.01		<0.02				
DDT	<0.01		<0.02				
dieldrin	<0.01		<0.02		<0.01		
endosulfan	<0.01				<0.01		
heptachlor			<0.02		<0.01		
endrin	<0.01						
c-HCH (lindane)	<0.01		<0.02		<0.01		
malathion	<0.01						
metolachlor	<0.01						
metribuzin	<0.01						
parathion	<0.01						
simazine	<0.01	<0.02-0.1	<0.02-2				
2,4,5-T	<0.01						
terbuthylazin		<0.02-0.2					
vinclozolin	<0.01						

GROUNDWATER - Natural and synthetic hormones

concentrations in ng/L

EDC name	NL	F	GB	GER	AUS	US	SA
17b-estradiol				<1			
estron				<1			
17a-ethinylestradiol				<1			
estriol				<1			
norethisteron				<1			
mestranol				<1			

GROUNDWATER - PCB and PAH

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Polychlorinated biphenyls:	<0.01						
Polynuclear aromatic hydrocarbons:							
acenaphthene	<0.01						
anthracene	<0.01						
benz(a)anthracene	<0.01						
benzo(a)pyrene	<0.01						
benzo(b)fluoranthene	<0.01						
benzo(k)fluoranthene	<0.01						
chrysene	<0.01						
indeno[1,2,3-c,d]pyrene	<0.01						
phenanthrene	<0.01						
Pyrene	<0.01						

GROUNDWATER - Organic compounds and Metals

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Different organic compounds:							
hexachlorobenzene	<0.01						
2,4-dichlorophenol	<0.01						
pentachlorophenol	<0.01						
styrene	<0.01						
Metals:							
arsenic	1-10	avg=6.5					
cadmium	<0.3	avg=0.3					
lead	<1-5						
mercury	<0.1						

GROUNDWATER - Pesticides

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
aldrin	<0.01						
2,4-D	<0.02						
DDD	<0.01						
DDE	<0.01						
DDT	<0.01						
diazinon	<0.01						
dieldrin	<0.01						
endosulfan	<0.01						
endrin	<0.01						
c-HCH (lindane)	<0.01						
malathion	<0.01						
parathion	<0.01						
simazine	<0.01						
2,4,5-T	<0.01						

SURFACE WATER - Natural and synthetic hormones

concentrations in ng/L

EDC name	NL	F	GB	GER	AUS	US	SA
bolasteron	<0.4						
a-boldenon	<0.4						
b-boldenon	<0.4						
diethylstilbestrol	<0.4						
dienoestrol	<0.4						
17a-estradiol	<0.4						
17b-estradiol	<0.4		<0.2	<1		median=9	
estron	<0.4-3.4		0.8-7.1	<1		median=27	
17a-ethinylestradiol	<0.4		<0.3	<1		median=73	
estriol				<1		median=19	
fluoxymestreron	<0.4						
hexestrol	<0.4						
methylboldenon	<0.4						
methyltesteron	<0.4						
norethandrolon	<0.4						
norethynodrel	<0.4						
normethandron	<0.4						
17b-nortestosteron	<0.4						
taleranol	<0.4						
17b-testosteron	<0.4						
zeranol	<0.4						
norethisteron				<1			
mestranol				<1			

SURFACE WATER - Industrial chemicals

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Alkylphenol(ethoxylates):							
pentyl-phenol	<0.05						
octyl-phenol	<0.05-0.66						
octylphenol-ethoxylates	0.14-0.92						
nonylphenol	<0.1-0.71		<0.2	<0.005-3.3		median=0.8	5
nonylphenol-ethoxylates	0.15-2.6						
Phthalates:		<0.01					
dimethyl phthalate	0.004-0.19						
diethyl phthalate	0.01-2.6		<0.2-0.2				
dipropyl phthalate	0.01-0.022						
dimethylpropyl phthalate	0.01-2.8						
di-n-butyl phthalate	0.01-1.9		<0.2	<0.03-0.7			0.04-76
butylbenzylphthalate	0.01-2.0		<0.2	<0.04-14			
dicyclohexyl phthalate	0.01-0.06						
di(2-ethylhexyl) phthalate	0.97-200		2.2-4.9	<0.1-10		7	04-06-1991
di-n-octyl phthalate	0.01-4.6		<0.2				
diisononyl phthalate			<0.2-0.3				
diisodecyl phthalate			<0.2-0.4				
diphenylphthalate			<0.2				

