CHEMICALS OF EMERGING CONCERN: IDENTIFICATION AND QUANTIFICATION TOOLS

Okonkwo OJ

Department of Environmental, Water & Earth Sciences, Faculty of Science, Tshwane University of Technology, 175, Nelson Mandela Drive, Private Bag X680, Pretoria, South Africa

EMERGING CONTAMINANTS: AN OVERVIEW

Emerging contaminants are synthetic or naturally occurring chemicals or any microorganisms that are not commonly monitored in the environment but have the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. They consist of the following:

- **Pharmaceuticals**,
- Pesticides,
- Industrial chemicals,
- **Surfactants**,
- **Personal care products,**
- Endocrine disrupting compounds (EDCs),
- Artificial sweeteners and food additives,
- Nanomaterials,
- Sunscreens and UV filters, and
- **Flame retardants**

EMERGING CONTAMINANTS: AN OVERVIEW (CONT'D)

They are consistently being found in:

- Groundwater,
- Surface water,
- Municipal wastewater,
- Landfill leachates and sediments and
- Drinking water, and food sources.

When these contaminants pass through drinking water treatment systems, by-products are generated whose chemical properties are as yet undetermined.

EMERGING CONTAMINANTS OF INTEREST

- **PHARMACEUTICAL AND PERSONAL CARE PRODUCTS (PPCPs)**
  - -Triclosan
  - -ARVs
- **ALKYLPHENOLS ETHOXYLATES**
  - -NP
- **PER FLUORINATED ALKYL SUBSTANCES (PFASs)**
  - -PFOA, PFOS
- **LEGACY AND NEW FLAME RETARDANTS**
  - -PBDEs
  - -HBCDs
  - -OPFRs

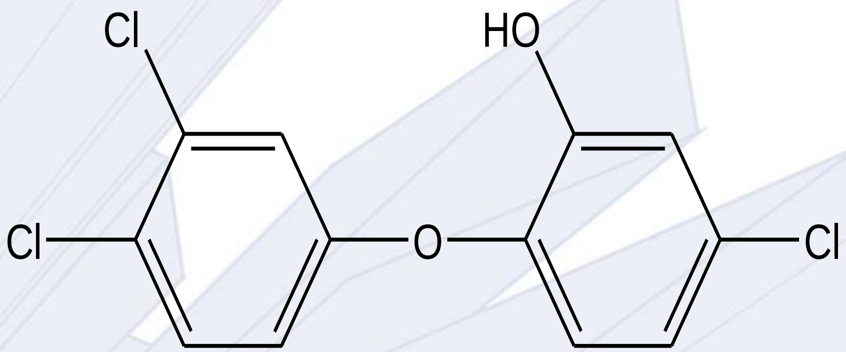
PHARMACEUTICAL AND PERSONAL CARE PRODUCTS (PPCPs)

- Determination of triclosan and triclocarban concentrations in a water treatment plant in Gauteng;

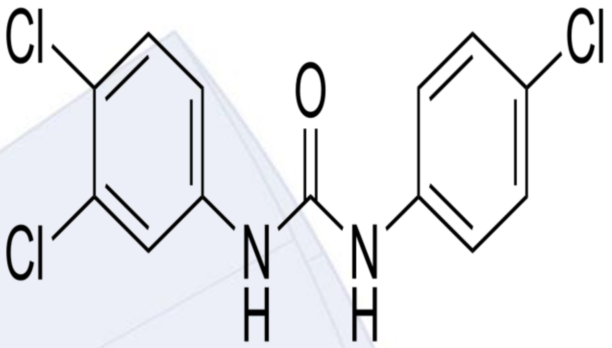
- Quantification of selected antiretroviral drugs in a wastewater treatment works in South Africa using GC-TOF-MS.

TRICLOSAN AND TRICLOCARBAN

The extensive use of personal care products, such as triclosan (5-chloro-2-(2,4-dichlorophenoxy) phenol and triclocarban 3-(4-Chlorophenyl)-1-(3,4-dichlorophenyl) urea in manufacturing industries as a very common **antibacterial agent** has increased in recent years. Triclosan and triclocarban are used in items such as toothpaste, disinfecting soaps, cosmetics, household sponges, socks and underwear.



