SUPPLEMENTARY MATERIAL 1

Supplementary Material 1 contains:

1) The 214 references (literature papers) that were consulted for this research study

2) Table S2: The initial raw data, which excludes the research gaps, showing CEC class, sampling mode, matrix, analytical method, etc,.

3) Table S3: The initial raw data, which details the research gaps: high level class description, actual research gap/s, and relative frequency (number, percentage of total)

4) Table S4: Some typical classes of CECs

5) Table S5: Some of the reported matrices analysed for CECs

6) Table S6: Reported definition of a CEC and references

7) Table S7: Summary of other reported descriptions/properties for CECs

8) Table S8 ISO requirements as per ISO ISO/IEC Directives Part 2 Principles and rules for the structure and drafting of ISO and IEC documents

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The 214 references (literature papers) that were consulted for this research study:

Abbreviations:
WRC: Water Research Commission

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Table S2 All Raw data capture from all the References

Study/ report/ Number	Class		Compounds - examples	Matrix analysed	Sampling X = Grab √ = Composite	Analytical Method/s used (mv)	Targeted (T)/ Non-target NT (Screen)	Accurac y/ PTS- similar	Reference
1/ Review	PPCPs, ECs: analgesics, antibiotics, antineoplastics, beta-blockers, perfluorinated compounds, personal care products, plasticisers		Ibuprofen Amoxicillin Fluoxetine Tamoxifen 4-Nonylphenol 17-Alpha-ethinylestradiol Bezafibrate Linalool Perfluoroocta=noic acid Bisphenol-A Benzophenone-4	Water, suspended solid, biosolid, sediment	X	X	T	X	1 J Wilkinson et al, 2017 (review)
2 Review	]ECs; Pharmaceuticals: NSAIDS, beta- blockers, anti-depressants, antiepileptic (Carbamazepine) Metabolites		17-beta-Estradiol Propranolol, Carbamazepine Diclofenac Clofibric acid Ranitidine Furosemide Bezafibrate Fluoxetine Valsartan	Wastewater, Surface water (Biosolid, amended soil, River sediment, Particulate phase)	√	High resolution MS (QTOF, orbitrap technology) 1	T, S	X	2 B Petrie et al, 2015 (review)

			Theophylline Tramadol Codeine Diazepam Ephedrine Amoxicillin Tamoxifen MDMA Cocaine Nicotine Bisphenol A 1- Benzophenone Methylparaben						
3	CECs: pharmaceuticals, pesticides		Fluconazole	Water, aquatic ecosystems, river basins, surface water	X	X	NT	X	3 J van Gils et al, 2019
4 Ghana	Perfluoroalkyl acids			river basin, tap water	X	HPLC-MS/MS 2	T	X	4 SK Essumang et al, 2017
5	Chlorinated and brominated contaminants, and their transformation products,		Flame retardants, Poly= brominated p-dioxins and furans: BDE-47 PBDE, TCC, TCS	Aquatic environment		GC-MS, GC-MS/MS, GC-HRMS, GC-QQQ-FT-ICR-MS,	T NT	X	5 SL Badea et al, 2020

	Personal care products					GC-Q-TOF-HRMS, APGC-TOF-HRMS, GCXGC-TOF HRMS, UHPLC-TOF-HRMS, LC-MS/MS, UPLC-MS/MS, UHPLC-orbitrap-HRMS, LC-Q-orbitrap HRMS, LC-IM-Q-TOF-HRMS, LC-APPI-orbitrap HRMS,APGC-APCI-QQQ-MS-MS			

						3			
6 Review	Non-nutritive artificial sweeteners		Aspartame, Cyclamate, Saccharin, Sucralase	Surface Tap Groundwater Sweater Lake atmosphere		GC-MS, LC-MS, LC-TOF-MS, LC-MS/MS, IC-MS/MS 4	T		6 SM Praveena et al 2019 (review)
7 Review	Microplastics, Pharmaceuticals, Personal care products, Bisphenol A, Phthalates-Alkylphenols, Perfluoroalkyl substances		Bisphenol A, Dimethyl phthalate, Nonylphenol, Perfluoro= dodecanoic acid	bottled water		various	T		7 R Akhbarizadeh et al, 2020 (review)
8 Review	Pharmaceuticals and Personal Care products: psychiatrics and stimulants, analgesics/anti-inflammatory drugs, antibiotics, anti(retro)virals,		Paracetamol, Carbamezapine, Lamivudine, Sulfamethoxazole, Valsartan 17-beta-Estradiol, Sulfadoxin, Triclosan DDT	African aquatic environment: wastewater, sludge, surface water, sediment, groundwater, drinking water		HPLC-UV/DAD/PDA GC-ECD, HPLC-MS/MS/QTOF/HRMS, GC-TOFMS 5	T	X	8 KO K’oreje et al, 2020 (review)

	cardiovascular drugs, hormones, other drugs; Organochlorine pesticides								
9 Review	CECs: Natural and synthetic hormones, pharmaceuticals, personal care products, EDCs, PFAS			Aquatic/ fresh water food webs	X	X	X	X	9 E Nilsen et al, 2019 (review)
10 Review	Personal care products, Preservatives, anti-oxidants and flavorants present in cosmetics and cleansing products (toothpaste), antiseptics, suncreens, insect repellant		Polycyclic musks HHCB, AHTN, Endocrine disruptor TCS, DEET, Methylparaben, Benzophenone	Surface water, Ground water, Wastewater	X	X	T	X	10 D Montes-Grajales et al, 2017 (review)
11	Environmentally related contaminants of high		Paraben, TCS, DEET, Musk ketone, Benzophenone,	Surface water, groundwater, industrial	X	GC-MS, LC-MS Triple quad	X	X	11 T Rasheed et al, 2019

	concern:micro-pollutants, pesticides, pharmaceuticals, hormones, endocrine disruptors, industrially related synthetic dyes, dyes containing hazardous pollutants		Penicillin, Benzo[alpha]pyrene, Dioxin, Polychlorinated biphenyl, Rhodamin B Methyl orange	wastewater streams		Linear ion trap quadrupole, Quadrupole-time of flight, triple quadrupole, quadrupole linear ion trap, immunoanalytical technique, microbiological assays, capillary electrophoresis 6			
12	ECs Pharmaceuticals Personal care Products EDCs		Penicillin, Caffeine, Diclofenac, Carbamazepine, Gemfibrozil, Propranolol,	Wastewater Environment, surface, Ground, drinking	X	X	X	X	12 A Gogoi et al, 2018

			HHCB, Triclosan 17-beta-Estradiol alkyl-p-Hydroxybenzoate,						
13	Legacy persistent organic pollutants: PCBs, OCP, PAHs		CB28, *o*,*p*-DDT, alpha-HCH	Indo-Pacific finless porpoises from Pearl River Estuary, China	√	GC-MS 7	T	X	13 D Gui et al, 2018
14	Emerging contaminants/POPs (persistent organic pollutants): polychlorinated dibenzo-p-dioxins, furans, dioxin-like polychlorinated biphenyls,, non-dioxin-like PCbs, OCPs, PBDEs, polychlorinated		DDT,HCH, Chlordane, D5, PCB8, beta-Hexachlorocyclohexane, 1,3,5-chlorobenzene, BDe47, fluorene	Arctic environment: seaweater, air, soil, sediment, sludge, iceberg	X	GC-TOF-MS 8	T, NT	X	14 S Lee et al, 2019

	naphthalenes, chlorobenzenes, PAHs, pseudo-POPs (dechlorane plus), NBFRs, OPFRs, phthalates, siloxanes, synthetic musk compounds, benzotriazole ultraviolet stabilisers								
15	CECs: PPCPs, EDCs, flame retardants, pesticides, artificial sweeteners		Ace taminophen, Estrone, Brominated bisphenol, Atrazine, Sucralose	water matrices: ground, drinking, wastewater, sludge, river		GC-MS, HPLC-MS/MS, LC/MS/MS, HPLC, T, NT ? 9	X	X	15 M Salimi et al, 2017
16 Review	Pyrethroid insecticides		Bifenthrin, Cypermethrin	Sediment	X	T	X	X	16 H Li et al, 2017 (review)
17	CECs: Pharmaceuticals, personal care		Amoxicillin, Triclosan, Methyl	wastewater	X	NT	X	X	17 RA Hamza et al, 2016

	products, pesticides, surfactants, disinfection by-products, flame retardants, perfluorinated compounds, nanomaterials		paraben, Malathion, DDT, Lauryl sulfate, Alkylphenol ethoxylates, 4-Nonylphenol, Chlorine, Hexabromocyclododecane, Perfluorooctanoic acid, Titanium dioxide						
18	CECs: pharmaceuticals, antibiotics, hormnes, personal care products, cyanotoxins, engineered nanomaterials, anti-microbial cleaning agents and their transformation products, plastics/microplastics		Microplastics, anti-microbials	agricultural water	X	X	NT	X	18 AEV Evans et al, 2019

19 Review	Insect repellent		N,N-Diethyl-m-toluamide	drinking water, surface water, wastewater, landfill leachate, ground water, drinking water	X , POCIS	GC-MS, LC-MS, LC-MS/MS 10	T	X	19 S Merel et al, 2016 (review)
20	Pharmaceuticals, antibiotics, anti(retro)viral, analgesic, anti-inflammatory, psychiatric drugs residue		Diclofenac, Chloramphenicol, Diazepam, Nevirapine	wastewater, surface water, groundwater	X grab	LC-magnetic sector-HR-MS 11	T (10)	X	20 KO K'oreje et al, 2016
21 Review	Anti inflammatory drug: Diclofenac		Diclofenac	Surface water waste Water, river, estuaries, lakes, groundwater, drinking water, well, seawater, aquifier, Soil	X	X	T	X	21 L Lonappan et al, 2016 (review)

22	Toxaphene and chlordane-related pesticides		CHB-50, Oxychlordane	peregrine falcon eggs from South Greenland		GC-MS-ECNI 12	T	√	22 K Vorkamp, et al, 2014
23	Pharmaceuticals: non-steroidal anti-inflammatory drugs, steroid hormones, antibiotics, psychiatric, cardiovascular, hypocholesterolaemic drugs		Ibuprofen, Paroxetine, Valsartan, EE2, Simvastatin, Erythromycin	aquatic environment, river, lake, estuaries, groundwater, marine water	X	GC-MSMS, LC-MSMS 13	NT	X	23 M Mezzelani et al, 2018
24 Review	Chiral pharmaceuticals, non-steroidal anti inflammatory drugs, beta blockers, herbicide, pesticides		Ibuprofen, Fipronil, Deltamethrin, Propranolol,	Surface, drinking, wastewater	X	X	T	X	24 Y Zhou et al, 2018 (review)
25	Contaminants of emerging concern: pharmaceuticals, sweetener, metabolite		Codeine, Sulfamethoxazole, Diclofenac, Sucralose, Benzoylecgonine	centralised and on-site wastewater treatment system effluents receiving	√	LC -MSMS 14	T	X	25 B Du et al, 2014

				common wastewater, surface water					
26	Stimulant		Caffeine And metabolite Paraxanthine	aquatic systems, drinking water, ground water, surface water, wastewater, rain water, sea water	X	T	X	X	26 JL Rodriguez-Gil et al, 2018
27	Microplastics and their sorbed contaminants, endogeneous additives; nanoplastics			marine environment, sea water, surface, sea ice, sediment, marine organisms, food web, higher order predators, humans	X	UV-VIS, spectrometry, electron microscopy, filed flow fractionation, dynamic light scattering	X	X	27 M Carberry et al, 2018

28	Plastics: additives and contaminants			Aquatic organisms, land based ecosystems, land and ocean environment ocean, human and non-human	X	X	T	X	28 S J Barnes, 2019
29	Hydrophobic organic contaminants: Halogenated flame retardants, synthetic musks, organochlorine pesticides, PCBs (polychlorinated bi-phenyls)		HBB, TCS pp-DDE	tropical urban catchment: water, sediment, biota: plankton, invertebrates and fish	X	GC-MSMS 15	T	√	29 Q Wang et al, 2018
30	Bacterial/viral contaminants, new chemicals, metal-elements, pharmaceuticals, anthropogenic		Aluminium, Clofibric acid, Sulfamethoxazole, Lamivudine, Estrone, Giardia, Adenovirus	Public source and drinking water supplies	X	HPLC-MS/MS, US EPA 1623, qPCR, in vitro: T47D-	T	X	30 R Benson et al, 2017

	waste indicators, hormones, dis-infection byproducts					KBluc bioassay 16			
31	Natural and synthetic estrogens; estrogenic activity and chemical concentration		Estrone, 17-beta-Estradiol, Estriol, 17-alpha-Ethinyl Estradiol	Source water, Treated/drinking waters	X	LC-FTMS, in vitro: T47D-KBluc bioassay 17	T	X	31 JM Conley et al, 2017
32	Per- and polyfluoroalkyl substances		PFOS, PFOA, PFBS, PFNA	Source water, Treated/ drinking waters	X	LC-MS/MS 18	T (19)	X	32 JS Boone, et al, 2019.
33	Contaminants of emerging concern: pharmaceutical		Acetaminophen Fluoxetine, Sulfamethoxazole, Estradiol, Morphine, Lamivudine	Source water, treated drinking water	X	HPLC-MS, HPLC-MS/MS, GC-MS 19	T	X	33 ET Furlong et al, 2017
34	ECs Metals, pesticides, nutrients, pharmaceuticals, hormones,		Aluminum, Triclocarban, Norverapamil, Progesterone, Atrazine,	Source water	X	HPLC-MS, HPLC-MS/MS, GC-MS; EC/Effect Concentrat	T	X	34 MS Kostich,Fulong, 2017.

	perfluorinated compounds		para-Nonylphenol, Ibuprofen, Atrazine, Metolachlor, Triclosan, para-Nonylphenol, Ibuprofen, Venlafaxine, Amitriptyline,			ion estimates 20			
35	Contaminants of emerging concern: microbial pathogens		Legionella, Mycobacteria, Crypto, Giardia,	Source water, treated drinking waters	X	USEPA Method 1623, qPCR	T	X	35 MJ Donohue, DN King, Wilson, 2017
36 Review	Pharmaceutical s; NSAID s		Ketoprofen	environment, raw and treated wastewater, surface water, river, lake, sea, sewage sludge, sediment, soil, landfill leachates, ground water	X	X	T	X	36 J Wang, A-qi Zhao, Bing-shu-He., 2018 (review)
37 Review	Microplastics		Microplastics	marine environment:	X	X	T	X	37

				ocean, lake, sea, river, coastal areas, Polar Region					HS Auta, CU Emenike, SH Fauziah, 2017. (review)
38	Antihistamines		Cimetidine, Diphenylhydra mine, Ranitidine, Loratidine	environment, surface waters, effluents, surface, ground, drinking, reclaimed water, suspended solid, sediment, invertebrate, fish			T		38 LA Kristofco, BW Brooks, 2017
39	CECs		Perchlorate	Atacama Desert: drinking water, surface, groundwater, soil, atmospheric aerosol and gases, eolian dust,	X	X	T	X	39 Vega, M., nerenberg, R., Vargas, I.T., 2018.

				fertiliser, nitrate deposits					
40	Pharmaceuticals and Personal care products (PPCPs)		Erythromycin, Chloramphenicol, Nalidixic acid, Tetracycline Sulfamethoxazole, Acetaminophen Atenolol, Diclofenac, Ibuprofen, Caffeine, Nalidixic acid, Atenolol, Aspirin, Diclofenac, Ketoprofen, Ibuprofen	African, Asia, South America, Europe, North America freshwater, aquatic environment, surface water, drinking water, wastewater, sediment, sewage sludge	X	X	T	X	40 AJ Ebele, M A-E Abdallah, S Harrad., 2017
41	Pharmaceuticals and metabolite: antibiotics, NSAIDs, antihistamines, lipid regulators,		Erythromycin, Sulfamethazine, Norsertraline, Diclofenac	Aquatic fauna, fish, invertebrates sediment, biota		GC-MS, LC-MS GC-HRMS, LC-HRMS, IC-HRMS, NMR,	T		41 TH Miller, 2018

	anti-depressants,					FT-ion cyclotron resonance direct infusion MS 21			
42	CECs: chemical and microbiological: pharmaceuticals, anthropogenic waste indicators, perfluoroalkyl and polyfluoroalkyl substances, inorganic constituents, microorganisms		Bupropion, Bromoform, Estrone, PFOA, PFDA, Ttriclocarban, Aluminium, Giardia, Polyomavirus	Source and treated/drinking water	X	LC-MS/MS, UPLC-MS/MS, LC-FT-MS with accurate mass, GC-MS, LC-MS, USEPA 2005a, USEPa, 2005b, USEPA 2001, USEPA 1994, 22	X	X	42 ST Glassmeyer EF Furlong, 2017
43	Pesticides**:** Chloroacetanilide herbicides:		Acetochlor, Alachlor, Butachlor, Metolachlor,	Environment: soil, surface, groundwater	X	X	T	X	43 SS Mohanty, HM Jena, 2019.

			s- Metolalochlor, Pretilachlor, Propachlor, Propisochlor						
44	Legacy POPs		Organochlorine pesticides, PCBs	Plasma in humans	X	GC-MS/MS 23	T	X	44 LA Henriquez-Hernandez, 2016,
45	Polychlorinated biphenyls Organochlorine pesticides		HCHs, DDT, sum of: Aldrin, Dieldrin and Endrin,	Tiber River and Estuary, water, suspended particulate matter, sediment	X	GC-ECD, GC-MS 24	T	X	45 P Montuori, Triassi, 2016
46	Pharmaceuticals: antibiotic		Erythromycin	Environment: wastewater effluent, inland, drinking, ground, estuarine and coastal systems, sewage sludge, biosolid, sediment, tissue of	X	X	T	X	46 BH Schafhauser, BW brooks, 2018.

				aquatic organisms					
47	Brominated flame retardants		TBBPA, HBCD, DBDPE, EBFR, PBDE	food and human milk: seafood, fish, chicken, vegetable, meat, egg, cereals, baby food	X	X	T	√	47 Z Shi, L Zhang, J Li, Y Wu, 2018.
48	Antimicrobial resistance genes		Quinolone resistance genes, AR and ARM in E Coli, ESBL/*Amp* C, Tetracycline resistance gene, Vancomycin resistance gene	Wastewaters, drinking water sources, aquatic systems, waste/dump landfills, urban residential areas, medical facilities	X	Culture-based methods, fluorescence microscopy, metagenomics, Qpcr,	T	√	48 W Gwenzi, et al 2018
49	Contaminants in sewage sludge: chemical: elements, PAH, PCB, PCP, pharmaceutical		Selenium, Benzo (a) anthracene, Diclofenac, TiO2; Polio virusi, Aspergillus spp, Giardia	Sewage sludge	X	X	T	X	49 K Fijalkowski et al, 2017

	s, nanoparticles; biological: virus, bacteria, fungi, protozoa, helminths		lamblia, Ascaris spp, Legionella, E Coli O157:H7						
50	Cyanobacterial blooms: cyanobacteria		*Microcystis aeruginosa*, *Anabaena ucrainica*	Water, lakes, dam, river, drinking water, reservoir, island	X	HPLC, ELISA,MALDI-TOF-MS, Chlorophyll measurements, molecular methods 25	T	X	50 LL Ndlela et al, 2016
51	EDC contaminants: steroid estrogens		E1, E2, E3, EE2	Groundwater, soil	X	GC-MS 26	T (37)	X	51 X Song et al, 2018
52	Plastics and microplastics		PE, PP, PET, PVC, HDPE, LDPE, PS,	Marine life, estuary, river, lake, water, sediment	X	Optical,/electron microscopy, NMR, FTIR, raman spectroscopy,	T	X	52 N Lascar et al, 2019

53	Halogenated flame retardants		Hexbromobenz ene, BB101, Declorane 603	Sediment	X	GC-MSMS 27	T	X	53 J Guo et al, 2019
54	Persistent organic pollutants; PAHs, PCBs, perfluorinated compounds, phthalates, OCPs		PFOA, Hexachlorocycl ohexane	Ocean Water, river	X	X	T	X	54 R Lohman et al, 2014
55	Enterohaemorr hagic E Coli O157: H7 isolates;: virulence genes, antibiotic resistance profiles		EHECO157:H7 ; stx1, stx2, antibiotic resistance to AMP, AMX, FOX, TMP	Environment al water, surface water, run-off water, catchment, drainage, river clinical stool	X	VITEK2, multiplex PCR, PFGE, MLST, PCR, gel electropho resis	T	X	55 Bolukaoto, J.Y., et al, 2019
56	Human enteric bacteria and viruses		Faecal coliforms, E Coli, Rotavirus, Enterovirus	Wastewater	X	RT-PCR	T	X	56 Osuolale, O., Okoh, A., 2017.
57	Invasive salmonella disease and non-typhoidal salmonella		Salmonella Salmonella enterica serotype Typhi (S Thyphi), S	Sub-saharan Africa – children	X	Standard mcrobiolo gical techniques	T	X	57 F Marks et al, 2017.

	disease/pathogens		Enterica serotype Paratyphi A, B, C (S Paratyphi A, B, and C); non-typhoidal salmonella (NTS) serovars						
58	Infectious disease causing viruses		Nipah, MERS-CoV, SARS-CoV, Ebola	Bats	X	X	T	X	58 Han, , X-J., 2015.
59	MultiDrug-resistant (DR) tuberculosis (TB)		DR-TB, Rifampicin-resistant-TB (RR-TB)	humans		DST drug susceptibility testing, molecular diagnostic assays:Xpert MTB/RIF. MTBDRplus,MTBDRsl , line probe assays, whole genome sequencing	T		59 ML Dlamini, 2019
60	Mycotoxins and fungi in		Aflatoxin B_1, Fumonisin B_2, Aspergillus	Beer	√	LC-MSMS, microscop	T	X	60 I Adekoya et al, 2018

	maize-based beer		flavus, Saccharomycer evisiae			y, molecular: Genetic Analyser (BLAST on NCBI) 28			
61	Mycotoxins		Zearalenone, Ochratoxin, Deoxynivalenol Total aflatoxin	Cereal-based products	X	ELISA, TLC-DD, GC-MS, LC-fluorescence, LC-ESI-MS, LC-MSMS,HPLC-MS, UHPLC-MSMS 29	T	X	61 AM Khaneghah et al, 2019
62	Selected food contaminants and allergens: pesticides, antibiotics, mycotoxins, aquatic toxins, allergens		Paraquat, Gentamycin, Aflatoxin B1, Tetrodotoxin, Gluten	Food	X	Immuno-Sensors, aptasensor, sandwich ELISA, LFIA, microfluidic ELISA,DNA probes,	T NT	X	62 AS Tsagkaris et al, 2019

						MIPS, DART-MS, Raman spectroscopy (SERS), LC-MS, HRMS, LC-MSMS, LC-QTOF-MS, Q-Orbitrap, SFC, HILIC 30			
63	Persistent organic pollutants and plastic pollution: PCB, DDT, PBDE, plastic additives, related biomarkers		PCB 28, PBDE 28, DDT, CYP1A	Whale sharks- skin biopsies	-	GC-LRMS, microscopy, FTIR, Western blot 31	T	X	63 MC Fossi, 2017
64	Blue mussels as sentinel organisms in		Fluoxetine,	Blue mussels	X	X	NT	X	64 J Beyer, 2017

	coastal pollution monitoring: PAH, PCB, metals, PBDE, organotin, OCP, pharmaceuticals, alkylphenols, nanoparticles, microplastics		4-Nonylphenol, Ethinyl estradiol, TBT, PCB7, Hg, PFOS, BDE-47						
65	agricultural contaminant: EDC: synthetic androgenic stroid		17 beta-Trenbolone	Guppy	X	ELISA	T	X	65 P Tomkins, 2017
66	Cyanobacterial algal blooms: microystin producers, toxins and genes		Total cyanobacteria, Microcystin, *Microcystis aeruginosa*, *Plankothrix*, *Anabaena*, *mcyA, E, G*	Lake water	X	Microscopy, qPCR, RT-qPCR, LC-MS/MS, ELISA 32	T (50)	X	66 J Lu et al, 2020
67	Algal toxins: Microcystins, nodularin		Microcystin-LR, Nodularin	Freshwater	X	UPLC-MSMS 33	T	X	67 NH Tran et al, 2020

68 Review	Nutrients, metals, trace organics, PAHs, PFCs, xenoestrogenic compounds, pesticides, VOCs, phthalates, faecal bacteria		N, P, Pb, Benzene, Diuron, BPA, E Coli, Salmonella, Giardia, Microplastics	Stormwater	X	X	NT	X	68 A Muller, 2020 (review)
69	Pharmaceuticals, personal care products, illicit drugs, emerging persistent organic pollutants (flame retardants, perfluoroalkyl substances, alkylphenols), microplastics,		Triclosan, Diclofenac, PBDE, PCP	Aquatic biota – fish, mussel, worm plant	X	LC, GC, UHPLC, GC-MS/MS, LC-MS/MS. HRMS: QTOF, Q-Orbitrap, HPLC-DAD, IC-MS/MS 34	NT	X	69 R Alvarez-Ruiz e al, 2020
70	Pharmaceuticals, agricultural products/ pesticides, narcotics and illegal drugs, food industry		Diclofenac, Atrazine, Cocaine, Bisphenol A, Triclosan,	Water resources: drinking water, wastewater effluent, river/surface	X	X	NT	X	70 Iy Lopez, 2019

	additives, personal care products			water, ocean/sea water, groundwater					
71	Organochlorin pesticides		DDT, HCH	Biological, environment al matrices	X	X	T	X	71 C Olisah 2019
72	Pharmaceutical s		Sulfamethoxaz ole, Diclofenac, Paracetamol	Aquatic environment: sludge, soil, surface water, sediment, groundwater, biota	X	X	T	X	72 S Fekadu 2019
73	Antibiotics		Ciprofloxacin	Surface fresh water: stream, river	X	X	T	X	73 M-C Danner, 2019
74	Persistent organic pollutants, organophospho rus flame retardants, PBDEs, PCBs, OCPs		BDE 47, CB 52, alpha-HCH	Landfill sediment and leachate	X	T: GC-MS, NT: UPLC-Q-TOF-MS 35	T AND NT	X	74 S Innocentia, 2019
75	Antiretroviral		Nevirapine, Lopinavir, Zidovudine	Surface water	X	UHPLC-MS/MS mv done 36	T (55)	X	75 TP Wood 2015

76	Antiviral drugs			Aquatic environemnt, wastewater treatment plants	X	LC-MS/MS, HILI, GCXGC-TOFMS, GC-MS 37	T	X	76 C Nannou, 2019
77	Plastic		Microplastic	Sediment, surface water	X	Microscopy, FT-IR	T	X	77 T Naidoo, et al,,2015
78 SA1 Review	Pharmaceuticals: NSAIDs, antibiotics, ARVs, steroid hormones		Naproxen, Sulfamethoxazole, N evirapine, 17-beta-Estradiol, Metformin, CarbarmazepineAtenolol, Mefloquine	African water bodies	Xgrab	HPLC-MS, LC-TOF-MS, LC-diode array/UV, Orbitrap-MS, GC-MS, ELISA 38	T	X	78 LM Madikizela, 2020 (review)
79 SA2	Azole antifungal drugs		Clotrimazole, Fluconazole	Wastewater, drinking water	X	UHPLC-MSMS (mv done) 39	T	X	79 HA Asress, 2020
80 SA3	Psychoactive drug residues and metabolites		Morphine, Cocaine, Heroin	Aquatic environment wastewater, lake	X	UHPLC-Q-TOF-MS (mv done) 40	T	X	80 DP Masemola , 2019
81 SA4	Antimicrobials for TB		Isoniazid, Rifampicin	Aquatic environment:	X	X	T	X	81

Review				wastewater, surface water, sediment					CA Magwira 2019 (review)
82 SA5	Antiretroviral drugs		Nevirapine, Efavirenz	Surface water, w astewater	Grab and composite	LC-MS/MS (mv done) 41	T	X	82 TT Mosekiemang , 2019
83 SA6	Antibiotic residues		Ciprofloxacin, Erythromycin, Sulfamethoxazole	Wastewater, sludge, sediment, surface water	X	LC-MS/MS Mv done 42	T	X	83 AC Faleye,2019
84 SA7	CECs pharmaceuticals, pesticide, steroid hormone		Nevirapine, Bromacil	Dam water, river sediment, fish	X	LC-MSMS Mv done 43	T	X	84 C Rimayi 2018
85 SA8	Chloro-s-triazines		Atrazine, Simazine	Lake, river, groundwater	X	GC-MS, LC-MSMS Mv done	T	X	85 C Rimayi 2018
86 SA9	Personal care products: antimicrobials		Triclosan, Triclocarban	Wastewater, freshwater, soil	X	Modelling 44	T	X	86 Musee, 2018
87 SA10	Veterinary pharmaceutical resiudes		Tetracycline, Estradiol, Diclofenac	Surface water	X	HPLC-UV Mv done	T	X	87 OSF Atoki 2018
88 SA11	Antiretroviral drugs		Nevirapine, Efavirenz	wastewater	√e	LC-MSMS Mv done 45	T	X	88 OA Abafe 2018

89 S12	Microplastic		microplastic	Waterbirds: faecal samples, feathers	X	microscop y	T	X	89 C Reynolds, 2018
90 SA13 Review	Rare earth elements		La, Gd, Ce	Dust, marine, aquatic systems, tap water, terrestrial and aquatic biota, human food, surface, groundwater, soil, sediment	X	x-ray absorption spectrosco py, icp-ms, ICP-OES, HPLC-ICP-MS, HGGC-QFAAS, ZIC-cHILIC-ICPMS 46	T	X	90 W Gwenzi, 2018
91 SA14	Pharmaceutical s, personal care products, EDCs, metabolites, illicit drugs		Cocaine, Carbamazepine , Naproxen, Diclofenac,	Wastewater, surface water	Grab and composite	LC-MSMS 47	X	X	91 Archer , 2017
92 SA15	Polybrominate d diphenyl ethers		Penta-, octa-, deca-BDE	Food products, aquatic and terrestrial animals, water, soil, human fluid	X	X	T	X	92 C olisah, 2018

93 SA16	Perfluorinated alkyl acids		PFBA, PFOA, PFBS	Plasma of crocodiles	X	LC-MSMS 48	T	X	93 I Christe, 2016
94 SA17	Perfluoroalkyl acids		PFOA, PFDA	Tissue of Tilapia (fish)		LC-MS 49	T	X	94 JT Bangma, 2017
95 SA18	Pharmaceutical s		Caffeine, Lamotrigine, Nevirapine, Valsartan	River, dam water	X	UHPLC-QTOF-MSMS (HR-MS) Mv done 50	T a dn NT	X	95 TP Wood , 2017
96 SA19 rev	Residual antibiotics, antibiotic resistant bacteria, antibiotic resistance genes		Nalidixic acid, *Tet B, sul3*	Surface water catchments	X	X	T (74)	X	96 AA Adegoke 2018
97 SA20	Anticoagulant poison/rodenti cides		Brodifacoum, Difethialone	Liver and blood from: Predators: caracal, otter, genet, honey badger, mongoose, Eagle owl	Xgrab	LC-MS/MS 51	T	X	97 LEK Serieys, 2019,
98 SA21	Brominated flame retardants		EH-TBB, BTBPE	Leachate, sediment	X	GC-EI-MS 52	T	X	98 OI Olukunle, 2015

99 SA22 review	NSAIDs		Ibuprofen, Naproxen,, Ketoprofen	Wastewater, surface water	X	X	T	X	99 ML Mlunguza, 2019 (review)
100 SA23	Antimicrobials in personal care products		Triclosan, Triclocarban	Wastewater, river, sewage sludge	X	LC-MSMS Mv done 53	T	X	100 RF Lehutso 2017
101 SA24	Engineered nanomaterials (modelling): car polich, sunscreen, cosmetics, toothpaste		TiO_2 ZnO SiO_2	Wastewater, landfill, freshwater	X	X	T	X	101 N Musee, 2017
102 SA25	OCPs and PCBs		Organochlorine pesticides HCH, HCB, Heptachlor, Aldrin, DDT and its metabolites (o,p’-DDD, p,p´-DDD, o,p’-DDE and p,p’-DDE), Dieldrin, Endrin, Mirex and PCBs.	water, sediment, pore water, surface sediment and bank soil,					102 E Gakuba, PhD Thesis

			The PCB congeners investigated were: PCB-28, 52, 77, 101, 105, 138, 153, 180						
103	Pathogens and pharmaceuticals, antibiotics, antibiotic resistance gene		Rotavirus, Sulfamethoxazole	Source-separated urine	Grab and composite	PCR, LC-MS/MS 54	T	X	103 HN Bischel, 2015
104 Review	Geogenic contaminants – metals, rare earth elements		Asbestos, Nickel, Iron	Serpentinitic ultramafic geological environments: soil systems, aquatic systems, atmospheric systems	X	X	T	X	104 W Gwenzi. 2020 (review)
105	NSAID: Diclofenac		Diclofenac	Environmental compartment: water soil, sediment, and biota	X	X	T	X	105 P Satishkumar, 2020
106	antibiotics		Penicillin, Tetracycline	wastewater	X	LC-MS 55	T	X	106

									S Al-Maadheed, 2019
107 Review	POPs: PCB, PBDE, OCP, PCN, PFAS		PBDE 209, DDT	Environment: Air, water, soil, sediment, food, aquatic organisms, humans	X	Supplementary information	T	X	107 P bruce-vanderpuije, 2018 (review)
108 Review	Microplastic		Microplastic	Aquatic food web – freshwater and marine environment	X	X	T	X	108 W Wang, 2019 (review)
109	microplastics		Microplastics	Marine environment	X	X	T	X	109 CG Alimba, 2019
110	Selective serotonin reuptake inhibitors		Fluoxetine, Sertraline	Aquatic systems: wastewater, freshwater, saltwater, drinking water, ground water	X	X	T	X	110 RA Mole, 2019
111	Contaminants: Pesticide, insecticide, herbicide, fungicide,		Atrazine, Diazinon, Naproxen, Lead, Mercury	Amphibians in water	X	X	NT	X	111 M Sievers, 2019

	metals, pharmaceuticals, salinity								
112	Pharamaceuticals, industrial chemicals, personal care producst, pesticides, illicit substances		Benzotriazole, DEET, Amisulpride	sediment	X	UPLC-QTOF-MSMS 56	T and NT	X	112 G Mascolo, 2019
113	Organic contaminants		Benzotriazole, Diclofenac, DEET, Butylparaben	Surficial sediment	X	UPLC-QTOF-MS-MS 57	T and NT	X	K Noguera-Oviedo, 2016
114	Chlorine tolerance – microbial pathogens		*Enterococcus*	Wastewater	X	PCR, agarose gel electrophoresis, BLAST analysis	T	X	114 M Owoseni, 2017
115	Groundwater contaminants: fertilizer, pharmaceutical, pesticide,		Nitrate, BTEX, atrazine, iron, Lead, Nevirapine, Paracetamol	groundwater	X	X	T and NT	X	115 NM Burri, 2019
116	Pharmaceuticals, hormones, pesticides,		DEEt, Cocaine, Atenolol	Surface waters/coastal lagoon:	X	NanoLC-HRMS 58	T	X	116 L Griffero, 2019

	drugs of abuse, lifestyle products			stream, lagoon, sea					
117	NSAIDs, parabens, natural and synthetic hormones,		Bisphenol A, Triclosan, Methyl paraben, Ketoprofen	Drinking water, well, river	X	GC-MS 59	T (90)	X	117 D Arismendi, 2019
118	Solvent stabilizer, food additive		1,4 -Dioxane	Groundwater, air, soil	X	GC-MS 60	T	X	118 KJG Pollitt, 2019
119	Emerging contaminants, antibiotic resistance genes		Bisphenol-A, Triclosan, Tetracycline, Ampicillin	Drinking water, waste water, surface water, sediment, soil, biota	X	X	T and NT	X	119 G Reichert, 2019
120	PCP, PAH, PFAS		Methyl paraben, Naphthalene, PFBS	Water, sediment, mussel	X	GC-MS, UPLC-HRMS 61	T	X	120 Y Aminot, 2019
121	Personal care products, pharmaceuticals, plasticisers, pesticides, surfactants, resistant bacteria		Naproxen, Picloram	Groundwater, surface water, waste water	X	X	NT (10)	X	121 M Taheran, 2018