SURFACE WATER - PCB and PAH

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Polychlorinated biphenyls:	<0.01-0.02	<0.02		<0.005-0.08			
Polynuclear aromatic hydrocarbons:							
acenaphthene	<0.01-0.02						
anthracene	<0.01-0.02						
benz(a)anthracene	<0.01-0.06						
benzo(a)pyrene	<0.01-0.07						
benzo(b)fluoranthene	<0.01-0.09						
benzo(k)fluoranthene	<0.01-0.04						
chrysene	<0.01-0.08						
indeno[1,2,3-c,d]pyrene	<0.01-0.05						
phenanthrene	<0.01-0.06						
pyrene	<0.01-0.1						

SURFACE WATER - Organic compounds and Metals

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Different organic compounds:							
bisphenol A	<0.01-22		<5.1	<0.005-0.2		median=0.14	
bisphenol F			<6				
butylbenzene	<0.01						
hexachlorobenzene	<0.01			<0.02			
2,4-dichlorophenol	<0.01						
pentachlorophenol	<0.01-0.3						
styrene	<0.01						
2,3,7,8-TCDD	<0.00001						
toluene		<0.02-1					
triclosan						median=0.14	
Metals:							
arsenic	1-4.2	avg=6.2			1-3		
cadmium	0.05-0.3	avg=0.7			<1		10-260
lead	1-13						10-1110
mercury	0.01-0.07				<0.1		

SURFACE WATER - Pesticides

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
alachlor	<0.02-0.1						
aldicarb	<0.02						
aldrin	<0.01						1-1000000
amitrol	<0.1						
atrazin	0.01-0.4	<0.02-1			<0.05		
carbendazim	0.5-75						
carbaryl	<0.03						
chlordane	0.05-1						
chlorpyrifos	<0.01						
2,4-D	<0.02	<0.02-0.2			<0.01		
DDD	<0.01			<0.001-1.4			0.1-0.28
DDE	<0.01						
DDT	<0.01				<0.005		
diazinon						median=0.07	
dieldrin	<0.01	<0.02		<0.001	<0.001	median=0.18	1-1000000
endosulfan	<0.01-0.05	<0.02-0.2		<0.001-0.005	<0.005		0.02-0.1
heptachlor					<0.005		0.02-0.2
endrin	<0.01						1-1000
c-HCH (lindane)	<0.01-0.08				<0.005	median=0.2	6.4
malathion	<0.01-0.1						
methoxychlor	<0.001			<0.05			
metolachlor	0.0002-0.09						
parathion	<0.01-0.8						
simazine	<0.01-0.05	<0.02-0.1					
2,4,5-T	<0.01						

SURFACE WATER - Pesticides

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
terbuthylazin		<0.02-1					
tributyltin	0.01-0.93			<0.002-0.003			

RIVERBANK FILTRATED/INFILTRATED WATER – Natural and synthetic hormones

concentrations in ng/L

EDC name	NL	F	GB	GER	AUS	US	SA
bolasteron	<0.4						
a-boldenon	<0.4						
b-boldenon	<0.4						
diethylstilbestrol	<0.4						
dienoestrol	<0.4						
17a-estradiol	<0.4						
17b-estradiol	<0.4						
estron	<0.4						
17a-ethinylestradiol	<0.4						
fluoxymestreron	<0.4						
hexestrol	<0.4						
methylboldenon	<0.4						
methyltesteron	<0.4						
norethandrolon	<0.4						
norethynodrel	<0.4						
normethandron	<0.4						
17b-nortestosteron	<0.4						
taleranol	<0.4						
17b-testosteron	<0.4						
zeranol	<0.4						

RIVERBANK FILTRATED/INFILTRATED WATER - PCB and PAH

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Polychlorinated biphenyls:	<0.01						
Polynuclear aromatic hydro carbons:							
acenaphthene	<0.01						
anthracene	<0.01						
benz(a)anthracene	<0.01						
benzo(a)pyrene	<0.01						
benzo(b)fluoranthene	<0.01						
benzo(k)fluoranthene	<0.01						
chrysene	<0.01						
indeno[1,2,3-c,d]pyrene	<0.01						
phenanthrene	<0.01						
pyrene	<0.01						

