Pharmaceuticals and personal care products in (PPCPs) in contaminated Red Sea seawater samples

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Background and motivation

- Pharmaceuticals and personal care products (PPCPs) considered as priority environmental pollutants
- Presence confirmed in the environment (soil, water, sediment, biota).
- Sewage and Water water release considered as major emission source into the aqueous environment
- Standard Sewage treatment procedures not designed for PPCP removal. However, difference reported dependent on treatment technology established.
- High levels reported in effluents from sewage treatment plants (STP)

Sampling location

lat: 21.5433, long: 39.1728 ||| N 21 32'36", E 39 10'22"

- Largest sea port on the Red sea
- Second-largest city in Saudi Arabia after the capital (Riyadh)
- Population: ca. 4 million inhabitants.

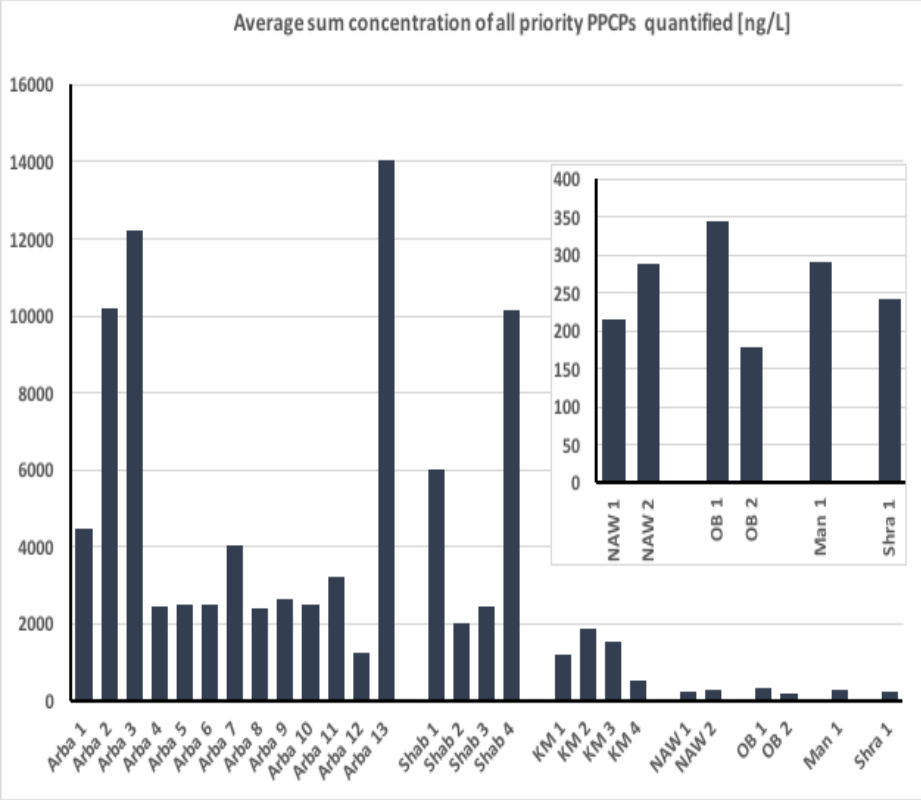
Sampling strategies

- Sampling March/May 2016 , 6 locations
- STP released in Lagoons with restricted water exchange during the summer season (low water level)
- Background locations as reference sites outside the city centre.
- Surface water (0.5 m below surface) collection (500 mL) Niskin bottles.
- Daily sampling for elucidation of emission variation.
- Storage cool (4 ºC) until SPE extraction (Oasis-MCX) and analysis (HPLC/QqQ-SIM; in ESI positive and negative).
- ^{13}C and ^{2}H isotope labeled internal standards for quantification