122			Sulfamethoxazole, DEET, Triclosan	Algal ponds	X	X	NT	X	122 ZN Norvill, 2016
123	Pharmaceuticals		Codeine, Diclofenac, Sulfamethoxazole	Surface water	X	LC-HRMS 62	T	X	123 P Branchet, 2018
	sentinel								
124	Polybrominated diphenyl ethers		PBDE-17, 47, 100, 99, 154, 153, 183, 209	Eggshells of bird s	X	GC-MS 63	T	X	AP Daso, 2015
125	Organochlorine pesticides, brominated flame retardants, perfluorinated compounds		HCB, PCB-52, BDE-99, PFOS	Penguin eggs	X	GC-ECD, LC-MS/MS 64	T	X	H Bouwman, 2015
126	Perfluoroalkyl substances		PFDA, PFOA, PFOS	Edible fish	X	LC-MSMS 65	T	X	PA Fair, 2019
127	Polychlorinated biphenyls		PCB, PBDE,PFAS	Bird feathers	X	X	NT	X	VLB jaspers, 2017
128	Mycotoxins		Aflatoxin B1, Ochratoxin A	Pearl millet	X	LC-MSMS 66	T	√	H Houissa, 2019
129	Polybrominated diphenyl ethers		PBDE-28, PBDE-100, PBDE-47	Chicken eggs, cow milk	X	GC-ECD	T	X	K Oloruntoba, 2019

130	Persistent organic pollutants		CB153,, Dieldrin, BDE47, PFOA	Tissue- polar bears	X	LR-GCMS, HR-GCMSMS , HRGC-HRMSUP LC-MSMS 67	T	X	RJ Letcher, 2018
131	Organochlorine residues		Heptachlor, Aldrin, Dieldrin	Water, sediment, fish	X	GC-ECD	T (100)	X	A Chukwuka, 2019
132	Halogenated natural products, POPS,		BC-10, BC-3, PCB 138	Chokka squid	X	GC-ECNIMS 68	T	X	Q Wu, 2019
133	Metallic elements		U, Hg, Pb	Turtle eggs	X	ICP-MS 69	T	X	M du Preez, 2018
134	Metallic elements		Hg, Pb, Cr	Crocodile eggs	X	? to check Icp?	T	YES	M du Preez, 2018
135	Trace metals, POPs, stable isotope analysis		Hg, C, N, CB-28	Tuna	X	AA, ICP-MS, isotope ratio MS 70	T	X	T Chouvelo, 2017
136	EDCs		Atrazine, BPA, EE2	Crocodile tissue, water	Grab, composite	GC-MS, AA, GC-FID, GC-ECD, HPLC-DAD, qPCR,	T	X	A Arukwe, 2016

						enzyme immunoassay 71			
137	Pharmaceuticals, perfluorintaed compounds, anthropgenic waste indicators, inorganics, microorganism		Sulfamethoxazole, PFOA, Triclosan, Lead, Giardia	Source and treated drinking water	?	?	T	?	Dr Suzanne van Drunick, year
138	Household antimicrobials		Triclosan	wastewater	X	GC-FID, GC-MS 72	T	X	T Letseka, 2017
139	Oestrogen hormones		E1, E2, EE2	Surface, drinking	X	UFLC-QTRAP-MSMS 73	T	X	SB Mnguni, 2018
140	Organochlorine pesticides		Dieldrin, Aldrin, Endrin	Sediment pore water, surface sediment	X	GC-MS 74	T	X	E Gakuba, 2017
141	Polychlorinated biphenyls		PCB5, PCB138, PCB206	River water	X	GC-ECD	T	X	Yahaya, 2018
142	Natural organic matter			Water	X	Direct, spectrometric (Uv-VIS,	T	X	N Chaukura, 2018

						fluorescence excitation-emission matrix), Fractionation (SEC, LC-OCD)			
143	Carbapenem (beta lactam antibiotics)-resistant bacteria		CRB37, CRB42	River water, river sediment	Xgrab	Culture methods	T	X	Hrenovic, 2019
144	Microplastic		Microfibre	River sediment	X	stereomicroscope	T	X	S de Villiers, 2018
145	Organophosphorus flame retardants		Tris-(Chloropropyl)-phosphate, tris-(2,3-Dibromo-propyl)-phosphate	Surface water	X	GC-MS 75	T	X	TB Chokwe, 2019
146	Metals, organics, pesticides, blu-green algae, pharmaceuticals, toiletries		X	Non-perrenial river water	X	X	NT	X	JA Day, et al, 2019
147	Organochlorine pesticides,		Dieldrin, Endrin, HCB,	River bank soil	X	GC-MS 76	T	X	E Gakuba, 2019

	polychlorinated biphenyls		HCH, PCB105, PCB180						
148	δ-endotoxins		Cry1Ab protein	Borehole water	X	ELISA	T	X	A du Pisanie, 2019
149	Agricultural pesticides		Carbofuran, Atrazine, Thiabendazole	River Tap water	X	GC-MS 77	T	X	M Machete, 2019
150	Pesticides /Endocrine disruptors - insecticides, fungicides, herbicides, steroid hormones		Azinphosmethyl, Endosulfan, Carbaryl, Chlorpyrifos Midstream, Basta, Arsenal, Roundup, EE2, E2	Dam water	X	ELISA; Yeast Oestrogen Screen (YES), Yeast Anti-oestrogen Screen (anti-YES), Yeast Androgen Screen (YAS) and Yeast Anti-androgen Screen (anti-YAS) recombinant yeast bioassays	T	X	JH van Wyk, 2014

151	Agricultural chemicals - pesticides, herbicides and plant growth regulants; INORGANICS		Diphenylamine, Imizalil, Thiabendazole, Imidacloprid and Propiconazole, Atrazine, Alachlor, Fluoride, Lead, Mercury, pH,	Water, sediment, air, poultry		LC-MSMS, GC-NPD, DSA-TOF-MS, ICP-MS 78	T	X	JM Dabrowski, 2015
152	Organic chemicals- Polycyclic aromatic hydrocarbons, DDX, polychlorinated biphenyls; certain metals		DDT, cis-Chlordane, PCB18, PCB209, Phenanthrene, Pyrene, Iron , Lead	Sediment, fish	X	GC-ion trap MS, USEPA 3035B for metals 79	T	X	Brent Newman, 2015
153	EDC		17-beta-Estradiol	Wastewater	X	Estrogen nano-biosensor, HPLC-UV, GC-MS 80	T	X	EI Iwuoha, 2015
154	Microbial communities		Cyanobacteria Synechococcus, Bacteroidetes,	Water, sediment	X	Next Generation	T	X	GF Matcher, 2015

			Gammaproteobacteria, Betaproteobacteria			Sequencing NGS			
155	Cyanobacteria-BMAA		β-N-Methylamino-L-alanine	Cultures	Na	LC-MS, UPLC-MS/MS 81	T	X	TG Downing, 2014
156	Engineered nanomaterials		Titanium nanoparticles: $nTiO_2$	Aquatic systems	X	Material Flow Analysis modelling with RQ values as output; Particle flow analysis models; Stochastic models; Dose response modles; quantitative structure-activity relationship model	T	X	N Musee et al, 2015

157	Brominated flame retardants		BDE-17, BDE-47, BDE-153	landfills, surface water, wetlands, groundwater, sediment and biota	X	Not sure Pdf damaged	T	X	OJ Okonkwo et al, 2015
158	selected polychlorinated biphenyl (PCB) congeners, organochlorine pesticides (OCPs), and pharmaceuticals and personal care products (PPCPs)		OCPs such as HCB, HCH (lindane), Aldrin, Heptachlor, Dieldrin, Endrin, Mirex and DDT with its metabolites *o,p*-DDE, *p,p*-DDE, *o,p*-DDD, *p,p*-DDD, *o,p*-DDT and *p,p*-DDT and 8 PCB congeners, PCB 28, PCB 52, PCB 77, PCB 101, PCB 105, PCB 138, PCB 153 and PCB 180	River water, sediment, wastewater, soil	X	LC-MS, GC-MS 82	T	X	Moodley et al, 2016

159	EDC activity		EDC activity: thyroid activity	Water (surface, drinking and treated sewage	X	thyroid and androgenic bioassays for the detection of EDC activity in water samples: GH3.TRE. Luc thyroid bioassay; HR-MS 83	T	√	NH Aneck-Hahn, et al, 2017
160	PAHs (as a compound class), atrazine (a pesticide), acetaminophen (a pharmaceutical), and triclosan (a personal care product).		Atrazine, Acetaminophen Triclosan	Millipore water		Quantum-dot based Fluorescence sensors	T	Xx	O. Adegoke, 2017
161	Toxicity tetsing		Aquatic toxicity testing	Effluent, resource upstream and downstream	X	Integrated Water Use Authorisation	T	X	NJ Griffin et al, 2019

				from sites in following sectors: municipal, agriculture, industrial, mining		Bioassay (IWUAB) Toolkit: *Vibrio fischeri* bioluminescent test: EN ISO 11348-3 (2007); *Selenastrum capricornutum* growth inhibition test: OECD Guideline 201 (2006); *Daphnia pulex* acute toxicity test: US EPA (2002); *Poecilia reticulata* acute toxicity test: US EPA (1996)			
162	EDCs: PFCs, oestrogens, pharmaceuticals		Oestrogens: Estrone (E1), 17β-estradiol (E2), 17α-	wastewater	√	GC×GC-TOFMS; LC/MS/MS analysis. 84	T	X	MAA Coetzee, 2018

			Ethinylestradiol (EE2) Perfluorinated chemicals: Perfluorobutanoic acid (PFBA), Perfluorodecanoic acid (PFDA), Perfluorooctanoic acid (PFOA), Perfluorohexanoic acid (PFHxA), Perfluoro-1-octanesulfonate (PFOS), Perfluoro-n-pentanoic acid (PFPeA) Perfluoro-1-hexanesulfonate (PFHxS) Pharmaceuticals: Nalidixic acid, Bezafibrate, Acetaminophen						

			, Carbamazepine , Stavudine and Lamivudine.						
163	Emerging and persistent contaminants, pathogens: 14 pharmaceutical groups, which included hormones, antibiotics, anti-inflammatories , anticonvulsants, cardiovascular agents, analgesics, anthelmintics, consumer product additives, bronchodilators, NSAIDS and ARVs,		Estradiol, Estrone, Estriol diethylstilbestrol Paracetamol, Ibuprofen, Caffeine and Sulphamethoxazole NSAIDs (Ketoprofen, Naproxen and Diclofenac) ; ARVs (Ritonavir and Efavirenz) ; *Proteobacteria* and *Firmicutes*	Influent/effluent wastewater, river water (upstream, down stream)	X	Orbitrap liquid chromatography high-resolution time of flight mass spectrometry (LC-HRT-MS) and gas chromatography x gas chromatography high-resolution time of flight mass spectrometry (GCxGC-HRT-MS); deoxyribo nucleic	NT	X	V Mhuka et al, 2020

						acid (DNA) extraction and polymerase chain reaction (PCR), next-generation sequencing analysis and biomarker analysis. 85			
164	Antibiotic resistant bacteria and genes		*Pseudomonas* spp. and *Bacillus* spp.; Antibiotic resistance bacteria, resistant to: beta-lactam antibiotics and Trimethoprim ; *ermB* and *ermF* Antibiotic resistance genes:responsible for resistance	Raw source water; Drinking water	X	LC-MS-MS (UPLC-QTOF/MS) and ELISA (immunosorbent assay rapid test); Gram staining, PCR, Antibiotic susceptibil	T (130)	X	CC Bezuidenhout, 2019

			to a range of antibiotics. *IntI1* and *ampC* were			ity test, Whole-genome sequencing, Microbiome analysis 86			
165	Emerging chemical pollutants		Acetaminophen, Triclosan, Atrazine and Polycyclic aromatic hydrocarbons (PAHs).	Tap water River water	X	fluorescence sensors (using quantum dot nanomaterials)	T	X	H Montaseri, 2019
166	Toxicity testing		-	agricultural run-off and acid mine drainage	X	A modified version of the *Daphnia* method described in USEPA (2002) and Truter (1994), and incorporated aspects of *Hydra*	T	X	P Singh, 2017

						toxicity testing			
167	PCB in fish		PCB28, PCB52, PCB101	Fish	BOUGHT	GC-MS SW-846 Method 8082 87	T	X	B Kampire, 2016
168	Cyanobacteria		Anabaena, Microcystis	Dam water	X	Microscope method	T	X	A Chinyama et al, , 2016
169	Cyanobacteria and microcystin toxins		*O. limnetica*	River, drinking water	X	Microscopy ELISA	T	X	ZA Mohamed, 2016
170	Trace elements		As, Cu, Pb	Surface water (dam), sediment and fish – tissue, blood	X	ICP-OES, ICP-MS 88	T	X	Lynch et al,, 2016
171	Metals		Fe, Pb, Cu	Intertidal water, surface sediment	X	ICP-MS 89	T	X	Sparks et al, 2016
172	Carbapenem-resistant bacteria		Carbapenem-resistant bacteria	Wastewater influent, effluent	24 h flow-proportional samples	ATB 32GN and Vitek 2 systems (BioMerieux); matrix-assisted laser	T	X	J Hrenovick et al, 2017

						desorption ionization–time of flight mass spectrometry MALDI-TOF MS 90			
173	Poly-chlorinated biphenyls		PCB28, 101, 180	Fresh water, particulate phase, mussels	X	GC-MS 91	T	X	Kampire et al, 2016
174	Metals and toxicity		Al, As, Fe	Sediment from river water	X	Bioassay: Phytotoxkit, Ostracodtoxkit F and the Diptera bioassay; ICP-OE	T	X	P Singh et al, 2017
175	NSAIDs		Naproxen, Ibuprofen and Diclofenac	wastewater	Xgrab	HPLC-PDA	T	X	LM Madikizela et al, 2017
176	Fluoride		Fluoride	Drinking water	-	-	T	X	H Wanke, 2017
177	Review: Nonyl=		NP, OP, NPE1, NPPE, OPPE	Environment: air, wastewater,		HPLC-GC-MS	T	X	TB Chokwe et al, 2017

	phenol ethoxylates			surface water,s ediment, biota, sludge		GC-FID, GC-MS/MS 92			
178	Pharmaceuticals and personal care products		Diclofenac, Triclosan, Oestradiol	Surface waters	X	X	T	X	E Archer et al, 2017
179	BTEX compounds in water (review)		Benzene, Toluene, Ethylbenzene, and Xylene)	Surface water, ground water, drinking water, contaminated ground water	X	X	T	X	OM Fayemiwo et al, 2017
180	Organo= chlorine pesticides		Heptachlor, Aldrin, Endrin	water, sediment pore water and surface sediment	X	GC-MS 93	T	X	E Gakuba et al, 2018
181	Poly= aromatic hydrocarbons		Naphthalene, Fluorine, Pyrene	Wastewater, wastewater sludge	X	GC-TOF-MS 94	T	X	S Ncube et al, 2017
182	Toxic elements/ metals		Cd, Fe, Pb	Sediment, water	X	ICP-MS 95	T	X	AA ambushe et al, 2019
183	Emerging substances of concern – pharmaceuticals, personal care		Atrazine, Diclofenac, PFDA	Reclaimed Water for potable reuse- treated wastewater,	X	GC-MS, HPLC, LC-MS 96	NT	X	L Petrik, 2019

	products, EDC, nanomaterials, pesticides, perfluorinated compounds			marine outfalls, sea water, marine sediment, beach sand, biota, seawed					
184	Chemicals of emerging concern - Pharmaceuticals, surfactants, personal care products, flame retardants		Triclosan, NP, PFOA, PBDE	Groundwater, surface water, municipal wastewater, landfill leachate, drinking water, food sources, sediment, wetland plants	X	GC-TOF-MS, GC-MS, LC-MSMS 97	NT	X	OJ Okonkwo, 2019
185	Engineered nano= particles		ZnO, Ag	wastewater	X	transmission electron microscope (HRTEM, JEOL-JEM 2100) and scanning electron	T	X	EFC Chauke et al, 2016

						microscopy, FTIR, X-ray diffraction, ICP-OES			
186	Antimicrobials and antibiotic resistant bacteria, agro= chemicals		Ampicillin, Chloramphenicol, Erythromycin, BenfuraCarb, Carbofuran; RBs to both β-lactam antibiotics (ampicillin and cephalothin) and to erythromycin (macrolide) and streptomycin (aminoglycoside)	Source, drinking water, distribution water	X	heterotrophic plate count; Colilert®-18/Quanti-Tray® and Colilert®-18/Quanti-Tray® 2000; HPLC-hybrid triple quadrupole ion trap mass spectrometer; disc diffusion method 98	T (150)	X	CC bezuidenhout, 2016
187	Micro= plastics		Bisphenol A, Phthalate and Calcium stearate; Polyethylene	Freshwater	X	Ecotoxicity tests – using Zebra fish Danio	T	X	K Mgaba, ?

			(PE), Polypropylene (PP), Polyvinyl chloride (PVC)			rerio, shrimps *caridina nilotica* and freshwater snails, *Melanoides tuberculate* and Algae			
188	Micro= plastics and pharma= ceuticals			Water	?	?	T	X	C Bezuidenhout, 2019
189	Natural organic matter		NOM	SA water: raw and drinking	X	TOC, DOC, UV254, ; SUVA, HP-SEC, BDOC; GPC; LC-OCD; FEEM spectroscopy	T	X	SS Marais et al, 2018
190	Agricultural chemicals-pesticides		Atrazine, Terbutylazine	Catchement water: surface,	?	?	T	X	Report No. 1956/1/15), Report No. TT 642/15

				ground; sediment; air					Vol 2
191	POPs: Organic contaminants and metals		Hg; Polychlorinated biphenyls; Chlordane	Aquatic ecosystems: Sediment, fish and mussels			T		WRC Report No. 1977/1/15
192				Wastewater from edible oil industry				X	WRC Report No. TT 702/16
193	alkylphenol ethoxylates and brominated flame retardants		NPEO, BPA	Milli-Q-water	-	GC-MS 99	T	X	TB Chokwe, 2015
194	Pesticides, trace elements			River water and sediment			NT	X	WRC **Report no. TT 739/17**
195	PAHs		Benzo(a)pyrene and Dibenz(a,h)anthracene	Aquatic ecosystems: sediment, fish and bird eggs			T	X	WRC Report No. 2422/1/16, 2016
196	Inorganics, Agricultural chemicals		Atrazine	surface water resources, sediments and groundwater			T	x	Vol 1
197	Various: chemical and			Reclaimed wastewater			NT		CD Swart et s, 2015

	microbiological								
198	Chemicals in laundry industry wastewater/effluent: salts, phosphates (from detergents), soil, FOGs (fats, oils and greases), heavy metals, residual textile material, heat, microbes and process by-products (such as adsorbable organically-bound halogens formed by soil-detergent-water reactions).		Triclocarban and Triclosan; Stilbene disulfonates and Coumarin derivatives; Sodium silicate; Hydrotropes include glycols, toluene sTlfonates and Cumene sulfonates; Butylated hydroxytoluene, Ethylenediaminetetraacetic acid (EDTA), bronopol, formaldehyde and isothiazolinones.; alkanolamides and alkylamine oxides	X	X	X	T	X	CD Swartz et al, 2017

199	Paper and pulp industry wastewater effluent		Organic substances (COD, BOD), • Compounds extracted from the wood such as resin acids, etc., • Chlorinated organics (AOX), chlorate (depending on bleaching agent used), • Nitrogen and phosphorus based compounds, • Suspended solids, • Metals, salts and • Coloured substances	Wastewater from paper/pulp effluent	X	X	T	X	Marlene van der Merwe, et al, 2017
200	Chemicals in wastewater from iron and steel industry		Polycyclic aromatic hydrocarbons (PAH) <0.05 mg/□	wastewater	X	X	T	X	Marlene van der Merwe, 2017

			(sum of Fluoranthene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, Indeno[1,2,3-cd]pyrene and Benzo[g,h,i]perylene						
201	Chemicals in the textile industry: acids, alkalis, bleach, dyes: reactive dyes, vat dyes, sulphur dyes, some direct dyes (more common in the paper industry), and disperse dyes, salts, size (e.g. starch), stabilisers, surfactants, and additives		Flame retardants	X	X	X	T	X	M. Le Roes-Hill. , et al, 2017

202	CECs in reclaimed wastewater for potable reuse: pharmaceuticals, pesticides, biocides, herbicides, personal care products, household chemiclas, transformation products, natural chemicals, industrial chemicals		Atrazine, Triclosan, Paracetamol Ammonia, nitrate plus nitrite, DOC, TOC, EC, pH, COD, Turbidity and UV254 absorbance. _ Perfluorinated compounds (PFCs) (all samples) _ Perfluoroheptanoic acid (PFHPA), Perfluorooctanoic acid (PFOA), Perfluorononanoic acid (PFNA), Perfluorooctane sulfonate	Xgrab		Chemical analyses outsourced to LiquidTech (UFS, Bloemfontein); bioassay tests for toxicity: Ames mutagenicity test, Daphnia 24–48-hour toxicity test, YES oestogenicity activity test In vitro	T	X	CD Swartz et al, 2018

			(PFOS), Perfluorodecanoic acid (PFDA) and Perfluoroundecanoic acid (PFUnDA) _ Priority CECs (all samples) _ Bisphenol A (BPA), Triclosan, 17α Ethinyl estradiol (EE2), Acetaminophen, Atrazine, Imidacloprid, Carbamazepine, Lamivudine, Simazine, Sulfametoxazole, Terbuthylazine and Cinchonidine.						
203	CECs in reclaimed wastewater for potable reuse: pharmaceutica		Atrazine, 17-beta Oestradiol, Triclosan	Reclaimed wastewater	X	GC, LC, with tandem MS (MS2), triple	T	X	CD Swartz et al, 2018

	sl, personal care products, endocrine disruptors					quadrupole (QqQ) MS, ion-trap MS (IT-MS), time-of-flight MS (QTOF-MS) detectors; capillary electrophoresis; ELISA 100			
204	CECs		Perfluorooctanoic acid; Acetaminophen; Bisphenol-A; EE2	Reclaimed wastewater for potable reuse	Grab, composite	Chemical analyses: UWC – no method details? Bioassay: Ames mutagenicity test, the Daphnia acute toxicity test and the YES (yeast estrogen	T	X	CD Swartz et al, 2018

						screen) test, to test for oestrogeni c activity; Risk Assessmen t			
205	Emerging substances of concern: anti-retro virals,		Cocaine, MDMA, Methamphetam ine, Efavirenz	wastewater	composite	UPLC-MS/MS 101			E Archer, ?
206									Water Research Commission Report: Report No 2432/1/18 LINK?
207	PAHs			sediment, fish and bird eggs			T	X	WRC Report, 2016
208	Specific EDCs		BPA, DINP (a phthalate) and EE2 (synthetic hormone)	Bottled water		Chemical analysis, bioassay	T	X	
209	Microplastics			Municipal water, river water,			T	X	J Bonthuys, 2018

				drinking water					
210	Antimicrobial substances and antibiotic resistant profiles		h				T	X	A Scoping study on the levels of antimicrobials and presence of antibiotic resistant bacteria in drinking water. WRC Report No. KV 360/16.
211	Water-borne pathogens			rivers, streams, wells, dams, pond water drinking Water, untreated sewage				X	WRC Report No: 2432/1/18
212	Cholerae and non-cholerae causing vibrio pathogens			Water, wastewater, aquatic animals: oyster, mussel, and abalone), crustaceans	Grab?	Spread plate method, MPN-PCR	T	X	AI Okoh , 2018

				(e.g., crabs, prawn, and lobster) and fish.					
213	Diarhoea-causing pathogens in water		Total coliforms and E. coli.; Clostridium perfringens agar, Salmonella; V. cholera spp.; Shigella spp.; Vibrio spp; protozoan parasites and enteric viruses; Noroviruses, rotaviruses, adenoviruses, several other endemic viruses as well as Cryptosporidium and Giardia parasites	water from household storage containers; surface: river; boreholes.	X	Colilert Quanti-TrayR/2000 technique (IDEXX); oxidase test, API-20E test, Gram-staining and standardised published multiplex PCR protocols.	T	X	N Potgieter, et al, 2018
214	Microbial pathogens in water resource sediments		three bacterial pathogens (Salmonella sp., Shigella sp.	Water, sediment			T (172)	X	WRC Report No. 2169/1/15)

			and V. cholera); dition, E.coli (indicator bacteria)						
214 articles/ References total									
21 x review articles = 9.7 %									

MS methods: 101 papers

Per and polyfluoro compounds: 18

Table S3 Initial raw data for research gaps only: Word version

Number	High level Class/description	Research gap – detailed description of actual gap	Total (% of total) [Rank]
1	**Toxicity/Risk/Impact**	1 Prognostic and diagnostic impact assessment	260 (21.5 %) [1]
		2 Total risk burden of PFOS and PFOA	
		3 Distribution with regards to human health	
		4 Environmental risks, spatially and temporally	
		5 Risks for human health	
		6 Combined effects in the human body	
		7 Tests for toxicology	
		8 Tests for risk assessment	
		9 Association and toxicity of individual CECs in bottled water	
		10 Ecotoxicological effects	
		11 Monitoring risk reduction	
		12 Transformation products during risk assessment	
		13 Sub-lethal effects on a wide range of aquatic organisms	
		14 Biological consequences of variable duration CEC exposures within and across generations in aquatic species	
		15 Linkage of multiple stressors with CEC exposure in aquatic systems	
		16 Trophic consequences of CEC exposure	
		17 Impacts in water bodies	
		18 New protocols for ecotoxicity test and measurement of different effects by using different organisms with suitable endpoints.	

		19 Impact on human health and environment	
		20 Impact on human health and environment - additive effects	
		21 Additive effects	
		22 Development of risk-based screening models to predict source, fate and behaviour in water	
		23 Further work is needed to better understand the effect threshold and dose-response relationship of DDTs in marine mammals, which has important conservation implications	
		24 Better development of effective risk ecological assessment methods for this emerging class of insecticides (pyrethroids)	
		25 Bioavailable LC50 values for the target pyrethroids	
		26 Sediment toxicity studies	
		use of Chironomus sp. needs to be considered	
		development of multi-species sediment toxicity methods	
		27 Risk assessment	
		toxic contribution from other pesticides which co-occur with pyrethroids in sediment should also be considered	
		the adverse effects of long-term exposure to pyrethroids in sediment at sublethal levels	
		28 Assessment of potential environmental and human risks Nanomaterials (NMs) pose.	
		29 The toxicological impact of NMs need to be assessed for their potential toxicity and bioaccumalation	
		30 Models for impacts of multiple contaminants and larger spatial scales	
		31 Impacts of nano-remediation	
		32 Toxicity of DEET to aquatic species still remains poorly assessed	
		33 Further studies are required to assess the impact of longterm exposure to low doses along with a mixture of other trace organic contaminants	

		34 Ecotoxicity tests, particularly in fish population already affected by endocrine disruptors down stream of wastewater treatment plants	
		35 DCF impact on human health	
		36 Future studies may include the toxicity studies of photo-transformation products of DCF and mixture toxicity	
		37 DCF - chronic exposure studies at lower but environmentally relevant concentrations	
		38 Toxicity to aquatic organisms	
		39 Guidelines and strategies for environmental risk assessment	
		40 Exposure studies using complex mixtures	
		41 Feeding studies to determine the real level of risk	
		42 Potential ecological risk of most pharmaceuticals after their introduction in the aquatic environment	
		43 Derivation of QSAR-based PNECs in future assessments	
		44 Health impacts - research on the health impacts of micro-plastics, both human and non-human	
		45 Long-term exposure by consuming these freshwater organisms remains unclear	
		46 Additional health effects data for some contaminants with limited data would help strengthen the conclusions on the public health significance from exposure to contaminants	
		47 The relative potential human health risk (s) associated with the presence in drinking water of chemical contaminants derived from the source water along with those that may be associated with contaminants formed during disinfection (disinfection byproducts) and those that may be posed by residual microbial (bacterial, viral) contaminants.	
		48 Additional health effects data for some contaminants with limited data would help strengthen the conclusions on the public health significance from exposure to contaminants	

		49 Exposure assessment should emphasize the subset of pharmaceuticals and CECs that were detected in both source and treated water samples	
		50 Understanding the potential for human health and ecosystem effects from the presence and distribution of pharmaceuticals in source and treated waters,	
		51 Comprehensive multiple contaminant assessment of sublethal toxicological effects.	
		52 The presence of microplastics in the marine environment poses a great threat to the entire ecosystem	
		53 Environmental hazards and risks of many antihistamines to non-target species are poorly understood.	
		54 Limited ecotoxicology data and monitoring information for coastal and marine waters	
		55 Loratidine: future research is needed to understand aquatic toxicology, hazards and risks associated with this AH	
		56 Water quality hazards of antihistamines poorly understood within and among regions	
		57 Chronic antihistamine exposures to non-target species must be considered in these urbanising surface waters	
		58 Identifying where environmental risks of specific pharmaceuticals are elevated	
		59 Environmental risks of antihistamines in these regions remain poorly understood ,e.g., The Middle East, Russia and Asia-Pacific	
		60 Only 11AH have been studied for toxicological effects in non-target aquatic species	
		61 Aquatic toxicity - future efforts are needed to carefully examine solubility considerations for ecotoxicity studies with diphenylhydramine and other pharmaceuticals.	

		62 Environmental ecotoxicology studies of antihistamine metabolites and degradates are lacking	
		63 Bioaccumulation and associated hazards of pharmaceuticals and other ionisable chemicals in aquatic life, including edible fish and shellfish	
		64 Environmental hazards and risks of many antihistamines remain poorly understood for non-target species, particularly in coastal environments	
		65 Ecotoxicology studies of antihistamine metabolites and degradates are lacking,	
		66 Determining exposure levels and possible standards for drinking water and food products.	
		67 Comprehensive assessment of the health risks of perchlorate by studying its abundance in the environment and food sources, as well as the pathways of exposure, is highly desirable	
		68 A risk assessment could be used to develop a standard for perchlorate in drinking water.	
		69 To date little is known about the impacts of their environmental presence on humans	
		70 To further the current understanding of the toxicological implications of chronic exposure to complex mixtures of PPCPs at sub-therapeutic levels in both target and non-target organisms	
		71 More research is needed to characterise the influence of such exposure on the status of public health in contaminated areas	
		72 Ecotoxicity studies rarely report tissue concentrations	
		73 Ecotoxicological studies should be based on reliable and robust analytical methods within the field	
		74 Measurement of internal concentrations: in biota will enable more reliable risk assessment for pharmaceuticals in the environment than those based solely on concentrations in water	

		75 Effect-based studies should also quantify compound concentrations with the observed effects in biota	
		76 We remain unclear on the the potential combined effects of pharmaceuticals on biota	
		77 Presence/risk: many CECS are incompletely removed during water treatment and thus are present in water distributed for potable use	
		78 Extensive use of pesticides has created a concern in general as their residues are widely found in various ecological niches	
		79 Future studies are needed to understand risks of ERY and other antibiotics to human health and the environment	
		80 Need to assess and manage pharmaceutical risks in environment	
		81 Future investigations on ERY risks to water and food supplies and associated ecosystems are recommended in these Lower-Income countries and rapidly developing megacities regions	
		82 Toxicity of DBDPE should be further investigated	
		83 Human exposure of DBDPE should be further investigated	
		84 Health effect of DBDPE should be further investigated	
		85 Further investigations of the sources, fates, and health effects of TBBPA in China should be a huge and urgent task, m?pollutant to the environment	
		86 It is suggested that the contamination levels, human exposure, toxicity and health effect of EBFR need to be deep investigated in a future study, especially for the DBDPE	
		87 Limited reviews have investigated sources, behaviour and health risks of antimicrobial resistance genes (ARGS) in the wastewater-human pathway.	
		88 Factors predisposing human and ecological health risks associated with antimicrobial resistance, particularly in developing countries, are largely missing in literature	

		89 Human ecotoxicology and health risks: limited information is available on the relative contribution of the various routes to the transfer of args into humans.	
		90 To better understand the health risks of args in wastewaters, systematic ecotoxicological case studies considering typical concentration in the various sources, intake rates, fate processes and threshold values are required.	
		91 Current ecological risk assessment protocols for synthetic chemicals including pharmaceuticals, animal feeds and other compounds are often limited to the individual compounds using a single bioassay :species known to be sensitive to the chemical	
		92 Review of risk assessment protocols to include potential risks associated with selecting for antimicrobial resistance, and interactions between antimicrobial resistance and other stressors considering various trophic levels including single species, populations, trophic interactions and ecosystems	
		93 To minimise health risks of args, a risk reduction framework was highlighted to reduce antimicrobials in the environment,	
		94 Pathogens: threats to human health and ecosystems from these compounds (ARGs) occurring in sewage sludge	
		95 The pathogenicity of many of these novel (bat) viruses for humans remains unknown, and further efforts are needed to determine their potential threats to humans	
		96 Bat viruses: further efforts are needed to determine (bat viruses) their potential threats to humans	
		97 What are the risk factors leading to infections of humans or intermediate animals exposed to bat-borne viruses	
		98 POPs (persistent organic pollutants) and whale sharks: ecotoxicological risk assessment of these endangered species - on whale shark biopsies and in other large filter feeder species	

		99 Toxicokinetics of dioxins and PBDEs or field studies of the exposure, accumulation and effect of nanoscale particulate contaminants	
		100 Comparatively little attention has been paid to the risk assessment of azole anti-fungal drugs	
		101 Azole antifungal drugs: validation studies should be conducted for those drugs that seem to pose human health and ecological risks	
		102 Future studies to deepen research on the determination of single and mixture toxicity of the azole anti-fungals	
		103 Anti-TB drugs: since antimicrobial compounds are mostly non-biodegradable (eg, INH) they may be toxic to sludge bacteria and kill them. Consequently this could decrease the efficiency of WWTP biological processes since sludge bacterial population will be decreased.	
		104 Although antimicrobial compounds have been detected in low concentrations in water sources, their presence is another public health concern due to their unknown chronic health effects that can happen after long-term ingestion through drinking water	
		105 ARVDs: the environmental impact of which is still relatively unknown	
		106 Generally, the prevalence of ARVDs in aquatic ssystems evident from this and other studies reflect the widespread and sustained utilization of these drugs, which may warrant further investigation into the health implications of pre-exposure to these compounds	
		107 Additional investigations are required on their toxicity - TCS, TCC	
		108 Quantification of potential risks of their ENMs metabolites – unquantified to date	
		109 Scarcity of chronic data in organisms usually used for risk assessment in different environmental compartments render it impossible to estimate the TCS and TCC long term impacts	

		110 ENMs: programs in different environmental systems including sediments and pore water as well as studies on their chronic toxicity to different taxa. Such screening models can allow the identification of hot spots and ultimately aid to develop appropriate and corrective strategies for specific situations and locales.	
		111 There is the necessity to link likely implications of both TCS and TCC, or their mixtures, to human health through the food chain-	
		future work is to consider interactions between TCS and TCC as a mixture, and the impact on the aquatic organisms where effects may be antagonistic, additive, or synergistic such that individual chemicals effects can either be reduced or enhanced	
		112 Microplastics: Globally, freshwater systems are among the most threatened of habitats and it is important that this emerging threat is recognized and mitigated.	
		113 Rare earth elements/REEs: to minimize health risks, a conceptual framework and possible mitigation measures are required	
		114 REEs: understanding the mixture effect of REEs and other stressors such as organic pollutants on acute and chronic ecotoxicology	
		115 REEs: Detailed ecotoxicological data on exposure routes, daily intakes, metabolism, and adverse effects in humans remain scarce.	
		116 There is a need for more eco-toxicological assessment on the sub-lethal effects of ECs and polluted water systems into identifying MIEs, KEs, KERs which certain ECs can modulate to advance current risk assessment approaches	
		117 ECs: Drawing definite conclusions regarding the health impact which these pollutants may cause when entering environmental water is no simple task, considering that these pollutants are present in complex mixtures with varying physicochemical properties, as well as their varying affinities to modulate a range of molecular and cellular pathways in wildlife species	

		118: Relationship between general health status and PFAA exposure in wildlife and humans is an area greatly understudied.	
		119: Humans are impacted by disease ; studies have yet to account for the influence potential changes in health status may have on PFAA burdens in an organism	
		120: Global action plan on antimicrobial resistance: WHO laid down 5 focal approaches in addressing the human risk associated with RAbs:	
		A awareness creation through education, communication, and training	
		B strengthening the knowledge and evidence base through surveillance and research	
		C reducing incidence of infection through sanitation, hygiene and infection control measures	
		D optimizing use of antimicrobial medicines in human and animal health	
		E develop economic case for sustainable investment with respect to the needs of individual countries	
		121 Effect of RAbs on human and biotic components of the environment include toxicity and emergence of difficult-to-control superbug. Despite global concern, little research inputs :encompassing this area have been done so far in S Africa	
		122 Potential risks of the increasing variety and volume of engineered nanomaterials (ENMs) entering into the ecosystem remain poorly quantified.	
		123 SUGEs: Identifying dormant human exposure pathways and health risk assessment, including ecotoxicology and human toxicology of various TGCs using environmentally relevant concentrations	
		124 Overall reduction of diclofenac by users, increasing the efficiency of WWTPs and periodic monitoring of diclofenac and its metabolites/transformation products in all environmental	

		compartments should have high priority to both protect the health of the population and reduce diclofenac contamination in the water cycle	
		125 Diclofenac: this pharmaceutical drug deriving from wastewaters of WWTPs and/or direct entry from household and pharmaceutical industries could accumulate in the aquatic environment, which may adversely affect aquatic life	
		126 POPs: lack of human animal and wildlife exposure data. There is no data for various matrices including indoor and outdoor air exposure assessment in workplaces/homes, cored sediments, ground and bore-hole water, wildlife-avian population data, amongst others.to address these knowledge gaps, further studies would be required.	
		127 Knowledge about impacts of microplastics exposure on aquatic primary producers, the trophic transfer process of microplastics and associated substances, and implications of consuming aquatic products for human health is much less known.	
		128 Conduct extensive monitoring programs on the abundance of microplastics in aquatic products that are at the point of human consumption in order to calculate the amount of microplastics introduced into humans via consuming aquatic products	
		129 Focus more efforts on the presence and toxicity of nanoplastics in aquatic organisms and evaluation of the implications for human health	
		130 Most countries in Africa and Asia – major contributors of global plastic pollution – are yet to come to terms with the enormity of microplastic pollution.	
		131 SSRIs: Present study employed a hazard assessment approach using THVs without a 1000 safety factor as recommended. If this safety factor had been used, then consistent exceedances would have been observed for these SSRIs across matrices, regions and treatment technologies	

		132 The survival of microbial pathogens in chlorinated effluents is a cause of concern over and above the potential health hazards associated with exposure to poorly treated effluents	
		133 Due to variability in spatio-temporal scale of given processes, the comprehensive characterization of the links between the surface, unsaturated and saturated zones in response to land use changes and the associated contamination risk remains a challenge	
		134 Processes such as shale gas exploitation (hydraulic fracturing) are among those which have come under scrutiny as a potential source of groundwater contamination	
		135 There is also a global need for effective early warning systems that are capable of anticipating risks associated with compounds used before they become "contaminants of emerging concern"'	
		136 In many developing countries, poor communities downstream of mining operations have little access to service provision. - Are dependent on local streams, wetlands and groundwater sources for their water supply	
		Many are at risk of acute metal toxicity from heavy metals	
		137 Parabens: to consider the potential risks of the consumption of these waters (tap, river, well, wastewater), knowing that compounds such as parabens have been categorized as endocrine- disrupting compounds.	
		138 1,4-dioxane: Sensitive transcriptomic, metabolic and stem cell studies are needed to understand 1,4-dioxane-induced early effects in the liver that can lead to genotoxicity and carcinogenesis	
		139 1,4-dioxane: research to investigate co-occurring exposures	
		Past epidemiologic study results may have been confounded by exposure of human subjects to other solvents (and/or risk factors) since few studies isolated exposure to common co-occurring 1,4-dioxane contaminants, such as TCE or 1,1,1-TCA.	