RIVERBANK FILTRATED/INFILTRATED WATER - Organic compounds and Metals

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
Alkylphenol(ethoxylates):							
pentyl-phenol	<0.05						
octyl-phenol	<0.05						
nonylphenol	<0.1						
Different organic compounds:							
hexachlorobenzene	<0.01						
pentachlorophenol	<0.01						
styrene	<0.01						
Metals:							
arsenic	3-30						
cadmium	<0.3						
lead	0.2-3						
mercury	<0.3						

RIVERBANK FILTRATED/INFILTRATED WATER - Pesticides

concentrations in µg/L

EDC name	NL	F	GB	GER	AUS	US	SA
alachlor	0.04						
aldrin	<0.01						
atrazin	0.01-0.4	0.03-0.6					
2,4-D	<0.02						
DDD	<0.01						
DDE	<0.01						
DDT	<0.01						
dieldrin	<0.01						
endosulfan	<0.01						
endrin	<0.01						
c-HCH (lindane)	<0.01						
malathion	<0.01						
parathion	<0.01						
simazine	<0.01	<0.02-0.05					
2,4,5-T	<0.01						
terbuthylazin		<0.02-0.15					

WASTEWATER TREATMENT PLANTS - Natural and synthetic hormones

concentrations in ng/L

	NL		F		GB		GER		AUS		US		SA	
EDC name	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**
bolasteron		<0.4												
a-boldenon		<0.4												
b-boldenon		<0.4												
diethylstilbestrol		<0.4												
dienoestrol		<0.4												
17a-estradiol	<0.7-15	<0.4												
17b-estradiol	17-150	<0.8	10-22	5-8		4.5-8.0						0.2-3.8		
estron	2-130	<0.4-11	8-18	3-8		2.5-9.4								
17a-ethinylestradiol	<0.3-0.6	<0.4-2.6	5-7	2-4								<0.1-0.3		
estriol			10-15	5-8										
fluoxymestreron		<0.4												
hexestrol		<0.4												
methylboldenon		<0.4												
methyltesteron		<0.4												
norethandrolon		<0.4												
norethynodrel		<0.4												
normethandron		<0.4												
17b-nortestosteron		<0.4												
taleranol		<0.4												
17b-testosteron		<0.4												
zeranol		<0.4												

WASTEWATER TREATMENT PLANTS – Industrial chemicals

concentrations in ng/L

	NL		F		GB		GER		AUS		US		SA	
EDC name	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**
Alkylphenol(ethoxylates):														
pentyl-phenol		<0.05												
octyl-phenol		<0.5-1.3												
octylphenol-ethoxylates		<0.7												
nonylphenol		<0.6-1.5				0.6-21		2.2-44						
nonylphenol-ethoxylates		<1.9-2.2												
Phthalates:														
dimethyl phthalate	<10													
diethyl phthalate	<4.1-44	<0.3-0.9												
dipropyl phthalate	<1													
dimethylpropyl phthalate	1.9-15	<1-20												
di-n-butyl phthalate	0.4-51	<0.4-0.8						<0.5-3.5						
butylbenzylphthalate	<10	<2												
dicyclohexyl phthalate	<1													
di(2-ethylhexyl) phthalate	<13-100	<0.5-2.4						<0.5-510						
di-n-octyl phthalate	<1													
Different organic compounds:														
bisphenol A		<0.04-4.1												
butylbenzene		<0.01												
styrene		<0.01												

WASTEWATER TREATMENT PLANTS - Metals

concentrations in µg/L

	NL		F		GB		GER		AUS		US		SA	
EDC name	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**
Metals:														
arsenic										<1				
cadmium										<0.1				
lead										<1				
mercury										<0.02				

WASTEWATER TREATMENT PLANTS - Pesticides

concentrations in µg/L

	NL		F		GB		GER		AUS		US		SA	
EDC name	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**	**INF**	**EFFL**
Pesticides:														
alachlor														
aldicarb														
aldrin														
amitrol														
atrazin										<0.5				
carbendazim														
carbaryl														
chlordane														
chlorpyrifos														
2,4-D										<0.5				
DDD										<0.01				
DDE										<0.01				
DDT										<0.01				
dieldrin										<0.01				
a-endosulfan										<0.005				
b-endosulfan										<0.005				
heptachlor										<0.005				
c-HCH (lindane)										<0.01				
methoxychlor										<0.01				
tributyltin								<0.01-0.18						

SEWAGE SLUDGE

concentrations in µg/kg d.w.