TRICLOSAN



TRICLOCARBAN

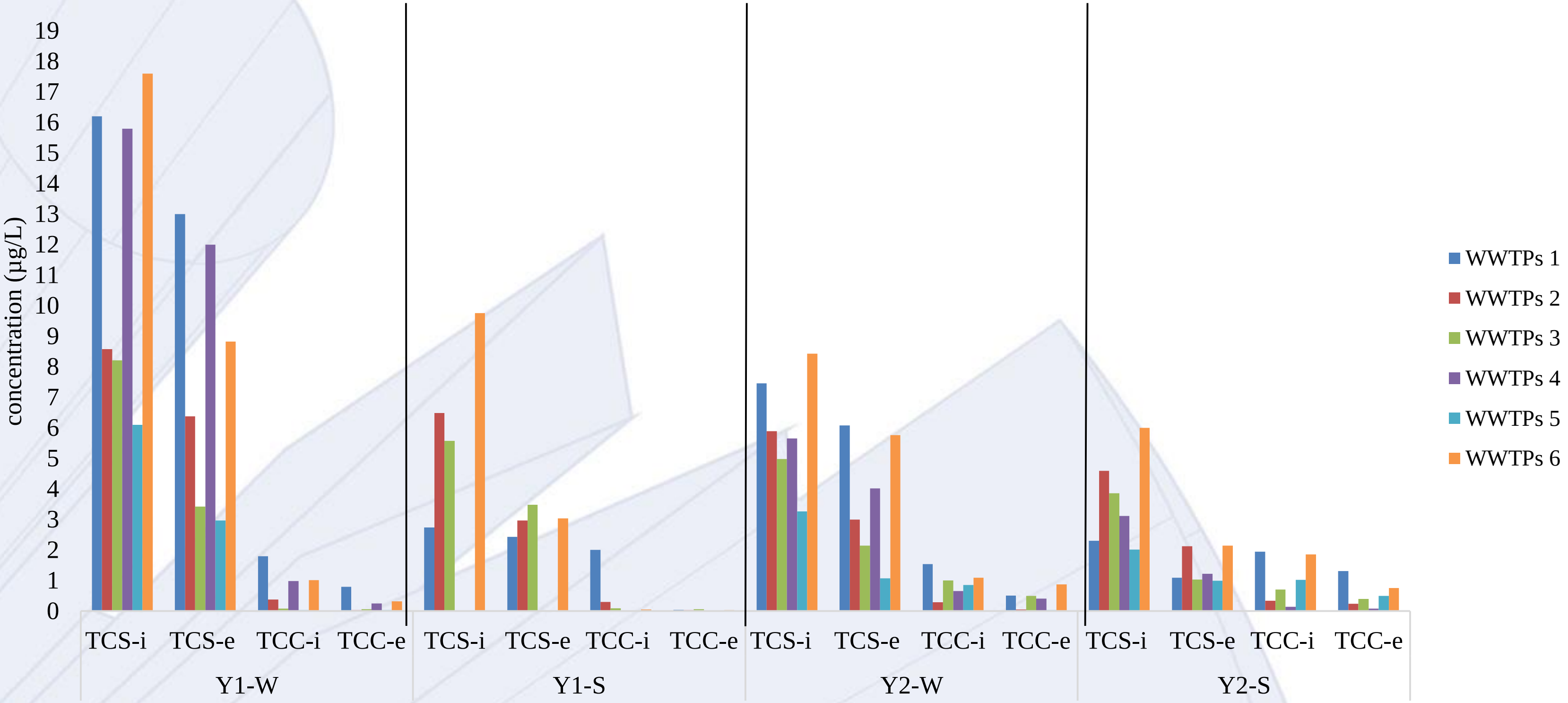
TRICLOSAN AND TRICLOCARBAN CONCENTRATIONS IN A WATER TREATMENT PLANT

Water samples were collected 2.5 L amber bottles from wastewater treatment plants in Gauteng. Samples were obtained from the following points:

- Influent;
- Effluent;

Sample collection was carried out in winter (dry) and summer (wet) seasons. LLE extraction methods were used to extract TCS and TCC. Methanol and acetone (1:1) were used as the extracting solvents. Extracts were cleaned up using silica gel. The extracted analytes were determined by liquid chromatography tandem mass spectrometry (Shimadzu LCMSMS8030, Kyoto, Japan).

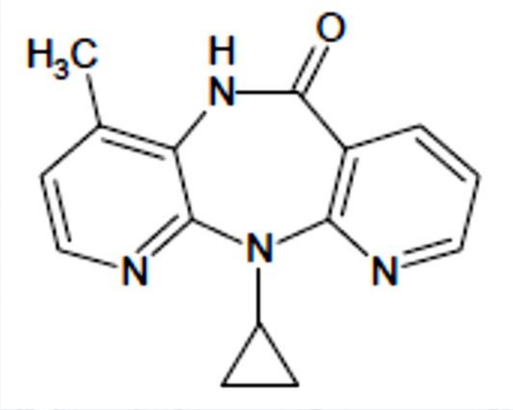
TOTAL MEAN CONCENTRATIONS (μg/L) OF TCS AND TCC IN INFLUENT (I) AND EFFLUENT (E) FROM SIX SELECTED WWTPS FOR YEAR 1 (Y1) AND YEAR 2 (Y2) IN SUMMER (S) AND WINTER (W) SEASONS



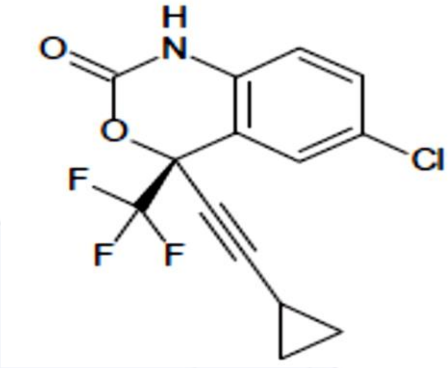
Lehutso et al (2017): *Emerging Contaminants* 3: 107-114

NEVIRAPINE AND EFAVIRENZ

The occurrence of PPCPs in the environment has been widely discussed and published in the literature for the last ten years. These compounds could well have been present in the water prior to this time, however, advances in analytical techniques and instrumentation have only allowed for their detection in the last decade. Many surveys have indicated that PPCPs are present in wastewater and effluents and, as such, can be expected to be a source of PPCPs in drinking water.



Nevirapine



Efavirenz

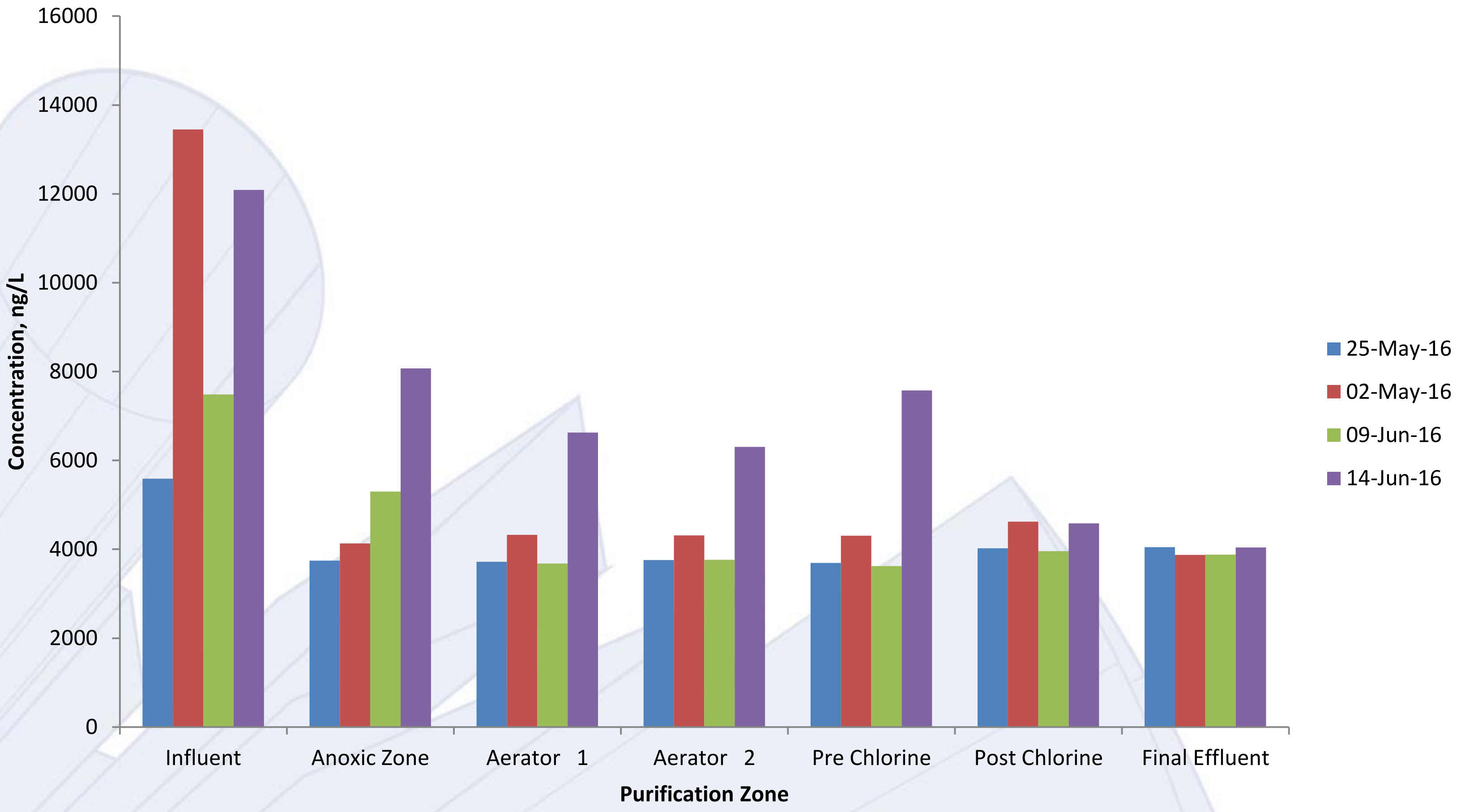
ARVs IN WASTEWATER TREATMENT PLANT: SAMPLE COLLECTION, EXTRACTION AND ANALYSIS

Samples were collected from a Wastewater Treatment Works in Gauteng. Samples were collected in 1 L clear Schott bottles from the following points:

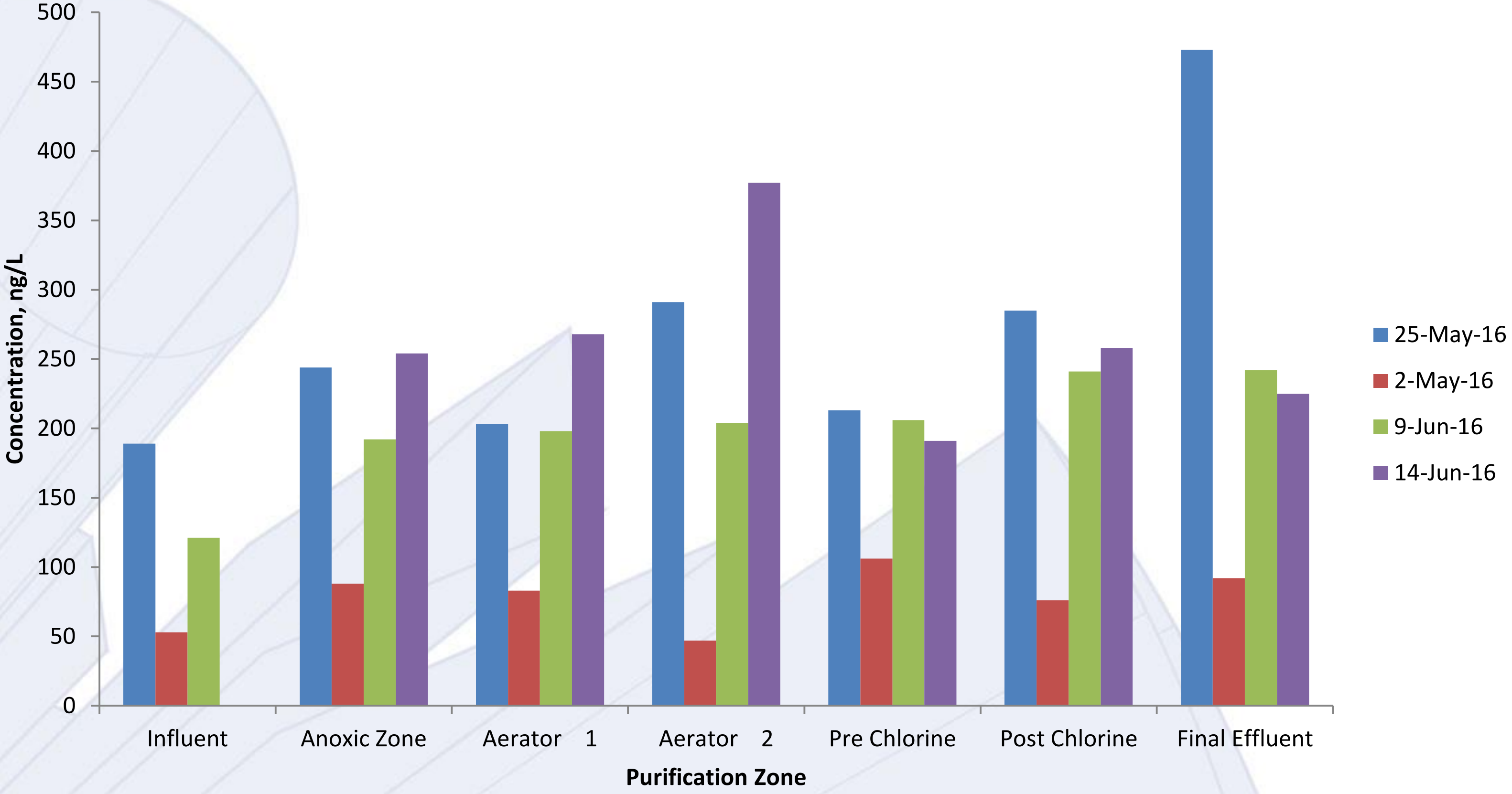
- Influent;
- Anoxic zone;
- Aerator 1;
- Aerator 2;
- Pre-chlorine;
- Post-chlorine
- Final effluent;

Cleanert PEP 60 mg 3 mL SPE cartridges (Bonna-Agela, China) were conditioned with dichloromethane, ethyl acetate, methanol and de-ionized water containing 0.1% phosphoric acid (v/v). Samples, 200 mL were eluted through the cartridges at a flow rate not exceeding 10 ml/min. The eluted samples were dried using Bond Elute sodium sulphate SPE cartridges washed with dichloromethane and ethyl acetate. The adsorbed compounds were desorbed from the cartridges by passing 500 µL of ethyl acetate (2x) and 600 µl dichloromethane through the cartridges under a gentle vacuum. The solvents were pooled in a GC vial and concentrated down to about 150 µL using a Techne Dry Block DB 3 (Bibby Scientific, USA) concentrator, manifold temperature of 40°C. The extracts were made up to 250 µl with ethyl acetate and analysed. Samples were analysed undiluted and diluted 10x with ethyl acetate. An Agilent 7890A GC (incorporating a Gerstel MPS 2 liquid auto sampler) coupled to a LECO Pegasus HT TOFMS (Leco, South Africa) was use to analyse sample extracts.