		Therefore it is important to consider co-contaminants when studying 1,4-dioxane.	
		140 Also groundwater is frequently used as as a potable-water source in many areas in Latin America, and contamination of these sources could have a direct impact on human health	
		141 Another possible threat to human health is the use of wastewater for agricultural irrigation, eg in Mexico.	
		142 The low number of studies regarding antibiotic resistance is also concerning, once the spread of antibiotic –resistant bacteria could be a big threat to human health in the next years	
		143 The number of chemicals produced and consumed rises every day and new info about their consequences in the environment are discovered	
		Therefore, priority lists must be updated periodically and should be always based on up-to-date information and data (occurrence, determination, toxicology) obtained in the country or target area.	
		144 PAH, PFOS: The risk assessment was based on EQS and PNEC values, available in literature for less than a third of the investigated compounds.	
		These ecotoxicology thresholds can be determined by in-silico approaches using large uncertainty factors, and undergo regular revisions accounting for new scientific evidences, which can drastically change the HQ determined here.	
		Future research should focus on the refinement of these thresholds, especially in the context of complex mixtures.	
		145 More research should be devoted to the toxicology of emerging contaminants in a variety of organisms and development of reliable methods for toxicity test at extremely low concentrations	

		146 Light-based mechanisms may also reduce the risks associated with antibiotic resistance in algal WWT through disinfection processes and the destruction of antibiotic resistance genes	
		147 The issue of groundwater as drinking water by 68% of population surveyed raises concerns about population exposure and potential health risks	
		148 The African penguin population has crashed and seems to be reducing even further.	
		1Whether chlorinated, brominated and fluorinated organic pollutants are solely responsible is unlikely,, but it may be contributing, as could compounds that have not yet been measured such as emerging chemicals, eg, chlorinated naphthalenes and pharmaceuticals	
		2 Sub-lethal effects, such as eggshell thinning and desiccation changes in reproductive effort since exposure, and behavioural changes that may be affected by chemical pollutants also cannot be ruled out and needs further investigation	
		149 While the risk/benefit assessment is complicated, consumption of several species of fish including from Charleston Harbor and its tributaries may pose risks as PFAS (especially PFOS) were identified as potential chemicals of concern	
		150 The detected residues of PFOS found in fish from Charlestown estuarine waters may be a potential risk for the health of consumers with elevated fish consumption	
		151 Even though seldom toxicological data are recognized about these emerging mycotoxins, to date, the potential threat they can present to the consumer health cannot be ignored	
		152 Mycotoxins: enniactins contamination: the low concentrations detected in this study might not have any consequences for human health.	

		However to date, authors cannot assert the effect of their chronic exposure on human health due to the lack of relevant toxicity data in vivo	
		153 Further studies are required to investigate the contribution of pearl millet in the daily intake of mycotoxins by Tunisian consumer for the monitoring of the risk ssessment	
		154 Mycotoxin risk assessment in Tunisian pearl millet revealed a worrisome situation that have to be faced by setting up strenuous regulatory thresholds and a strict control system within the food and feed trade, in order to prevent and narrow mycotoxins as a major issue requiring priority attention	
		the current regulations mostly take account about major mycotoxins namely AFs, OTA, DON, ZEA, FBs and scarcely about emerging mycotoxins and derivatives produced by several fungi occurring in food and feed	
		Consequently the undeniable toxicological effects on human and animals health associated to a mixture of toxic metabolites exposure, highlighted the obvious challenge to widen the legislations in order to encompass further mycotoxins with respect to the food consumption patterns	
		155 Increased efforts towards integrating data and observations of reproductive anomalies in wild populations exposed to emerging contaminants and endocrine disrupting substances like pesticides, are recommended	
		This will aid better understanding of the effects of endocrine-modulating chemicals and other environmental stressors on reprotoxic effects in wild populations	
		156 Metal elements in sea turtles: Mercury concentrations in egg contents were low compared with available data, and also did not exceed mercurys TRV for bird eggs	

		The TRVs for Sr and Cu were exceeded. However, the hatching success of the S African leather backs is such to suggest that there is very little toxicological influence, although sub-lethal effects and mixture effects should not be ignored	
		157 Sea turtles: In addition to organic compounds, like DDE, some metals are also known endocrine disruptors and may influence sex ratios during development without affecting hatching success.	
		There is also the added complication from climate change	
		158 TRV for copper is between 10-20 mg/kg dm, which was reached and exceeded in Crocodile Farm and wild eggs. Cu may therefore pose a threat to developing crocodiles	
		159 TRV for Se is 8 mg/kg dm – the highest found in a wild crocodile egg was 5.8 mg/kg dm. Se may therefore also pose a risk to the developing embryo	
		160 There are 5 publications on metallic elements in Nile Crocodile tissues other than eggs. The 3 that measured Hg all concluded that this element is of concern	
		161 Metals in crocodiles: there are very few toxicological publications on other freshwater, marine, or terrestrial reptiles from Afriaca	
		The findings in Zimbabwe, and those represented here, indicates a large gap in our understanding of the concentrations and threats of metals and metalloids in an important class of animals in Africa	
		162 Metals in crocodile eggs: at least Hg, Se and Cu were identified here as metals of concern.	
		Mercury and copper are waste, industrial and mining-related, and this concern should therefore be extended to all areas where the four, currently recognized, African crocodiles occur	
		163 Metals in crocodile eggs: Fe was identified as a possible contributor to thickening of egg shells as a barrier to gas and water exchange ,	

		possibly increasing the effort required for the hatchling to emerge from tightly packed shells under sand or nesting materials	
		164 Considering the increasing international focus on mercury, and recognizing that the major river systems of the KNP are trans-boundary, underscores the need for further research on the biology and ecotoxicology of all African	
		reptiles and associated habitats	
		165 The analysis of emerging contaminants could help to define more comprehensive or exhaustive chemical contamination profiles, although this study demonstrated that classically and historically monitored contaminants are already very informative	
		166 PCBs: high levels of these chemicals (PCBs) in the water imply high exposure risk to the immediate communities subsisting on resources from the water as well as to the general population, since the pollutants will disperse up to several kilometres from the contamination source and may persist for decades, given their high half-lives.	
		167 Anthropogenic pressure in the form of discharge of untreated wastewaters, cause the bacteriological changes of the riverine ecosystem	
		Bacteriological changes are accompanied by an increase in silt and clay fractions together with increased concentration of heavy metals in sediment	
		Input of wastewaters from human and animal healthcare centres results in the appearance of clinically important CRB42 (carbapenem-resistant bacteria) in both river water and sediment.	
		168 Disinfection of hospital wastewater prior to its discharge into the natural environment should be performed in order to avoid both the propagation of CRB42 in the environment and consequent public-health threat.	

		169 Synthetic microfiber pollution and ingestion poses a potential threat to the health of not only marine and freshwater ecosystems , but also humans	
		170 It is important to note that at present, there is no scientific evidence for chemical, physical or vector-related impacts of microfiber ingestion on human health	
		171: Organophosphorus flame retardants: Ongoing toxicological studies have shown several toxic effects of these compounds, such as the potential for ecological and human health concerns of neurotoxin and carcinogenic nature	
		172 The extent and magnitude of OPs (organophosphorus compounds) occurrence in the environment, combined with striking structural similarity to toxic organophosphorus pesticides, has led to public concern over risks posed by these substances.	
		173 Taking into account the high levels of these pollutants in WWTW effluents, long-term	
		exposure and bioaccumulation of these OPFRs and other emerging flame retardants in the aquatic environment, indicates that further studies are needed to define the environmental risk produced by these pollutants	
		174 OCPs, PCBs, - these contaminants are sources of various environmental and human health hazards due to their biomagnification through the food chain.	
		175 OCPs, PCBs: Humans are exposed to them mainly through water and food consumption or the physical environment which may be contaminated	
		176 Genetically modified transgenic Bt maize plants: Environmental risk assessments tend to neglect aquatic ecosystems as a relevant context for assessing the potential risks associated with GM crops	

		177 Agricultural pesticides: Numerous chronic and acute environmental health risks are associated with agricultural pesticide exposure	
		178 Agricultural pesticides: Current study found much higher concentrations of atrazine and other EDCs in drinking water in this study, which presents a much higher potential of exposure and the possibility of a myriad of effects on humans and the environment (fauna, flora)	
		179 Agricultural pesticides: further studies are recommended, including epidemiological investigations to establish the prevalence of environmental health risks and specifically to to establish a cause-effect- relationship between human exposure to the studied pesticides and potential environmental health risks highlighted in other studies.	
		180 Pesticides: more South African used pesticides should be studied for endocrine disrupting activity to understand the dose-response relationships, before hoping to embark on predicting health or environmental risk	
		181 Pesticides: modes of action associated with insecticides and herbicides varied and individual chemicals or formulations needs comprehensive testing to predict the mechanism of action	
		182 Agricultural chemicals: in general, the application of models in rik assessment of pesticides in South Africa is under-utilised.	
		183 Agricultural chemicals: Without adequately defining exposure, it is not possible to reliably assess the risk a pesticide poses to the environment	
		184 Agricultural chemicals: improved prioritization of environmental risk (to inform environmentally friendly use of pesticides), monitoring and modelling approaches are therefore essential to close the gap on assessing the risks of pesticides in the environment	

		185 Agricultural chemicals: risk assessment at the time of registration would provide a proactive understanding of risks of a chemical prior to approving its use.	
		186 Agricultural chemicals: a screening approach identifying highly mobile pesticides and their associated risks should be adopted	
		187 Agricultural chemicals: as inorganic chemicals have also been implicated in causing ED effects it is important to include their analysis to establish a bseline against which to interpret the hazards and risks posed by agricultural chemicals.	
		Failure to include these, results in less confidence in interpreting both the bioassay results that may be obtained- and exposure assessments.	
		Use of this water quality data is required in order to meaningfully interpret the context of hazards posed by organics and inorganics, without which a differential diagnosis may be difficult to reach.	
		188 Agricultural chemicals: the ED bioassays used in this study detect chemicals based on their biological activity and determine the total androgenic and oestrogenic content of of a given sample.	
		Significant reponses in an in vitro bioassay should be used as an indicator for further investigation using in vivo test models, and/or identification of the active chemical	
		189 Agricultural chemicals: samples collected in the Vals and Renoster rivers however showed comparatively higher values, with some samples exceeding 0.7 ng/L trigger value	
		The frequent detection of atrazine, simazine, and terbuthylazine (all known EDCs) in combination with the observed ED bioassay responses highlights this geographical area as a priority for further research, where a more detailed survey of the contamination of human and livestock drinking water resources (surface and groundwater) and associated health risks is recommended.	

		190 Agricultural chemicals: the predicted cancer and toxicity risks based on exposure to pesticides in water in each of the case study sites is low.	
		Given the inherent risks associated with pesticide exposure, in combination with the fact that this and many other studies have shown that pesticides regularly occur in surface and ground water that is used for human consumption and livestock watering, provides strong justification for the development of risk-based domestic and livestock use water quality guidelines that include priority pesticides used in the country.	
		Indices of use, toxicity and mobility could be used to prioritise pesticides for which water quality guidelines should be developed.	
		191 PAH, PCB, OC: Contaminant concentrations in many fish species and in mussels were high enough to pose a potential chronic and carcinogenic health risk to human consumers.	
		192: There is therefore a need for the development and validation of whole sediment toxicity testing procedures for freshwater and coastal ecosystems in SA, as a tool for determining whether contaminants in sediment are exerting a toxic effect on sediment-dwelling organisms.	
		193 PAH, PCB, OC pesticide: the concentrations of several chemicals in the tissue of fish caught and mussles collected in Durban Bay and the uMngeni and Isipingo River estuaries were high enough to pose a potential risk to the health of human consumers.	
		The most notable were PCBs and Mercury	
		Since it was never the intent of this study to perform a comprehensive human health risk assessment, it is recommended that a comprehensive risk assessment be performed.	
		194 PAH, PCB, OC: a key unknown in the context of determining the potential human health risk posed by contaminants in fish and shellfish	

		tissue are fish and shellfish consumption rates for SA recreational and subsistence fishers.	
		195 PAH, PCB, OC based on the findings of this study there is a possibility that recreational and subsistence consumers in other large coastal cities may also face potential health risks through the consumption of fish and shellfish caught and collected in estuaries and indeed also the freshwater reaches of catchments.	
		It is therefore recommended that the potential risk of exposure to contaminants through a fish and shellfish consumption pathway be extended to other large coastal cities	
		196 Engineered nanomaterials: Further research should test the applicability of these models in predicting the behavior and toxicity of other nanomaterials to establish their suitability and hence applicability in decision making for risk assessment that covers nanomaterials in general	
		197 Environmental factors such as pH, ionic strength, and temperature and retention times are relevant environmental factors that require monitoring in the event of accidental release of ENMs to establish expected impacts and potential mitigation measures.	
		These factors influence the kinetic transport, migration, bioavailability and effects of ENMs from the point of discharge and could be used to estimate risks of known ENMs discharged	
		198 EDCs: Currently there is no trigger value available for thyroid activity in drinking water.	
		Further research to determine this is recommended, as this value is extremely important when doing a health risk assessment.	
		199 EDCs removal from wastewater: This study partially quantified the risks resulting from discharging EDCs into receiving water bodies	
		As only a few EDCs were evaluated, there is a need to study additional groups of these compounds.	

		200 Emerging and persistent contaminants/pathogens; other microbial communities such as fungi, viruses, and protozoans should be investigated to identify the recurrent biomarkers and their toxigenic compounds	
		201 Emerging and persistent contaminants/pathogens: Th identification of transformation products would lead to the possible synthesis of transformation products that could be used for toxicological studies	
		202 Emerging/persistent contaminants/pathogens: The toxicology of emerging contaminants and/or transformation products should be periodised as regulations and policies are written	
		203 Antibiotic resistant bacteria and genes: considerable body of knowledge is being generated to establish the occurrence of antibiotics, ARB and ARGs in aquatic systems, particularly in drinking water distribution systems.	
		How environmental conditions affect the associated genetic and metabolic changes is not clearly understood	
		204 Antibiotic resistant bacteria and genes: Connecting contaminants of emerging concern in aquatic ecosystems to waste and impacts on human health is a theme that is poorly understood and needs to be explored	
		205 Test organisms for toxicity assessments: Due to the sensitivities observed over time, H vulgaris may be used for chronic toxicity testing and D pulex for acute toxicity testing	
		206 PCBs: PCBs are still expected to be detected in water due to the environmental recycling of this refractory type of compound	
		207 Cyanobacteria: Cyanobacteria have been found to be potentially toxic to animal and human health	
		208 Microcystin toxins: The presence of toxic O limnetica and/or its MC toxins in the final drinking water poses a risk to humans and animal health	

		209 Trace elements: Even essential trace elements may yield toxic effects when exposure levels become elevated	
		210 Trace elements: A health risk is also associated with the consumption of L capensis muscle tissue as As and Se recorded THQ values greater than 1.	
		211 Trace elements: Future studies performed within the Vaal Dam reservoir should be accompanied by accurate determination of health risk factors for the local population relying on fish from this system as a regular food source.	
		212 Metals: Metals accumulate over time and can pose threats to the condition of the water column and health of benthic marine organisms. I	
		213 PCB residues: While industries are a key component of the countrys economy, little research has been conducted on PCB contamination and no literature is available for PCB analysis in different organs of fish from the North End Lake	
		214 PCB residues: The presence of PCBs in fish of the NE lake could be harmful since they may be biomagnified through the food chain, with humans being the end consumer	
		215 Non steroidal anti inflammatory drugs: More work is required to assess the extent of water pollution in several regions of SA	
		216 Alkyl phenol ethoxylates: as sewage is known to be released into wetlands and oceanic waters, studies of APE levels in these compartments inhabitants (birds, frogs, algae, daphnia, dolphins, etc) need to be undertaken in order to assess the impact of APEs on biodiversity of such bodies	
		217 Alkyl phenol ethoxylates: there is a paucity of data on the adverse health impacts of NPE1-3. Hence studies should be undertaken to establish the minimum health risk concentration for each isomer as well	

		as to investigate the synergic health effect of a combination if different environmentally relevant concentrations of APEs	
		218 Alkyl phenol ethoxylates: there is a scarcity of data on human biological monitoring for APEs around the globe and more research also needs to be directed toward NPE isomer identification, as the available studies determined exposure to technical mixtures of OPs and NPs	
		219 Alkyl phenol ethoxylates: NPE(1-3) as emerging environmental contaminant should be studied systematically to evaluate their potential threat to environmental and human health. To accomplish this goal, research activities should look into, among others:	
		1) developing analytical methods to measure these pollutants in a variety of matrices down to trace levels	
		2) fate and transport of NP and NPE(1-3) in air	
		3) more toxicity data to assess the effects on terrestrial organisms such as plants	
		4) potential effects on wildlife due to long-term exposure to low concentrations of NP and NPEs	
		220 Pharmaceutical and personal care products:- establishing the possible endocrine-disrupting effects of commonly-detected PPCPs and other micro-pollutants through a tiered eco-toxicological approach	
		221 Pharmaceutical and personal care products: establish and/or improve initiatives such as the National Toxicity Monitoring Programme (NTMP) to assist with environmental risk assessment through the use of AOP (adverse outcome pathway) networks	
		222 BTEX in water: In spite of the negative effects they pose to human health, BTEX compounds remain overlooked and untreated in municipal systems, thereby increasing the risk of water-related diseases through their ingestion	

		223 BTEX in water: Studies have reported the presence of btex compounds in drinking water, indicating extensive health risks that may not be immediately evident	
		224 BTEX in water: The use of groundwater (in form of boreholes) increases the risk of these compounds being ingested as they have been reported to naturally occur in groundwater, and are present in many industrial effluents disposed into the environment	
		225 Toxic elements: toxicity study using a model organism such as zebra fish will assist in monitoring the toxic effects of potentially toxic elements in reproductive and nervous systems of the organism.	
		226 CECs in recycling/reuse: combined effects and concentrations are mostly unknown	
		227 CECs in recycling/reuse: under certain conditions, sewage flows back to shore in detectable quantities that could be harmful	
		228 CECs in recycling/reuse: reverse osmosis is not 100% effective for potable water recovery + brine is very toxic (eg, Beaufort West)	
		229 CECS in recycling/reuse: treat the retentate from RO as highly hazardous	
		230 CECs in recycling/reuse: treat sludges from sewage plants as highly hazardous	
		231 CECs in recycling/reuse: implement barriers, monitoring programmes and assessment programmes to eliminate or minimize the risks	
		232 CECS in recycling/reuse: carefully test drinking water from the seawater desalination plants or reused sewage water for toxicity, which need not be costly	
		233 Engineered nanoparticles: investigation on the bacterial species highly sensitive to the presence of ZnO ENPs, in order to understand which stages of the activated sludge wastewater treatment processes are more affected by the presence of nanoparticles. This will help to	

		develop methodologies for overcoming the potential adverse effects of ENP	
		234 Engineered nanoparticles: investigations on the impacts of ENP sludge accumulation on sludge treatment processes, such as anaerobic digestion	
		235 Engineered nanoparticles: elucidation of the mechanism governing ENPs accumulation on sludge and biofilms, which may help assess the possible mitigation of their long-term impacts	
		236 Microplastics: to conduct ecotoxicity test to examine effect of different major plastic types, sizes, and shapes in SA on Zebra fish Danio rerio, shrimps caridina nilotica and freshwater snails , Melanoides tuberculate and Algae	
		237 Microplastics: to conduct ecotoxicity test to assess effect of selected plasticizers to different aquatic organisms	
		238 Microplastics: to develop methods for toxicity testing to study microplastics in South African freshwater systems	
		239 Microplastics: develop appropriate toxicity end points	
		240 Effluent wastewater: best practise to improve effluent quality:	
		1solids: install grids over drains to prevent solids from entering wash-water	
		2 disinfection: use correct disinfection chemicals, eg caustic soda in areas contaminated with fats, anf acids for lime deposits	
		3 cleaning agents: use cleaning agents in the correct concentrations and apply according to manufacturers instructions	
		4 degumming: qif possible, reduce amount of phosphoric acid used in degumming by improving the neutralization process or by using alternatives such as enzymes	
		5 maintenance: institute a preventative maintenance protocol: regular servicing of expellers and other mechanical equipment, etc	

		6 educate staff: make staff aware why its important to reduce the amount of wastewater generated and improve the quality of the wastewater	
		7 chemical audits: consider substituting different chemicals and/or materials, eg caustic soda in solution may be cheaper than the solid form and results in less loss of consumables, reduced corrosion and improved soap-stockk quality	
		8 caustic soda usage – monitor addition carefully to prevent saponification of neutral oil	
		9 soap splitting- use continuous soap splitting rather than batch to reduce the volume of acid water	
		10 detergents: minimize the use of detergents in cleaning operations to prevent emulsification of oil in wastewater	
		11 fat traps: use fat traps judiciously- to prevent oil from entering wash-down water	
		12 Measure and monitor: the volume of effluent produced from each area. Monitor the quality of effluent produced from different processes to identify areas where product and/or consumables are being lost	
		13 Product recovery: recovery at from effluent to increase soap-stock production and improve wastewater quality	
		241 River water quality: research is also needed to determine the impact of the identified pollutants on the aquatic ecosystems in the Swannies, Klipdrift and Palmiet Rivers	
		242 Polycyclic aromatic hydrocarbons in aquatic ecosystems: The number of bio-assays can be broadened to include assays capable of detecting endocrine disruptive effects	
		243 Polycyclic aromatic hydrocarbons: evaluation of fish species composition and numbers to further describe pollution effects in the system	

		244 Agricultural chemicals: The risk a pesticide poses to human health (and aquatic environment) is dependent on a number of factors, including relative toxicity of the chemical, relative mobility (as influenced by physicochemical properties), recommended application rates (quantity of use) and agricultural practices (correct use of nozzles).	
		As farmers almost always have a choice of different chemicals to target a specific pest on a specific crop, it is recommended that a manual providing guidelines on choosing agricultural chemicals that minimise effects in non-target environments (both human and ecological health) be produced	
		245 Agricultural chemicals: The use of sentinel monitoring yielded valuable information towards the site-specific animal health assessment. The observations would suggest that further studies into human health with bromide as a key priority chemical are indicated	
		246 Agricultural chemicals: it is also acknowledged that a revision of the 1996 SA Water Quality Guidelines is underway with the irrigation volume being addressed first	
		It is argued that both Domestic and Animal Watering sections also urgently require revision to align with risk-based approaches that are necessary to appropriately assess and manage the hazards and risks present	
		247 Agricultural chemicals: research should focus on the integration of these models into the risk assessment process conducted during the registration of pesticides. While the registration process considers the toxicity of a pesticide, there are no exposure assessment procedures performed to assess the environmental fate and predicted environmental concentrations under S African conditions	
		248 Agricultural chemicals: Given the relatively low ED risks associated with agricultural chemicals in this study, comparative studies comparing the ED effects associated with different crop types,	

		land uses and other important point sources (eg, mining, industrial, sewage effluent) are encouraged so as to provide improved perspective of the relative importance of these different sources on ED effects	
		249 CECS in waste water treated for direct potable reuse: human health risks	
		Bio-assays showed the improvements in wastewater quality following treatment through the various treatment works, and the results showed how these bio-assays are able to be used to monitor the water quality.	
		Thus it is recommended that a battery of bio-assays representing different trophic levels be included in a monitoring programme if direct reuse of wastewater is known to occur either intentionally or unintentionally	
		Different bio-assays can be selected as long as various activities are tested.,eg, different oestrogen mimicking assays and anti-androgenic activity may be included.	
		Findings from health risk assessment studies revealed the need to manage two risks:	
		1 the constant presence of EE2 in the final effluent	
		The risk of children swimming in the brine channel and ingesting the contaminant EE2, has risk priority number 144 and is located in the unacceptable area of the risk matrix.	
		As water reclamation processes were found not to treat the water to a satisfying level with respect to EE2, countermeasures were recommended	
		Electrochemical removal could be a good option in a pilot project for the plant in the future, but more research needs to be completed for an appropriate design and implementation of this process	
		Ozonation and GAC are therefore the technologies chosen as countermeasures due to the reasons stated above.	

		2 In addition, building a wall was suggested to constrain unauthorized people from reaching the brine channel	
		A fence has earlier been built and rebuilt several times around the area but has been stolen and is therefore not a good option to prevent children from the community to enter.	
		A wall was previously built around the drinking water treatment plant in the town and has been effective according to the superintendent.	
		250 Urban wastewater epidemiology: need to broaden our understanding on CEC presence, fate, risk:	
		Metabolites (fate and risk), partitioning	
		Range of lethal/sub-lethal risk parameters (PNECs)	
		Minimum therapeutic doses and ADIs	
		Drinking Water Equivalent Levels (DWEL ADI)	
		251 Microplastic pollution: The potential health impacts of individual compounds or mixtures are also mostly unknown	
		252 Microplastic pollution: The full impact and risks of microplastics pollution in water is yet to be discovered	
		253 Microplastic pollution: Given the low dilution potential of local freshwater resources, coupled with ongoing waste management problems, the impacts of microplastics on local freshwaters resources and the biological processes dependent on it remains unclear	
		254 Microplastic pollution: The links between pollutants in microplastics and potentially more vulnerable rural populations need to be examined.	
		Although the full impact of microplastics on the environment and biota is not yet understood, the potential threats should not be taken lightly	
		255 Microplastic pollution: the risks posed by microplastics must be tackled on various levels	
		Currently most plans and interventions focus on end-of-pipe solutions	

		256 Urban wastewaste epidemiology: Gaps in knowledge, research, policy:	
		Early warning showing public health concerns is a gap	
		257 Use environmentally relevant concentrations in microplastics exposure studies	
		258 Microplastics: to conduct ecotoxicity test to examine effect of different major plastic types, sizes, and shapes in SA on Zebra fish Danio rerio, shrimps caridina nilotica and freshwater snails , Melanoides tuberculate and Algae	
		259 Microplastics: to conduct ecotoxicity test to assess effect of selected plasticizers on different aquatic organisms	
		260 Microplastics: to develop methods for toxicity testing to study microplastics in South African freshwater systems	
2	Analysis/Tests/Methods	1 Analysis - methods for enantiomers	118 (9.8 %) [2]
		2 Analysis/ methods - Speed of analysis	
		3 Analysis/ methods – non-targeted screening	
		4 Analysis/ methods – retrospective analysis	
		5 Analysis/ methods – optimization	
		6 Analysis/ methods- Need for metabolomics	
		7 Measurement in biosolids and amended soils	
		8 Analysis/methods – need for untargeted screening	
		9 Analysis/methods – need for unknown screening	
		10 Analytical/method - sensitivity	
		11 Analysis/test methods - quantification of contaminants	
		12 Analysis/test methods - use of internal and surrogate standards for quality control	

		13 Analysis/test methods - retention time index (RTI) with alkane mixtures	
		14 Analysis/methods - Better development of accurate sediment quality criteria	
		15 Analysis/methods - effective risk ecological assessment methods for this emerging class of insecticides (pyrethroids)	
		16 Analysis/methods - bioavailability-based measurements for pyrethroids in field-collected sediments	
		17 Accurate measurements of the bioavailable fraction of pyrethroids in a sediment and quality effects data are needed to assure accurate sediment toxicity assessments.	
		18 Analysis/methods/accuracy	
		19 The concentrations of DEET reported in multiple studies should be considered carefully and critically according to the following:	
		Type of analysis (gcms vs lcms), detection of DEET in lab blanks or field blanks, correction of DEET concentrations with a stable isotope, recovery of such stable isotope.	
		21 Analysis/methods - MS/MS instruments with higher sensitivity and appropriate methods are needed to quantify this “micro-pollutant”DCF.	
		22 Analytical test standardisation	
		23 Analtical: new approaches and methods to detect and quantify nanoplastics in the environment	
		24 Analytical/methods- using methods capable of detecting PFAS concentrations with LCMRLs at or below 1ng/L	
		25 Ten analyses had concentrations in excess of 1/10 of their respective Effective concentration suggesting more detailed characterisation of these analytes	
		26 A lack of a systematic approach to the detection and quantification of pharmaceuticals has provided a fragmented literature of serendipitous approaches.	