EDC name	NL	F	GB	GER	AUS	US	SA
Natural and synthetic hormones:							
17b-estradiol		0.06-0.30					
estron		<0.04-0.28					
17a-ethinylestradiol		1.4-2.8					
estriol		0.12-0.8					
Alkylphenol(ethoxylates):							
octyl-phenol						<500-13000	
nonylphenol		18000-180000		<1-200000			
Phthalates:							
diethyl phthalate	1-15						
dimethylpropyl phthalate	1-15						
di-n-butyl phthalate	1-15						
di(2-ethylhexyl) phthalate	20-50	10000-22000					
Polybrominated biphenyls:							
4,4-dibromo biphenyl	<0.3						
2,4,2',5'-tetrabromobiphenyl	<0.8						
2,5,2',5'-tetrabiphenyl	<0.8						
2,4,5,2',5'-pentabromobiphenyl	<0.3						
2,4,5,2',4',5'-hexabromobiphenyl	<0.6						
3,4,5,3',4',5'-hexabromobiphenyl	<1.1						

SEWAGE SLUDGE

concentrations in µg/kg d.w.

EDC name	NL	F	GB	GER	AUS	US	SA
decabromobiphenyl	<7.1						
Polybrominated diphenylethers:							
2,4,2',4'-tetrabromodiphenylether	0.7-35						
2,4,5,2',4'-pentabromodiphenylether	0.5-29						
2,3,4,2',4',5'-hexabromodiphenylether	<5.3-7.1						
2,4,5,2',4',5'-hexabromodiphenylether	<36-920						
Polychlorinated biphenyls:	10-1000	70-700			30-110		
Polynuclear aromatic hydrocarbons:							
acenaphthene	100-5000						
anthracene	100-5000						
benz(a)anthracene	100-5000						
benzo(a)pyrene	100-5000						
benzo(b)fluoranthene	100-5000						
benzo(k)fluoranthene	100-5000						
chrysene	100-5000						
indeno[1,2,3-c,d]pyrene	100-5000						
phenanthrene	100-5000						
pyrene	100-5000						
Pesticides:							
DDD					<10		

SEWAGE SLUDGE

concentrations in µg/kg d.w.

EDC name	NL	F	GB	GER	AUS	US	SA
DDE					<10		
DDT					<10		
dieldrin					<10-140		
heptachlor					<10		
c-HCH (lindane)					<10		

SEWAGE SLUDGE - Metals

concentrations in µg/kg d.w.

EDC name	NL	F	GB	GER	AUS	US	SA
arsenic	500-5000				2300-6400		
cadmium	300-2500	<10000			900-2200		
lead	100000-200000				23000-149000		
mercury	200-2200	<5000			<10-4300		
chromium		20000-500000					

Annex B: Analytical methods used and monitoring of EDCs in water by GWRC members

Compound	In use	Tested in waste water	Tested in receiving water	Tested in drinking water	Test method eg. GC-MS, HPLC	Limit of detection
DDT, DDE, DDD	- - - RSA - -	- - UK - GER -	USA FR UK RSA GER AUST	- FR UK RSA GER -	GC/ECD GC-MS GC-MS GC-MS GC/ECD GC/µEDC	0.003 µg/l 0.02-0.04 µg/l 0.01 µg/l 0.01 µg/l 0.1 µg/l 0.005 µg/l
Lindane	- - UK RSA - -	- - UK - GER -	USA FR UK - GER AUST	USA FR UK RSA GER -	- GC-MS GC-MS GC-MS GC/ECD GC/µECD	- 0.02-0.04 µg/l 0.01 µg/l 0.01 µg/l 0.01 µg/l 0.005 µg/l
Dieldrin	- - - RSA - -	- - UK RSA GER -	USA FR UK RSA GER AUST	- FR UK RSA GER -	APHA GC-MS GC-MS GC-MS GC/ECD GC/µECD	0.025 µg/l 0.02-0.04 µg/l 0.06 µg/l 0.01 µg/l 0.01 µg/l 0.001 µg/l
Heptachlor	- - - RSA - -	- - UK RSA GER -	- FR UK RSA GER AUST	USA FR UK RSA GER -	GC-MS GC/ECD GC-MS GC-MS GC/ECD GC/µECD	0.025 µg/l 0.02-0.04 µg/l 0.006 µg/l 0.01 µg/l 0.01 µg/l 0.005 µg/l
Endosulfan	- - - RSA - AUSR	- - UK RSA GER -	USA FR UK RSA GER AUST	- FR - - GER AUST	GC/ECD GC-MS GC-MS GC-MS GC/ECD GC/µECD	0.008 µg/l 0.04 µg/l 0.006 µg/l 0.01 µg/l 0.01 µg/l 0.005 µg/l
Toxaphene	-	-	USA	USA	GC/MS	0.001 µg/l
PCB	- - RSA	USA - RSA	USA FR RSA	USA FR RSA	GC-MS GC/MS GC/ECD	- - -