EFAVIRENZ CONCENTRATIONS (ng/L) AT VARIOUS STAGES OF THE WWTW PURIFICATION PROCESS



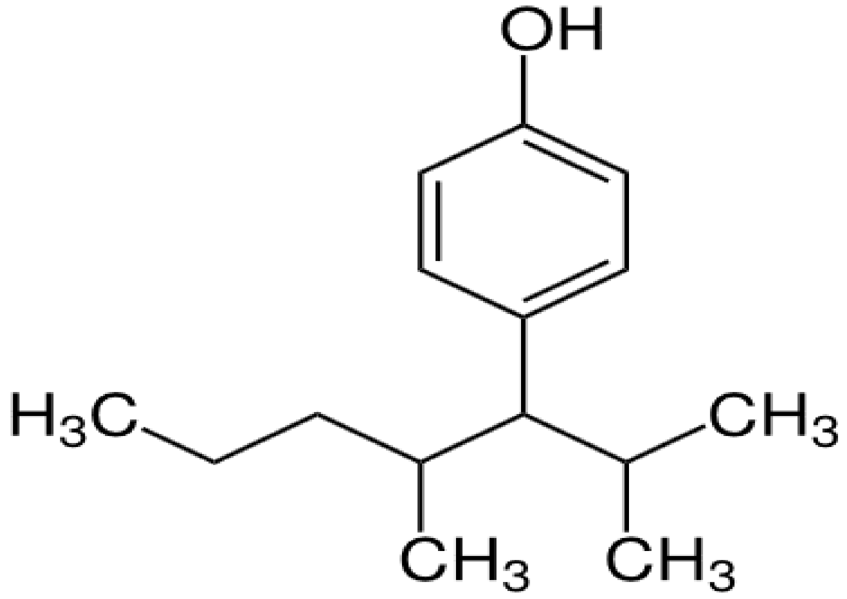
NEVIRAPINE CONCENTRATIONS (ng/L) AT VARIOUS STAGES OF THE WWTW PURIFICATION PROCESS



Schoeman et al (2017): *Emerging Contaminants* 3: 95-106

ALKYLPHENOL ETHOXYLATES

Alkylphenol ethoxylates are one of the most widely used surfactants. They have been used in **domestic detergents, pesticide formulations** and **industrial products**. These compounds find their way into the environment in their original form and as natural degradation products of the parent alkylphenol ethoxylates that are popularly used in commerce for their surfactant properties.



ALKYLPHENOL ETHOXYLATES: SAMPLE COLLECTION, EXTRACTION AND ANALYSIS

Water sampling procedure involved dipping each bottle (250 mL brown bottle) below the surface water and allowing it to fill. The samples were collected from six (6) points along the stretch of Vaal River from the most accessible point.

Briefly, about 250 mL of sample preserved with acetic acid and methanol (MeOH) was extracted using solid phase extraction (SPE) with Strata-X Polymeric Reverse Phase cartridge (500 mg/ 6 mL from Separations, South Africa). Before use, the SPE cartridge was conditioned with 6 mL of 30% MeOH in DCM followed by the addition of 6 mL of MeOH at a flow rate of approximately 10 mL/ min and the compounds eluted with 3 x 2 mL of mixture of DCM-Hexane (4:1). Thereafter, elutes were collected and reduced to dryness under gentle stream of nitrogen and derivatized with heptafluorobutyric anhydride as described by Chokwe et al (2014), prior to analysis by GC/MS.

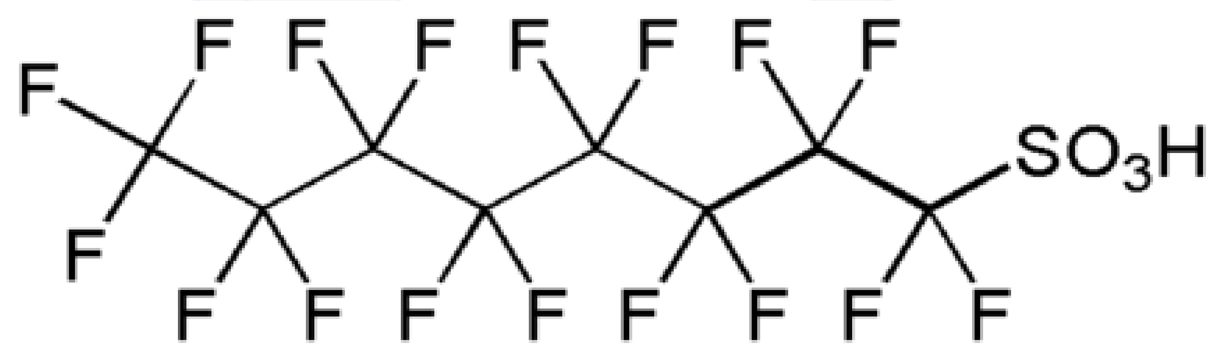
LEVELS (μg/L) OF APEs IN WATER SAMPLES ALONG THE VAAL RIVER CATCHMENT

Compds	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H	Site I	Site J
	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
NP	0.11	0.08	0.09	0.06	0.06	0.09	0.08	0.08	0.08	0.08
OPPE	0.58	ND	0.64	0.61	0.47	ND	ND	0.41	1.93	0.55
di-NPE1	0.35	0.34	0.34	0.37	0.26	0.14	ND	0.35	0.94	0.33
di-NPE2	0.14	ND	0.16	0.10	0.14	0.08	ND	0.39	0.69	0.08
mono-NPE	0.61	ND	0.56	0.71	0.43	ND	ND	0.68	0.55	0.73
NPPE1	0.07	0.04	0.05	0.07	3.75	0.21	0.04	0.09	0.06	0.05
NPPE2	0.05	0.06	0.05	0.10	3.26	1.50	0.11	0.24	0.05	0.07

Chokwe et al (2014): *Water Sci. Technol*. 69 (12), 2389-2396

PERFLUOROALKYL SUBSTANCES

Perfluoroalkyl substances (PFASs) are important chemicals that have been widely used in different industrial applications. Due to their unique chemical and thermal stabilities coupled with their excellent water-and-fat repellent properties, these chemicals have been widely used in different applications. A wide range of consumer products, including **textiles, papers, cosmetics, insecticide formulations, leather products, decoration materials, additives, surfactants, foam extinguishers** and **fluoropolymers**, amongst others, often contain these chemicals. These chemicals may be released into the environment during their manufacturing, and more importantly through discharges from industrial wastewater treatment plants (WWTPs).



Perfluorooctanesulfonate (PFOS)

PFASs: SAMPLE COLLECTION, EXTRACTION AND ANALYSIS

A total of 2.5 L of source and treated water sample was collected from the intake unit of the Vaal River and from sampling points located after the treatment plants, respective. Approximately, 500 mL of each sample in triplicate was subjected to solid-phase extraction (SPE) using ENVI™-18 solid-phase cartridges (Sigma-Aldrich: Aston Manor, South Africa). Prior to the extraction, the SPE cartridges were pre-conditioned with 2 mL of methanol followed by 2 mL of MilliQ water. The targeted compounds were eluted with 2 x 4 mL of methanol. The cleaned extract was blown to incipient dryness under a gentle stream of nitrogen gas. The dried extract was reconstituted with methanol prior to the instrumental analysis. Ten microlitres extracted samples were analysed using liquid chromatography tandem mass spectrometry (Shimadzu LC-MS 8030 triple quadrupole system, Tokyo, Japan).