		27 Occurrence: reliable measurement of trace levels of contaminants across different environmental compartments (water, sediment, biota – of which biota has been largely neglected).	
		28 Advancements in mass spectrometric methods for imaging could be pursued to identify localisation of pharmaceuticals within an organism	
		29 Standardised analytical methods: where possible and adhere more strictly to method validation guidelines to ensure robust quantification	
		30 Harmonisation of the available guidelines for method validation that exist would enable movement away from method performance towards method validation	
		31 Guidelines for method validation using HRMS are also lacking	
		32 Focus more on untargeted, hyphenated HRMS analytical methods for screening purposes. Use of hrms would avoid biased pre-selection of contaminants.	
		33 Identification	
		34 Develop and validate new in silico approaches for mining of so called “big data” generated from untargeted methods	
		35 Standardised analytical methods: where possible and adhere more strictly to method validation guidelines to ensure robust quantification	
		36 The use of stringent qa/qc design and consistent field protocols and lab methods	
		37 More effort is needed on validation and benchmarking, especially of newly developed technology such as smart-phone based methods, to avoid false negative results and ensure that methods fit for purpose.	
		38 LODs are not always monitored in real food matrices and thus potential matrix effects are not always considered	
		39 Instrumental reference methods are essential to verify the presence of an analyte at the level of interest	
		40 Insufficient method validation and the absence of benchmarking towards instrumental methods was noticed	

		41 The emergence of smartphone-based methods	
		42 Instrumental methods: confirmatory analysis plays a key role in food chain sustainability. The long and complicated sample preparation remains a challenge that has to be faced in the future.	
		43 Increasing focus on green chemistry	
		44 More effort has to be paid on the development of screening methods either aimed to reduce the number of samples being analyses by instrumental methods or the use of non-destructive methods of enhanced analysis	
		45 Validation and benchmarking issues have to be considered carefully to ensure methods do not provide false-negative resultS and are fit for purpose	
		46 The constant need for revaluation of the available regulations in line with recent advances in methods development.-The application of the legal requirements is partially reflected in the reviewed methods, showing that there is still space for improvement	
		47 The WFD biota EQSs are generally not adapted for mussels.	
		48 The need for critical attention amog environmental researchers on key aspects of study quality.	
		49 There are several key advantages to using sediment or biota as monitoring matrices as alternatives to water samples;	
		50 Increased application of Mytilus spp. As sentinels for chemical status assessments in coastal waters may seem more appropriate.	
		51 To further clarify and minimise the influence of confounding non-target factors in mussel monitoring, e.g., by adopting international harmonisation and standardization of study conditions and program designs.	
		52 Developed methods exhibit drawbacks in terms of accuracy/reliability in quantitative analysis of algal toxins in	

		environmental water samples since earlier methods are based on external calibration approach.	
		53 Losses of algal toxins during the analytical process and matrix effects in UHPLC-MSMS analyses	
		54 Aquatic biota samples: emphasis on fat removal -It is necessary to improve fat removal methods; they should be able to remove all, or almost all, of the fatthy content, without interfering with the compounds recoveries. It should be easy, fast and cheap.	
		55 Aquatic biota samples: the development of multi-residue vs specific contaminants-Research is needed to find new methods, capable of extracting as many compounds as of as many classes as possible in the same process	
		56 Aquatic biota samples: the implementation of a standardised nomenclature. The standardisation could help information exchange in the scientific community and would help scientific dissemination.	
		57 Aquatic biota samples: Moreover, information on sAmple weight, LODs, LOQs, and recoveries is very valuable and should be provided.	
		58 Anti TB drugs: Complexity of matrices in which these compounds are disposed and the complex nature of some of the compounds themselves as well as their high polarity and thermal liability adds to the challenges of analyzing them in the environment	
		59 In addition to the scarcity of commercially available standards for ARVD metabolites, complicated method development for target analytes of diverse physico-chemical properties likely contributes to the limited data	
		60 Useful EP degradation and stability studies thoughout the sample collection and extraction stage were not carried out to determine stability of each compound during sample handling	

		61 Development of methodology tailored for diverse emerging pollutants in water and sediments could assist to analyse a wider range of emerging pollutants such as acidic polar organic compounds	
		62 Enantioselectivity of chiral contaminants	
		63 Development of enantioselective methods for profiling chiral APIs which can interact differently with biological organisms, exhibiting different pharmacokinetics is gaining interest in the scientific community and is recommended in future studies	
		64 Rare earth elements (REEs: To better understand the environmental and human health risks associated with REEs, appropriate advanced analytical facilities, research funding and expertise are required, yet all of these are currently lacking in most African countries	
		65 European countries are lagging behind China and USA across all indices in the analysis of PBDEs	
		66 An expansion of measurements for chemicals of emerging concern needs to be addressed.	
		67 RAbs: There is a need to incorporate more integrative (multidisciplinary) approaches and state-of the art tools for appropriate detection and action	
		68 Development of bio-indicators and local knowledge systems (ethno-medical geology) to identify specific TGCs.	
		69 Continuous monitoring should involve screening of matrices via targeted and non-targeted analyses for new and understudied POPs. This would reflect POP contaminants that humans and wildlife are exposed to. This gap could be addressed with a complementary non/semi-targeteed analytical approach that would aid in identification of unknown contaminants, and result in more robust risk assessments. Collection of data froma wider range of analytes would be beneficial to help identify the main sources of POPs and establish their importance in different regions. Non-target analyses of archived sample extracts	

		could be investigated to assess spatial and temporal trends in data deficient areas	
		70 SSRIs: It is important to note that fluoxetine, and potentially other SSRIs, exhibits appreciable binding (up to ~`50%) to suspended particulates, yet analytical methods for SSRIs in the aquatic matrices examined here commonly prefilter water samples to remove these particles prior to extraction, a practice that likely has underestimated surface water levels of SSRIs	
		71 For researchers to provide more details of experimental protocols and results	
		as we learn more about the long-term ecotoxicological impacts of ECs and their TPs in the environment, it is critical to synthesize key information on validated analytical methods, sensitive test methods for ecological effects, occurrence data, treatment data, and environmental fate data that will facilitate the development of potential regulations to reduce ECs in the environment	
		72 Currently no single measure is able to describe the water quality for any one water body	
		73 Research to develop rapid in situ detection of 1,4-dioxane	
		74 Detection on-site and in real time is critical given the spatially dispersed nature of private wells, the potential for changing water supply characteristics.	
		75 Research to improve detection capabilities will involve the development of highly selective binding and sensing components and will require field testing under various scenarios.	
		76 Even for mercury, a recent study has indicated that still several knowledge gaps existed related to variation within feather parts, among feather types and between feathers of the same type	
		77 NOM: alternatively, surrogate parameters such as DOC and TOC can be monitored instead	

		78 Agricultural chemicals: as inorganic chemicals have also been implicated in causing ED effects; it is important to include their analysis to establish a bseline against which to interpret the hazards and risks posed by agricultural chemicals.	
		Failure to include these, results in less confidence in interpreting both the bioassay results that may be obtained- and exposure assessments.	
		Use of this water quality data is required in order to meaningfully interpret the context of hazards posed by organics and inorganics, without which a differential diagnosis may be difficult to reach.	
		79 PAH: It is strongly recommended that both parent and alkylated polycyclic aromatic hydrocarbons should be analysed, to facilitate source tracking	
		80 PAH, PCB, OC pesticide: In context, all 209 possible congeners should be analysed.	
		however, for costs of analyses this study should concurrently evaluate the the efficacy of using ELISA tests as a rapid screening tool for PCBs in South Africa.	
		81 PAH, PCB, OC pesticide: There is therefore, an urgent need to define baseline concentrations to toxicologically significant metals in S African freshwater ecosystems	
		82 PAH, PCB, OC pesticide; There is therefore a need for the development and validation of whole sediment toxicity testing procedures for freshwater and coastal ecosystems in S Africa, as a tool for determining whether contaminants in sediment are exerting a toxic effect on sediment-dwelling organisms.	
		83 Aquatic microbial diversity: it is now becoming known that numerical abundance of a particular species does not always directly correlate with metabolic activity or potential growth rate of that species	

		A more accurate assessment of whether a bacterial taxon is actively metabolizing can be achieved by quantifying the rRNA as opposed to the rDNA	
		84 Engineered nanomaterials: Environmental factors such as pH, ionic strength, and temperature and retention times are relevant environmental factors that require monitoring in the event of accidental release of ENMs to establish expected impacts and potential mitigation measures.	
		85 Brominated flame retardants: Chemical profile of water and sediment samples with respect to trace metals should be carried out in order to establish whether there is any relationship between the analytes of interest and other contaminants	
		86 Brominated flame retardants:The developed sample pre-concentration extraction kit should be subjected to a mixture of other emerging contaminants to test its ruggedness	
		87 Brominated flame retardants: Work should be done on the so called “novel flame retardants” that are currently used to replace the legacy flame retardants that have been reported in water systems in developed countries, but not in any developing country	
		88 Brominated flame retardants: The use of separating funnel extraction for the isolation of TBBPA derivative resulting from in situ derivatization is recommended in order to obtain acceptable analytical results	
		89 Emerging organic pollutants: The metabolites of pesticides, PCBs, pharmaceuticals and personal care products, and musk ketones should also be analysed as most of these pollutants may be broken down into other compounds in the environment or as it passes through the human body	
		90 Emerging and persistent contaminants/pathogens: systematic approach that simultaneously determines parent compounds, transformation products and degradation products is long overdue.	

		91 Antibiotic resistant bacteria/arb and genes in drinking water: Rapid elisas are sensitive and can detect very low antibiotic residues	
		It is possible to conduct these at DWPFs as part of water safety planning (WSP), particularly where upstream land use involves the use of large quantities of antibiotics in human or animal medicine.	
		The cost for setting up the equipment and analysis is not prohibitively high	
		It would allow for the quantification of antibiotic residues in water samples and provide trends over time	
		92 Fluorescent Sensors for screening ECP: a portable sensor should also be developed based on these sensor materials, to allow for on-site, real-time monitorigng of ECPs in surface waters	
		A non-targeted screening method based on a mixture of different QDs should be investigated, as well as additional compound class type sensors, to enable early detection of overall change in water quality with respect to ECPs	
		93 Carbapenen-resistant bacteria: Designs of the published studies which deal with the presence of CRBP- in raw or treated wastewater were not quantitative.	
		94 Carbapenem resistant bacteria: Therefore the findings of CRBP grown at 37°C may overestimate its significance in the natural environment as an anthropogenic reservoir of clinically important CRBP or reservoir of resistance genes which could be spread to autochthonous bacteria.	
		95 Nonsteroidal anti-inflammatory drugs: The development of very sensitive analytical methodology for the study of NSAIDs in various sample matrices is required	
		96 Fluoride in water: The results of these previous studies have not been consistent in terms of characterizing the fluoride content of Namibias groundwater.	

		97 Fluoride in drinking water: It is necessary to assess all water quality parameters, including nitrate and TDS, in relation to the population affected at both the national and sub-regional scales	
		98 Alkyl phenol ethoxylates (APEs): wastewater effluents were identified as a major source of APEs and their degradation by-products in the environment; thus, more studies should be undertaken to measure the levels of APEs at WWTP outfalls, and terrestrial environments close to agricultural, mining and chemical industries, as the concentration are expected to be highest there.	
		99 Alkyl phenol ethoxylates (APEs): as sewage is known to be released into wetlands and oceanic waters, studies of APE levels in these compartments inhabitants (birds, frogs, algae, daphnia, dolphins, etc) need to be undertaken in order to assess the impact of APEs on biodiversity of such bodies	
		100 Alkyl phenol ethoxylates (APEs): Indoor dust has been implicated as an important exposure route for other persistent organic pollutants, such as TBBPA and PCBs; an accurate assessment (occurrence and fate) of alkylphenol ethoxylates in the indoor environment is of major importance for developing countries as the use of these EDCs is suspected to be on the rise	
		101 Organochlorine pesticides: The uMngeni River: very limited studies have been carried out on the qualitative and quantitative analysis of pesticides in this river.	
		102 CECs in recycling/re-use: combined effects and concentrations are mostly unknown	
		103 CECs in recycling/re-use: could not test for transformed secondary by-products	
		104 CECS in recycling/re-use: carefully test drinking water from the seawater desalination plants or reused sewage water for toxicity, which need not be costly	

		105 Microplastics: to conduct ecotoxicity test to examine effect of different major plastic types, sizes, and shapes in SA on Zebra fish Danio rerio, shrimps caridina nilotica and freshwater snails , Melanoides tuberculate and Algae	
		106 Microplastics: to conduct ecotoxicity test to assess effect of selected plasticizers on different aquatic organisms	
		107 Microplastics: to develop methods for toxicity testing to study microplastics in South African freshwater systems	
		108 Microplastics: method to get microplastics in solution	
		109 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: polymer compositions of microplastics	
		110 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: POPS (including DDT and PFAS), metals, and other chemicals in plastics and microplastics	
		111 Polycyclic aromatic hydrocarbons (PAHs) in aquatic ecosystems: The chemical analysis of the metabolized PAHs would complete the picture of what is happening to the parent PAHs after entering the animals bodies.	
		This would necessitate more funding because these analytical standards are expensive and not always readily available in SA. Each of the 16 parent PAHs has more than 2 metabolites that could be quantified chemically increasing the analytical load and associated expenses	
		112 Polycyclic aromatic hydrocarbons (PAHs) in aquatic ecosystems: The biomarker response results could not conclusively be attributed to PAHs, and therefore a broad spectrum screening for a much larger variety of organic chemical pollutants is advised for this densely populated area of Gauteng.	
		Chemical compounds that can be considered include: polychlorinated biphenyls, brominated flame retardants, organochlorine pesticides,	

		plasticisers, pharmaceuticals and personal care products and perfluorinated compounds, just to name a few compound classes	
		113 Agricultural chemicals: While the analytical approach adopted in this study catered for a large number of different pesticides, it is important to note that glyphosate (most heavily applied pesticide in the country) was not included in screening or quantitative analysis.	
		Considering its high quantity of use as well as increasing evidence of human health-related effects, future research should focus on developing analytical methods for detection of this pesticide (and its breakdown products) in water resources in S Africa	
		114 Urban wastewater epidemiology: compare sampling, detection, monitoring methods:	
		Mass loading	
		Composite sampling vs grab sampling	
		ISTD addition	
		115 Microplastic pollution: due to lack of standardized units to report the concentration of microplastics in the environment, it is at this stage difficult to compare results	
		116 Drug-resistant microorganisms: Methods to be established in this study will be a vital contribution towards the surveillance of antimicrobial resistance activities in the water sector and possible alignment with existing activities in the health sector	
		117 Antimicrobials/antibiotic resistant bacteria: sufficient repeats be conducted so that statistical analyses could be done to investigate the relationship between ARB, antimicrobials, agrochemicals and physico-chemical parameters	
		118 To broaden the suite of contaminants tested	

3	**Studies/Research**	1 Restrictions on environmental releases and continued monitoring are still essential in China, where studies on BFRs, especially non-PBDEs BFRs, remain limited relative to its important role in the BFR market	118 (9.8%) [2]
		2 Bulk of studies documenting args in aquatic systems are focused on antibiotics, while those on antivirals, antifungal, antimalarials, and antihelminthics are rare	
		3 Research covering a broad spectrum of args is urgently needed in most developing countries. Yet such research is limited by lack of funding, expertise and research facilities	
		4 In light of the entire Africa continent, the inadequacy in reported blooms and advances in this area of research require critical intervention and action	
		5 In African countries, the issue of toxic blooms is a compounding one in addition to existing water issues and challenges. It is not surprising, therefore that there is a lag in research in this area	
		6 The systematic assessment of all the processes linked to eutrophication in order to have a practical solution	
		7 Research in Africa has been geared more towards reports and investigations of toxicity in the area of blooms – more work needs to be done	
		8 In light of Africa's unique vulnerability to climate change, as opposed to other continents, knowledge dissemination and collective research is critical	
		9 The establishment of more collaborative research not only on an intercontinental scale but knowledge sharing within the continent, particularly in the central countries	
		10 The spillover (transmisison modes) of bat viruses is still something of a black box, that is scarcely understood, and much more research is needed to expand our understanding of the spillover events.	

		The role of bats in transmission of these infectious diseases needs to be further investigated because of lack of direct experimental data on transmission of viruses from bats to intermediate animal hosts	
		11 Further research and clarification, such as for substances whose mode of uptake and accumulation deviate from general partitioning and when there could be a concentration dependency of the uptake (eg, for PFCs)	
		12 More attention needs to be paid to the emerging pollutants by conducting systematic studies reporting the concentrations needed for the environmental risk assessment of emerging pollutants.	
		13 Limited studies on flows of TCC and TCS in many developing countries such as those in Africa, Asia and South America	
		14 Research on REEs in developing regions, including Africa is needed, given prevailing conditions predisposing humans to health risks, e.g., untreated drinking water	
		15 Future studies will benefit from these inclusion of these newly identified PFAAs	
		16 Studies undertaken in Ghana over past 17 yr have reported POP concentrations in a wide variety of matrices; however, these have been on local POP distributions.	
		17 Most of the available studies regarding microplastics effects were conducted under laboratory conditions, which may be less relevant to the realistic environment	
		18 Perform more studies to reveal the effects of microplastics on aquatic primary producers and influencing factors	
		19 Conduct further studies on the factors that affect the selectivity of aquatic organisms for microplastics and the toxicity and fate of ingested microplastics in aquatic organisms	
		20 SSRIs: In fact it appears critical that more research be focused on areas that will be experiencing the largest increases in population	

		growth and concentration of these populations in cities over the coming years, particularly where wastewater treatment infrastructure and environmental management systems are limited.	
		21 SSRI: Similar mechanistic partitioning and toxicity work has not been done with citalopram and paroxetine indicating an area of imperative research need because citalopram was one of the most frequently detected SSRIs and paroxetine was predicted to exceed the THV (Cmin) almost half of the time in influent detections.	
		22 To develop a strong research base for future quantitative reviews	
		23 To better study and thus understand the effects of multiple stressors	
		24 With increasing number of studies detecting pharmaceuticals in groundwater bodies, the question concerning antibiotic resistance and proliferation of compounds in the aqueous environment should concern us	
		25 Pharmaceuticals: further studies are needed concerning the consequences of these compounds, both in their individual concentrations and as cocktails, in the groundwater environment	
		26 Future studies are needed to illicit the impact of products used in emerging technologies in a more comprehensive way	
		27 Low number of studies in the soil, groundwater, coastal areas and within biota tissues.	
		Studies regarding contamination of the benthic community or biofilms were not found in this research, even though these organisms play a very important role in energy and food cycle	
		28 The low number of studies regarding antibiotic resistance is also concerning, once the spread of antibiotic –resistant bacteria could be a big threat to human health in the next years	
		29 The risk assessment was based on EQS and PNEC values, available in literature for less than a third of the investigated compounds.	

		These ecotoxicology thresholds can be determined by in-silico approaches using large uncertainty factors, and undergo regular revisions accounting for new scientific evidences, which can drastically change the HQ determined here.	
		Future research should focus on the refinement of these thresholds, especially in the context of complex mixtures.	
		30 Research should be focused on the development of hybrid systems for degradation and removal of these contaminants from municipal wastewaters	
		31 Very few studies have quantified the potential of EC sorption to algal biomass	
		32 PFOS in fish: thus there is a need to conduct more studies on fish in areas that are fished by recreational and subsistence consumers, screening level risk assessments with further studies on contaminant sources and mitigation measures for a cleaner environment	
		33 Clearly, more research is needed to investigate whether feathers can be useful to monitor the internal concentrations of other classes of contaminants	
		34 Metal elements: compared with Sr in egg contents, both species had concentrations in their eggshells an order of magnitude higher. Further, the mean Sr concentrations in the leatherback eggshells were more than double the mean in loggerhead shells.	
		Authors could not explain this discrepancy. Further work is needed in this regard	
		35 Mercury concentrations in the wild crocodile egg contents from KNP were slightly higher than from elsewhere., but remarkably lower in eggshells from most other sites	
		The maximum concentration in a wild egg did not reach TRV 2mg/kg dm. There remains a well justified concern and further investigation is warranted	

		36 Other interesting perspectives would include further work on environmental matrices (e.g., speciation of metals in water) and on lower trophic level organisms in the different areas, to thoroughly understand the processes of metal transfer leading to the differences observed in top predators	
		37 In the future, studies on POPs in the sediment of this river should focus on their distribution according to particle sizes of the sediment and comparison of depth and surface sediment concentrations	
		38 PCBs in water: further studies are recommended in order to make a definitive conclusion	
		39 Flame retardants: Taking into account the high levels of these pollutants in WWTW effluents, long-term	
		exposure and bioaccumulation of these OPFRs and other emerging flame retardants in the aquatic environment, indicates that further studies are needed to define the environmental risk produced by these pollutants	
		40 Pesticides: clearly, pesticides as potential endocrine disruptors needs more research specifically focused on understanding the details of interaction with the diversity of factors presented by the endocrine system. Although herbicides as a subgrouping stand out ad being understudied, both fungicides and insecticides need more attention in SA	
		41 Pesticides: Biomarkers representing a larger part of the endocrine response system should be studied and validated. In particular, molecular (gene expression) biomarkers should be used more widely since this sensitive response system could be used following brief exposure experiments	
		42 Fungicides: Fungicides, on the other hand, were mostly associated with anti-androgenic activity, either by inhibiting binding of male hormone to its receptor (AR) or by inhibiting the activity of the enzyme 5-alpha-reductase.	

		The role of fungicides as disruptors in the female reproductive system, especially as aromatase enzyme inhibitors needs more study	
		43 Pesticides: Research regarding potentially affected wildlife populations needs more studies.	
		44 Agricultural chemicals: samples collected in the Vals and Renoster rivers however showed comparatively higher values, with some samples exceeding 0.7 ng/L trigger value	
		The frequent detection of atrazine, simazine, and terbuthylazine (all known EDCs) in combination with the observed ED bioassay responses highlights this geographical area as a priority for further research, where a more detailed survey of the contamination of human and livestock drinking water resources (surface and groundwater) and associated health risks is recommended.	
		45 Agricultural chemicals: in this respect a comparative study of the relative importance of different sources of EDCs in the environment is recommended to prioritise and focus future research initiatives in this field.	
		46 PCB, PAH, OC pesticide in sediment, biological tissue: findings of this study motivate for similar studies in other coastal cities.	
		47 PCB, PAH, OC pesticide in sediment, biological tissue: it is recommended that similar studies be performed in other cities along the South African coastline	
		48 PCB, PAH, OC this study has highlighted the potential use of small, forage fish (specifically ambassids) as sentinels for contaminant monitoring in SA estuaries, based on the fact that they accumulated numerous contaminants in their tissue to high concentrations.	
		It is recommended that a study that compares concentrations of chemicals in the tissues of ambassids and larger fish between putatively contaminated and uncontaminated estuarine ecosystems in the eThekwini area of KZN be performed.,	

		as a case study on the potential use of these fish as sentinels for contaminant monitoring.	
		49 PCB, PAH, OC pesticide: The relationship between chemical concentrations in the tissue of ambassids and larger commonly consumed fish should be explored to determine whether concentrations in ambassids can be used to predict likely concentrations in larger, commonly consumed fish.	
		50 17 beta-estradiol in wastewater: further work is required for actual development of device prototype	
		51 17 beta-estradiol in wastewater: further work is required to develop new aptameric biosensor for other e-EDCs including 17-alpha-ethinylestradiol/EE, estriol, and estrone, as well as combinatorial aptamer biosensor that will be used for the determination of the total e-EDC content of a water sample.	
		52 BMAA - the insights gained into the possible regulatory function of BMAA in cyanobacteria require an urgent follow-up study to confirm the function of this molecule and thereby supply a fundamental physiological basis for any environmental parameter-based alert level framework	
		It is recommended	
		a) That research into role of BMAA as a response regulator be completed so as to support environmentally-based models of BMAA presence and	
		a) That a long-term monitoring project be initiated to collect adequate data to support or refute the lab findings on physicochemical parameter-based prediction of BMAA levels in cyanobacterial blooms	
		The current findings, together with the recommended work, will provide a sound basis for an alert level framework for the analysis of BMAA in recreational and potable water resources	

		53 Engineered nanomaterials: Future research studies should focus more on nanomaterials in the same state that they are likely to end up in aquatic systems	
		This should generate more reliable data that could support better models than those could be derived from the use of pristine or functionalized materials, such as nTiO2 particles currently used, some of which may not find their way into aquatic systems	
		54 Engineered nanomaterials: Further research should test the applicability of these models in predicting the behavior and toxicity of other nanomaterials to establish their suitability and hence applicability in decision making for risk assessment that covers nanomaterials in general	
		55 EDCs: Research has focus mainly on oestrogenic activity, but it is clear that EDCs also affect other pathways, including the hypothalamic pituitary thyroid axis.	
		Studies have reported associations between exposure to thyroid disrupting chemicals and neurobehavioral disorders, obesity and reproductive abnormalities, among others	
		56 Emerging chemical pollutants: Enhanced selectivity via surface modification of the QDs should be investigated	
		57 Further work is needed to optimize the immobilization of the nanomaterials to enable reuse	
		58 EDCs removal from wastewater: This study partially quantified the risks resulting from discharging EDCs into receiving water bodies	
		As only a few EDCs were evaluated, there is a need to study additional groups of these compounds.	
		Thus, more in-depth studies are needed to gain better insight into the magnitude of the eco-toxicological effects on the environment and the potential risks to users of the discharged water and the disposed sludge from wastewater treatment plants.	

		59 Emerging and persistent contaminants/pathogens: available and emerging antibiotic-resistant genes in microbial communities present in wastewater treatment plants should be investigated	
		60 Emerging/persistent contaminants/pathogens: research should be promoted on new technologies for the removal of emerging contaminants from wastewater	
		61 Antibiotic resistant bacteria and genes: The present study provided some data for examples of drinking water production systems typically in operation in South Africa.	
		However, a coordinated study is needed to btain baseline data for the various compartments of the environment in order to adequately link it with health	
		62 arb and genes in drinking water: the data gathered in the present study showed that the underlying genetic elements that confer antibiotic resistance may potentially also lead to increased virulence.	
		A further investigative study is thus necessary to examine the health-related impacts of the bacterial species that have been identified and their associated virulence studies	
		63 Fluorescent sensors for screening ECP in water: as a result of the positive outcomes of this project, further work on the optimization studies of the sensor materials is recommended, particularly with respect to testing therof for real water samples in which the presence of the target ECPs has been confirmed by traditional (chromatographic-mass spectrometric) methods.	
		64 Test organisms for toxicity testing: This experiment platform provided a platform for future biological toxicology studies in SA as both displayed sensitivity to water quality and proved to be suitable organisms for the acute toxicity testing method	
		65 PCBs: In SA, research concerning PCB contaminants in water and mussels is sparse.	

		66 Trace elements: A health risk is also associated with the consumption of L capensis muscle tissue as As and Se recorded THQ values greater than 1.	
		This should be confirmed in follow-up surveys of the local population in the Vaal Dam area.	
		67 PCB residues: While industries are a key component of the countrys economy, little research has been conducted on PCB contamination and no literature is available for PCB analysis in different organs of fish from the North End Lake	
		68 Fluoride in water: While several studies have attempted to address the possible causes for fluoride accumulation in Namibia, no endeavor has been made to link elevated fluoride content in potable water to the population geographic distribution.	
		69 Fluoride in drinking water: We are not aware of a similar study in the sub-continent, particularly in neighbouring countries, where cross-border water management is essential, partly due to shared aquifers and transboundary perennial rivers	
		70 Alkyl phenol ethoxylates: wastewater effluents were identified as a major source of APEs and their degradation by-products in the environment; thus, more studies should be undertaken to measure the levels of APEs at WWTP outfalls, and terrestrial environments close to agricultural, mining and chemical industries, as the concentration are expected to be highest there.	
		71 Alkyl phenol ethoxylates: within effluent studies, as these pollutants are directly linked to urbanization, the impact of population increase in metropolitan areas need to be assessed for APEs pollution	
		72 Alkyl phenol ethoxylates: as sewage is known to be released into wetlands and oceanic waters, studies of APE levels in these compartments inhabitants (birds, frogs, algae, daphnia, dolphins, etc) need to be undertaken in order to assess the impact of APEs on biodiversity of such bodies	

		73 Alkyl phenol ethoxylates: there is a paucity of data on the adverse health impacts of NPE1-3. Hence studies should be undertaken to establish the minimum health risk concentration for each isomer as well as to investigate the synergic health effect of a combination if different environmentally relevant concentrations of APEs	
		74 Alkyl phenol ethoxylates: there is a scarcity of data on human biological monitoring for APEs around the globe and more research also needs to be directed toward NPE isomer identification, as the available studies determined exposure to technical mixtures of OPs and NPs	
		75 Alkyl phenol ethoxylates: NPE(1-3) as emerging environmental contaminant should be studied systematically to evaluate their potential threat to environmental and human health. To accomplish this goal, research activities should look into, among others:	
		1) developing analytical methods to measure these pollutants in a variety of matrices down to trace levels	
		2) fate and transport of NP and NPE(1-3) in air	
		3) more toxicity data to assess the effects on terrestrial organisms such as plants	
		4) potential effects on wildlife due to long-term exposure to low concentrations of NP and NPEs	
		76 Pharmaceutical and personal care products: Several key points should receive priority in future studies to ensure sustainability of our freshwater resources, namely:	
		1 further reports on the occurrences of PPCPs and their metabolites in surface waters	
		2 establishing the possible endocrine-disrupting effects of commonly-detected PPCPs and other micro-pollutants through a tiered eco-toxicological approach	

		3 investigating the contribution of environmental micro-pollutants towards the global epidemic of AMR	
		4 report on the effectiveness of WWTPs to remove priority micro-pollutants, such as EDCs, as well as biological pathogens	
		5 raising public awareness of the consequences of liberal and irresponsible PPCP use and disposal	
		6 establish and/or improve initiatives such as the National Toxicity Monitoring Programme (NTMP) to assist with environmental risk assessment through the use of AOP (adverse outcome pathway) networks	
		7 developing more effective water treatment technologies to eradicate persistent micro-pollutants from the water system in order to deem the system safe for reuse.	
		77 BTEX in water: research trends indicate that there is still room for more studies to be conducted on the occurrence of BTEX compounds in various water systems, as well as to examine future treatment techniques that can help alleviate unpleasant health effects and possibly reduce water-related deaths	
		78 Organochlorine pesticides: The uMngeni River: very limited studies have been carried out on the qualitative and quantitative analysis of pesticides in this river.	
		79 Organochlorine pesticides: In the future, studies on POPs in the sediment of this river should focus on their distribution according to particle sizes of the sediment and comparison of depth and surface sediment concentrations	
		80 Polycyclic aromatic hydrocarbons: Further studies can be done to pinpoint the sources, considering that Northern Works WWTP receives sewage mainly from domestic and food industries while Goudkoppies receives sewage mainly from the chemical industry	

		81 Toxic elements: future study will focus on assessing the transfer of toxic elements to humans through food chain (sediment/water-plant-animal-human chain)	
		82 Toxic elements: toxicity study using a model organism such as zebra fish will assist monitoring the toxic effects of potentially toxic elements in reproductive and nervous systems of the organism.	
		83 Antimicrobials and antibiotic resistant bacteria: future research is conducted so that statistical analyses could be done to investigate the relationship between ARB, antiiotics and physico-chemical parameters	
		84 Antimicrobials and antibiotic resistant bacteria: the presence of antibiotic resistance genes/genetic materilas in the ARBs is investigated.	
		85Antimicrobials and antibiotic resistant bacteria: In addition, the presence of these antibiotic resistance genes/genetic materials in bulk water should also be investigated with a focus on the potential for transfer to susceptible bacteria	
		86 Microplastics: to conduct ecotoxicity test to examine effect of different major plastic types, sizes, and shapes in S Africa on Zebra fish Danio rerio, shrimps caridina nilotica and freshwater snails , Melanoides tuberculate and Algae	
		87 Microplastics: to conduct ecotoxicity test to assess effect of selected plasticizers to different aquatic organisms	
		88 Microplastics: to develop methods for toxicity testing to study microplastics in south African freshwater systems	
		89 Microplastics and pharmaceuticals: as drivers for antimicrobial resistance:	
		The following questions and themes as well as authors own insights, seems appropriate for S Africa	
		1 factors that affect release, transformation, persistence and transportation in surface and ground waters	

		2 baseline and time trends	
		3 polymer compositions of microplastics	
		4 POPS (including DDT and PFAS), metals, and other chemicals in plastics and microplastics	
		5 leaching of chemicals from plastics under SA conditions (high temperatures, dry periods and UV)	
		6 biological effects studies in laboratory and field	
		7 sinks and sources	
		8 runoff and waste sites	
		9 accumalation in humans, animals, plants, and other biota	
		Microplastics in ground-and tap waters	
		10 aerial deposition	
		11 investigate the interaction of microplastics, bacteria, and antimicrobial resistance	
		90 Natural organic matter:	
		1 In order to develop a better understanding of NOM character and its removal, there is neeed to carry further investigations.	
		Seasonal variations of different NOM fractions should inform the correct Nom removal methods to enhance effectiveness of removal	
		2 Extensive sampling that will account for all the geographic locations in S Africa is required	
		3 Further development and refining of nanomaterials for NOM photolysis could alos increase treatability of the various fractions of NOM	
		91 River water quality: This practical model was applied to a small-scale river system (main focus was Grabouw, and not the entire catchment). More research is required on large-scale rivers to determine how variability affects the outputs of these models	

		92 River water quality: research is also needed to determine the impact of the identified pollutants on the aquatic ecosystems in the Swannies, Klipdrift and Palmiet rivers	
		93 Polycyclic aromatic hydrocarbons in aquatic ecosystems: Add a social component to the study in which the human populations physical interaction and dependence on the Klip River running through Soweto/lenasia is quantified, ie, using questionnaires and interviewing citizens	
		94 Agricultural chemicals: decisions relating to monitoring of pesticides in the selected study areas benefited significantly from the pesticide use data, prioritization matrix and pesticide use maps developed in this project.	
		It is recommended that these resources be consulted when undertaking similar studies in the future.	
		94 Agricultural chemicals: While the analytical approach adopted in this study catered for a large number of different pesticides, it is important to note that glyphosate (most heavily applied pesticide in the country) was not included in screening or quantitative analysis.	
		Considering its high quantity of use as well as increasing evidence of human health-related effects, future research should focus on developing analytical methods for detection of this pesticide (and its breakdown products) in water resources in S Africa	
		95 The use of sentinel monitoring yielded valuable information towards the site-specific animal health assessment. The observations would suggest that further studies into human health with bromide as a key priority chemical are indicated	
		96Agricultural chemicals: Given the chllenges related to monitoring (due to the transient nature of contamination) and that pesticide contamination in water resources occurs primarily as a result of nonpoint sources (runoff, leaching) further research should focus on modelling techniques aimed at assessing the fate, transport and	

		mitigation/management options of pesticides in water at multiple scales (field to catchment)	
		97 Agricultural chemicals: research should focus on the integration of these models into the risk assessment process conducted during the registration of pesticides. While the registration process considers the toxicity of a pesticide, there are no exposure assessment procedures performed to assess the environmental fate and predicted environmental concentrations under S African conditions	
		98 Drug resistant microorganisms: The contribution of drinking water chemicals disinfectants on the development of resistance profiles is an issue which requires further investigation	
		99 Drug-resistant microorganisms: a followup WRC study is thus underway, the overall goal of which is to establish methodologies to monitor the dynamics of antibiotic resistant bacteria and genes in raw and final water samples drinking water samples in selected conventional and advanced drinking water plants in S Africa	
		100 Drug resistant microorganisms: this project will also provide a platform to engage on the broader on antimicrobial resistance, with the potential to arrive at a multi-sectorial research agenda	
		101 Antimicrobials/antibiotic resistant bacteria: a comprehensive study on antimicrobial substances removal capacity of various drinking water treatment configurations in operation in SA.	
		These should also be done under varied flow conditions	
		102 Antimicrobials/antibiotic resistant bacteria: the presence, distribution and dynamics of antibiotic resistance genes in the ARBs should be investigated	
		However the presence of these genes/genetic materials in bulk water should also be investigated with a focus on the potential for transfer to susceptible bacteria	

		103 Preservatives, anti-oxidants and flavorants present in cosmetics and cleansing products has been less studied	
		104 Further studies of additional classes of pharmaceuticals and other CECs in on-site wastewater effluents	
		105 The focus of research should be accordingly transferred from PBDE to other currently used BFRs in later study.	
		106 To better study and thus understand the effects of multiple stressors	
		107 Aquatic microbial diversity: the advent of new NGS technologies that substantially decrease the cost of generating sequence datasets provide and opportunity to apply the approach taken in this study widely to include other important estuarine systems around the SA cpastline	
		108 EDCs removal from wastewater: This study partially quantified the risks resulting from discharging EDCs into receiving water bodies	
		As only a few EDCs were evaluated, there is a need to study additional groups of these compounds.	
		109 Emerging and persistent contaminants/pathogens: there is a need to expand the scope of the study to include several rivers that feed into drinking water treatment plants	
		110 Urban wastewaste epidemiology: Gaps in knowledge, research, policy:	
		Surrogate chemicals/physico-chemical properties association	
		Early warning showing public health concerns	
		Near/real time	
		Sensing/monitoring (large datasets, modelling)	
		111 Analysis/methods - Better development of accurate sediment quality criteria	
		112 The need for critical attention amog environmental researchers on key aspects of study quality.	