Target Compounds

Trivial name	IUPAC	Abbreviation	Target Mode
Acetaminophen	4-(Acetylamino)phenol	ACE	Anti-inflammatory
Aminotriptyline	3-(5,6-dihydrodibenzo[2,1-b:2',1'-f][7]annulen-11-ylidene)-N,N-dimethylpropan-1-amine	AMT	Antidepressant
Atenolol	2-[4-[2-hydroxy-3-(propan-2-ylamino)propoxy]phenyl]acetamide	ATN	β1 receptor antagonist
Atrazine	6-chloro-4-N-ethyl-2-N-propan-2-yl-1,3,5-triazine-2,4-diamine	ATZ	Pesticide
Benzophenone	diphenylmethanone	BEP	UV-Blocker
Caffeine	1,3,7-trimethylpurine-2,6-dione	CAF	Stimulant
Captopril	(2S)-1-[(2S)-2-methyl-3-sulfanylpropanoyl]pyrrolidine-2-carboxylic acid	CAP	angiotensin-converting enzyme (ACE) inhibitor
Carbamazepine	5H-dibenzo[b,f]azepine-5-carboxamide	CBZ	Antiepileptic
Cephalexin	(7R)-3-Methyl-7- (α- D -phenylglycylamino) -3-cephem-4-carboxylic acid monohydrate	CEP	Antibacterial
Chlorphenamine	3-(4-chlorophenyl)-N,N-dimethyl-3-pyridin-2-yl-propan-1-amine	CPN	Antihistamin
Ciprofloxacin	1-cyclopropyl-6-fluoro-4-oxo-7-(piperazin-1-yl)-quinoline-3-carboxylic acid	CIP	Antibacterial
Diclofenac	[2-(2,6-Dichloroanilino)phenyl]acetic acid	DCF	Antiinflamatory
Fluoxetine	N-methyl-3-phenyl-3-[4-(trifluoromethyl)phenoxy]propan-1-amine	FLX	Antidepressant
Ibuprofen	2-(4-Isobutylphenyl)propanoic acid	IBP	Anti-inflammatory
Metformin	N,N-Dimethylimidodicarbonimidic diamide	MET	Anrti diabetic
Methylparaben	Methyl 4-hydroxybenzoate	MEP	Preservative
Metronidazole	2-(2-methyl-5-nitro-1H-imidazol-1-yl)ethanol	MTP	antibacterial
N,N-dietyl-meta-toluamid	N,N-Diethyl-3-methylbenzamide	DEET	Pesticide
Ranitidine	N-(2-[(5-[(dimethylamino)methyl]furan-2-yl)methylthio]ethyl)-N-methyl-2-nitroethene-1,1-diamine	RAN	Gastric Treatment
Simvastatin	(1S,3R,7S,8S,8aR)-8-{2-[(2R,4R)-4-hydroxy-6-oxotetrahydro-2H-pyran-2-yl]ethyl}-3,7-dimethyl-1,2,3,7,8,8a-hexahydronaphthalen-1-yl 2,2-dimethylbutanoate	SIV	Lipid regulator
Sulfamethoxazole	4-Amino-N-(5-methylisoxazol-3-yl)-benzenesulfonamide	SMX	Antibacterial
Triclocarban	3-(4-Chlorophenyl)-1-(3,4-dichlorophenyl)urea	TRB	Antibacterial
Triclosan	5-Chloro-2-(2,4-dichlorophenoxy)phenol	TRC	Antibacterial
Trimethoprim	5-(3,4,5-Trimethoxybenzyl)pyrimidine-2,4-diamine	TMP	Antibacterial
Warfarin	(RS)-4-Hydroxy-3-(3-oxo-1-phenylbutyl)- 2H-chromen-2-one	WAR	Anticoagulant