MEAN CONCENTRATIONS (ng/L) OF TARGETED PFAS IN SOURCE AND TREATED WATER SAMPLES

	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUdA	PFDoA	PFTrDA	L-PFBS	L-PFHxS	L-PFHpS	L-PFOS	Sum
P1	0.11	0.60	0.60	1.13	**1.26**	0.13	0.43	0.08	0.01	ND	0.07	2.59	0.37	38.88	46.25
P2	0.07	0.60	0.41	0.38	**0.27**	0.08	0.06	0.05	0.01	0.01	0.09	1.12	ND	8.07	11.24
P3	0.09	0.56	0.39	0.40	**0.33**	0.10	0.10	0.06	0.01	ND	0.05	1.14	0.01	6.08	9.33
P4	0.09	0.63	0.57	0.40	**0.47**	0.09	0.13	0.08	0.01	ND	0.12	2.26	0.12	12.41	17.38
P5	0.06	0.66	0.50	0.51	**0.49**	0.13	0.10	0.08	0.02	0.01	0.10	1.22	0.04	9.54	13.46
P6	0.07	0.57	0.48	0.50	**0.45**	0.16	0.10	0.15	0.03	0.02	0.00	1.10	ND	3.56	7.17
P7	0.10	0.61	0.80	0.61	**0.50**	0.18	0.10	0.16	0.04	0.02	0.02	1.48	0.02	2.67	7.31
P8	0.06	0.53	0.45	0.50	**0.53**	0.19	0.15	0.14	0.02	ND	0.10	1.63	0.07	6.74	11.11
P9	0.07	0.50	0.33	1.69	**1.70**	0.58	0.46	0.04	0.03	0.05	ND	1.00	ND	7.39	13.84
P10	0.06	0.53	0.37	0.43	**0.48**	0.18	0.15	0.16	0.02	ND	ND	1.65	ND	2.24	6.26
P11	0.06	0.54	0.40	0.40	**0.62**	0.15	0.18	0.14	0.03	0.03	0.10	2.58	0.13	5.09	10.47
P12	0.04	0.46	0.39	0.46	**0.55**	0.20	0.15	0.10	0.04	ND	0.03	1.74	0.02	3.00	7.18
P13	0.09	0.47	0.44	0.42	**0.34**	0.16	0.07	0.13	0.02	0.01	0.04	1.91	0.04	2.24	6.37
P14	0.06	0.58	0.46	0.48	**0.61**	0.18	0.20	0.15	0.03	ND	0.10	2.25	0.12	4.12	9.35
P15	0.04	0.47	0.41	0.40	**0.48**	0.19	0.15	0.15	0.01	0.01	0.05	2.25	0.00	3.14	7.72
P16	0.07	0.69	0.42	0.44	**0.59**	0.18	0.15	0.19	0.02	0.02	0.07	2.12	0.09	9.87	14.94
P17	0.06	0.61	0.37	0.34	**0.63**	0.16	0.21	0.20	0.05	0.01	0.04	2.44	0.03	6.87	12.02
P18	0.11	0.54	0.49	0.47	**0.57**	0.17	0.26	0.16	0.05	0.02	0.09	1.47	ND	4.30	8.68
P19	0.13	0.79	0.46	0.47	**0.54**	0.14	0.13	0.09	0.05	0.02	0.17	1.43	0.10	12.98	17.50
P20	0.08	0.78	0.58	0.47	**0.45**	0.11	0.19	0.16	0.05	0.01	0.09	1.50	0.00	7.44	11.89
P21	0.07	0.88	0.48	0.43	**0.58**	0.11	0.21	0.21	0.07	0.03	0.00	1.58	0.04	5.61	10.31
P22	0.10	0.81	0.50	0.38	**0.60**	0.17	0.14	0.19	0.05	0.02	0.04	2.43	ND	5.90	11.33
P23	0.07	0.66	0.35	0.35	**0.56**	0.20	0.22	0.15	0.04	0.02	0.02	2.96	0.02	5.08	10.70
P24	0.10	1.34	0.46	0.48	**0.44**	0.18	0.27	0.21	0.03	0.02	0.02	2.24	0.02	4.05	9.85
P25	0.13	0.68	0.55	0.36	**0.46**	0.15	0.09	0.10	0.04	0.01	0.02	1.86	0.02	2.05	6.52
P26	0.10	0.84	0.48	0.37	**0.49**	0.16	0.09	0.12	0.02	0.01	0.02	1.34	ND	2.18	6.21
P27	0.08	0.86	0.46	0.40	**0.57**	0.13	0.12	0.12	0.04	0.01	0.04	2.17	0.05	4.01	9.04
P28	0.07	0.72	0.36	0.35	**0.61**	0.18	0.12	0.15	0.01	ND	0.04	2.32	0.06	3.24	8.22

CONCENTRATIONS OF PERFLUOROOCTANOATE AND PERFLUOROOCTANE SULFONATE IN SEDIMENT OF WESTERN CAPE RIVERS, SOUTH AFRICA

In this study, we report for the first time, the presence of PFOA and PFOS in the South African aquatic environment, a result indicating PFC contamination of major rivers in the region. Moreover, there have been few studies conducted in the identified rivers, that is, the Salt, Diep and Eerste Rivers, for the presence of emerging persistent organic pollutants such as PFCs, although several studies have focused on metal contamination.

Tshwane University of Technology

We empower people

CONCENTRATION OF PFOA/PFOS IN SEDIMENT (ng/g DRY WT.) AND SAMPLING POINTS GEOGRAPHIC COORDINATES

River	Sample Site	Latitude	Longitude	PFOA	PFOS
Diep	S.1	S34°01'50.9"	E18°44'51.9"	497,5 ± 20,4	52,2 ± 1,8
	S.2	S34°01'51.1"	E18°44'52.1"	10,7 ± 2,0	32,4 ± 2,1
	S.3	S34°01'50.5"	E18°44'51.5"	772,5 ± 3,04	119,3 ± 9,31
	S.4	S34°01'49.9"	E18°44'51.8"	100,2 ± 2,7	121,1 ± 4,6
	S.5	S34°01'50.9"	E18°44'51.9"	227,5 ± 8,82	87,78 ± 11,6
	S.6*	S34°01'51.1"	E18°44'52.1"	176,3 ± 5,92	2,53 ± 0,0
Eerste	S.1	S33°49'47.4"	E18°31'13.2"	23,9 ± 0,0	69,9 ± 4,0
	S.2	S33°49'51.9"	E18°31'14.4"	75,1 ± 2,0	75,1±2,0
	S.3	S33°49'52.6"	E18°31'14.7"	15,2 ± 0,9	60,0 ± 3,7
	S.4	S33°49'53.3"	E18°31'14.9"	100,0 ± 5,04	6,08 ± 0,36
	S.5	S33°49'47.4"	E18°31'13.2"	162,4 ± 0,39	0,715 ± 0,2
	S.6	S33°49'51.9"	E18°31'14.4"	193,2±13,9	0,72 ± 0,12
Salt	S.1	S33°56'14.4"	E18°28'89.2"	86,9 ± 1,7	ND
	S.2	S33°56'14.1"	E18°28'88.9"	38,6 ± 0,24	ND
	S.3	S33°56'08.4"	E18°28'53.2"	64,6 ± 2,52	ND
	S.4	S33°56'04.6"	E18°28'49.7"	94,0 ± 2,34	19,98 ± 0,54
	S.5	S33°56'01.2"	E18°28'48.4"	187,0 ± 3,04	16,32 ± 3,52
	S.6	S33°56'59.9"	E18°28'48.3"	156,0 ± 2,03	0,225 ± 0,08