		113 Aquatic biota samples: the implementation of a standardised nomenclature. The standardisation could help information exchange in the scientific community and would help scientific dissemination.	
		114 Alkyl phenol ethoxylates (APEs): wastewater effluents were identified as a major source of APEs and their degradation by-products in the environment; thus, more studies should be undertaken to measure the levels of APEs at WWTP outfalls, and terrestrial environments close to agricultural, mining and chemical industries, as the concentration are expected to be highest there.	
		115 Alkyl phenol ethoxylates (APEs): as sewage is known to be released into wetlands and oceanic waters, studies of APE levels in these compartments inhabitants (birds, frogs, algae, daphnia, dolphins, etc) need to be undertaken in order to assess the impact of APEs on biodiversity of such bodies	
		116 Alkyl phenol ethoxylates (APEs): Indoor dust has been implicated as an important exposure route for other persistent organic pollutants, such as TBBPA and PCBs; an accurate assessment (occurrence and fate) of alkylphenol ethoxylates in the indoor environment is of major importance for developing countries as the use of these EDCs is suspected to be on the rise	
		117 Organochlorine pesticides: The uMngeni River: very limited studies have been carried out on the qualitative and quantitative analysis of pesticides in this river.	
		118 CECs in recycling/re-use: combined effects and concentrations are mostly unknown	
4	**Monitoring**	1 Long-term monitoring encompassing all aquatic matrices	**89 (7.4% [3]**

		2 Routine monitoring of antibiotics and resistant bacterial strains in drinking water	
		3 Monitoring of new CECs	
		4 Limited survey/monitoring has been performed in other countries or regions	
		5 Targeted monitoring	
		6 Monitoring of persistent CECs, antiretrovirals, like nevirapine	
		7 Monitoring of biota	
		8 Monitoring- Importance of further characterising the nationwide aquatic occurrence of those analytes whose ambient water concentrations appear to frequently exceed well established ECs and their pathways into the environment	
		9 Monitoring info- limited monitoring information for coastal and marine waters	
		10 Environmental monitoring studies of antihistamine metabolites and degradates are lacking, but deserve attention in the future	
		11 Monitoring- Unique global scanning approach:to identify specific chemicals and locations for future environmental assessment and management efforts	
		12 Monitoring- the Tiber waters should be continuously monitored since POPs may still pose some risks to aquatic ecosystems.	
		13 Scope of monitoring- other antibiotics deserve attention from environmental assessors and managers	
		14 The monitoring of HBCD in China should also be continued for a long time	
		15 Restrictions on environmental releases and continued monitoring are still essential in China, where studies on BFRs, especially non-PBDEs BFRs, remain limited relative to its important role in the BFR market	
		16 Monitoring/sampling- Solid waste repositories (non engineered landfills), onsite sanitation systems (pit latrines, septic tanks), funeral	

		parlours and cemeteries/gravesites constitute overlooked potential hotspots sources of args.	
		17 The necessity of introduction of monitoring program for emerging pollutants	
		18 In the area of technological advances and effective monitoring, most countries are in the early implementation stages and have only recently made efforts into the investigation of cyano bacterial blooms, with identification and toxicity being the primary information screened for.	
		19 A development of monitoring guidelines specific to particular regions of the continent or of the entire continent may prove very useful and is strongly recommended.	
		20 The implementation of the guidelines and accessability is also a needed practical intervention	
		21 Mussels as sentinels for chemical monitoring is rational for many reasons, and development of environmental assessment criteria specially adapted for these sentinels is a strategically important endeavour.	
		22 Anti TB drugs: high cost of advanced analytical tools needed are limiting effective monitoring of these compounds in the environment.	
		23 Along with the antibiotics of common usage, the emerging contaminant candidate list should include: nevirapine, efavirenz, carbamazepine, methocarbamol, venlafaxine (hydrochloride) and bromacil. They are contaminants that require operational monitoring in South African urban waters.	
		24 Future national monitoring programs in developing counties should consider including TCS and TCC as results suggest both are a concern for freshwater and in WWTPs.	
		25 ENMs; field monitoring data are required	
		26 REEs: Most studies have focused on additional studies on La, Gd, Ce., there is a need for extending the environmental monitoring and	

		characterization studies to other 12 REES, excluding Pm, which does not occur naturally	
		27 Carbamazepine, naproxen, diclofenac, ibuprofen to be regarded as priority ECs for environmental monitoring due to their regular detection and persistence in environmental waters, and their possible contribution towards adverse health effects in humans and wildlife.	
		28 Recent identification of novel fluorinated compounds in aqueous film forming foams and environmental samples can serve as target compounds to expand PFAA measurements to include possible replacement chemicals	
		29 SUGEs: Conducting health surveillance studies to provide baseline data, and determine whether conditions are improving or worsening. Such surveillance studies should include occupational workers in the mining industry, sculptors, carvers and engravers and their families.	
		30 Periodic monitoring of diclofenac and its metabolites/transformation products in all environmental compartments should have high priority to both protect the health of the population and reduce diclofenac contamination in the water cycle	
		31 Many European and African countries lack monitoring studies in their research programs. Same situation is observed in Mediterranean, Asia (excluding China) and Australia.	
		32 Diclofenac: the above challenges will be addressed by shifting to more monitoring research and improving the efficiency of WWTPs through advanced technologies without any secondary pollution in all countries to save the water cycle and ecosystem	
		33 POPs: another issue is the lack of annual measurements and systematic monitoring over time for POPs in all regions	
		34 Temporal data have been assessed, but majority of datasets do not show trends due to limited sampling periods, and limited sample size.	

		More consistent monitoring produces nationwide data, leading to informed risk management studies	
		35 Conduct extensive monitoring programs on the abundance of microplastics in aquatic products that are at the point of human consumption in order to calculate the amount of microplastics introduced into humans via consuming aquatic products	
		36 SSRIs: Among wastewater treatment technologies examined	
		, THV exceedances for each SSRI were not observed among treatment type, though effluent levels and exceedances were consistently lower than influent sewage, which highlights the importance of extending monitoring efforts in regions with limited treatment capacity.	
		37 In a world where water consumption is predicted to increase, water scarcity will continue to intensify and a dependence on water reuse will become common practice, the monitoring of pollutants will become imperative.	
		38 It is up to the scientific community to clearly impress the importance of monitoring networks and the upkeep and development of long-term data sets on decision makers, while prioritizing the need for installation and maintenance of measuring systems in the face of resource constraints	
		39 Environmental risk assessment revealed special concern on hormones derived from improper wastewater disposal. Results allowed the identification of of highly vulnerable sites and critical compo3unds for which further monitoring and assessment is highly recommended.	
		40 ECs: these substances are not included in the usual monitoring program of WWTPs	
		41 Domestic effluent can contain equal or even higher concentrations of pharmaceuticals than hospital effluent	
		This reveals the importance of monitoring urban WWTP and establishing a priority list of contaminants	

		42 Since agriculture is one of the main economic activities in latin America, monitoring the occurrence of emerging contaminants in soil is also very important	
		43 Feathers can be useful as a biomonitor for POPs, mercury and several other metals under the conditions that appropriate sampling designs and pretreatment of samples along with QA/QC protocols during storage, preparation and analysis are taken into account	
		the specific bird species, the type of feather, the type of pollution and potential external contamination are very important to consider for a successful biomonitoring strategy.	
		44 Further studies are required to investigate the contribution of pearl millet in the daily intake of mycotoxins by Tunisian consumers for the monitoring of the risk ssessment	
		45 Metallic elements: due to their toxic threat, authors suggest at least Hg, Al, Pb, As, Co, Cd, Cu, V, Ni, Zn, Mn, and Sr be monitored	
		46 Autors also suggest adding Au, Ba,and Tl to this list, since it seems to be receiving more attention from terrestrial and marine perspectives	
		47 Based on authors observations of Sr, it seems prudent to add the remaining alkaline earth metals, Ca, Ra, Be, Mg.	
		48 Metal-elements: economic development and other forces such as conflict and population growth around the Indian Ocean basin are likely to increase pollutant releases and trends need to be monitored	
		49 NOM in water: Owing to expensive equipment used in NOM characterization, it Is not possible to routinely monitor the levels and character of NOM in source waters	
		50 NOM: alternatively, surrogate parameters such as DOC and TOC can be monitored instead	
		51 NOM water utilities are just beginning to appreciate the need to monitor NOM	

		52 Agricultural chemicals: despite monitoring limitations, mentioned above, this study did reveal relatively high concentrations of particularly atrazine, terbuthylazine and simazine in maize, and sugar cane areas.	
		Their ubiquitous presence in water resources warrants further investigation in areas where use is high	
		In particular, more detailed surveys of groundwater resources and boreholes that deliver drinking water and for human and animal consumption should be surveyed in more detail	
		53 Agricultural chemicals: In all study areas, the detection of pesticides was well predicted by indices used in the prioritization procedure, particularly quantity of use and mobility (as indicated by GUS index).	
		In addition, qualitative screening analysis was also instructive in helping to identify specific pesticides in the selected catchment study areas for further quantitative analysis.	
		It is therefore recommended that the combination of these predictive and analytical tools be consulted when planning future pesticide monitoring and risk assessment studies of this nature	
		54 Agricultural chemicals: improved prioritization of environmental risk (to inform environmentally friendly use of pesticides), monitoring and modelling approaches are therefore essential to close the gap on assessing the risks of pesticides in the environment	
		55 PAH, PCB, OC pesticide:: Contaminant concentrations in many fish species and in mussels were high enough to pose a potential chronic and carcinogenic health risk to human consumers.	
		This finding has important implications in that it calls for the more frequent monitoring of contaminant monitoring in fish and shellfish and the communication of the findings to recreational and subsistence fishers	

		56 PAH, PCB, OC pesticide: There is a need for the routine monitoring of these contaminants in aquatic monitoring programs	
		57 PAH: PAHs were ubiquitous in sediment in the eThekwinin area, and in catchments where the predominant land-use is urban or industrial were likely to have been predominantly derived from anthropogenic sources	
		It is recommended , therefore, that PAHs should routinely be analysed in sediment as part of aquatic monitoring programmes in urbanized and industrialised areas.	
		58 PAH, PCB, OC pesticide: this study has highlighted the potential use of small, forage fish (specifically ambassids) as sentinels for contaminant monitoring in SA estuaries, based on the fact that they accumulated numerous contaminants in their tissue to high concentrations.	
		It is recommended that a study that compares concentrations of chemicals in the tissues of ambassids and larger fish between putatively contaminated and uncontaminated estuarine ecosystems in the eThekwini area of KZN be performed.,	
		as a case study on the potential use of these fish as sentinels for contaminant monitoring.	
		59 17 beta estradiol in wastewater: considering that only 78% of EE, the major component of birth control pill, is removed by water treatment plants, it is very urgent to develop aptasensors for monitoring EE level in water for domestic usage.	
		60 17 beta estradiol in wastewater: another important research to undertake is the development of electrochemical elisa library for the major estrogenous endocrine disrupting chemicals. Commercial elisa systems are mainly basedon UV-Vis measurements	

		61 Aquatic microbial divrsity: In addition, the reduced cost could make it feasible to use of this technology for routine monitoring of sensitive estuarine systems	
		62 BMAA: our understanding of the transient nature of BMAA in cyanobacteria indicates a requirement for frequent monitoring of cyanobacteria in drinking water sources where elevated chlorophyll content is detected.	
		63 BMAA: the complex nature of the apparent nitrogen: carbon ratio regulation of BMAA production indicates the necessity for a long-term monitoring program wherein all relevant physicochemical parameters are measured in conjunction with BMAA so as to develop an applicable,	
		environmental model for BMAA risk so as to inform an alert level guideline and better manage exposure risk	
		64 Brominated flame retardants: Phosphorous flame retardants which have also replaced the BFRs should be monitored in water systems since information on these is still scarce in South Africa	
		65 Emerging organic pollutants: Continue monitoring studies with the recommendations that eThekwini includes organic pollutants in its monitoring studies of water bodies	
		66 Emerging chemical pollutants: it is necessary that the technologies developed in this initial project be applied to the monitoring of the target ECPs in real water samples to optimize and validate the results and to determine effects of various variables and parameters (such as pH, contact time and interferences) on their performance	
		67 Emerging/persistent contaminants/pathogens: a water reference laboratory should be established in S Africa that would support the monitoring labs	

		68 Fluorescent sensors for screening ECP in water: portable sensor should also be developed based on these sensor materials, to allow for on-site, real-time monitorigng of ECPs in surface waters	
		69 Trace elements: It is recommended that trace element concentrations within L capensis be monitored to determine if the trend identified above is maintained	
		70 Metals: It is important to monitor both the surface sediment and aqueous environment, as these form sinks for pollutants	
		71 Metals: Information from the present study can be used as baseline data, for future monitoring of metal concentrations in Cape Town, South Africa	
		72 Carbapenem resistant bacteria: Since CRBP grown at 42°C was not found in natural water samples beyond the vicinity of hospitals, these bacteria may be used as an indicator of hospital wastewaters	
		73 PCB residues: Because of the persistence of these contaminants and the resulting harmful effects to organisms and human health, it is necessary to continue to monitor their distribution in the environment.	
		74 PCB residues: Therefore , regulatory implementation for monitoring of wastewater emissions into this lake need to be implemented, as this is suspected to be the primary source of PCBs in the NE Lake	
		75 Toxic elements: Authors recommend continuous monitoring control measures in studied areas as a high priority.	
		76 CECs in recycling/reuse: implement barriers, monitoring programmes and assessment programmes to eliminate or minimize the risks	
		77 CECs There is a need to conduct a national monitoring programme in order to obtain the spatial distribution of these emerging contaminants	

		77 Polycyclic aromatic hydrocarbons in aquatic ecosystems: incorporating results from this study into management of this water catchment one must keep in mind that PAHs are mainly airborne.	
		Therefore a successful monitoring program of any water catchment for these compounds would require an integrated approach including air quality monitoring	
		78 From a monitoring perspective, further research should focus on the development and use of passive samplers (including biomonitors) in providing time integrated measurements of pesticide contamination	
		79 Agricultural chemicals: Given the typically transient nature of pesticide contamination in water resources, the consistent detection of atrazine and terbuthylazine at study sites in the Free State indicates a saturation of the water resource, to the extent that a more detailed monitoring programme, with a higher frequency of sample collection (or more sites) is warranted so as to establish a more accurate picture of exposure associated risks	
		80 CECs in wastewater for direct potable reuse: It is recommended that a battery of bioassays representing different trophic levels be included in a monitoring programme if direct reuse of wastewater is known to occur either intentionally or unintentionally	
		Different bioassays can be selected if various activities are tested, e.g., different oestrogen mimicking assays and anti-androgenic activity may be included	
		81 Urban wastewater epidemiology: compare sampling, detection, monitoring methods:	
		sensing/monitoring (large datasets, modelling)	
		82 Drug-resistant microorganisms: Methods to be established in this study will be a vital contribution towards the surveillance of antimicrobial resistance activities in the water sector and possible alignment with existing activities in the health sector	

		83 Drug resistant microorganisms: Outcomes from this study will inform future water quality monitoring considerations on the reclamation of wastewater for drinking purposes.	
		84 There are several key advantages to using sediment or biota as monitoring matrices as alternatives to water samples;	
		85 To further clarify and minimise the influence of confounding non-target factors in mussel monitoring, e.g., by adopting international harmonisation and standardization of study conditions and program designs.	
		86 Urban wastewater epidemiology: compare sampling, detection, monitoring methods:	
		Mass loading	
		Composite sampling vs grab sampling	
		87 To further clarify and minimise the influence of confounding non-target factors in mussel monitoring, e.g., by adopting international harmonisation and standardization of study conditions and program designs.	
		88 Continuous monitoring should involve screening of matrices via targeted and non-targeted analyses for new and understudied POPs. This would reflect POP contaminants that humans and wildlife are exposed to. This gap could be addressed with a complementary non/semi-targeteed analytical approach that would aid in identification of unknown contaminants, and result in more robust risk assessments. Collection of data froma wider range of analytes would be beneficial to help identify the main sources of POPs and establish their importance in different regions. Non-target analyses of archived sample extracts could be investigated to assess spatial and temporal trends in data deficient areas	
		89 Engineered nanomaterials: Environmental factors such as pH, ionic strength, and temperature and retention times are relevant	

		environmental factors that require monitoring in the event of accidental release of ENMs to establish expected impacts and potential mitigation measures.	
5	**Removal/reduction/ remediation/treatment/purification**	1 Removal by waste water treatment plants (WWTPs)	**81 (6.7%) [4]**
		2 Performance and removal mechanisms in wastewater treatment systems	
		3 Monitoring treatment	
		4 Performance of Point-of-use (POU) technologies for their removal	
		5 Role of microorganisms in removal of CECs in wastewater stabilisation ponds	
		6 Design of waste stabilisation ponds (WSP) toward optimization – inclusion of tertiary treatment step	
		7 Knowledge on the performance of POUs towards removal of CECs	
		8 Treatment technologies for removal from water	
		9 Removal - Novel materials for effective environmentally friendly treatment processes -	
		10 Combination of treatment methods for efficient ECs removal	
		11 Health standards for treatment	
		12 Adequacy/performance of treatment techniques (chemical, biological, membrane filtration, adsorption)	
		13 Efficient removal of new CECs	
		14 Treatment plant operational variables	
		15 The mechanisms and optimise the main parameters related to the AOP performance for CEC removal	
		16 Investigation of the removal of all ESOC groups in granular systems	
		17 Impacts of nano-remediation	
		18 Removal of Diclofenac (DCF)	

		19 Treatment efficacy: The need for additional research to identity the scope and magnitude of drinking water treatment efficacy with respect to those pathogens found in drinking water	
		20 Estimate removal, if any, of microbial pathogens, from source waters by currently used drinking water treatment processes under typical plant operating conditions	
		21 Identify possible candidate organisms that may be amenable to enhanced reduction or removal	
		22 Remediation- Exploiting microbes for remediation of microplastic contaminated environments:	
		23 Remediation - use of microbes for biodegradation	
		24 Remediation- involving the general public, the socio-economic sectors, tourism and companies specialising in waste management.	
		25 Apply targeted remedial actions.	
		27 Biological perchlorate reduction – research opportunities	
		28 Expanding the microbial diversity for perchlorate removal	
		29 Bioprospecting PCRM in places could emerge as an opportunity to learn more about the different metabolic pathways involved in perchlorate respiration	
		30 Biological perchlorate reduction in saline environments	
		31 Reducing perchlorate in these fertilisers could help to diminish perchlorate contamination. Biological reduction of perchlorate could help to accomplish this goal.	
		32 Perchlorate contamination also presents opportunities to study biological perchlorate reduction -This info would be helpful to design novel, sustainable and efficient pathways to remove perchlorate from sources as water or fertilisers.	
		33 There is a clear need for the development of advanced WWTP technologies to more efficiently remove /degrade PPCPs	

		34 The various remediation technologies for the chloroacetanilide herbicides – focus of most of the studies have only been limited to the reduction in the concentration of the parent compounds	
		35 Incomplete removal of the drugs, such as ciprofloxacin, that is worrying due to cumulative unknown health effects when ingested over a long time	
		36 ARVDs: a nationwide study of the presence, use pattern, material flow analysis and removal rate of ARVDs is necessary in order to estimate the load of ARVDs released into the surrounding surface and fresh water bodies, since ARVDs may have associated ecological risks to aquatic organisms	
		37 Mitigation measures to minimize environmental risks: numerous techniques have been investigated for removal of organic ECs. Investigations focusing on REEs remain scarce.	
		38 Sewer systems must be provided with modern technology to remove RAbs from wastewater while the surface water must be safe-guarded, probably by compartmentalization, from receiving runoff from agricultural farm without first passing through the sewer system.	
		39 Increasing the efficiency of WWTPs for diclofenac and its metabolites/transformation products in all environmental compartments should have high priority to both protect the health of the population and reduce diclofenac contamination in the water cycle	
		40 Diclofenac: wastewater/sludge used for irrigation/fertilizer may eventually cause human toxicity through the consumption of diclofenac-accumalated plants. However, inefficiency of WWTPs is to blame for these toxicants in effluents. Hence, advanced treatments with low-cost solutions are needed to address to rescue WWTPs struggling with huge quantities of wastewaters.	
		41 Such emerging contaminants call for optimization of the existing treatment processes and introduce further and advanced treatment	

		technologies including advanced oxidation (ozonation/hydrogen peroxide)	
		42 Advancements in water treatment systems that prove effective in eliminating ECs will need to be demonstrated at full-scale to prevent further contamination of the environment by persistent ECs	
		43 Research to improve 1,4-dioxane treatment. Considering the prevalent contamination in groundwater that serves as a source for drinking water in many contaminated sites, advancing advanced oxidation process technologies for smaller, modular applications are needed.	
		44 Research should be focused on the development of hybrid systems for degradation and removal of these contaminants from municipal wastewaters	
		45 Knowledge of removal of ECs in algal WWT ponds – due to complexity of the ecology and environmental conditions- this area of research is still in its infancy	
		46 Long HRTs in algal ponds may allow removal mechanisms with slow kinetics to become significant. This may for example, allow time for hydrolysis, or biodegradation following deconjugation	
		47 Several authors have reported that photodegradation of ECs occurs in algal ponds, which is expected due to the large surface-area-to-volume ratios of algal ponds.	
		However, few studies have properly isolated the significance of photodegradation from other removal mechanisms in algal ponds	
		48 NOM: conventional WTPs are not designed to effectively remove NOM.	
		49 NOM: another area of research that is rapidly gaining prominence in NOM removal is the use of ceramic membranes	
		50 NOM: despite being in the formative stages of research, these approaches have great potential in that they can be co-opted into	

		existing water treatment processes and increase the NOM removal efficiency.	
		51 Agricultural pesticides: this study highlights the question of the efficacy of existing water treatment technologies in the study areas, due to their inability to completely eliminate EDCs during water treatment processes.	
		This suggests the need for water treatment in the indicated areas to be investigated	
		52 Emerging organic pollutants: The results from this study show that wastewater treatment plants are possible sources of these organic pollutants and it is therefore recommended that the wastewater treatment plants upgrade their processes to include the removal of organic pollutants	
		53 Emerging organic pollutants: Future studies should also look at degrading or completely removing organic pollutants- from the environment	
		54 EDCs removal from wastewater: EDCs include a multitude of organic compounds with widely ranging functional groups, which complicates optimization of the removal of these compounds by wastewater treatment processe.	
		It is apparent that other factors, apart from those already identified, e,g., SRT, HRT, in activated sludge processes, also play a role in the removal of these compounds from wastewater.	
		These unknown factors need to be identified and investigated in future studies.	
		For activated sludge processes, important factors to consider are biomass morphology and sludge bacterial species diversity	
		55 EDCs removal from wastewater: laboratory-scale experiments can make a significant contribution towards understanding the role that different variables play in the removal of EDCs.	

		Some of the compounds were fairly well removed in the integrated pond system and the role of anaerobic ponds needs to be evaluated.	
		56 Emerging/persistent contaminants/pathogens: research should be promoted on new technologies for the removal of emerging contaminants from wastewater	
		57 Microcystin toxins: This study showed that conventional water treatment processes, such as pre-oxidation, coagulation, sedimentation, sand filtration, and chlorination, in Egyptian DWTPs were ineffective in the elimination of all cyanobacterial cells and/or extracellular MC toxins	
		58 Microcystin toxins: The presence of toxic O limnetica and/or its MC toxins in the final drinking water poses a risk to humans and animal health	
		Therefore, DWTPs using such conventional treatment methods in Egypt and other countries necessitates alternative treatment approaches to remove cyanobacterial cells and their toxins	
		59 Pharmaeuticals and personal care products: Report on the effectiveness of WWTPs to remove priority micro-pollutants, such as EDCs, as well as biological pathogens	
		60 Pharmaceutical and personal care products: developing more effective water treatment technologies to eradicate persistent micro-pollutants from the water system in order to deem the system safe for reuse.	
		61 BTEX in water: Studies have also highlighted the persistent presence of BTEX compounds in air, and have reported the transportation of these compounds from air into water bodies as a result of rainfall	
		As a result, it is imperative that the remediation of these compounds in water is prioritized in future water treatment systems	

		62 BTEX in water: Current municipal water treatment systems do not detect or treat BTEX compounds, thereby creating a risk of ingestion by end users of municipal-suppliedd potable water.	
		63 BTEX in water: as occurrences of cancer-related deaths increase and unexplainable health defects in newborn babies rise, it is important that future water treatment technologies focus on previously-overlooked pollutants such as btex compounds.	
		64 BTEX in water: The use of futuristic treatment materials such as nano-materials and tannin adsorbents could create more efficient water treatment systems, and reduce risks related to consumption of unclean water	
		65 BTEX in water: in addition to fully understanding the level of occurrence of these compounds in water, it is important to examine their chemical and physical properties, so as to better understand and optimize the mechanisms of remediation using emerging techniques and materials	
		66 BTEX in water: the successful extraction and characterization of tannins, as well as the synthesis of tannin-based adsorbents, could provide a novel platform for removal of compounds such as btex in water, without any environmental or human health ill effects	
		67 Toxic elements: pollution control and remediation measures should be practiced to prevent further deterioration of water quality	
		68 Toxic elements: pollution control and remediation measures should be practiced to prevent further deterioration of water quality	
		69 CECS in recycling/reuse: wastewater treatment, even in best operational system, is not adequate	
		70 CECs in recycling/reuse: single advanced oxidation system, e.g., UV or peroxide, is not adequate	
		71 CECs in recycling/reuse: need a tertiary treatment stage including combined advanced oxidation	

		72 CECs in recycling/reuse: employ combined advanced oxidation as tertiary treatment	
		73 Natural organic matter: Further development and refining of nanomaterials for NOM photolysis could also increase treatability of the various fractions of NOM	
		74 CECs in ww treated for direct potable reuse: evaluation of indicative removal potential	
		Since the project team was not able to collect 24 hr composite samples, it is difficult to evaluate the indicative removal potential of the treatment units since plug flow characteristics can be observed when taking grab samples,	
		75 Microplastic pollution: While the impacts of microplastics on local freshwater resources are still poorly understood, better water purification, as well as strategies to reuse and recycle plastics as a resource stream, should receive more attention	
		This can help to minimize future negative costs and impacts	
		76 Antimicrobials/antibiotic resistant bacteria: a comprehensive study on antimicrobial substances removal capacity of various drinking water treatment configurations in operation in SA.	
		77 Reviewing voluntary schemes to reduce pharmaceutical use	
		78 Overall reduction of diclofenac by users, increasing the efficiency of WWTPs and periodic monitoring of diclofenac and its metabolites/transformation products in all environmental compartments should have high priority to both protect the health of the population and reduce diclofenac contamination in the water cycle	
		79 Hence, the majority of countries from these regions are yet to reduce, re-use or re-cycle? Plastic materials to enhance its abatement	
		80 Brominated Flame Retardants: the findings of this study can be incorporated into the Estuarine Management Plan and used to identify	

		and prioritise areas of the catchment where contaminant source identification, reduction and control procedures should be implemented	
		81 Microplastic pollution; Single –use plastics is also something that should be reduced significantly	
6	**Fate/Degradation/transformation-products/tp id/metabolites**	1 Further studies should be performed in order to provide a better characterisation of the transformation products of DEET, particularly with respect to their toxicity at low concentrations and within a mixture of trace organic contaminants	**67 (5.6%) [5]**
		2 DCF Transformation products	
		3 Transformation rate - of the compounds in biota - should be taken into consideration in the future	
		4 Transformation products - future research should emphasize the formation of pharmaceutical-derived disinfection by-products,	
		5 The elucidation of biotransformation pathways to inform toxicokinetic and effect-based assessments.	
		6 The metabolites and transformation products formed during the degradation processes are yet to be explored.	
		7 CECs in recycling/reuse: could not test for transformed secondary byproducts	
		8 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: factors that affect release, transformation, persistence and transportation in surface and ground waters	
		9 Polycyclic aromatic hydrocarbons (PAH) in aquatic ecosystems: The chemical analysis of the metabolized PAHs would complete the picture of what is happening to the parent PAHs after entering the animals bodies.	
		10 Fate of these contaminants into the sewage biomass and their conversion into more toxic or pharmacologically active metabolites during the treatment	

		11 Environmental fate of nano-particles (NM) need to be assessed	
		12 Environmental fate of NMs need to be assessed for their potential toxicity and bioaccumalation	
		13 Research to understand processes in soils and sludges	
		14 DCF fate	
		15 Fate in humans	
		16 Importance of further characterising the nationwide aquatic occurrence of those analytes whose ambient water concentrations appear to frequently exceed well established ECs and their pathways into the environment.34	
		17 Occurrence: Currently, very little is known about the occurrence, fate and and behaviour of PPCPs in the African freshwater aquatic environment.	
		18 Little is known about the fate of the intermediate end-products to date.	
		19 Environmental fate of DBDPE should be further investigated	
		20 Further investigations of the sources, fates, and health effects of TBBPA in China should be a huge and urgent task, mpollutant to the environment	
		21 Moreover the transient and longterm trajectory of args in wastewater remains unclear	
		22 Fate of args and the microbial ecology of bacterial consortia in biofilms and their antimicrobial degradation capacity warrants further investigation.	
		23 REEs: environmental behavior and fate: Understanding the fate processes REEs undergo is critical in their environmental risk assessments.	
		24 REEs: Detailed mechanistic information on the environmental processes REEs undergo remains scarce	

		25 An ongoing research under South African Research Chairs encompassing the presence and the fate of antibiotics	
		26 Perform more in vitro studies to discern the fate and behavior of microplastics and their associated contaminants in the human digestive tract	
		27 Dedicated research is needed in order to better understand the fate of ECs in algal ponds. Future research in the area should focus on:	
		A the effect of daily fluctuations in temperature, pH, and dissolved oxygen experienced on EC removal in algal ponds	
		B the influence of algal biomass on EC sorption, especially considering the effects of pH and temperature variations	
		C the biodegradation of ECs by algae and algal-bacterial communities under conditions relevant to algal WWT	
		D the significance of EC photodegradation in the presence of high dissolved and suspended solids, and the risks regarding their degradation products	
		28 Apprehending the mechanisms of metal regulation by the different fish populations, through the analysis of metallothioneins in detoxification organs and/or through the analysis of genetic markers of metallothioneins, would also be of interest	
		29 Natural organic matter (NOM): their fate in the environment is an issue of concern	
		30 Efforts to study microplastic and microfiber pollutant pathways should therefore include focus on communities and areas who do not have access to water infrastructure.	
		31 Agricultural chemicals: part of our uncertainty related to the effects of pesticides in the environment relates to the fact that the predicted fate and transport of pesticides in the environment are not considered in the South African pesticide registration process	

		Currently the DAFF does not possess a mechanism or tools to adequately assess the environmental fate of pesticides under S African conditions.	
		As such DAFF is unable to estimate or predict the likelihood, and quantity, of a pesticide that can move into non-target environments.	
		32 Alkyl phenol ethoxylates (APEs): in addition the fate and transport of the longer chain NPE in the environment is still not well understood	
		334 Polycyclic aromatic hydrocarbons (PAHs): The chemical analysis of the metabolized PAHs would complete the picture of what is happening to the parent PAHs after entering the animals bodies.	
		34 Agricultural chemicals: Given the chllenges related to monitoring (due to the transient nature of contamination) and that pesticide contamination in water resources occurs primarily as a result of nonpoint sources (runoff, leaching) further research should focus on modelling techniques aimed at assessing the fate, transport and mitigation/management options of pesticides in water at multiple scales (field to catchment)	
		35 Agricultural chemicals: research should focus on the integration of these models into the risk assessment process conducted during the registration of pesticides. While the registration process considers the toxicity of a pesticide, there are no exposure assessment procedures performed to assess the environmental fate and predicted environmental concentrations under S African conditions	
		36 Urban wastewater epidemiology: broaden the understanding on CEC fate:	
		Metabolites (fate and risk), partitioning	
		37 The large daily and seasonable fluctuations in temperature, DO, and pH commonly experienced in algal ponds should impact the rates (and quantitative significance) of hydrolysis, sorption, biodegradation, and photodegradation	

		38 Transformation products - future research should emphasize the formation of pharmaceutical-derived disinfection by-products,	
		39 Emerging and persistent contaminants/pathogens: a systematic approach that simultaneously determines parent compounds, transformation products and degradation products is long overdue.	
		40 Emerging and persistent contaminants/pathogens: The identification of transformation products would lead to the possible synthesis of transformation products that could be used for toxicological studies	
		41 Degradation intermediates	
		42 Degradation pathways of halogenated contaminants	
		43 Degradation products	
		44 Degradation products - future research should emphasize the formation of degradates	
		45 Degradation products: future research on PPCPs should not focus only on the parent (intact) compounds but also on their potential degradation products/metabolites in various matrices	
		46 Fate of args and the microbial ecology of bacterial consortia in biofilms and their antimicrobial degradation capacity warrants further investigation.	
		47 ARVDs: the degradation kinetics and breakdown products of these ARVDs need to be investigated	
		48 Biodegradation of ECs by algae has mainly been reported in lab studies, are based on monocultures of algae grown in specific media. This must be verified in wastewater	
		49 Due to the presence of organic compounds absorbing and scattering light, indirect photodegradation mechanisms should dominate over direct photolysis for most ECs in algal ponds, and all photodegradation processes are likely limited to no more than 10-20cm from the surface	
		50 NOM: another potential method is photodegradation	

		51 Emerging organic pollutants: Future studies should also look at degrading or completely removing organic pollutants from the environment	
		52 EDCs removal from wastewater: Another factor which affects accurate estimation of EDC removal is the degradation of certain compounds, e.g., estrogen E2 is converted to E1 during treatment.	
		Furthermore, parent compounds can break down to metabolites, which could also be endocrine-disrupting.	
		This also needs to be considered in future studies	
		53 Emerging and persistent contaminants/pathogens: A systematic approach that simultaneously determines parent compounds, transformation products and degradation products is long overdue.	
		54 BTEX in water: the possible degradation of BTEX compounds to useful intermediates or harmless end-products can also be achieved by synthesizing materials that include degradation catalysts in the form of highly reactive nanoparticles	
		55 Agricultural chemicals: While the analytical approach adopted in this study catered for a large number of different pesticides, it is important to note that glyphosate (most heavily applied pesticide in the country) was not included in screening or quantitative analysis.	
		Considering its high quantity of use as well as increasing evidence of human health-related effects, future research should focus on developing analytical methods for detection of this pesticide (and its breakdown products) in water resources in S Africa	
		56 The large daily and seasonable fluctuations in temperature, DO, and pH commonly experienced in algal ponds should impact the rates (and quantitative significance) of hydrolysis, sorption, biodegradation, and photodegradation	

		However, little is known on whether BFRs are widespread and significant contaminants of sediment and biological tissue in South African coastal ecosystems, a situation that warrants further attention	
		57 Behaviour of human originated metabolites and biodegradation	
		58 Human originated metabolites: prevalence, fate, treatment	
		59 Challenges with metabolites	
		60 Occurrence: Currently, very little is known about the occurrence, fate and and behaviour of PPCPs in the African freshwater aquatic environment.	
		61 Degradation products: future research on PPCPs should not focus only on the parent (intact) compounds but also on their potential degradation products/metabolites in various matrices	
		62 There are no documented data on the levels of ARV metabolites in wastewater	
		63 ARVDs: future work should include metabolites in order to assess their environmental impact.	
		64 Quantification of potential risks of their ENMs metabolites – unquantified to date	
		65 Emerging organic pollutants: The metabolites of pesticides, PCBs, pharmaceuticals and personal care products, and musk ketones should also be analysed as most of these pollutants may be broken down into other compounds in the environment or as it passes through the human body	
		66 Pharmaceutical and personal care products: further reports on the occurrences of PPCPs and their metabolites in surface waters	
		67 Urban wastewater epidemiology: broaden understanding on CEC presence, fate risk:	
		Metabolites (fate and risk), partitioning	

7	**Distribution/spatial-temporal variability/occurrence**	1 Distribution in environment	58 (4.8%) [6]
		2 Distribution: Multigenerational studies in a variety of species sufficient for reliable estimation of species sensitivity distributions	
		3 Available of data - Data on the nationwide distribution of most of our analytes is sparse,	
		4 Survey of perchlorate in the environment (water supply, soil, indoor dust) and in food, prioritising areas with high levels of perchlorate, is an important first step towards determining exposure levels and possible standards for drinking water and food products.	
		5 Currently very little is known about the levels of PPCPs in biota in general. Few studies have investigated PPCP residues in fish, birds, mammals.	
		6 Seasonal variability- there appears gaps in knowledge about seasonal variability in concentrations of commonly and consistently detected PPCPs in the aquatic environment	
		7 Tissue specific distribution should also be determined, where possible,	
		8 In the future, studies on POPs in the sediment of this river should focus on their distribution according to particle sizes of the sediment and comparison of depth and surface sediment concentrations	
		9 PCBs: Most of the PCBs are bound to the soil and sediments and may be released to the water slowly over a long period of time	
		10 Alkyl phenol ethoxylates: within effluent studies, as these pollutants are directly linked to urbanization, the impact of population increase in metropolitan areas need to be assessed for APEs pollution	
		11 Organochlorine pesticides: In the future, studies on POPs in the sediment of this river should focus on their distribution according to	

		particle sizes of the sediment and comparison of depth and surface sediment concentrations	
		12 Antimicrobials/antibiotic resistant bacteria: the presence, distribution and dynamics of antibiotic resistance genes in the ARBs be investigated	
		13 Spatial mapping of SUGEs ((serpentinitic ultramafic geological environments.) hotspots in Africa at a country level using remote sensing including drones and spatial analysis tools (eg, GIS, geostatistics)	
		14 Genetic diversity of the Tunisian pearl millet across different agroecological zones could probably interfere on its vulnerability to mycotoxins infestation within regions	
		15 Further investigation of future and possibly retrospective trends and behavior with a focus on annual variations of eg, SCCPs, PCNs, PBDEs, PFSAs, and PFCAs in polar bears are needed	
		16 Strong regional variations in the concentrations of HNPs (halogenated natural products) are frequently observed	
		17 PAH, PCB, OC pesticide: there are significant sources of PCBs in highly urbanized and industrialised catchments in the eThekwini area, as reflected in concentrations of these chemicals analysed in sediment for this study	
		A more comprehensive assessment of the spatial extent and magnitude of contamination of sediment by these should be performed, for the purpose of source identification, reduction and control.	
		18 Fluoride in water: The distribution of fluoride concentrations in Namibias groundwater was not assessed in relation to the spatial distribution of human population.	