Compound	In use	Tested in waste water	Tested in receiving water	Tested in drinking water	Test method eg. GC-MS, HPLC	Limit of detection
Atrazine	USA - UK RSA - AUST	- - UK RSA GER -	USA FR UK RSA GER AUST	USA FR UK RSA GER -	LC-MS GC-MS HPLC GC-MS GC-MS GC-MS	- 0.02 µg/l 0.01 µg/l 0.1 µg/l 0.01 µg/l 0.05 µg/l -
Simazine	USA FR UK RSA GER -	- - - RSA GER -	USA FR UK RSA GER -	USA FR UK RSA GER -	- GC-MS HPLC GC-MS GC-MS -	- 0.02 µg/l 0.01 µg/l 0.1 µg/l 0.03 µg/l -
Terbutylazine	- FR UK RSA GER -	- - - RSA GER -	- FR - RSA GER -	USA FR - RSA GER -	- GC-MS - GC-MS GC-MS -	- 0.02 µg/l - 0.1 µg/l 0.03 µg/l -
2’4’-D	USA - UK RSA GER AUST	- - - RSA GER -	USA - UK RSA GER AUST	USA - UK RSA GER -	- - HPLC GC-MS GC-MS LC-MS	- - 0.01 µg/l 0.1 µg/l 0.05 µg/l 0.01 µg/l
Metoxychlor	USA - - RSA - -	- - UK RSA - -	USA - UK RSA - -	USA - - RSA - -	GC/ECD - HPLC GC-MS - -	0.01 µg/l - 0.01 µg/l 0.1 µg/l - -
Deltamethrin	USA FR UK	- - UK	USA FR -	- FR -	LC-MS GC-MS -	- 0.02 µg/l -

Compound	In use	Tested in waste water	Tested in receiving water	Tested in drinking water	Test method eg. GC-MS, HPLC	Limit of detection
	RSA GER -	RSA GER -	RSA GER-	RSA GER -	GC-MS,HPLC GC/ECD -	0.1 µg/l 0.01 µg/l -
p-Nonyl phenol Ethoxy-Late	USA FR UK RSA GER-	USA - UK - GER	USA - UK RSA GER	- - - - -	- - - HPCL --	- - - µ/l --
p-Octyl phenol Ethoxy-Late	USA FR UK - GER-	USA - UK - GER-	USA - - - GER	- - - - --	- - - - --	- - - - --
Bisphenol A	USA FR UK RSA GER-	USA - UK - GER-	USA - UK - GER-	- - UK - GER-	- - HPCL - GC-MS-	- - 5 µ/l - 0.005 µg./l
Cadmium	N/A	FR UK RSA	FR UK RSA	FR UK RSA	ICP-AES/AA AA ICP	10.0/0.5 µg/l 0.3 µg/l 5 µg/l
Mercury	N/A	FR UK RSA	FR UK RSA	FR UK RSA	Atomic Fluor AA AA	0.25 µg/l 0.1 µg/l 2 µg/l
Arsenic	N/A	FR - RSA	FR UK RSA	FR UK RSA	ICP-AES, AA AA Hg/ICP	50/5 µg/l 1 µg/l 5 µg/l
Lead	N/A	FR - RSA	FR UK RSA	FR UK RSA	ICP-AES/AA AA ICP	50/5 µg/l 1 µg/l 30 µg/l

Compound	In use	Tested in waste water	Tested in receiving water	Tested in drinking water	Test method eg. GC-MS, HPLC	Limit of detection
Natural and synthetic hormones						
17ß-Estradiol	N/A	USA FR UK	USA FR UK	- FR UK	LC-MS GC-MS GC-MS-MS	1 ng/l 0.04 ng/l 0.3 ng/l
Ethinyl-estradiol	N/A	USA FR	USA FR	- FR	GC-MS GC-MS	0.02 ng/l 0.32 ng/l
Estrone	N/A	USA FR	USA FR	- FR	Immino assay GC-MS	- 0.04 ng/l
Estriol	N/A	USA FR	USA FR	- FR	- GC-MS	- 0.08 ng/l