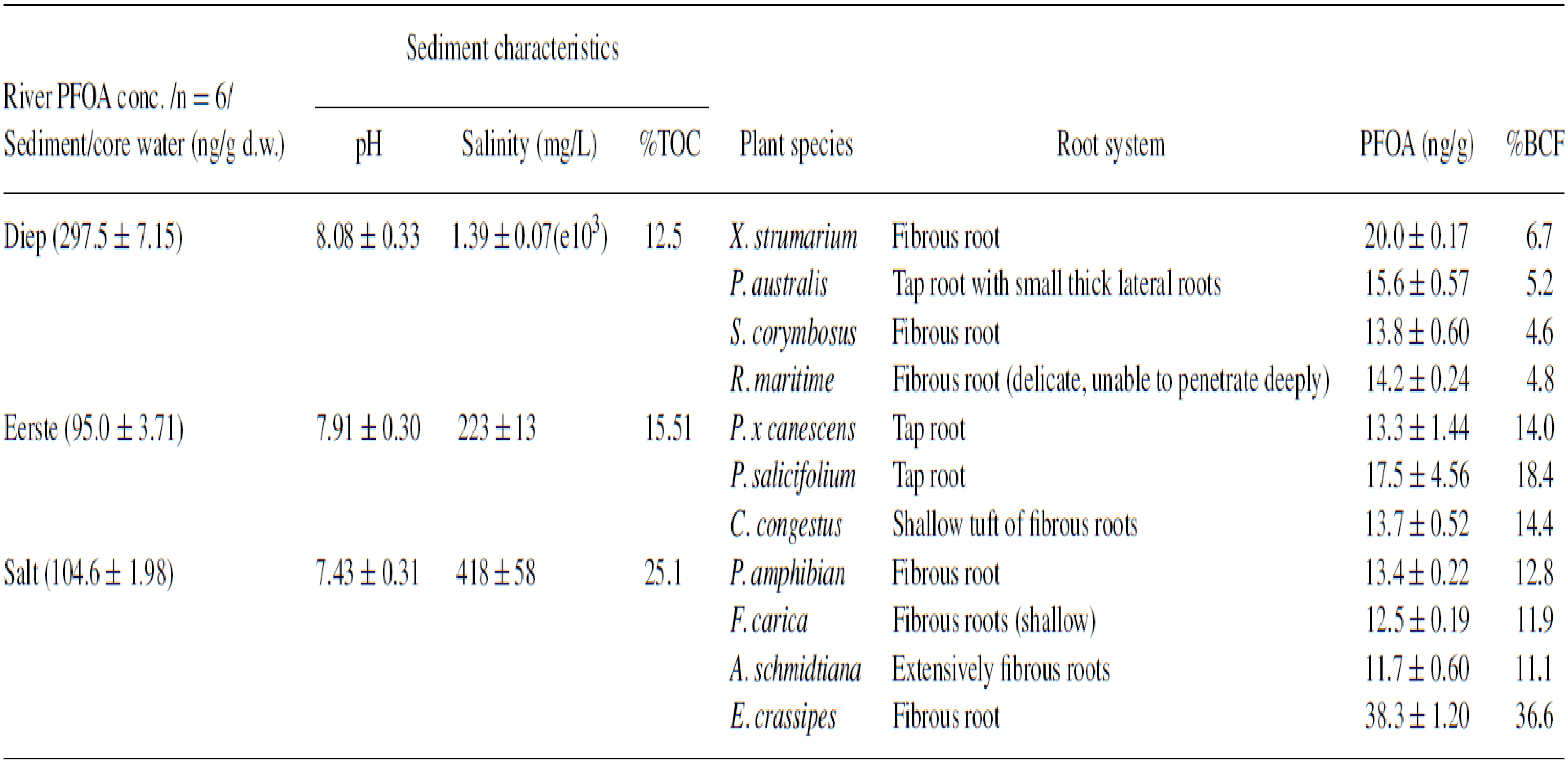
*Repeat samples, ND: concentration was below the detection limit. Samples were collected in duplicate for PFOA and PFOS quantification. Injections duplicated for each sample.

Mudumbi et al (2014): *Carpathian Journal of Earth and Environmental Sciences*, Vol. 9, No. 3, 147 - 158

SUSCEPTIBILITY OF RIPARIAN WETLAND PLANTS TO PERFLUOROOCTANOIC ACID (PFOA) ACCUMULATION

The aim of this study was to determine the susceptibility of commonly found riparian wetland plants and reeds exposed to natural environmental effects to PFOA accumulation from known PFOA concentration in riparian wetland sediment. To date most studies have utilised controlled laboratory studies, which in effect do not represent natural environmental conditions, particularly for studies which focus on the bioaccumulation of PFOA.

SUMMARY OF STUDIED RIPARIAN WETLAND PLANTS, WITH THEIR PFOA CONCENTRATION, ROOT SYSTEM, AND PERCENT BIOCONCENTRATION FACTOR



River PFOA conc. /n = 6/ Sediment/core water (ng/g d.w.)	Sediment characteristics			Plant species	Root system	PFOA (ng/g)	%BCF
	pH	Salinity (mg/L)	%TOC				
Diep (297.5 ± 7.15)	8.08 ± 0.33	$1.39 \pm 0.07(e10^3)$	12.5	*X. strumarium*	Fibrous root	20.0 ± 0.17	6.7
				P. australis	Tap root with small thick lateral roots	15.6 ± 0.57	5.2
				S. corymbosus	Fibrous root	13.8 ± 0.60	4.6
				R. maritime	Fibrous root (delicate, unable to penetrate deeply)	14.2 ± 0.24	4.8
Eerste (95.0 ± 3.71)	7.91 ± 0.30	223 ± 13	15.51	*P. x canescens*	Tap root	13.3 ± 1.44	14.0
				P. salicifolium	Tap root	17.5 ± 4.56	18.4
				C. congestus	Shallow tuft of fibrous roots	13.7 ± 0.52	14.4
Salt (104.6 ± 1.98)	7.43 ± 0.31	418 ± 58	25.1	*P. amphibian*	Fibrous root	13.4 ± 0.22	12.8
				F. carica	Fibrous roots (shallow)	12.5 ± 0.19	11.9
				A. schmidtiana	Extensively fibrous roots	11.7 ± 0.60	11.1
				E. crassipes	Fibrous root	38.3 ± 1.20	36.6