		19 CECs There is a need to conduct a national monitoring programme in order to obtain the spatial distribution of these emerging contaminants	
		20 Environmental occurrence	
		21 Occurrence of waterborne pathogens - major gap	
		22 Comprehensive data on perchlorate in environment and food sources is needed	
		23 Occurrence: Currently, very little is known about the occurrence, fate and and behaviour of PPCPs in the African freshwater aquatic environment.	
		24 Occurrence: reliable measurement of trace levels of contaminants across different environmental compartments (water, sediment, biota – of which biota has been largely neglected).	
		25 Occurrence: limited data on tissue concentrations exist	
		26 ERY occurrence data is comparatively limited in coastal and marine systems across large geographic regions including South-West Asia, Eastern Europe, Africa and Central and South America.	
		27 Environmental occurrence information was more readily available for water matrices than for solids and wildlife.	
		28 The occurrence of fecal contamination indicators is frequently not correlated with the presence of other pathogenic microorganisms that may inhibit sewage sludge and survive the treatment process	
		29 There are no known reports from Africa in the open literature on the occurrence of azole antifungals in the aquatic environment, except this one	
		30 Information about occurrence of firstline antI-tubercular compounds in SA water bodies is lacking despite the fact that several hundred kilograms of the drugs are administered daily in order to control the TB epidemic	

		31 Anti TB drugs: the occurrence of co-trimoxazole in municipal wastewater has also been sparsely studied In SA	
		32 As with wastewater and surface water , there is no data on occurrence of firstline anti- tubercular drugs in sediments in SA	
		33 Most anti microbial drugs are perpetually replaced in aquatic environment due to their continued use. Their occurrence and persistence in the aquatic environment is of great concern as far as balanced aquatic ecosystems and public health impacts are concerned	
		34 Programs in different environmental systems including sediments and pore water as well as studies on their chronic toxicity to different taxa. Such screening models can allow the identification of hot spots and ultimately aid to develop appropriate and corrective strategies for specific situations and locales.	
		35 ARVDs: a nationwide study of the presence, use pattern, material flow analysis and removal rate of ARVDs is necessary in order to estimate the load of ARVDs released into the surrounding surface and fresh water bodies, since ARVDs may have associated ecological risks to aquatic organisms	
		36 An ongoing research under South African Research Chairs encompassing the presence and the fate of antibiotics	
		37 Diclofenac: soils and sediments are the least understood compartments on earth	
		38 There are a few constraints to minimize the factors known to influence the occurrence of diclofenac: increased consumption, direct discharge of household wastewater, global warming, climate change, and inefficiency of WWTPs. The pattern of diclofenac usage has grown exponentially; thus, we must consider all options to reduce the entry of this pollutant in our waste stream.	
		39 With increasing number of studies detecting pharmaceuticals in groundwater bodies, the question concerning antibiotic resistance and	

		proliferation of compounds in the aqueous environment should concern us	
		40 The number of chemicals produced and consumed rises every day and new info about their consequences in the environment are discovered	
		Therefore, priority lists must be updated periodically and should be always based on up-to-date information and data (occurrence, determination, toxicology) obtained in the country or target area.	
		41 Variety and co-occurrence of Alternaria and Fusarium emerging mycotoxins in Tunisian pearl millet might postulate the presence of several mycotoxigenic fungal species	
		42 Genetic diversity of the Tunisian pearl millet across different agroecological zones could probably interfere on its vulnerability to mycotoxins infestation within regions	
		43 The occurrence of HNPs is difficult to predict and differs from the environmental distribution of POPs	
		44 So far, little information existed on the occurrence of HNPs in marine regions in Africa	
		45 HNPs were more abundant than anthropogenic POPs in chokka squid from 3 marine sites off of S Africa	
		46 In chokka squid, different distributions of HNPs between the 3 sites at South Africa suggest differences in HNP producers, therefore confounding the predictions of the occurrence and concentrations of HNPs in the marine environments	
		47 Differences between samples from the Indian site and Atlantic ocean were also noticed for PCB153 and PCB 138.	
		48 Pesticides: the capacity to determine environmental concentrations of pesticides is urgently needed in South Africa	

		Dedicated but affordable, analytical facilities are needed to validate working concentrations as well as environmental concentrations of pesticides	
		49 Brominated Flame Retardants: a collaborative study identified significant widespread brominated flame retardant contamination of sediment in eThekwini area	
		BFRs are persistent, bioaccumalative and lipophilic, with the result that they may pose similar ecological and human risks to PCBs	
		However, little is known on whether BFRs are widespread and significant contaminants of sediment and biological tissue in South African coastal ecosystems, a situation that warrants further attention	
		50 Emerging chemical pollutants: The literature review regarding occurrence information surrounding ECPs in S African water bodies has found that there is limited data available in this country	
		As such, the creation of a database that contains pertinent information surrounding the occurrence, toxicity (especially chronic), persistence and bioaccumulative potential of all ECPs would provide an invaluable resource from both a scientific and environmental point of view. This database should be in the public domain and scientists from across the country should be granted easy access to it.	
		51 Carbapenem-resistant Gram-negative bacteria are mainly studied as a cause of human infections, while reports regarding the occurrence of viable carbapenem-resistant bacterial populations (CRBP) outside medical institutes are globally scarce.	
		52 Non-steroidal anti-inflammatory drugs: Although there is enough evidence on the occurrence of them in European water bodies, their presence in SA environment is not fully known	
		53 Non steroidal anti-inflammatory drugs: Relatively few published reports on the occurrence of them in SA WWTPs have emerged	

		54 Alkyl phenol ethoxylates: Though these studies confirmed NP as the major product, more information on the behaviour and degradation of the longer chain NPE6-16 in different environmental matrices and biota becomes of utmost importance	
		55 Pharmaceutical and personal care products: further reports on the occurrences of PPCPs and their metabolites in surface waters	
		56 BTEX in water: research trends indicate that there is still room for more studies to be conducted on the occurrence of btex compounds in various water systems, as well as to examine future treatment techniques that can help alleviate unpleasant health effects and possibly reduce water-related deaths	
		57 Microplastics and pharmaceuticals as drivers for antimicrobial resistance: Microplastics in ground-and tap waters	
		58 Urban wastewater epidemiology: 2 broaden understanding on CEC presence:	
		Metabolites (fate and risk), partitioning	
		Minimum therapeutic doses and ADIs	
		Drinking Water Equivalent Levels (DWEL ADI)	
8	**Data**	1 Data collection on antimicrobial use, in livestock is scarce,	51 (4.2%) [7]
		2 Develop standardised techniques for data collection and sharing on microplastics	
		3 Data collection and sharing especially across transboundary catchments	
		4 Data collection for less developed countries where information is sparse, impacts are not well understood and monetary values (costs of agricultural water pollution) have not been assigned	
		5 Data collection	

		6 Completeness of reported data - varied levels	
		7 Access to data	
		8 Lack of data	
		9 Data base for monitoring data	
		10 Publication of full data sets	
		11 Data- other researchers to collect data and further investigate this important issue	
		12 Data- cross sectional data set - not available	
		13 Data- The availability of detailed panel sets for mismanaged plastic waste will allow the use of more advanced techniques such as decomposition analysis	
		14 Availability of data	
		15 Data - on plastics pollution	
		16 Data review/re-evaluation- data should be re evaluated as health reference guidelines for additional PFAS analytes (both individual compounds and mixtures) are determined	
		17 Toxicity data: A significant challenge to estimating Hazard Quotients/HQs is the sparseness (or absence) of directly measured data available for estimating potential ecological effect concentrations (ECs).	
		18 EC data: Lack of EC data for many of the analytes studied in this study, incomparability of available EC types for different analytes	
		19 Data on the nationwide distribution of most of our analytes is sparse,	
		20 Time profiles of analyte concentrations are particularly rare.	
		21 Inactivation or removal of waterborne pathogens during water treatment - lack of data	
		22 Occurrence- Environmental occurrence data from megacities and developing continents is lacking	

		23 Occurrence- Environmental occurrence of antihistamines in coastal and marine systems was limited and monitoring data from Africa and South America were largely lacking	
		24 Comprehensive data on perchlorate in the environment and food sources is needed	
		25 Data on contamination level of EBFR in China and even the world is still severly limited	
		26 Data on the occurrence of ARVDs in wastewater and environmental samples are still relatively limited	
		27 There are no documented data on the levels of ARV metabolites in wastewater	
		28 In addition to the scarcity of commercially available standards for ARVD metabolites, complicated method development for target analytes of diverse physico-chemical properties likely contributes to the limited data	
		29 Lack of MECs data in South Africa is a major issue; as a result it was not feasible to ascertain the accuracy of the estimated PECs based on several proposed ranking criteria frameworks	
		30 Lack of market penetration data for products containing TCS and TCC – for SA and global- makes it difficult to compare and refine the model results in this study	
		31 POPs: lack of human animal and wildlife exposure data. There is no data for various matrices including indoor and outdoor air exposure assessment in workplaces/homes, cored sediments, ground and bore-hole water, wildlife-avian population data, amongst others; to address these knowledge gaps, further studies would be required.	
		32 POPs: Of high importance would be human exposure studies which could include collection of serum and breastmilk samples from vulnerable groups, occupationally exposed workers, and the general population. Analyses of these samples should ideally be coupled with	

		dietary patterns, and workplace/home exposure hazards in questionnaires to clearly correlate POP conc with socio-demographic characteristics.	
		33 SSRIs: Data was scarce or non-existent for South America and Africa, indicating potential risks for SSRIs to aquatic life in those regions requires further attention- .	
		34 The scarcity of centralized and easily accessable data for most products is an issue, in particular for emerging contaminants.	
		35 It is up to the scientific community to clearly impress the importance of monitoring networks and the upkeep and development of long-term data sets on decision makers, while prioritizing the need for installation and maintenance of measuring systems in the face of resource constraints	
		36 Low number of data regarding WWTPs and hospital effluents is concerning, since their effluents are considered the main source of emerging contaminants into aquatic environments.	
		37 Increased efforts towards integrating data and observations of reproductive anomalies in wild populations exposed to emerging contaminants and endocrine disrupting substances like pesticides, are recommended	
		38 Metal elements: more data are needed on elemental levels in marine turtles, supplemented with persistent organic pollutant analyses that normally have much slower turnover in bodies than metals and metalloids to discriminate between demes.	
		39 Data on organic contaminants will also be very useful	
		As newer types of persistent organic pollutants such as brominated flame retardants and perfluorinated compounds have been detected in African penguin Spheniscus demersus eggs from South African coast	
		40 There are no data regarding the concentration of clinically important carbapenem-resistant bacteria in riverine ecosystems	

		41 BMAA: in the absence of conclusive data on the possible exposure routes and experimental validation of the ALS/PDS theory, it seems prudent to take measures, such as the placement of warning signs, to prevent any exposure	
		42 Engineered nanomaterials: Further research is required to generate experimental data at micro- and macrocosm levels where natural conditions are simulated.	
		Data from these experiments could support scientific findings and support better management decisions on environmental risks through modelling	
		43 Emerging chemical pollutants: The literature review regarding occurrence information surrounding ECPs in S African water bodies has found that there is limited data available in this country	
		As such, the creation of a database that contains pertinent information surrounding the occurrence, toxicity (especially chronic), persistence and bioaccumulative potential of all ECPs would provide an invaluable resource from both a scientific and environmental point of view. This database should be in the public domain and scientists from across the country should be granted easy access to it.	
		44 Aquatic toxicity testing: DWS need to be engaged as regards storage of data generated by the IWUAB toolkit and its application in Water Use licensing	
		45 ARB and genes in drinking water: Furtehrmore, with such substantial data being gathered in the current study, there is a need to link WGS data to inhibition zone analysis data.	
		This will not only give insight into the world of these identified bacterial species, but will also make it possible to trace their lineage and possibly find innovative remediation solutions.	
		The Whole Genome Sequencing will provide and overview of ARGs associated with target genera	

		46 Metals: There is limited published data about metal concentrations in coastal water and surface sediment in Cape Town	
		47 Non steroidal anti inflammatory drugs: This study is based on the determination of selected NSAIDs in Umbilo and Kingsburgh WWTPs	
		48 It is further recommended that regular updates of pesticide use data, spatial crop distribution and associated pesticide use maps are produced to ensure the availability of up to date information for use in design of monitoring programmes and risk assessment studies	
		49 Agricultural chemicals: data on physicochemical properties of pesticides in South African environmental conditions are not available.	
		International databases were therefore consulted in order to obtain the relevant data for- calculation of mobility (GUS) index, Studies have shown that physicochemical properties of pesticides can vary geographically, depending on local climatic and soil conditions.	
		50 CECs in wastewater treated for direct potable reuse: process performance and plant reliability analysis	
		Overall, the current historical process data is not suited as is for deriving process monitoring models	
		However, there is scope, given rigorous data collection programmmes, for univariate monitoring of key quality variables 9slow sample rates), or multivariate monitoring of operational variables (fast sample rates	
		A future direction for statistical analysis is to consider how process unit reliabilities affect other process unit reliabilities, and in turn, the reliability of the entire plant under consideration.	
		For this, multivariate and conditional distribution fitting would be required, which would require rigorous data collection at a high data quality	
		51 Antimicrobials/antibiotic resistant bacteria: data from such studies be used to determine if mitigation is necessary and if so, which	

		strategies could be used or developed that would be appropriate for local conditions	
9	**Regulation**	1 Regulation: lack of regulations on the concentration limits of ESOC in the environment	51 (4.2%) [7]
		2 Regulation There is no official guideline limit available for drinking water	
		3 DCF regulation	
		4 Regulation on Use of drugs	
		6 Apart from unregulated mycotoxins, defined as emerging mycotoxins, Fusarium and Alternaria emerging mycotoxins were the most prevalent in this study	
		7 Variety and co-occurrence of Alternaria and Fusarium emerging mycotoxins in Tunisian pearl millet might postulate the presence of several mycotoxigenic fungal species	
		This pose threat to consumer health due to their cytotoxic and mutagenic effects leading to chronic diseases, although no legislations have been established yet.	
		8 Overall, the overlap environmental conditions corresponding to the climate factors, harvesting periods, poor storage and transport conditions, wrong handling and agriculture practices might trigger fungal proliferation and exacerbate mycotoxins production in Tunisian pearl millet.	
		Additionally , grain damage mainly due to insects invasion, might induce greater fungal ingress and mycotoxin production.	
		Thus, its critical to increase awareness by implementing preventive strategies, proper and adequate agriculture practices that would mitigate mycotoxins issue in food and feed commodities especially, that in	

		Tunisia, pearl millet crop is usually cultivated in harsh conditions by smallholder subsistence farmers.	
		9 Mycotoxin risk assessment in Tunisian pearl millet revealed a worrisome situation that have to be faced by setting up strenuous regulatory thresholds and a strict control system within the food and feed trade, in order to prevent and narrow mycotoxins as a major issue requiring priority attention	
		the current regulations mostly take account about major mycotoxins namely AFs, OTA, DON, ZEA, FBs and scarcely about emerging mycotoxins and derivatives produced by several fungi occurring in food and feed	
		10 Consequently the undeniable toxicological effects on human and animals health associated to a mixture of toxic metabolites exposure, highlighted the obvious challenge to widen the legislations in order to encompass further mycotoxins with respect to the food consumption patterns	
		11 There is a need to control and reduce the release of PBDEs and other POPs in Nigeria and other developing countries at the end of life of consumer products, to avoid further environmental contamination, safeguard free-range cattle and chicken breeding and reduce or prevent human exposure to these chemicals	
		12 PCBs: Hence there is a need for strict control and regulations on the use and safe disposal of these organic chemicals in order to safeguard the health of the inhabitants of the communities in the neighbourhood of the river	
		13 Agricultural chemicals: while a trigger value has been recommended there is no standardized method or guideline to assess human health risks associated with endocrine disrupting chemicals, an area which requires further research	
		14 EDCs: Currently there is no trigger value available for thyroid activity in drinking water.	

		15 EDCs: Although a trigger value of 11 ng dihydrotestosterone equivalent/L has been proposed by Brand et al (2013), it may be necessary to adapt this value for South African conditions.	
		16 PCB residue: Therefore , regulatory implementation for monitoring of wastewater emissions into this lake need to be implemented, as this is suspected to be the primary source of PCBs in the NE Lake	
		17 It was an observation during this project that many authorisations and licenses granted failed to include the constituents relevant to the process involved.	
		The inclusion of all the relevant constituents that are linked to the agricultural activity in question must be included in any licence or authorisation granted.	
		Establishing these lists for organic and inorganic constituents remains a fundamental research priority that will allow for appropriate monitoring, assessment and thus management thereof	
		18 Agricultural chemicals: it is also acknowledged that a revision of the 1996 SA water Quality Guidelines is underway with the irrigation volume being addressed first	
		It is argued that both Domestic and Animal Watering sections also urgently require revision to align with risk-based approaches that are necessary to appropriately assess and manage the hazards and risks present	
		19 Microplastic pollution: due to lack of standardized units to report the concentration of microplastics in the environment, it is at this stage difficult to compare results	
		1 Regulation-no systematic legal control over their discharge and/or environmental levels of pharmaceutical residues has been setup yet	
		2 Standardised procedures for EPV- there are no formalized implementation model and sophisticated methods in practise u to now.	

		3 It is proposed that it is urgent to implement EPV targeting ketoprofen pollution:	
		4 Determining exposure levels and possible standards for drinking water and food products.	
		5 A risk assessment could be used to develop a standard for perchlorate in drinking water.	
		6 More importantly, critical limits of TBBPA must be set to restrict unnecessary release of this	
		7 Restrictions on environmental releases and continued monitoring are still essential in China, where studies on BFRs, especially non-PBDEs BFRs, remain limited relative to its important role in the BFR market	
		8 Threats of new sludge contaminants should lead to stronger limits considering the direct use of sewage sludge as a fertiliser on land..	
		9 To make a firm recomm.endation on TAF (total aflatoxin) in the cereal based products, further research is required	
		10 Scientists who are using mussel sentinels to perform compliance monitoring in coastal waters must from a regulatory standpoint use fish-based biota EQSs as assessment criteria for classifying their mussel-based monitoring data	
		11 Internationally agreed pollution assessment criteria for mussel sentinels are largely lacking	
		12 Prioritization of what ECs need to be regulated in the environment will become important,	
		13 Setting new standards for the quality of wastewater treatment plants as well as mandating the authorities of water management systems to integrate the municipal, agricultural and industrial water consumers in a closed cycle can simultaneously solve the problems of freshwater scarcity and environmental pollution in long-term	
		14 The PFOS concentration in fillets exceeded the human screening values for cancer risk in certain species and locations	

		15 Non-perrennial rivers: In consequence, intermittent rivers are particularly vulnerable in many parts of the world because of a lack of legislation, and therefore a lack of adequate management practices, protecting them and their waters	
		16 PAH, PCB, OC: sediment quality guidelines provide a useful tool for screening contaminant concentrations in sediment so as to prioritise sites that require further attention, eg, thro biological assessment	
		There are sediment quality guidelines for organic chemicals in SA freshwater and coastal ecosystems, and the only metal guidelines are those used t for determining whether sediment identified for dredging in SA ports is of a suitable quality for openwater disposal	
		Because of this lack of sediment quality guidelines there is no consistency in the use of international sediment quality guidelines by SA researcher	
		There is therefore a need to define sediment quality guidelines for freshwater and coastal ecosystems in SA	
		17 Aquatic toxicity testing: package finalization should be undertaken in a process that engages DWS Staff. The recommended compliance criteria were highlighted as an area that needs rethought. This process should engage legal input in order to produce legally defensible compliance criteria. Engaging DWS staff with appropriate seniority will aid in adoption and utilization of the IWUAB toolkit	
		18 Aquatic toxicity testing: the potential of setting criteria for effluent, rather than the resource, needs reconsideration	
		19 Aquati toxicity testing: once the IWUAB toolkit has been finalized to a level required by DWS, it should be adopted to provide support for the use of toxicological testing in Water Use Licensing in order that all tools to appropriately manage resource quality are in use.	

		20 Fluorescent sensors for screening ECP in water: the development of South African guideline values or water quality limits for ECPs should receive attention from policy makers in order to safeguard human health	
		21 CECs in recycling/reuse: include limits for indicator ECs in drinking water guidelines	
		22 CECs in recycling/reuse: make WWTW discharge standards stricter	
		23 Agricultural chemicals: The risk a pesticide poses to human health (and aquatic environment) is dependent on a number of factors, including relative toxicity of the chemical, relative mobility (as influenced by physicochemical properties), recommended application rates (quantity of use) and agricultural practices (correct use of nozzles).	
		As farmers almost always have a choice of different chemicals to target a specific pest on a specific crop, it is recommended that a manual providing guidelines on choosing agricultural chemicals that minimise effects in non-target environments (both human and ecological health) be produced	
		24 Reclamation of municipal wastewater to potable standard: standards for drinking water quality from indirect potable reuse (IPR) and DPR (direct potable reuse) plants should be included in the sans 241 guidelines as a separate section for water reclamation plants producing drinking water	
		25 Reclamation of municipal wastewater for drinking water: DWS should use the info provided in this report to adopt and implement standards for direct and indirect potable reuse in SA as a high priority	
		26 Reclamation of municipal wastewater for drinking purposes: Regulation of IPR and DPR plants should be included in, and given specific attention to, in both the Blue Drop program, as well as the Green Drop program (for wastewater treatment plants supplying reuse plants with secondary or tertiary treated wastewater)	

		27 Microplastic pollution: Often these contaminants are largely unregulated	
		28 Microplastic pollution: The aim would be not to ban plastics, like an international treaty, but that countries need to adhere to an international negotiated set of standards and practices to protect human health and the environment	
		29 1,4 -dioxane: research to establish a health-based drinking water targets.	
		30 The implementation of the guidelines (monitoring cyanobacterial blooms) and accessability is also a needed practical intervention	
		31 Aquatic biota samples: the implementation of a standardised nomenclature. The standardisation could help information exchange in the scientific community and would help scientific dissemination.	
		32 To further clarify and minimise the influence of confounding non-target factors in mussel monitoring, e.g., by adopting international harmonisation and standardization of study conditions and program designs.	
10	Source/evaluation of additional sources	1 Source: Importance of unprotected shallow wells located near pit latrines and septic tanks on the contamination of major drinking water sources in developing countries	31 (2.6%) [8]
		2 Source - Identifying the main source of microplastic pollution in the environment	
		3 Sources - the original sources and classes of plastics and microplastics entering the marine environment need to be identified	
		4 To understand the sources of perchlorate contamination	
		5 Further investigations of the sources, fates, and health effects of TBBPA in China should be a huge and urgent task, mpollutant to the environment	

		6 Limited reviews have investigated sources, behaviour and health risks of antimicrobial resistance genes (ARGS) in the wastewater-human pathway.	
		7 A comprehensive overview of specific urban stormwater pollution sources is still missing.	
		8 The extent of potential contribution from washing of buildings and structure surfaces	
		9 The contribution of other pollutants than TSS from construction activities	
		10 The contribution of pollutants from non-metallic building surface materials	
		11 The significance of the pollution contribution from gardens, parks, other green areas, especially in anticipation of future climate changes characterised by increased rainfall depths and intensities in many regions of the world	
		12 The significance of faecal pollution caused by urban pets and wildlife	
		13 The continuing introduction of new materials and products, and potentially of new pollutants, into the urban environment suggests that the identification of important stormwater pollution sources, and of the associated pollutants, is a continuing process	
		14 The source of the triazines to the groundwater needs to be further investigated	
		15 REEs: Further studies are needed to track the sources of REEs in different environmental matrices	
		16 Landfills have been identified as a source of persistent organic pollutants which can leach into the wider environment if not properly constructed and lined with geomembranes	
		17 African penguin population has crashed: plastic ingestion as a source. Plastics along coasts of SA have been shown to contain	

		persistent pollutants. This potential source should be further investigated.	
		18 PFOS in fish: thus there is a need to conduct more studies on fish in areas that are fished by recreational and subsistence consumers, screening level risk assessments with further studies on contaminant sources and mitigation measures for a cleaner environment	
		19 The rivers that carry water from outside the park sustain its aquatic life that includes the Nile crocodile, but also transports pollutants into the Park. Hence, improvements in source mitigation remains an important task and responsibility for all involved	
		20 The investigation of metal isotope ratios would be useful to understand the origin and the sources of metal contamination (Cu or Hg isotopes).	
		21 Discharges from this WWTP- (Northern WW) may be considered as one of the sources of pollutants such as OCPs in the uMngeni River	
		22 Carbapenem-resistant bacteria: Studies demonstrating the anthropogenic impact on the riverine ecosystem in general have lacked information on the origin of the pollution	
		23 Microplastic and synthetic microfiber: The results of this study also suggest that the use of rivers for clothes washing activities, in rural communities for whom rivers are the only source of accessable water, represents a direct vector of microfiber transport to the environment	
		24 Brominated Flame Retardants: this study has provided evidence for significant sources of organic and metal contaminants to aquatic ecosystems in the Durban Bay catchment	
		The sources of contaminants need to be identified, controlled and reduced if there is to be any improvement in water and sediment quality in Durban Bay.	
		25 Brominated Flame Retardants: the findings of this study can be incorporated into the Estuarine Management Plan and used to identify	

		and prioritise areas of the catchment where contaminant source identification, reduction and control procedures should be implemented	
		26 Emerging organic pollutants: The tributaries of the Umgeni River should also be monitored to identify possible sources of pollution load	
		27 Polycyclic aromatic hydrocarbons: Further studies can be done to pinpoint the sources, considering that Northern Works WWTP receives sewage mainly from domestic and food industries while Goudkoppies receives sewage mainly from the chemical industry	
		28 CECs in recycling/reuse: practise great caution with unconventional water sources for potable reuse	
		29 Microplastics and pharmaceuticals as drivers for antimicrobial resistance in the environment: sinks and sources	
		1 Monitoring/sampling- Solid waste repositories (non engineered landfills), onsite sanitation systems (pit latrines, septic tanks), funeral parlors and cemeteries/gravesites constitute overlooked potential hotspots sources of args.	
		ENMs: programs in different environmental systems including sediments and pore water as well as studies on their chronic toxicity to different taxa. Such screening models can allow the identification of hot spots and ultimately aid to develop appropriate and corrective strategies for specific situations and locales.	
11	Knowledge	1 Knowledge to guarantee safety of used water	29 (2.4%) [9]
		2 Knowledge on Fate	
		3 Knowledge on Behavior	
		4 Knowledge on Effects	
		5 Knowledge on Treatmen t technologies for their removal	

		6 Knowledge on fate of persistent transformation products after treatment of ECs	
		7 Knowledge of new CECs	
		8 There is a comparative lack of knowledge about microplastics research in freshwater environments	
		9 Little or no public and private sector awareness of the possible detrimental dangers posed by microplastics and nanoplastics as compared to macroplastics.	
		10 Gaps in the current state of knowledge about this emerging class of environmental contaminants: PPCPs	
		11Limited breadth of target analytes indicating that progress within the field remains relatively slow	
		12 Limited reviews have investigated sources, behaviour and health risks of antimicrobial resistance genes (ARGS) in the wastewater-human pathway.	
		13 Very little is known about the ability of anti-biotic resistance strains in sewage sludge, and then in soil, strong pathogenic strains, such as EHEC pathogen O104:H4.	
		14 Knowledge about typical variability of hazardous anthropogenic substances in mussels living in non-polluted and in polluted waters is important.	
		15 The analysis of EPs in aquatic biota samples involves different techniques, procedures and the need for extensive knowledge about the physico-chemical properties of the compounds.	
		16 ARVDs: An in-depth knowledge of the chemical constituents present in environmental media is essential for the assessment of the associated risks to the environment and human health	
		17 Research on REEs in developing regions, including Africa is needed, given prevailing conditions predisposing humans to health risks, e.g., untreated drinking water	

		18 PBDEs: more studies should be carried out in Africa and European environment in order to counterbalance the dominance of the USA and China, bearing in mind that these pollutants takes several years to phase out of the eco-system	
		19 Many advances have been made towards better groundwater characterization. Still, great uncertainties persist in these methods and in our understanding	
		20 Uncertainty also results from a poor understanding of how our activities will impact groundwater, and this is particularly true for newer practices.	
		21 Although there is reasonable knowledge on the general biology of the Nile Crocodile and the other 3 crocodilians in Africa, there is very little known about hatching success apart from nest predation	
		22 Non-perrennial rivers: Processes taking place in N-PRs are poorly understood	
		23 Non-perrennial rivers: Lack of knowledge, combined with the dynamic and sometimes unpredictable nature of N-PRs, makes them challenging to manage	
		24 Pesticides: clearly, pesticides as potential endocrine disruptors needs more research specifically focused on understanding the details of interaction with the diversity of factors presented by the endocrine system. Although herbicides as a subgrouping stand out at being understudied, both fungicides and insecticides need more attention in SA	
		25 BMMA: these data offer the first indication of the possibility of developing alert levels for BMAA based on commonly measured physicochemical parameters	
		26 Carbapenem-resistant bacteria: Published papers on CRBP in nature are mostly focused on single bacterial isolates	

		27 Urban wastewaste epidemiology: Gaps in knowledge, research, policy:	
		Surrogate chemicals/physico-chemical properties association	
		Early warning showing public health concerns	
		Near/real time	
		Sensing/monitoring (large datasets, modelling)	
		28 PCBs: There is no reported literature on PCB levels in the North End Lake in PE	
		29 There are currently no available reports on the NSAID content at these sites.	
12	Ecology/trophic transfer	1 A major gap exists in our understanding of the ecology of waterborne pathogens	26 (2.2%) [10]
		2 Fate of args and the microbial ecology of bacterial consortia in biofilms and their antimicrobial degradation capacity warrants further investigation.	
		3 The ecology of bat-borne infections: 1 are bats the natural reservoirs or just transient carriers of these novel viruses	
		4 The concentration of diclofenac in sewage sludge is associated with an alarming level, thus confirming that direct discharge of household, hospital and pharmaceutical industrial wastewtaers into the environment and/or the inefficiency of conventional WWTPs has a profound impact on the occurrence of diclofenac in the water cycle that extends to the entire ecosystem	
		5 Diclofenac: Increasing exposure of the biota in the water cycle will not only raise ecological risks to the ecosystem but also significantly harm mammals, including human beings	
		6 Diclofenac might create an ecological problem for non-target species, including human beings, during chronic exposure	

		7 Knowledge about impacts of microplastics exposure on aquatic primary producers, the trophic transfer process of microplastics and associated substances, and implications of consuming aquatic products for human health is much less known.	
		8 Pay more attention to the ecotoxicological effects of microplastics on higher order predators and freshwater organisms	
		9 Conduct more studies to clarify the role of microplastics as vectors for pathogenic microorganisms and potential ecological risks	
		10 To establish the ecological importance of behavioural alterations.	
		11 Behavioural endpoints provide useful sub-lethal indicators of how contaminants influence amphibians, and coupled with standard ecotoxicological endpoints, can provide valuable information for population models assessing the broader ecological consequences of environmental contamination	
		12 Continued political indifference, social stigma, and disregard of ecosystem services results in an underevaluation of groundwater as a renewable resource.	
		13 Risk assessment for water and sediment indicated a potential risk for the local aquatic environment from contaminants of both legacy (PAHs) and emerging (PFOS, UV filter octocrylene concern)	
		Implications for the ecosystem and the aquaculture activities would require further investigation.	
		14 Considerations of ecological, atmospheric- and other environmental factors in connection to Arctic warming also need to be considered in the context of temporal trends and behavior of these OHCs	
		15 Ecological significance of microplastic and synthetic microfiber pollution has become a global concern	
		16: Organophosphorus flame retardants: Ongoing toxicological studies have shown several toxic effects of these compounds, such as the	

		potential for ecological and human health concerns of neurotoxin and carcinogenic nature	
		17 Bt maize: No studies that can inform risk assessments regarding the effect of Bt maize on aquatic ecosystems have been done in S Africa.	
		18 Bt maize: It is important that future studies address the possible effects of Cry proteins on non-target species that are closely related to the target pests of Cry proteins	
		19 Bt maize: The characterization of exposure of aquatic organisms along with the known specificity of the insecticidal trait, linked to the ecology of non-target species present in that habitat, will contribute to improved risk assessment studies on aquatic environments	
		20 Agricultural pesticides: Current study found much higher concentrations of atrazine and other EDCs in drinking water in this study, which presents a much higher potential of exposure and the possibility of a myriad of effects on humans and the environment (fauna, flora)	
		21 River water quality: research is also needed to determine the impact of the identified pollutants on the aquatic ecosystems in the Swannies, Klipdrift and Palmiet rivers	
		22 Microplastic pollution: Given the low dilution potential of local freshwater resources, coupled with ongoing waste management problems, the impacts of microplastics on local freshwaters resources and the biological processes dependent on it remains unclear	
		23 Trophic transfer mechanisms	
		24 Knowledge about impacts of microplastics exposure on aquatic primary producers, the trophic transfer process of microplastics and associated substances, and implications of consuming aquatic products for human health is much less known.	

		comprehensively evaluate- the synthetic effects of microplastics and environmental toxicants and identify the role of microplastics in trophic transfer of environmental contaminants	
		25 PAH, PCB, OC pesticide: The study should also investigate the importance of small, forage fish as a vector for the transfer of contaminants through estuarine food webs, including to higher trophic level organisms such as birds.	
		26 Toxic elements: future study will focus on assessing the transfer of toxic elements to humans through the food chain (sediment/water-plant-animal-human chain)	
13	Management	1 Sustainable CECs management.	21 (1.7%) [11]
		2 Control strategies for commonly occurring CECs	
		3 Urban planning	
		4 Control of informal settlements, which generally lack sewerage systems	
		5 A lot of measures are not yet in place for the mitigation of cyanobacterial blooms, particularly in the implementation of plans for most countries	
		6 ARVDs: the similarity in removal rates between conventional and DEWATS WWTPs allows new insights for planning local wastewater treatment, and potential reuse applications, in periurban areas that are not served by conventional sewer lines	
		7 The effective dosage at 0.75 mg/l to 1.0 mg/l obtained in this study is hereby proposed as an alternative disinfectant dose that could facilitate the control of microbial pathogens in wastewater treatment plants	
		8 With conditions often changing faster than scientist or policy makers can anticipate, adaptive management strategies and interdisciplinary	

		research provide a means to address sustainable resource governance under uncertain conditions.	
		9 These results suggest the need for implementation of management policies at basin scale including efficient WWTP and special regulation on agricultural activities within and nearby internationally recognized sites for conservation	
		10 Due to environmentally unsound management of e-waste and other consumer products containing PBDEs at municipal dumpsites in Nigeria, food from animal origin (chicken eggs, cow milk) was found to be contaminated with PBDEs	
		11 NOM: central analytical facilities accessible to a number of Water Treatment plants can be established for NOM control	
		12 Water Quality in Non-Perennial rivers is naturally highly variable	
		Basic principles proposed for management of NP rivers/these systems:	
		1 rivers need to be assessed on a case-by-case basis until such time as we can apply general principles to an understanding of WQ in N-PRs	
		2 abstraction of both surface and groundwater, and storage of water in upstream dams, needs to be strictly limited and understanding of the groundwater regime is crucial if we are to avoid unsustainable "mining"" of the resource	
		3 effluents need to be controlled and conservative effluent standards need to be set, sometimes on a case-by-case basis, for both ground and surface water	
		4 flows may need to be augmented at certain times of the year	
		5 buffer zones need to be set, and where possible, these should be designed to encourage the growth of natural vegetation	
		6 the most useful step towards improving management of these systems would be the development of a much-simplified version of DRIFT-Arid for assessing water requirements for N-PRs, using additional test cases	

		across the spectrum from episodic to semi-permanent systems and in different biomes	
		7 this should be linked to the development of a suitable monitoring programme for a number of N-PRs, particularly those for which water allocations have already been set.	
		8 in seeking to deepen our knowledge of the ecological functioning of N-PRs it needs to be understood that because of the inherent variability of these systems, shortterm investigations are of limited use and that study projects need to be long-term (10 years or more)	
		Therefore, serious measures must be taken by the local government to reduce the contamination effects of the river water and protect the environment.	
		13 Agricultural chemicals: despite this technical knowledge gap, the need for improved management of pesticides in the environment has been echoed by the DAFF, formerly DoA	
		14 PAH, PCB, OC pesticides: the findings of this study can be incorporated into the Estuarine Management Plan and used to identify and prioritise areas of the catchment where contaminant source identification, reduction and control procedures should be implemented	
		15 Fluoride in water: This study reveals that fluoride content in Namibias drinking water is a significant problem that needs addressing	
		16 CECs in recycling/reuse : prevent release of untreated or partially treated sewage to ocean or surface water	
		17 Polycyclic aromatic hydrocarbons in aquatic ecosystems: incorporating results from this study into management of this water catchment one msut keep in mind that PAHs are mainly airborne.	
		18 It was an observation during this project that many authorisations and licenses granted failed to include the constituents relevant to the process involved.	