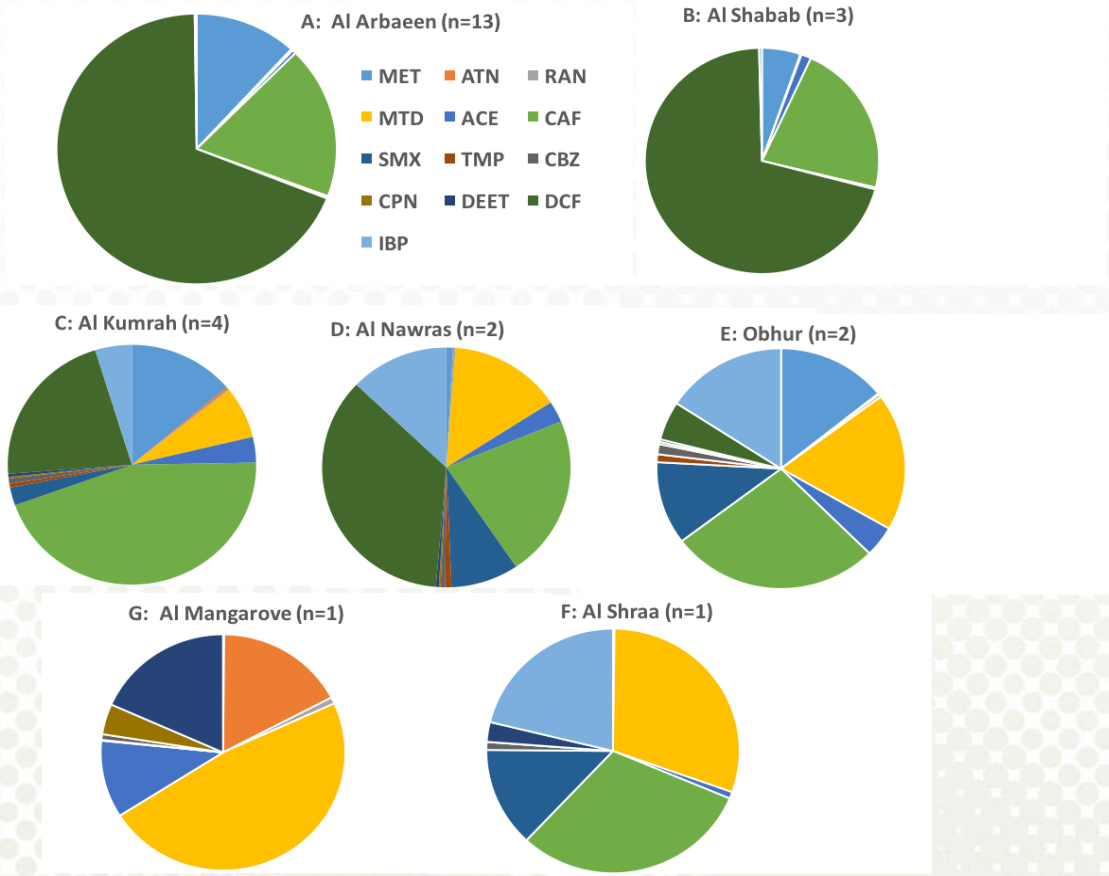
Concentration levels



Presence confirmed

Compounds	Abbreviation	CAS number
Acetaminophen	ACE	103-90-2
Atenolol	ATN	29122-68-7
Caffeine	CAF	58-08-2
Carbamazepine	CBZ	298-46-4
Chlorphenamine	CPN	113-92-8
Diclofenac	DCF	15307-86-5
Ibuprofen	IBP	1568-27-1
Metformin	MET	657-24-9
Metronidazole	MTD	443-48-1
N,N-diethyl-m-toluamid	DEET	134-62-3
Ranitidine	RAN	66357-35-5
Sulfamethoxazole	SMX	723-46-6
Trimethoprim	TMP	738-70-5

Distribution profile



Comparisons

Compounds	Asia							Europe			America
	KSA, Red Sea	China	KSA*	KSA**	Taiwan	Hong Kong	Vietnam	UK	Belgium	Germany	USA
SMX	63	134[a]	730		ND	47		Nd	96	480 [e]	3.4 [g]
DCF	14020	32.7	1260		53.6			195	ND	6.2 [f]	0.6 [g]
IBP	508	31.1	930		57.1			755		0.6 [f]	30 [g]
CBZ	110	25.5	1200		3.83		23		321		0.9 [g]
ACE	2363			99600	16.7			ND			11 [g]
CAF	7708		16500		16.9					15 [f]	44.7 [h]
ATZ	2.2		30								
DEET	49		415								
MET	4801			31200							
Ref.	This study	Xu et al. 200; Zhao et al, 2010	Alidina et al. 2014]	Shraim et al 2012	Jiang et al. 2014; Fang et al. 2012	Minh et al. 2009	Manaki et al 2007]	Thomas et al. 2004	Wille et al 2010	Hirsch eta. Al 1999; Weigel etal. 2002	Vidal-Dorsch et al. 2012; del Rey et al. 2012

* KSA: Kingdom of Saudi Arabia, WWTPs effluents, ** KSA: Kingdom of Saudi Arabia, raw wastewa
samples.

Conclusions

- High PPCP levels indicate release of insufficiently treated Sewage water.
- Levels found in similar concentrations as reported from Western Europe and Asian Location.
- Elevated PPCP levels found even in the background reference sites (ng/L range)
- Antibiotics present in the primary remission sites

For detailed information:

Ali, Aasim; Thorsen Rønning, Helene; Alarif, Walied; Kallenborn, Roland; Al-Lihaibi, Sultan.
Occurrence of pharmaceuticals and personal care products in effluent-dominated Saudi Arabian coastal waters of the Red Sea. *Chemosphere* 2017 ;Volum 175. s. 505-513

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