Mudumbi et al (2014): ***Intern J Phytoremediation***

https://www.tandfonline.com/action/showCitFormats?doi=10.1080/15226514.2013.810574

LEGACY AND NEW FLAME RETARDANTS

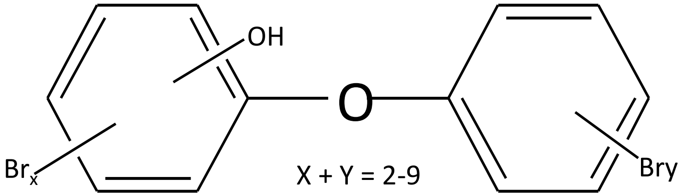
Brominated flame retardants, BFRs, are a group of brominated organic compounds with inhibitory effect on the ignition of combustible organic materials. BFRs are structurally diverse group of compounds with bromine atoms. Bromine, added to organic compounds compared to elements of the same group such as fluorine, chlorine and iodine have shown to be the most effective in the inhibition of fires and are materials of choice because of low cost and lower loading of substrate .

NATURAL FLAME RETARDANTS

Hydroxylated PBDEs

OH-PBDEs

- *2-OH-PBDE-47*
- *6-OH-PBDE-47*




Marine Sponge

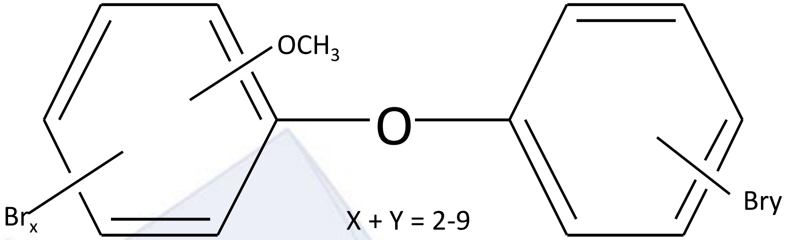

Red algae

Methoxylated PBDEs

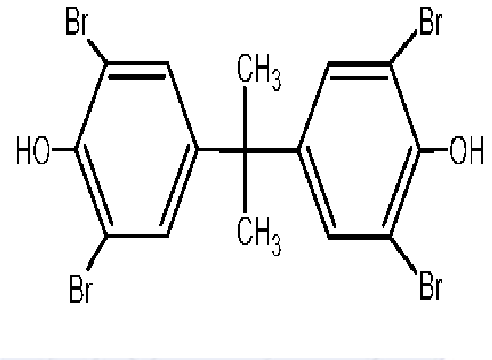
MeO-PBDEs

- Two abundant congeners are natural products
  - *2-MeO-PBDE-68*
  - *6 MeO-PBDE-47*

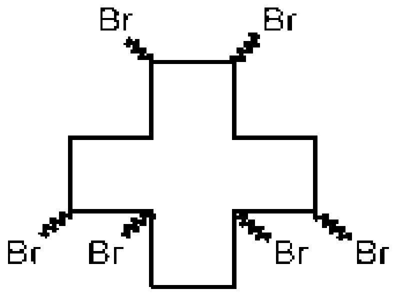
Fish oil



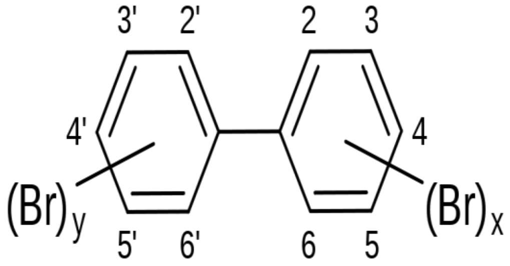
BASIC STRUCTURES OF BFRs



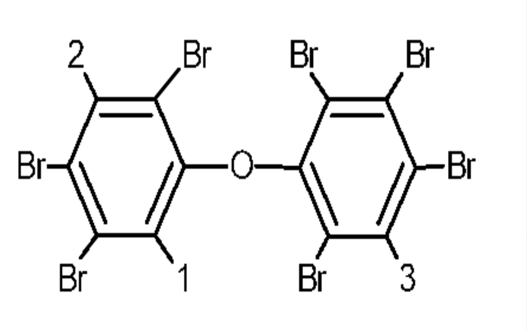
TBBPA



HBCD



PBBs



PBDEs

POLYBROMODIPHENYL ETHER (PBDEs)

The most commonly used PBDEs are commercial mixtures of:

- pentabromodiphenyl ether (c-PentaBDE),
- octabromodiphenyl ether (c-OctaBDEs) and
- Decabromodiphenyl ether (decaBDEs)

LEGACY AND NEW FLAME RETARDANTS: SAMPLE COLLECTION, EXTRACTION AND ANALYSIS

Samples, water and sediment, were collected from a treatment plant. Sampling points were located at the dam, raw water entering the plant, after sedimentation before chlorination and lastly chlorinated water living the plant. Samples were stored in 4°C. Water parameters were conducted upon reaching the laboratory.

The purified extracts was analysed by Shimadzu model 2010 plus gas chromatograph coupled with a model QP 2010 ultra-mass spectrometer (Shimadzu, Japan) using electron ionisation and injected automatically by a Shimadzu A0C-20i auto sampler.

MEAN CONCENTRATIONS (ng/L) OF LEGACY AND "NOVEL"BFRS IN TREATMENT POTABLE WATER PLANT

Compd.	W1	W2	W3	W4	W5	LOD[a]	LOQ[b]
BDE-28	-*	115±3.8	-	-	-	0.01	0.1
BDE-47	42.7±0.8	232±3.7	74.7±0.6	42.7±0.8	40.0±1.1	0.01	0.09
BDE-100	-	-	-	-	-	0.02	0.19
TBB	18.7±1.0	29±1.3	16.0±1.1	13.3±0.8	90.7±5.1	0.01	0.29
BDE-99	-	56±3.2	-	-	13.3±0.2	0.02	0.32
BDE-154	-	165±3.5	-	-	-	0.01	0.33
BDE-153	-	56±8.2	-	-	-	0.01	0.32
HBCD	-	117±4.0	-	-	-	0.02	0.34
BDE-183	-	85±2.7	-	-	-	0.01	0.33
TBPE	-		-	-	-	0.03	0.33
TBPH	-		-	-	-	0.06	0.42