		The inclusion of all the relevant constituents that are linked to the agricultural activity in question must be included in any licence or authorisation granted.	
		Establishing these lists for organic and inorganic constituents remains a fundamental research priority that will allow for appropriate monitoring, assessment and thus management thereof	
		19 Agricultural chemicals: Given the chllenges related to monitoring (due to the transient nature of contamination) and that pesticide contamination in water resources occurs primarily as a result of nonpoint sources (runoff, leaching) further research should focus on modelling techniques aimed at assessing the fate, transport and mitigation/management options of pesticides in water at multiple scales (field to catchment)	
		20 Microplastic pollution: at the heart of the matter are unsustainable production and consumption patterns, inadequate waste management and inappropriate disposal of plastics	
		21 Microplastic pollution: Also need to promote best practices in in water, waste and wastewater management, amongst other things.	
		Plastics can be designed to be inherently recyclable	
		, and there is lots of potential to turn waste items into new products.	
14	Sampling	1 Sampling - mode and strategy	19 (1.6%) [12]
		2 Sampling- frequency	
		3 Integrated sampling and residence time- dependent studies	
		4 Sampling- One-time grab samples from sampling locations are not particularly representative of any definable general class of sites.	
		5 Sampling: more detailed and focus time series sample collection designs that better capture temporal variation.	

		6 Monitoring/sampling- Solid waste repositories (non-engineered landfills), on-site sanitation systems (pit latrines, septic tanks), funeral parlours and cemeteries/gravesites constitute overlooked potential hotspots sources of args.	
		7 Useful EP degradation and stability studies thoughout the sample collection and extraction stage were not carried out to determine stability of each compound during sample handling	
		8 POPs: temporal data have been assessed, but majority of datasets do not show trends due to limited sampling periods, and limited sample size. More consistent monitoring produces nationwide data, leading to informed risk management studies	
		9 Further studies should be conducted with a more detailed sampling plan throughout the Maipo River, into which the effluents of main wastewater treatment plants are discharged	
		10 Declining bird species exposed to PBDEs: Analysis of additional samples is therefore recommended to fully evaluate this potential impact	
		11 Metals in crocodile eggs: it would be opportune to collect, analyse and interpret organic and inorganic residue data for more crocodile eggs from more rivers now that concerns have been established	
		12 Pesticides: Pesticide contamination in water resources is typically transient, with peak/high concentrations most often being associated with specific events – during actual spraying or during heavy rainfall.	
		Sampling frequency adopted in all catchments in this study is unlikely to represent peak concentrations	
		13 Aquatic microbial diversity: the physico-chemical analysis of water samples is not a very sensitive measure of changes in the type (inorganic vs organic) nutrient concentration or anthropogenic pollution within the system.	

		We observed changes in the abundance of dominant microbial species in sediment samples that were not observed in the water column along the length of estuaries with apparently small salinity and nutrient gradients.	
		These findings lend strong support for the need to focus on sediment sampling when monitoring estuarine health and aquatic ecosystems in general.	
		14 Aquatic toxicity testing: sampling recommendations need to be assessed to more completely consider how to address conflicting impacts, in particular, where diffuse release of effluent is present	
		This process should be undertaken with DWS input	
		15 Aquatic toxicity testing: sampling frequency recommendations need to be clarified, in particular for agriculture.	
		Stipulations on modifying sampling regimes based on assessment of collected site-specific data need to be specifically addressed	
		16 Cyanobacteria: It was recommended that depth profiling of the occurrence of cyanobacteria be done in order to identify an abstraction depth in the multi-level intake of the reservoir that has relatively low levels of cyanobacteria cells	
		17 Natural organic matter: Extensive sampling that will account for all the geographic locations in South Africa is required	
		18 CECs in waste water treated for direct potable reuse: evaluation of indicative removal potential	
		Since the project team was not able to collect 24 hr composite samples, it is difficult to evaluate the indicative removal potential of the treatment units since plug flow characteristics can be observed when taking grab samples,	
		It is therefore recommended that sufficient resources be allocated in future studies that will allow for 24 hr composite sampling to be performed	

		19 Urban wastewater epidemiology: compare sampling, detection, monitoring methods:	
		Mass loading	
		Composite sampling vs grab sampling	
15	Use/consumption	1 Production/sales/use	17 (1.4) [13]
		2 DCF consumption	
		3 Reduction in use	
		4 We remain unclear on the scale of pharmaceuticals and their potential combined effects on biota	
		5 Lack of market penetration data for products containing TCS and TCC – for SA and global- makes it difficult to compare and refine the model results in this study	
		6 ARVDs: a nationwide study of the presence, use pattern, material flow analysis and removal rate of ARVDs is necessary in order to estimate the load of ARVDs released into the surrounding surface and fresh water bodies, since ARVDs may have associated ecological risks to aquatic organisms	
		7 Hence, majority of countries from these regions are yet to reduce, re-use or re-cycle? Plastic materials to enhance its abatement	
		8 Information along the lines of product consumption by geographical region or by sector is not readily available to environmental researchers, stakeholders or law makers	
		9 Restricting the consumption of certain products, such as antibiotics to crucial cases and replacement of some others with less harmful compounds, are possible strategies in short-term	
		10 PFOS in fish: In the meantime, consumption advisories should be considered as a prudent public health measure.	

		11 Agricultural chemicals: Additional useful resources with regards to characterizing pesticide use include databases produced by cropLife South Africa and Agrilntel, which provide information on active ingredients and recommended rates of application of registered pesticides for different crops in the country	
		12 The policy also specifically mentions the need to protect water quality through releasing fewer pesticides and/or less toxic pesticides into the environment, and to use practices that minimize the movement of pesticides to surface water and groundwater.	
		13 PAH, PCB, OC pesticide: a key unknown in the context of determining the potential human health risk posed by contaminants in fish and shellfish tissue are fish and shellfish consumption rates for SA recreational and subsistence fishers.	
		14 Pharmaceutical and personal care products: raising public awareness of the consequences of liberal and irresponsible PPCP use and disposal	
		15 Various best practice measures that can assist in reducing the amount of wastewater generated and/or decrease the potential environmental toxicity of the effluent:	
		1 leakages- regularly fix leakages in storage units and pipes	
		2 spillages – institute measures to reduce spillages and/or collect product from spillages for reprocessing; eg, install spill collection trays at appropriate sites	
		3 solids: install grids over drains to prevent solids from entering wash-water	
		4 degumming: qif possible, reduce amount of phosphoric acid used in degumming by improving the neutralization process or by using alternatives such as enzymes	
		5 maintenance: institute a preventative maintenance protocol: regular servicing of expellers and other mechanical equipment, etc	

		6 educate staff: make staff aware why its important to reduce the amount of wastewater generated and improve the quality of the wastewater	
		7 Train staff how to implement appropriate measures, and provide refresher instructions at timely intervals	
		8 chemical audits: consider substituting different chemicals and/or materials, eg caustic soda in solution may be cheaper than the solid form and results in less loss of consumables, reduced corrosion and improved soap-stock quality	
		9 caustic soda usage – monitor addition carefully to prevent saponification of neutral oil	
		10 soap splitting- use continuous soap splitting rather than batch to reduce the volume of acid water	
		11 detergents: minimize the use of detergents in cleaning operations to prevent emulsification of oil in wastewater	
		12 fat traps: use fat traps judiciously- to prevent oil from entering wash-down water	
		13 Measure and monitor: the volume of effluent produced from each area. Monitor the quality of effluent produced from different processes to identify areas where product and/or consumables are being lost	
		14 Product recovery: recovery at from effluent to increase soap-stock production and improve wastewater quality	
		16 Agricultural chemicals: It is further recommended that regular updates of pesticide use data, spatial crop distribution and associated pesticide use maps are produced to ensure the availability of up to date information for use in design of monitoring programmes and risk assessment studies	
		17 Microplastic polution: at the heart of the matter are unsustainable production and consumption patterns, inadequate waste management and inappropriate disposal of plastics	

16	Models	1 Models for impacts of multiple contaminants and larger spatial scales	17 (1.4%) [13]
		2 Models of pollutants in different phases, beside water	
		3 Development of accurate models to facilitate decisions on tolerable pollution loads, equitable sharing of pollution reduction and locally appropriate interventions	
		4 Development of modelling frameworks for CECs including mixtures and interaction between CECs	
		5 Model-supported analysis can be used in further investigation in order to define the flux of POPs and plastic additives in this species (whale sharks)	
		6 Future research with SSRIs is necessary to reduce uncertainties by improving predictive utility of models and approaches for cross-species extrapolations, particularly given diverse behavioral consequences increasingly reported for SSRIs and other neuroactive substances in aquatic systems	
		7 Agricultural chemicals: in general, the application of models in risk assessment of pesticides in South Africa is under-utilised.	
		8 Agricultural chemicals: a critical component of any modelling procedure is the identification of relevant exposure assessment scenarios that characterize environmental conditions that are used for model input parameters.	
		. These conditions vary widely across the country- and thus, for the purposes of modelling, exposure assessment scenarios can be developed which are broadly representative of agriculture practiced in major production areas of the country	
		9 Agricultural chemicals: For adoption in SA it is essential that these models are interrogated so as to clearly identify their data requirements	

		and their suitability for performing exposure assessments in South Africa.	
		These requirements need to be assessed against data that is currently available in S Africa to determine the viability of using these models for risk assessment of pesticides in S Africa	
		10 Agricultural chemicals: improved prioritization of environmental risk (to inform environmentally friendly use of pesticides), monitoring and modelling approaches are therefore essential to close the gap on assessing the risks of pesticides in the environment	
		11 Engineered nanoparticles: The quality of the neural network models is directly related to the quality of the data used in their construction. In order to improve the data, more consistent testing and reporting of descriptors should be promoted.	
		Moreover, there is a need to measure endpoints related to behavior and effects concurrently to reduce data ambiguity	
		12 River water quality: The model used in this research tends to be useful in small river systems. However, this model will need to be expanded to predict how pollutants are transported over larger distances	
		13 River water quality: This practical model was applied to a small-scale river system (main focus was Grabouw, and not the entire catchment). More research is required on large-scale rivers to determine how variability affects the outputs of these models	
		14 Agricultural chemicals: data on physicochemical properties of pesticides in South African environmental conditions are not available.	
		International databases were therefore consulted in order to obtain the relevant data for- calculation of mobility (GUS) index, Studies have shown that physicochemical properties of pesticides can vary geographically, depending on local climatic and soil conditions.	

		Considering this limitation, however, the occurrence of pesticides detected in water resources in this (and other) studies was well predicted by physicochemical data available in international databases.	
		The fact that these originate from international databases should therefore not be seen as a reason for not relying on this data for future modelling approaches undertaken in S Africa	
		15 Agricultural chemicals: Given the chllenges related to monitoring (due to the transient nature of contamination) and that pesticide contamination in water resources occurs primarily as a result of nonpoint sources (runoff, leaching) further research should focus on modelling techniques aimed at assessing the fate, transport and mitigation/management options of pesticides in water at multiple scales (field to catchment)	
		16 Agricultural chemicals: research should focus on the integration of these models into the risk assessment process conducted during the registration of pesticides. While the registration process considers the toxicity of a pesticide, there are no exposure assessment procedures performed to assess the environmental fate and predicted environmental concentrations under S African conditions	
		17 CECs in wastewater treated for direct potable reuse: process performance and plant reliability analysis	
		Overall, the current historical process data is not suited as is for deriving process monitoring models	
		However, there is scope, given rigorous data collection programmmes, for univariate monitoring of key quality variables 9slow sample rates), or multivariate monitoring of operational variables (fast sample rates	
		A future direction for statistical analysis is to consider how process unit reliabilities affect other process unit reliabilities, and in turn, the reliability of the entire plant under consideration.	

		For this, multivariate and conditional distribution fitting would be required, which would require rigorous data collection at a high data quality	
17	Scope	1 Preservatives, anti-oxidants and flavorants present in cosmetics and cleansing products has been less studied	15 (1.2%) [14]
		2 Further studies of additional classes of pharmaceuticals and other CECs in on-site wastewater effluents	
		3 The focus of research should be accordingly transferred from PBDE to other currently used BFRs in later study.	
		development of methodology tailored for diverse emerging pollutants in water and sediments could assist to analyse a wider range of emerging pollutants such as acidic polar organic compounds	
		POPs: a potential decline in legacy POPs in Ghana can be forseen with low-toxicity pesticide alternatives and regulations implemented by Ghana, However, more consideration could be placed on emerging contaminants (such as PFASs, HFRs) and unintentionally produced POPs (PCCD/Fs, PBDD/Fs, PCNs and dlPCBs), as trends of these contaminants in the environment are less well understood	
		4 To broaden the suite of contaminants tested	
		5 To better study and thus understand the effects of multiple stressors	
		6 Emerging hospital pathogens: A baumannii and K pneumonia were confirmed among CRB42 only in river water sampled after discharge of wastewater from a general hospital	
		7 Aquatic microbial diversity: the advent of new NGS technologies that substantially decrease the cost of generating sequence datasets provide and opportunity to apply the approach taken in this study widely to include other important estuarine systems around the SA cpastline	

		8 EDCs removal from wastewater: This study partially quantified the risks resulting from discharging EDCs into receiving water bodies	
		As only a few EDCs were evaluated, there is a need to study additional groups of these compounds.	
		9 Emerging and persistent contaminants/pathogens: there is a need to expand the scope of the study to include several rivers that feed into drinking water treatment plants	
		10 Emerging and persistent contaminants/pathogens: the level and impact of emerging contaminants can be well understood by including sediments in the study	
		11 Emerging and persistent contaminants/pathogens: available and emerging antibiotic-resistant genes in microbial communities present in wastewater treatment plants should be investigated	
		13 Polycyclic aromatic hydrocarbons in aquatic ecosystems: The biomarker response results could not conclusively be attributed to PAHs, and therefore a broad spectrum screening for a much larger variety of organic chemical pollutants is advised for this densely populated area of Gauteng.	
		Chemical compounds that can be considered include: polychlorinated biphenyls, brominated flame retardants, organochlorine pesticides, plasticisers, pharmaceuticals and personal care products and perfluorinated compounds, just to name a few compound classes	
		14 Agricultural chemicals: While the analytical approach adopted in this study catered for a large number of different pesticides, it is important to note that glyphosate (most heavily applied pesticide in the country) was not included in screening or quantitative analysis.	
		Considering its high quantity of use as well as increasing evidence of human health-related effects, future research should focus on developing analytical methods for detection of this pesticide (and its breakdown products) in water resources in S Africa	

		15 Urban wastewater epidemiology: Gaps in knowledge, research, policy:	
		Surrogate chemicals/physico-chemical properties association	
		Early warning showing public health concerns	
		Collaboration between scientific disciplines and governing bodies	
		Near/real time	
		Sensing/monitoring (large datasets, modelling)	
18	Mixtures	1 Complexity of Mixtures of CECs in aquatic environment	15 (1.2%) [14]
		2 Monitoring of new CECs	
		3 Mixture effects- almost complete lack of directly measured mixture toxicity data for pairs (let alone higher order mixtures)) of the analytes	
		4 Future studies deepen research on determination of single and mixture toxicity of the azole antifungals	
		5 There is necessity to link likely implications of both TCS and TCC or their mixtures to human health through the food chain-	
		6 Future work to consider interactions between TCS and TCC as a mixture, and the impact on the aquatic organisms where effects may be antagonistic, additive, or synergistic such that individual chemicals effects can either be reduced or enhanced	
		7 Understanding the mixture effect of REEs and other stressors such as organic pollutants on acute and chronic ecotoxicology	
		8 As we learn more about the long-term ecotoxicological impacts of ECs and their TPs in the environment, it is critical to synthesize key information on validated analytical methods, sensitive test methods for ecological effects, occurrence data, treatment data, and environmental fate data that will facilitate the development of potential regulations to reduce ECs in the environment	

		9 The risk assessment was based on EQS and PNEC values, available in literature for less than a third of the investigated compounds.	
		These ecotoxicology thresholds can be determined by in-silico approaches using large uncertainty factors, and undergo regular revisions accounting for new scientific evidences, which can drastically change the HQ determined here.	
		Future research should focus on the refinement of these thresholds, especially in the context of complex mixtures.	
		10 African penguin population has crashed: effects of combinations cannot be excluded, as well as more subtle effects on reproduction, development, and behaviour.	
		11 Pesticides: more research is needed regarding the behavior of pesticides in mixture, to understand the interaction of these chemicals when attempting to predict endocrine disruption when dealing with mixtures	
		12 Pesticides: Although population effects needs more attention, understanding the complex interactions when exposed to complex mixtures in the field at individual levels must continue	
		13 Agricultural chemicals: it is important to note that mixtures of agricultural chemicals may result in additive, synergistic or antagonistic responses, implying that the expected ED bioassay response may be higher or lower than anticipated from known responses of individual chemicals.	
		in this respect a comparative study of the relative importance of different sources of EDCs in the environment is recommended to prioritise and focus future research initiatives in this field.	
		14 Urban Waastewater epidemiology: Gaps in knowledge, research, policy:	
		Surrogate chemicals/physico-chemical properties association	

		15 Microplastic pollution: The potential health impacts of individual compounds or mixtures are also mostly unknown	
19	Epidemiology	1 Human epidemiology for links between CECs and public health risk	12 (1.0%) [15]
		2 Further epidemiological studies by employing more samples and analysing more known and unknown POP compounds are urgently needed to clarify the relationships more robustly	
		3 Epidemiology studies to link STMs and risk	
		4 Epidemiology- Although the epidemiological evidence base remains weak, ARGs originating from wastewater could contribute to antimicrobial resistance in humans.	
		5 REEs: Epidemiological data linking human health to REEs exposure remains weak.	
		6 Epidemiological data based on controlled experiments linking dietary intake to human health conditions, for example in areas known for REEs pollution	
		7 SUGEs: Conducting case-control epidemiological research linking TGCs to human health effects.	
		8 Reseacrh to understand 1,4-dioxane exposure and effects in human populations.	
		9 Sufficiently powered epidemiology studies investigating the general population have yet to be conducted	
		10 Such studies are urgently needed to better understand human exposure and the public health implications of 1,4-dioxane exposure	
		11 Agricultural pesticides: further studies are recommended, including epidemiological investigations to establish the prevalence of environmental health risks and specifically to establish a cause-effect-	

		relationship between human exposure to the studied pesticides and potential environmental health risks highlighted in other studies.	
		12 Pesticides: pesticide-linked epidemiology should be investigated by including or linking to endocrine disruption research	
20	Bioaccumulation	1 Bioaccumalation and biomagnification potential, uaing biotic samples	11 (0.9%) [16]
		2 Bioavailable LC50 values for the target pyrethroids	
		3 Application of bioavailability-based measurements are more limited for pyrethroids in field-collected sediments	
		4 Bioaccumulation of DCF in the food web	
		5 Bioaccumalation	
		6 Bioaccumulation and associated hazards of pharmaceuticals and other ionisable chemicals in aquatic life, including edinble fish and shellfish	
		7 Bioaccumalation- Future research Is warranted to understand bioaccumulation and associated hazards of pharmaceuticals and other ionisable chemicals in aquatic life, including edinble fish and shellfish	
		8 Bioaccumalation: another important area that ha s to be properly addressed is the bioaccumulation of PPCPs in aquatic organisms such as: algae, crustaceans, and fish	
		9 Bioaccumalation- POPs could persist in the environment, bioaccumalate through the food chain and effect human health and environment.	
		10 However a lack of bioaccumulation data for TCS and TCC in edible plants makes this task implausible, and therefore merits further attention	
		11 The possibility of bioaccumulation of a varity of substances is concerning, and it should be further investigated, mainly in Latin America, a continent with an extremely high biodiversity.	

21	Collaboration of expertise	1 REEs: The establishment of regionally and internationally –funded research centres and collaborative networks to pool scarce analytical research facilities, financial and human resources from various countries, with individual countries providing pilot study sites , is one option	11 (0.9%) [16]
		2 REEs: Research in Africa is currently conducted by isolated research groups in very few countries, with limited coordination and communication among the groups.	
		3 1,4 -dioxane: research to establish a health-based drinking water targets.	
		4 Variations in state guidance values for 1,4-dioxane demonstrates the lack of consensus on the methodology to derive a health-based target.	
		6 Emerging/persistent contaminants/pathogens: a water reference laboratory should be established in S Africa that would support the monitoring labs	
		7 Fluorescent sensors for screening ECP in water: the development of South African guideline values or water quality limits for ECPs should receive attention from policy makers in order to safeguard human health	
		The DOH and the DWS are encouraged to partner with the WRC to invest in the further development and ultimate use of novel monitoring technologies which can enhance and complement the current status quo regarding water management	
		8 Reclamation of municipal waste water for drinking water: DWS should help water service providers (municipalities and water boards) to have access to proficient scheme and plant managers, and skilled process controllers, by funding training programmes for scarce skills (such as membrane treatment plant operation).	

		Although DWS could take the lead in this regard, they should be closely assisted by other departments and institutions, such as CoGTA, SALGA, doh, ETC in the implementation thereof	
		9 CECs in wastewater treated for direct potable reuse: It is imperative that a national (virtual) centre for analysis of contaminants of concern (including all specialized chemical and microbiological analyses) be established, consisting of a network of laboratories,. More specifically,	
		More specifically, the following is proposed:	
		2.1 that a national laboratory network for advanced water quality analysis be established, which will have the framework of a virtual centralized facility, but consist of regional laboratory networks in four of the provinces: W Cape, Gauteng, KZN, and Free State	
		2.2 is is the intention that the national lab network for advanced water quality analysis will:	
		A facilitate regional b cooperation between the labs	
		B Propose validated, SOPs	
		2.3 provide competitive analysis cost (different packages) for WSPs:	
		Develop regional capacity and expertise for specialized water quality analysis,	
		Promote the exchange of scientific data and technical knowledge	
		2.4 Financial and institutional support from the Dept of water and Sanitation will be crucial in ensuring the success and sustainability of the water reuse regional laboratory networks	
		The DWS is the sector leader, and as such, needs to make the case for the importance of credibility in water quality testing	
		Private-public partnerships could also be a viable option for this purpose, either as part of the Strategic Water Partners Network or something similar.	
		10 Urban wastewater epidemiology: Gaps in knowledge, research, policy:	

		Collaboration between scientific disciplines and governing bodies	
		11 Microplastic pollution: recommendation: reduce, reuse, recycle, redesign and recover plastics as far as possible:	
		Need a collective effort between global institutions, governments, manufacturers, retailers and consumers alike.	
22	Information	1 Most of the information on algal blooms available is from 21 countries, in the peripheral parts of the continent, with a large information gap in the more central countries.	11 (0.9%) [16]
		2 There needs to be a serious effort to consolidate information and technologies available within the continent to aid in curbing the water issues facing Africa.	
		3 Their presence of anti-microbial compounds in potable drinking water has not been well explored. There is no information of antibiotics in potable drinking water in S Africa	
		4 There is currently no information indicating the hydrolysis of firstline antitubercular drugs in aquatic environments	
		5 Information on microbial pathogens of known and emerging concern in source and treated drinking water - lack of data	
		6 Limited ecotoxicity information; robust assessments could not be performed for most of the rapidly urbanisisng and large geographic regions of the world	
		7 Data- Relatively limited information from many regions, including developing countries and rapidly urbanising areas in Africa, Latin America and Asia.	
		8 The consolidation of standard measurements and parameters is a key factor in having comparable and informative data on the state of toxic blooms in the continent as a whole	
		9 Information on HNPs /halogenated natural products is frequently not available	

		10 Aquatic microbial diversity: The need for information on which taxa are metabolically active in resident microbial communities is particularly important as a tool for monitoring episodic anthropogenic pollution in urbanized estuaries such as Swartkops systems	
		11 Brominated flame retardants: Phosphorous flame retardants which have also replaced the BFRs should be monitored in water systems since information on these is still scarce in South Africa	
23	Priority Contaminant List	1 The number of chemicals produced and consumed rises every day and new info about their consequences in the environment are discovered	9 (0.7%) [17]
		Therefore, priority lists must be updated periodically and should be always based on up-to-date information and data (occurrence, determination, toxicology) obtained in the country or target area.	
		2 Chemical/environmental Priority Substances List	
		3 Priority Chemical Contaminant List- a potential source for new analytes to be considered for future studies is USEPAs Contaminant Candidate List	
		4 Priority Chemical Contaminant List- Non-steroidal anti-inflammatory drugs remaining in environment are a kind of priority hazard substances	
		5 Targeted EPV-Ketoprofen: another first line NSAID with comparable or even higher global consumption than diclofenac in human and veterinary medicine, is also one of potential candidates as priority substance for targeted EPV	
		6 Priority contaminant List: Cimetidine, diphenylhydramine and ranitidine were commonly reported antihistamines	
		7 Priority Contaminant List : Perchlorate is a ubiquitous water contaminant, of environmental concern due to its inhibitory effect on mammalian thyroid function.	

		8 Development of internationally harmonised assessment criteria for prioritised contaminants specially adapted for blue mussel sentinels	
		9 Along with the antibiotics of common usage, the emerging contaminant candidate list should include: nevirapine, efavirenz, carbamazepine, methocarbamol, venlafaxine (hydrochloride) and bromacil. They are contaminants that require operational monitoring in South African urban waters.	
24	Water pollution/mitigation	1 Water pollution mitigation- Assessment of voluntary schemes and design of approaches for other contexts,	9 (0.7%) [17]
		2 Water pollution mitigation- Collaboration between researchers and farmers	
		3 Toxic elements: pollution control and remediation measures should be practiced to prevent further deterioration of water quality	
		4 CECs in recycling/reuse: sewage is contaminating fish stock wild caught in the marine environment	
		5 CECs in recycling/reuse : prevent release of untreated or partially treated sewage to ocean or surface water	
		6 Polycyclic aromatic hydrocarbons: evaluation of fish species composition and numbers to further describe pollution effects in the system	
		7 Agricultural chemicals: Given the chllenges related to monitoring (due to the transient nature of contamination) and that pesticide contamination in water resources occurs primarily as a result of nonpoint sources (runoff, leaching) further research should focus on modelling techniques aimed at assessing the fate, transport and mitigation/management options of pesticides in water at multiple scales (field to catchment)	

		8 Microplastic pollution: the problem with microplastic pollution of freshwater resources might be more significant than we think	
		9 Microplastic pollution: when microplastics contaminated water and soil are used for drinking and crop production, water and food security as well as the well being of the population may be affected.	
25	Transfer mechanism of antibiotic resistance genes	1 It has been hypothesized that the presence of antimicrobial residues in the aquatic environment may select for bacterial strains that are resistant to antibiotics. Their presence may facilitate the development of antibiotic resistance and transfer of these antibiotic resistance genes to human pathogens	6 (0.5) [18]
		2 Serpentinitic ultramafic geological environments)/SUGEs: transfer mechanisms, using mass balance analysis, isotopic tracers, and speciation modelling	
		3 Antibiotic resistant bacteria and genes: considerable body of knowledge is being generated to establish the occurrence of antibiotics, ARB and ARGs in aquatic systems, particularly in drinking water distribution systems.	
		How environmental conditions affect the associated genetic and metabolic changes is not clearly understood	
		4 Drug resistant microorganisms: The contribution of drinking water chemicals disinfectants on the development of resistance profiles is an issue which requires further investigation	
		5 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: factors that affect release, transformation, persistence and transportation in surface and ground waters	
		6 Antimicrobials/antibiotic resistant bacteria: the presence, distribution and dynamics of antibiotic resistance genes in the ARBs be investigated	

26	Resources	1 Lack of funds, sophisticated analytical tools, international . H and awareness may be some factors responsible for deficiencies in studies, on the analysis of PBDEs in developing countries especially in Africa	6 (0.5%) [18]
		2 Pesticides: the capacity to determine environmental concentrations of pesticides is urgently needed in South Africa	
		Dedicated but affordable, analytical facilities are needed to validate working concentrations as well as environmental concentrations of pesticides	
		3 Rare earth elements (REEs: To better understand the environmental and human health risks associated with REEs, appropriate advanced analytical facilities, research funding and expertise are required, yet all of these are currently lacking in most African countries	
		1 Reclamation of municipal ww for drinking water: DWS should help water service providers (municipalities and water boards) to have access to proficient scheme and plant managers, and skilled process controllers, by funding training programmes for scarce skills (such as membrane treatment plant operation).	
		Although DWS could take the lead in this regard, they should be closely assisted by other departments and institutions, such as CoGTA, SALGA, DOH, et., in the implementation thereof	
		2 CECs in ww treated for potable reuse: A further important factor, and one that needs to be addressed from the outset, is the need for well-trained and experienced personnel and managers for the regional laboratory networks	
		Follow-up projects by the WRC, WISA, universities, water boards, and the Energy and Water Sector Education and Training Authority will be required to create an enabling climate for planning staffing and career development in the regional lab networks.	
		3 CECs in water treated for potable reuse: evaluation of indicative removal potential	

		Since the project team was not able to collect 24 hr composite samples, it is difficult to evaluate the indicative removal potential of the treatment units since plug flow characteristics can be observed when taking grab samples,	
		It is therefore recommended that sufficient resources be allocated in future studies that will allow for 24hhr composite sampling to be performed	
27	Education	1 Education of communities on CECs pollution	6 (0.5) [18]
		2 Awareness/public education-creating awareness through education of the public, private and government sectors will go a long way in reducing the entry of microplastics into the environment	
		3 REEs: Public awareness on the potential existence, sources, and human health risks of REEs in drinking water, especially in sub-Saharan Africa	
		4 Raising free-range cattle and chicken should be avoided in the vicinity of municipal dumpsites, and the local residents should be informed about the high risk of exposure to PBDEs and other POPs accumulating in their food	
		5 Emerging chemical pollutants: The creation of a universally accepted standard definition surrounding what exactly an ECP is and which compounds from part of this definition will greatly aid in the science of analyzing and studying ECPs	
		6 CECs in recycling/reuse: initiate a chemical awareness campaign to consumers	
28	Behaviour	1 The conduct of ECs under traditional sewage treatment and advanced treatment techniques	6 (0.5)

			[18]
		2 Behavior of mixtures	
		3 Behaviour: there are no detailed studies addressing the behaviour and dynamics of PPCPs in freshwater systems,	
		4 Limited reviews have investigated sources, behaviour and health risks of antimicrobial resistance genes (ARGS) in the wastewater-human pathway.	
		5 Drug-resistant microorganisms: a followup WRC study is thus underway, the overall goal of which is to establish methodologies to monitor the dynamics of antibiotic resistant bacteria and genes in raw and final water samples drinking water samples in selected conventional and advanced drinking water plants in S Africa	
		6 Antimicrobials/antibiotic resistant bacteria: the presence, distribution and dynamics of antibiotic resistance genes in the ARBs be investigated	
29	Interaction	1 DCF: Interactions with other pollutants: with metals, inorganics, organics	6 (0.5) [18]
		2 Interaction with other environmental stressors	
		3 The potential synergistic or antagonistic interactions between args and environmental stressors are not considered.	
		4 Future work to consider interactions between TCS and TCC as a mixture, and the impact on the aquatic organisms where effects may be antagonistic, additive, or synergistic such that individual chemicals effects can either be reduced or enhanced	
		5 Agricultural pesticides: Also of great concern is the potential for atrazine to act synergistically with other pesticides to increase their toxic effects	

		6 Microplastics and pharmaceuticals as drivers of antimicrobail resistance: investigate the interaction of microplastics, bacteria, and antimicrobial resistance	
30	Policy	1 New and innovative policy and mechanisms at national level should be implemented to acquire market, and toxicity data to bridge such gaps in order to support risk assessment of ECs as experimental data for such chemicals is often missing or highly scarce	5 (0.4%) [19]
		. In order to address these and similar shortcomings, the link between groundwater, groundwater dependent sectors and groundwater governance needs to be understood and communicated, both in policy and in practice.	
		2 This case study highlights the need for strategies to limit contamination of the water resource given the predicted future expansion of Sub-Saharan urban centres	
		3 Microplastics and pharmaceuticals as drivers for antimicrobial resistance:	
		1 Following the action taken in other parts of the world, eg USA, Sweden, UK, elsewhere, SA needs to consider the immediate ban on the import, manufacture, use, formulation, sale, and export of microbeads in products	
		2 as an example, in sept.2002, the SA government, reps of labour and of industry, signed a memorandum of agreement concerning use of disposable polythene shopping bags.	
		Research conducted in 2010 showed a continued increase in carrier-bag consumption will continue over time, despite the price increases.	
		Thus, it may be imperative to review and tighten SAs responses to plastic pollution. Implementation of the Waste RDI roadmap needs to be strengthened in order to provide much needed guidance on waste management in SA environment.	