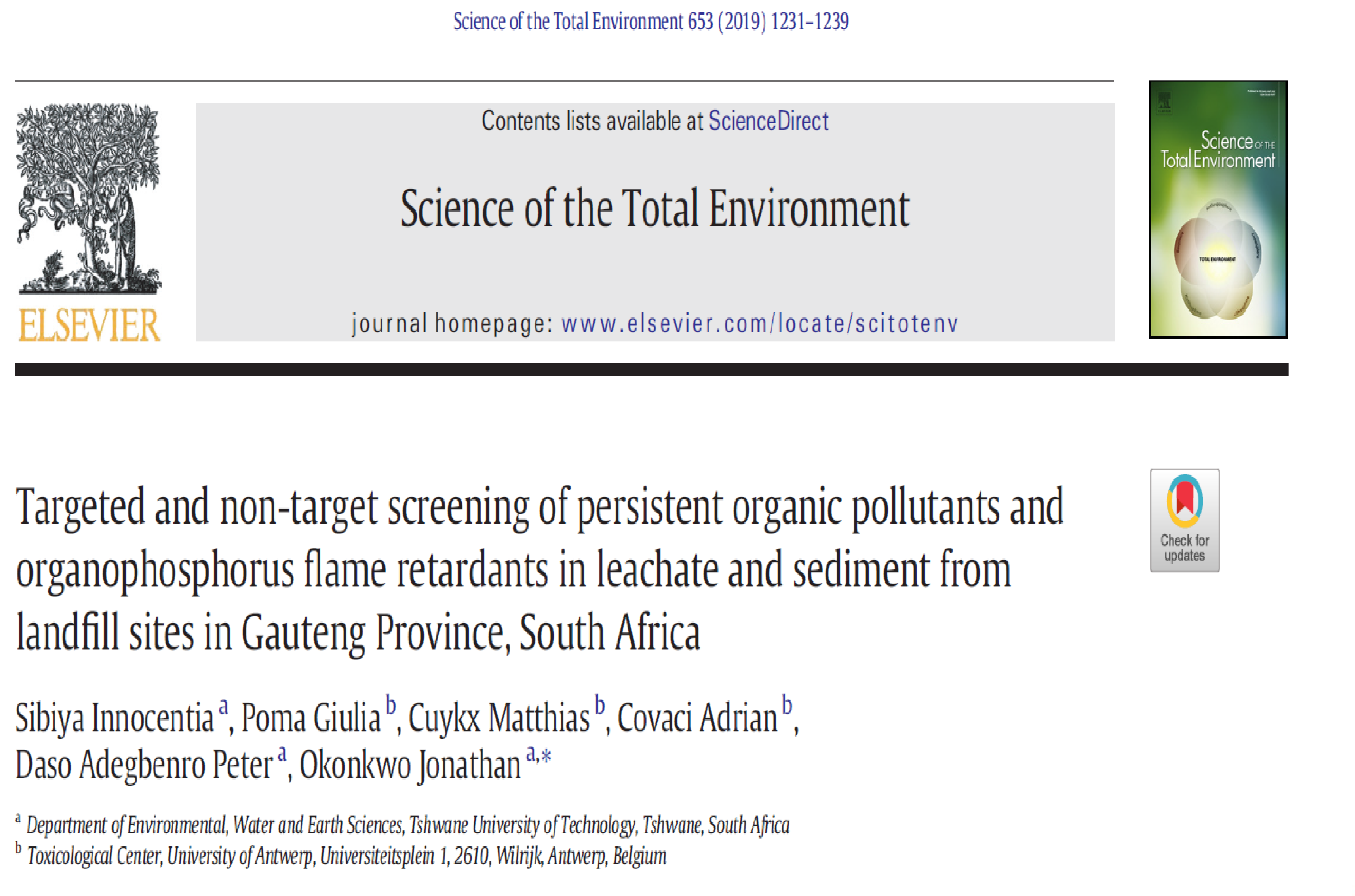
N.B: Compd= compound, *Below detection, [a]limit of detection and [b]limit of quantitation (ng μL^{-1}); W1= Dam (centre) W2= Dam just being pumped out; W3= after sedimentation before chlorination; W4= after chlorination ;W5= screen

TARGETED AND NON-TARGET SCREENING OF PERSISTENT ORGANIC POLLUTANTS AND ORGANOPHOSPHORUS FLAME RETARDANTS IN LEACHATE

Reports on POPs in landfill sites in South African are very scarce. Only PBDEs have so far been reported in landfill sites in South Africa. Therefore, the present study reports on the concentrations of selected PBDEs, PCBs, OCPs and OPFRs in leachate, as well as on non-target screening of leachates from the two busiest and largest landfill sites in Pretoria and Johannesburg. OPFRs were also determined for the first time in leachate samples from four Pretoria and three Johannesburg landfill sites.

TARGETED AND NON-TARGET SCREENING OF PERSISTENT ORGANIC POLLUTANTS AND ORGANOPHOSPHORUS FLAME RETARDANTS IN LEACHATE

About 2.5 L raw leachate and approximately 1000 g of sediment samples were collected from each site in pre-washed and acetone rinsed amber bottles. For leachate collection, the grab sampling technique was employed by dipping thoroughly cleaned beaker into leachate ponds; while sediment samples were collected 5 cm below the surface of the leachate pond, at the same location as the leachate sample. After collection, the samples were sealed immediately, stored in cooler boxes, transported to the laboratory and kept at 4 °C in a cold room. Sediment samples were air-dried and sieved. Twenty millilitres of leachate from Marie Louis (Johannesburg) and Hatherly (Pretoria) were transferred into 50 mL PP falcon tubes, the Marie Louis sample was first diluted 10 times with MilliQ water µm sieve prior extraction.



Science of the Total Environment 653 (2019) 1231–1239

Contents lists available at ScienceDirect

Science of the Total Environment

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

Targeted and non-target screening of persistent organic pollutants and organophosphorus flame retardants in leachate and sediment from landfill sites in Gauteng Province, South Africa

Sibiya Innocentia [a], Poma Giulia [b], Cuykx Matthias [b], Covaci Adrian [b], Daso Adegbenro Peter [a], Okonkwo Jonathan [a,*]

[a] Department of Environmental, Water and Earth Sciences, Tshwane University of Technology, Tshwane, South Africa
[b] Toxicological Center, University of Antwerp, Universiteitsplein 1, 2610, Wilrijk, Antwerp, Belgium

CONCLUSIONS

The studies we have conducted so far have:

- Shown the presence of some of the emerging contaminants;
- The current levels detected so far are fairly low compared to levels reported in in other countries and recommended levels;

There is a need to conduct a national monitoring programme in order to obtain the spatial distribution of these emerging contaminants

ACKNOWLEDGEMENTS

- Water Research Commission (WRC) with the BFRs project;
- Rand Water Chair on organic contaminants;
- Organization for the Prohibition of Chemical Weapon for sponsoring some parts of this project and for financial assistance;
- Tshwane University of Technology, Pretoria, South Africa for providing the enabling environment

ENVIRONMENTAL-ANALYTICAL RESEARCH IN CHEMISTRY (EARch) GROUP IN TUT

Tshwane University of Technology

We empower people

Thank you all!