		3 Although plastic does not seem to feature much as one of the water quality concerns in SA, increasing awareness raising, most likely will reduce the consumption of single use plastics, and increase the use of value added plastics, thereby reducing environmental plastic pollution	
		4 Plastic packaging seems to be the most obvious and visible component of inland plastics pollution.	
		Given market forces and few regulations, meaning voluntary reduction of the plastic components of packaging, or promoting the use of recyclable or re-usable plastics (which are more expensive)\, seems remote	
		However, even remote opportunities can be advanced, and these opportunities should be investigated	
		There is an opportunity to harness the circular economy concept for redefine products and services to design waste- out, while minimizing negative impacts	
		3 Education	
		The inclusion of waste management into the education curricula is important. Currently, training is only offered at higher education level at CSIR and NWU in partnership offers a BSc Hons course in Environmental Sciences (specialization in waste management) and Masters degree in waste management, as implementing agency of the Department of Science and Technology	
		4 Urban wastewater epidemiology: Gaps in knowledge, research, policy:	
		5 Microplastic pollution: The aim would be not to ban plastics, like an international treaty, but that countries need to adhere to an international negotiated set of standards and practices to protect human health and the environment	

31	Resistance/Persistence	1 POPs could persist in the environment, bioaccumalate through the food chain and effect human health and environment.	5 (0.4%) [19]
		2 Further ERY contributions to antibiotic resistance development from other sources, including landfill leachates, require additional study, particularly in rapidly urbanising areas.	
		3 Monitoring -studies investigating antimicrobial resistance along the whole source-wastewater-human pathway are still lacking.	
		4 Most anti microbial drugs are perpetually replaced in aquatic environment due to their continued use. Their occurrence and persistence in the aquatic environment is of great concern as far as balanced aquatic ecosystems and public health impacts are concerned	
		5 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: factors that affect release, transformation, persistence and transportation in surface and ground waters	
32	Bioassay	1 Bioassay- consideration in the use and reporting of in vitro bioassay data; combining in vitro and in vivo bioassays and chemical analyses of estogenicity provides a considerable advantage as opposed to using only one method	5 (0.4%) [19]
		2 Bioassay -the use of in vitro bioassays to compensate for the inability to identify interactions of toxicant mixtures	
		3 Applying bioactivity measures to water quality monitoring has the potential to permit more comprehensive evaluation of water quality efficiently and effectively and guide further testing and assessment	
		4 Bioassay - use of in vitro: development of effective techniques adapted to a variety of media, and a change in the regulatory construct to one that is not focused	
		5 Aquatic toxicity testing: Recommendations regarding selection of bioassays should be reassessed in light of data presented here	

33	Reporting	1 Improve reporting: the reproducibility and replicability of studies could be improved by better standardised reporting of methods and data	5 (0.4%) [19]
		2 It would also help avoid typographical errors if all publications used the same units of measurement when reporting concentrations in water	
		3 arb and genes in drinking water: It is also important that findings from studies such as this one should be circulated to the relevant stakeholders.	
		Such data must also be made available to communities in such a manner that would make it easily understandable to all members	
		4 In light of Africa's unique vulnerability to climate change, as opposed to other continents, knowledge dissemination and collective research is critical	
34	Partitioning of CECs to solid matter	1 Limited information is available on the partitioning of ARGS between the various solid and aqueous phases.	4 (1.3%) [21]
		2 SUGEs: phase partitioning, speciation and transfer mechanisms, using mass balance analysis, isotopic tracers, and speciation modelling and	
		3 Very few studies have quantified the potential of EC sorption to algal biomass	
		4 PCBs: Most of the PCBs are bound to the soil and sediments and may be released to the water slowly over a long period of time	
35	Chiral contaminants	1 Stereoselectivity of chiral pharmaceuticals in WWTPs	4 (0.3%) [20]

		2 Potential effects of chiral pharmaceuticals on non-target plants and animals	
		3 Enantioselectivity of chiral contaminants	
		4 Development of enantioselective methods for profiling chiral APIs which can interact differently with biological organisms, exhibiting different pharmacokinetics is gaining interest in the scientific community and is recommended in future studies	
36	Retention of contaminants by plastic particles	1 Microplastic pollution; Microorganisms can also attach to these tiny plastic particles	3 (0.2%) [21]
		This means that microplastics can carry persistent organic pollutants and toxins over long distances	
		2 Microplastics and pharmaceuticals as drivers of antimicrobial resistance: factors that affect release, transformation, persistence and transportation in surface and ground waters	

Table S4 Some typical Classes of CECs

Number	**Class**	**Sub-class**	**Example**
	CHEMICAL		
	Algal toxins		
	Brominated contaminants		
	Flame retardants	Brominated, chlorinated, organo-phosphate based	
	Chlorinated contaminants		
	Chlorinated paraffins		
	Cosmetics products		
	Current-use pesticides		
	Detergents and detergent metabolites (hereinafter referred to as "detergents"),		Triclosan chlorophene
	Endocrine-disrupting chemicals (EDCs)	alkylphenols (APs), phenolic compounds; xenoestrogens;	bisphenol A (BPA), paraben nitrophenol; phenol; estradiol; 17-alpha-ethinylestradiol)
	Engineered nanomaterials		
	Fragrances		Polycyclic musk
	Halogenated natural products		

	Herbicides		
	Hexachlorobutadiene		
	Hormones		
	Household chemicals and food additives	Plasticiser	Bisphenol A
	Illicit drugs		
	Industrial compounds/chemicals	Flame retardants x-ray contrast fluid PAH	TDCPP, TCEP Iopromide Benzo(a)pyrene
	Life style products/ lifestyle compounds (LS)		
	Manufactured nanoparticles		
	Many substances used in daily life, ranging from pharmaceuticals to detergents		
	Marine plastics		
	Metabolites/transformation products		
	Microplastics		
	nanomaterials		TiO2, ZnO
	Natural chemicals	Stimulant Hormone	Caffeine 17-beta-estradiol
	New unintentionally generated PCBs		

	Newly formulated pesticides (specifically chlorpyrifos and pyrethroid pesticides)	specifically chlorpyrifos and pyrethroid pesticides	chlorpyrifos
	Organochlorine pesticides		
	Organotins		
	Other emerging pollutants;		
	Other organic compounds used in everyday domestic, agricultural, and industrial applications		
	PAHs,		
	PCBs		
	Per and polyfluoroalkyls perfluorinated compounds (PFCs) PFAS/PFOS/forever chemicals		Perfluorodecanoic acid
	persistent organic Pollutants (POPs)		
	Personal care product (PCP)/ personal-use products	Disinfectant/antimicrobial Fragrance preservative	Triclosan, chlorophen Polycyclic musk paraben
	Pesticides	algicide; herbicide; biocide; fungicide; insecticide; fumigants;	Simazine Atrazine, terbutylazine Imidacloprid

		attractants)	
	Pharmaceuticals/ pharmaceuticals products (prescription and nonprescription)	antibiotics; anti-diabetics; anti-epileptic; anti-microbial; anti-inflammatories; analgesics; anti-malarial; anti-ulcer; antihistamine; anti-depressant; beta-blocker antiretroviral	Sulfamethoxazole Sulfonylurea Carbamazepine Penicillin Diclofenac Paracetamol Cinchonidine Ranitidine Benzodiazepine atenolol Lamivudine
	Phthalates		
	Plasticizers		
	Platinum group elements (PGE)		
	Polychlorinated naphthalenes		
	Polycyclic aromatic hydrocarbons (PAHs)		
	Radionuclides		
	Rare earth elements		
	Residues		
	Short chain chlorinated paraffins		

	Siloxanes		
	Stanols		
	Steroidal hormones		
	Steroids		
	Sterols		
	Various trace elements		
	Water treatment by-products	By-product	NDMA Nitrosodi-methylamine
	MICROBIOLOGICAL		
	antibiotic resistant bacteria and resistance genes (ARBs and ARGs) produced as a result of mutation due to antibacterial drugs		
	sapoviruses		
	Waddlia chondrophila		
	Streptococcus parauberis		
	Human enteric bacteria and viruses		
	microbial pathogens (e.g., E Coli, rotavirus, Crypto, etc		E Coli, rotavirus, Crypto,
	infectious biological water contaminants		E Coli isolates
	cyanobacterial blooms is)		Microcystis

Table S5 Reported matrices analysed for CECs

No.	Water Raw source	Waste: Water, other	Solid	Biota	Food	Other: Air Human
1	groundwater	raw	sediment	porpoise	beer	blood plasma
2	raw source water	treated	soil	sharks	cereal	milk
3	river	industrial	suspended particulate matter	peregrine falcon eggs	sea food	human
4	dam	sludge	suspended solid	bats	fish	clinical stool
5	lake	landfill	dust	marine organisms	chicken	source separated urine
6	river basin	landfill leachate	surface sediment	food web	vegetable	cultures
7	tap	agricultural water	bank soil	higher order predators	meat	air
8	drinking	acid mine drainage	SUGE: soil systems	aquatic organisms	eggs	atmospheric aerosol and gases
9	bottled	waste/dump landfills	Surficial/surface sediment	land-based ecosystems	cereal	SUGE: atmospheric systems
10	rain	sewage sludge	particulate phase	land environment	baby food	urban residential areas
11	ice	run-off	sediment from river water	ocean environment	food products	medical facilities
12	sea	drainage	marine sediment	non-human	edible fish	Worm plant
13	estuary	wastewater treatment plants	sediment in rivers	plankton	chicken eggs	
14	well	effluent	beach sand	fish	cow milk	

15	aquifier	agricultural run-off	sediment in estuaries	invertebrates	tuna	
16	marine environment	resource upstream and downstream from sites in following sectors: municipal, agriculture, industrial, mining	sediment in canals	tissue of aquatic organisms	poultry	
17	iceberg	influent/ effluent wastewater		Whale sharks: skin biopsies	fish: tissue, blood	
18	ocean environment	municipal wastewater		Blue mussels	food sources	
19	tropical urban catchment	reclaimed wastewater		Guppy		
20	public source	wastewater from paper/pulp effluent		biological and environmental matrices		
21	public drinking			water birds: faecal samples, feathers		
22	Polar Region water supplies			terrestrial and aquatic biota		

23	reclaimed water			Plasma of crocodiles		
24	estuarine system			Tissue of tilapia		
25	coastal system			porpoise		
26	reservoir			Liver and blood from Predators: caracal, otter, genet, honey badger, mongoose, Eagle owl		
27	island			aquatic organisms		
28	ocean environment			aquatic food web		
29	environmenta l			Amphibians in water		
30	surface			egg shell of birds		
31	catchment			penguin eggs		
32	storm			bird feathers		
33	surface water catchments			Tissue polar bears		
34	pore water			Pearl millet		
35	SUGE: aquatic systems			Chokka squid		
36	freshwater			Turtle eggs		
37	salt water			Crocodile tissue		

38	coastal lagoon: stream, lagoon, sea			Crocodile eggs		
39	algal ponds			biota, seaweed		
40	borehole water			wetland plants		
41	wetlands			fish and bird eggs		
42	millipore water			aquatic animals: oyster, mussel, and abalone), crustaceans (e.g., crabs, prawn, and lobster)		
43	Intertidal water,					
44	contaminated ground water					
45	river water (upstream, down stream)					
46	sediment pore water					
47	Reclaimed Water for potable reuse- treated wastewater					
48	distribution water					

49	water from household storage containers					
Totals (/118)	49	21	16	42	18	12
%	31	13.3	10.1	26.6	11.4	7.6
Rank	1	3	5	2	4	6

MS methods: 101 papers
Per and polyfluoro compounds: 18

Table S6 References for the definition of a CEC

Number	Definition	Includes chemical	Includes inorganic	Includes micro= biological	Reference
1	EC newer or emerging organic and inorganic contaminants (substances which are not yet, or which have only recently been, regulated but which may be of environmental or human health concern), consisting of a range of pharmaceutical and personal care product ((specifically macrolides, diclofenac and triclosan), residues (inter alia illicit drug metabolites), perfluoroalkyl compounds, plasticisers, newly formulated pesticides (specifically chlorpyrifos and pyrethroid pesticides), other endocrine disrupting chemicals (specifically estradiol and bisphenol A), perfluorinated substances, platinum group elements (PGE), and microplastics. These emerging contaminants (ECs) are derived from various sources, notably waste water treatment works, e-wastes recycling, and pharmaceutical facilities, but also from non-point sources such as run-off from streets and agricultural land. Despite their presence at typically ug/L or sub-ug/L concentrations, residues of several ECs have been observed to cause biological disruption/dysfunction, and generational effects, in exposed organisms via a number of mechanisms including endocrine dysfunction	yes	yes	No	[28] A.B. Cundy, F.M. Rowlands, G. Lu , , W.-X. Wang Review A systematic review of emerging contaminants in the Greater Bay Area (GBA), China: Current baselines, knowledge gaps, and research and management priorities. Environmental Science & Policy, Volume 131, May 2022, Pages 196-208 https://doi.org/10.1016/j.envsci.2022.02.002

	Given the global concern around these Contaminants, and their relative environmental ubiquity in water, sediment and biota				
2	EC ‘‘Any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects’’. CECs can enter the environment through nonpoint sources (for example, runoff) and point sources (for example, concentrated animal feeding operations and treated-effluent discharge from wastewater treatment plants), which can increase concentrations of CECs especially in highly populated areas. . CECs include pharmaceuticals (prescription and nonprescription), steroidal hormones, stanols, sterols, detergents and detergent metabolites (hereinafter referred to as “detergents”), personal-use products, pesticides, polycyclic aromatic hydrocarbons (PAHs), flame retardants, plasticizers, and other organic compounds used in everyday domestic, agricultural, and industrial applications. Many substances used in daily life, ranging from pharmaceuticals to detergents fall under this description	yes	yes	yes	[29] United States Geological Survey (USGS (Churchill et al., 2020; Philip et al., 2018) Churchill, C.J., Baldys, S., III, Gunn, C.L., Mobley, C.A., and Quigley, D.P. (2020). Compounds of emerging concern detected in water samples from potable water and wastewater treatment plants and detected in water and bed-sediment samples from sites on the Trinity River, Dallas, Texas, 2009–2013. U.S. Geological Survey

					Scientific Investigations Report 2019–5019, 1–57, https://doi.org/10.3133/sir20195019. Philip, J.M., Aravind, U.K., and Aravindakumar, C.T. (2018). Emerging contaminants in Indian environmental matrices – a review. Chemosphere 190, 307–326, https://doi.org/10.1016/J.
3	CECs Organic pollutants Are present in the environment Might be hazardous to human and environmental health Originate from WWTPs	yes	no	no	[30] Gunilla Oberga, Annegaaike Leopold Review article. On the role of review papers in the face of escalating publication rates – a case study of

					research on contaminants of emerging concern (CECs) Environment International 131 (2019) 104960: 1-16 https://doi.org/10.1016/j.envint.2019.104960
4	CECs: chemical substances from anthropogenic origin present in the environment at trace and ultratrace levels (µg/L – ng/ L). CECs usually refer to a wide range of substances such as pesticides, pharmaceuticals, personal care products, flame retardants, hormones, antibiotic resistant bacteria and resistance genes (ARBs and ARGs), etc., being pharmaceuticals and pesticides the most frequently detected due to their widespread human use. CECs are continuously discharged into the environment mainly through wastewater treatment plant (WWTP) effluents since conventional wastewater treatments are not designed to remove efficiently these compounds. The presence of CECs in environmental compartments is a matter of current concern, mainly due to the undesirable ecological and toxicological effects that	yes	yes	Yes	**[31]** **J**.C.G. Sousa, A.R. Ribeiro, M.O. Barbosa, M.F.R. Pereira, A.M.T. Silva, A review on environmental monitoring of water organic pollutants identified by EU guidelines, J. Hazard. Mater. 344 (2018) 146–162, doi:10.1016/j.jhazmat.2017.09.058.

	may cause on aquatic organisms as a consequence of their persistence in receiving water bodies .				
5	Emerging organic contaminants (EOCs) are anthropogenic chemicals (e.g. pharmaceuticals, personal care products and lifestyle compounds (PCP-LS), pesticide compounds, and per and polyfluoroalkyls), that have been detected in the environment due to advances in analytical techniques and for which there are growing concerns regarding their potential harmful impact on the environment. However, most EOCs are not regulated in the environment or routinely monitored in groundwater. Their properties, environmental behaviour and toxicological effects are still poorly understood. There are 30,000 to 70,000 registered chemicals in daily-used products, and about 4000 new chemicals are registered every day. There are many newly emerging substances present in the environment, which may have adverse impacts on human health and ecosystems, for which limited occurrence data are available. Micro-plastics are also a potentially important emerging organic contaminant group in groundwater.	yes	no	no	[32] Jasmina Lukaˇc Reberski, , Josip Terzi´c, , Louise D. Maurice , Dan J. Lapworth Emerging organic contaminants in karst groundwater: A global level assessment Journal of Hydrology Journal of Hydrology 604 (2022) 127242 https://doi.org/10.1016/j.jhydrol.2021.127242
6	Organic Micro Pollutants which are often also referred to as trace organic compounds, trace organic contaminants. Since most of them are not yet regulated, they are often also classified as emerging contaminants or chemicals of emerging concern.	yes	no	no	[33] Torsten C. Schmidt Recent trends in water analysis triggering future monitoring

					of organic micropollutants Analytical and Bioanalytical Chemistry (2018) 410:3933–3941 https://doi.org/10.1007/s00216-018-1015-9
7	Emerging Contaminants (ECs)/Emerging Microbial Contaminants (EMCs) Emerging contaminants (ECs) represent a recently detected wide group of families of synthetic or naturally occurring compounds, such as endocrine-disrupting chemicals (EDCs), pharmaceuticals and personal care products (PPCPs), flame retardants, nanoparticles, etc.. These compounds are omnipresent and pose risks to human health and the environment. For instance, prolonged exposure to EDCs such as alkylphenols (APs), bisphenol A (BPA), parabens (PBs) or phthalates can impact the reproductive system in humans and wild life. Flame retardants and PPCPs can cause neurotoxicity and impact the normal routine of the endocrine system . Nanoparticles, commonly used in industrial and consumer products can cause cytotoxicity and cell damage. More information is needed regarding their environmental risks. These concerns have led the scientific community across the globe to shift its focus from conventional "priority"	yes	yes	yes	[34] Ravinder Kumar, Arun K. Vuppaladadiyam Elsa Antunes, Anna Whelan, Rob Fearon, Madoc Sheehan, Louise Reeves Emerging contaminants in biosolids: Presence, fate and analytical Techniques Emerging Contaminants 8 (2022) 162e194 https://doi.org/10.1016/j.emcon.2022.03.004

	pollutants to “emerging” or “new generation” contaminants. ECs enter into the environment via a number of routes, which include municipal, hospitals, wastewater treatment plants (WWTPs), sewer leakage/overflow , and runoff from gricultural and urban areas, the application of biosolids and treated effluent to land. From the above-mentioned sources of ECs, WWTPs are regarded as a major concentrator of ECs since they receive wastewater from different sources like domestic waste, sewage and industrial trade waste, infiltration of groundwaters. The range of concentrations of ECs in the effluents of wastewater vary from a few ng/L to mg/L, and their types and concentrations depend on the socioeconomic status of the community feeding the WWTPs. However, current WWTPs are traditionally not equipped with advanced technologies to remove ECs at such low concentrations. Treatment plants were traditionally designed with the removal of nutrients and organic material in mind. The insufficient removal of ECs leads to their accumulation either in effluent or sludges, resulting in either the contamination through release of effluent to the receiving aquatic habitat or sorption onto biosolids/sludge. Moreover, the microbial contaminants in the environment, more precisely, antibiotic-resistant genes/bacteria produced as a result of mutation due to antibacterial drugs, are also considered ECs and specifically called emerging microbial contaminants				

	(EMCs). A few examples of EMCs are sapoviruses , Waddlia chondrophila and Streptococcus parauberis . In addition, horizontal gene transfer phenomena allow the transfer of genetic material between microorganisms, implying that antibiotic-resistant genes can be further transferred between microbial populations.				
8	Contaminants of emerging concern (CECs), such as pharmaceuticals, illicit drugs, pesticides, herbicides, personal care products and each of their metabolites/transformation products are being ubiquitously found in a variety of environmental compartments at parts per billion/trillion concentrations given their widespread usage in healthcare, recreational/illicit drug use, and agriculture.	yes			[35] Keng Tiong Ng, , Helena Rapp-Wright, , Melanie Egli , , Alicia Hartmann, ,Joshua C. Steele, , Juan Eduardo Sosa-Hernández, , Elda M. Melchor-Martínez ,Matthew Jacobs, , Blánaid White, Fiona Regan, , Roberto Parra-Saldivar, , Lewis Couchman, ,Rolf U. Haldend, Leon P. Barrona, High-throughput multi-residue quantification of

					contaminants of emerging concern in wastewaters enabled using direct injection liquid chromatography-tandem mass spectrometry Journal of Hazardous Materials Volume 398, 5 November 2020, 122933 1-14 https://doi.org/10.1016/j.jhazmat.2020.122933
9	Emerging organic Contaminants In recent years, synthetic organic compounds, often known as emerging organic contaminants (EOCs), are becoming more of a growing international concern regarding their occurrence in, and contamination of, groundwater bodies	yes	no	no	[36] D. Mooney, K.G. Richards, M. Danaher, J. Grant, L. Gill, P.-E. Mellander, C.E. Coxon, An investigation of anticoccidial

					veterinary drugs as emerging organic contaminants in groundwater Science of the Total Environment 746 (2020) 141116, 1-16 https://doi.org/10.1016/j.scitotenv.2020.141116
10	Emerging environmental contaminant It is ubiquitous in environmental media, biotic matrixes, and humans, and thus is deemed to be an emerging environmental contaminant; a high-priority compound that critically requires further toxicological studies or for which regulatory measures could be envisaged E.g., tris(1,3-dichloro-2-propyl)phosphate ,	yes			[37] Chen Wang, , Haibo Chen, Hui Li, Jun Yu, Xiaoli Wang, Yongdi Liu Review article Review of emerging contaminant tris(1,3-dichloro-2-propyl)phosphate: Environmental occurrence, exposure, and risks to organisms and human Health

					Environment International Volume 143, October 2020, 105946, 1-16 https://doi.org/10.1016/j.envint.2020.105946
11	**Contaminants of emerging concern (CECs)** Among those refractory Organic Contaminants, contaminants of emerging concern (CECs) are a potentially important issue with respect to the suspected risk of human health and to environment. One of the definitions of CECs is proposed by United States Geological Survey as "any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects" . CECs include but are not limited to pharmaceutical and personal care products (PPCPs), perfluorinated compounds (PFCs), persistent organic pollutants (POPs), and nanomaterials	yes	yes	no	[38] Chengdu Qi, Jun Huang, Bin Wang, Shubo Deng, Yujue Wang, Gang Yu Contaminants of emerging concern in landfill leachate in China: A review Emerging Contaminants Volume 4, Issue 1, 2018, Pages 1-10 https://doi.org/10.1016/j.emcon.2018.06.001
12	Chemicals of emerging Arctic concern/persistent organic pollutants Identified chemicals that are present/detected in the Arctic but are not current regulated internationally (684 in data base). They are characterized as persistent organic pollutants (POPs) and as CECs.	yes	no	no	[39] Marta Plaza-Hernandez, Juliette Legler, Matthew MacLeod

	As well as including ‘emerging’ chemicals with POP-like characteristics; it also considers some chemicals and groups of substances that may not meet the classical definition of POPs These are: per-and polyfluoroalkyl substances, brominated flame retardants, chlorinated flame retardants, organo-phosphate based flame retardants and plasticizers, phthalates, short chain chlorinated paraffins, siloxanes, pharmaceuticals and personal care products, polychlorinated naphthalenes, hexachlorobutadiene, current-use pesticides, organotins, polycyclic aromatic hydrocarbons, new unintentionally generated PCBs, halogenated natural products, marine plastics and microplastics The term ‘chemicals of emerging concern’ (CEC) is increasingly being applied to refer to environmental contaminants that are gaining attention, either because they are being newly introduced (in some cases as replacements for chemicals that are being phased out or banned) or because advances in analytical chemistry permit their identification and/or quantification in (environmental) samples with a sufficient degree of reliability. The current assessment is purposely entitled Chemicals of Emerging Arctic Concern because the intention here is to consider CECs that are being found in the Arctic. These are chemicals that may warrant consideration for regulation under the Stockholm Convention.				Integration of production and use information into an exposure-based screening approach to rank chemicals of emerging Arctic concern for potential to be planetary boundary threats. Emerging Contaminants Volume 7, 2021, 213-218 https://doi.org/10.1016/j.emcon.2021.10.001

	Four criteria are used to establish whether a chemical qualifies for consideration as a POP according to the Stockholm Convention: chemicals need to persist in the environment for extended periods of time, have the potential to undergo long range transport; accumulate in humans, flora or fauna, and cause adverse effects. Some of the chemicals of emerging Arctic concern meet these criteria and are already under consideration for global regulation or have yet to be assessed				
13	Contaminants of emerging concern (CECs) various pesticides and pharmaceuticals, particularly interested due to their applications; to be biologically active and persistent toward atmospheric conditions. Such properties suggest on their long-term stability and potential adverse effects in the environment. Hence, these artificial products can be considered as contaminants of emerging concern (CECs)	yes		no	[40] Matija Cvetnić, Mirjana Novak Stankov, Marin Kovačić, Šime Ukić, Tomislav Bolanča Hrvoje Kušić, Bakhtiyor Rasulev, Dionysios D. Dionysiou, Ana Lončarić Božić Key structural features promoting radical driven degradation of emerging contaminants in water

					Environment International Volume 124, March 2019, Pages 38-48 https://doi.org/10.1016/j.envint.2018.12.043
14	Contaminants of emerging concern (CECs) The main criteria for inclusion in the initial list of candidate substances were that i) the substance is suspected of posing a significant risk to, or via, the aquatic environment, meaning there is reliable evidence of hazard and of a possible exposure to aquatic organisms and mammals, but ii) there is not enough information to assess the EU-wide exposure for the substance, i.e. insufficient monitoring data or data of insufficient quality, nor sufficient modelled exposure data to decide whether to prioritise the substance Various pesticides and pharmaceuticals, (eg, trichlorfin, Imidacloprid) particularly interested due to their applications; to be biologically active and persistent toward atmospheric conditions. Such properties suggest on their long-term stability and potential adverse effects in the environment. Hence, these artificial products can be considered as contaminants of emerging concern (CECs)	yes			[41] European Commission: Raquel N. Carvalho, Lidia Ceriani, Alessio Ippolito and Teresa Lettieri Directive 2008/105/EC, as amended by Directive 2013/39/EU, in the field of water policy: Development of the first Watch List under the Environmental Quality Standards Directive 2015

					JCR, 2018. Technical Report: Development of the First Watch List under the Environmental Quality Standards Directive. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/development-first-watch-list-under-environmental-quality-standards-directive
15	**CECs:** Used definition as given by US Geological Survey, Reference 2 “any synthetic or naturally occurring chemical that is not commonly monitored in the environment, but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects”. CECs include but are not limited to pharmaceutical and personal care products (PPCPs), perfluorinated compounds (PFCs), persistent organic pollutants (POPs), and nanomaterials.	yes	yes	no	[42] Chengdu Qi, Jun Huang, Bin Wang, Shubo Deng, Yujue Wang, Gang Yu Contaminants of emerging concern in landfill leachate in China: A review Emerging Contaminants

					Volume 4, Issue 1, 2018, Pages 1-10 https://doi.org/10.1016/j.emcon.2018.06.001
16	CECs Used definition given by S Sauve (2014): A large number of chemicals present in the environment remain unknown to the scientific community, or the information related to their identity and physicochemical properties is limited. These chemicals of emerging concern (CECs) are suspected to exhibit adverse health effects in humans.	yes	yes	no	[43] Noelia Caballero-Casero , Lidia Belova, Philippe Vervliet, Jean-Philippe Antignac, Argelia Castano~, Laurent Debrauwer, Marta Esteban Lopez, Carolin Huber, Jana Klanova, Martin Krauss, Arjen Lommen, Hans G.J. Mol , Herbert Oberacher ,Olga Pardo , Elliott J. Price , Vera Reinstadler , Chiara Maria Vitale ,Alexander L.N. van Nuijs Adrian Covaci ,

					Towards harmonised criteria in quality assurance and quality control of suspect and non-target LC-HRMS analytical workflows for screening of emerging contaminants in human biomonitoring TrAC Trends in Analytical Chemistry Volume 136, March 2021, 116201, 1-14 https://doi.org/10.1016/j.trac.2021.116201
17	Contaminants of emerging concern (CEC) naturally occurring, manufactured or manmade chemicals or materials which have now been discovered or are suspected present in various environmental compartments and whose toxicity or persistence are likely to significantly alter the metabolism of a living being. (eg., pesticides, pharmaceuticals and personal care products, fragrances, plasticizers, hormones, flame	yes	yes	no	[44] Sébastien Sauvé & Mélanie Desrosiers Review: A review of what is an emerging contaminant

	retardants, nanoparticles, perfluoroalkyl compounds, chlorinated paraffins, siloxanes, algal toxins, various trace elements including rare earths and radionuclides, manufactured nanoparticles and water treatment by-products, etc.) Such potential CEC should remain "emerging" as long as there is a scarcity of information in the scientific literature or there are poorly documented issues about the associated potential problems they could cause. In general, we expect CECs to be chemicals that show some potential to pose risks to human health or the environment and which are not yet subjected to regulatory criteria or norms for the protection of human health or the environment. Not all CECs will actually prove to be evil and have some potential to cause tangible concerns; the focus is that the lack of pertinent environmental fate and ecotoxicological or toxicological data prevent the proper evaluation of associated risks. An already regulated presumed well-known contaminant could certainly regain "emerging" status as new scientific information becomes available and thus force regulatory agencies to re-evaluate their norms and guidelines				Chemistry Central Journal 2014, 8:15 http://journal.chemistrycentral.com/content/8/1/15
18	CECs Quoted definition by Sauve 2014: anthropogenic sources and recently, in addition to traditional pollutants, the so-called "Contaminants of Emerging Concerns (CECs)" are becoming central for scientific research and legislation.	yes	yes	no	[45] Monica Rigoletto, Paola Calza, Elisa Gaggero, Enzo Laurenti *

	Pharmaceutically active compounds, personal care products, endocrine-disrupting chemicals and pesticides are some of CECs that have been increasingly detected in water. They are ubiquitous, very persistent and not easy to remove by classic wastewater treatment plants. CECs may accumulate in the aquatic environment, but at present the lack of data on their environmental fate and ecotoxicological impact prevents a proper and complete evaluation of the risks associated with these organic compounds				Hybrid materials for the removal of emerging pollutants in water: classification, synthesis, and properties Chemical Engineering Journal Advances Volume 10, 15 May 2022, 100252, 1-16
19	Emerging contaminant (EC): New substances with no clear immediate effects Emerging contaminants could be natural or synthetic substances that are not commonly monitored in the environment. At present, these substances are not adequately considered in legislation, They can encompass chemicals not previously included in national or international monitoring programmes but continuously introduced into the environment by anthropogenic activities, and well-known contaminants that have gained interest with the revelation of new aspects of their occurrence, fate or effects . More than 700 emerging pollutants, their metabolites and transformation products are listed as present in the European aquatic environment (www.norman-network.net). The fact that emerging pollutants are present in water bodies as complex mixture has to be considered. The ubiquity and the high number of	yes	yes	NO	[46] Lucrezia Lamastra, Matteo Balderacchi, Marco Trevisan Inclusion of emerging organic contaminants in groundwater monitoring plans MethodsX Volume 3, 2016, Pages 459-476 https://doi.org/10.1016/j.mex.2016.05.008

	potentially toxic compounds could lead to synergistic effects The identification of sources and pathways of contamination/pollution and the prediction of their impacts on groundwater quality are possible combining indicators and tracers. This is useful for the development or the improvement of new conceptual models. Conceptual models intend to describe and optionally quantify systems, processes and their interactions and are developed to different incremental degrees of complexity. Emerging contaminants and pollutants include any compound for which a conceptual model is missing Eg Organic Wastewater Contaminants: (OWCs): can include pharmaceutical products, industrial compounds, pesticides and other emerging pollutants (personal care, life style and cosmetics products etc.). In terms of chemical use and emissions, pesticide use and agriculture sector are one of the main responsible of the diffuse pollution. Anyway the contamination profile is dominated by industrial compounds, followed by pesticides and pharmaceuticals. OWCs are primarily released into the environment by domestic households, industry, hospitals and agriculture (Fig. 1), while secondary contamination of soils and vegetation can occur through utilisation of biosolids, sludge and manure in agriculture. Other specific sources of OWCs in groundwater are sewer leaching and urban storm water recharge, both of which directly affect urban				

	groundwater. Moreover, these contaminants are present in the effluents from wastewater treatment plants and can contaminate rivers and through-flow lakes. Emerging Pollutants are also characterised by: consumer concerns about safety, the high number of potentially monitored compounds, the high cost of monitoring and the scarcity of data on the effects and behaviour				

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Table S7: Summary of other reported descriptions/properties for/of CECs

Number	Property/description
1	Environmental contaminants that are gaining attention, due to them being newly produced or because they can be identified and accurately quantified in environmental samples;
2	New substances with no clear immediate effects;
3	Well-known contaminants that have gained interest with the revelation of new aspects of their occurrence, fate or effects;
4	Are biologically active;
5	Can encompass chemicals not previously included in national or international monitoring programmes but which are continuously introduced into the environment by anthropogenic activities;
6	Can enter the environment via a number of routes;
7	Have the potential to undergo long range transport;
8	Can be present in water bodies as complex mixture;
9	Can cause secondary contamination: e.g., of soils and vegetation, or through the utilisation of biosolids, sludge and manure in agriculture;

10	Not easy to remove by classic wastewater treatment;
11	Have long term stability;
12	Has potential to enter the environment;
13	Is suspected of posing a significant risk to, or via, the aquatic environment, meaning there is reliable evidence of hazard and of a possible exposure to aquatic organisms and mammals
14	There is not enough information to assess the EU-wide exposure for the substance, i.e. insufficient monitoring data or data of insufficient quality, nor sufficient modelled exposure data to decide whether to prioritise the substance;
15	Toxicity or persistence are likely to significantly alter the metabolism of a living being;
16	Residues of several ECs that have been observed to cause biological disruption/dysfunction, and generational effects, in exposed organisms via a number of mechanisms including endocrine dysfunction;
17	Their properties, environmental behaviour and toxicological effects are still poorly understood;
18	Limited occurrence data are available on them;
19	There is a scarcity of information in the scientific literature or there are poorly documented issues about the associated potential problems they could cause;
20	Consumer concerns about their safety;
21	The high number of potentially monitored compounds;

22	The high cost of monitoring them;
23	The scarcity of data on the effects and behavior

Table S8 ISO requirements as per ISO ISO/IEC Directives Part 2 Principles and rules for the structure and drafting of ISO and IEC documents: Clauses on subdivisions of the document only

https://www.iso.org/sites/directives/current/part2/index.xhtml

Clause	**Subdivisions of the document – “main title”**	**“Sub-clause”**
11	**Title**	11.1 Purpose or rational
		11.2 Normative or formative
		11.3 Mandatory, conditional or optional?
		11.4 Numbering and subdivision
		11.5 Specific principles and rules
12	**Forward**	12.1 Purpose or rational
		12.2 Normative or informative?
		12.3 Mandatory, conditional or optional?
		12.4 Numbering and subdivision
		12.5 Specific principles and rules
13	**Introduction**	13.1 Purpose or rationale
		13.2 Normative or informative?
		13.3 Mandatory, conditional or optional?
		13.4 Numbering and subdivision
		13.5 Specific principles and rules
14	**Scope**	14.1 Purpose or rationale
		14.2 Normative or informative?
		14.3 Mandatory, conditional or optional?
		14.4 Numbering and subdivision

		14.5 Specific principles and rules
15	**Normative references**	15.1 Purpose or rationale
		15.2 Normative or informative?
		15.3 Mandatory, conditional or optional?
		15.4 Numbering and subdivision
		15.5 Specific principles and rules
16	**Terms and definitions**	16.1 Purpose or rationale
		16.2 Normative or informative
		16.3 Mandatory, conditional or optional?
		16.4 Numbering and subdivision
		16.5 Specific principles and rules
		16.6 Overview of the main elements of a terminology entry
		16.7 Other elements of a terminology entry
17	**Symbols and abbreviated terms**	17.1 Purpose or rationale
		17.2 Normative or informative
		17.3 Mandatory, conditional or optional?
		17.4 Numbering and subdivision
		17.5 Specific principles and rules
18	**Measurement and test methods**	18.1 Purpose or rationale
		18.2 Normative or informative
		18.3 mandatory, conditional or optional
		18.4 Numbering and subdivision
		18.5 Specific principles and rules
19	**Marking, labelling and packaging**	19.1 Purpose or rationale

		19.2 Normative or informative?
		19.3 Mandatory, conditional or optional?
		19.4 Specific principles and rules
20	**Annexes**	20.1 Purpose or rationale
		20.2 Normative or informative
		20.3 Mandatory, conditional or optional?
		20.4 Numbering and subdivision
		20.5 Specific principles and rules
21	**Bibliography**	21.1 Purpose or rationale
		21.2 Normative or informative?
		21.3 Mandatory, conditional or optional?
		21.4 Numbering and subdivision
		21.5 Specific principles and rules