



Fate of Estrogens in Kuwaiti Municipal Wastewater Treatment Plants

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Overview

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Introduction

- ❑ Estrogens are hormones that produced naturally or synthetically (man-made).
 - Common natural estrogenic are Estrone (E₁), estradiol (E₂) and estriol (E₃).
 - Examples of the synthetic steroid are ethynyl estradiol (EE₂) and Diethylstilbetrol (DES). They are commonly used in manufacturing birth control pills.

- ❑ Both natural and synthetic estrogens can adversely affect humans, animals or fish. They can disrupt the reproductive and sexual systems of fish, wildlife and humans.

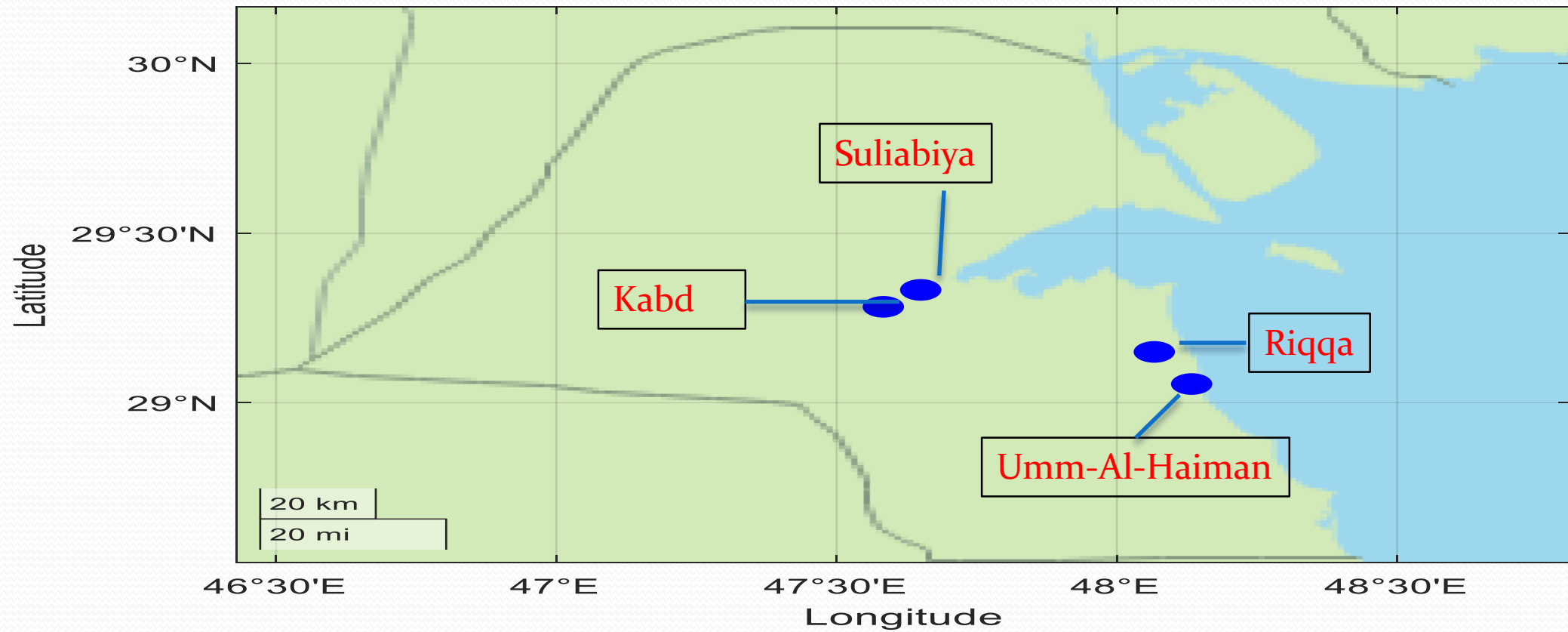
- ❑ According to WHO, the adverse impact of estrogens can appear at low concentrations as 1 ng/l.

Introduction Cont.

- ❑ Estrogens are often excreted as urine, and thus, they end ultimately in wastewater treatment plants (WWTPs).
- ❑ WWTPs are considered to be the major point sources of pollution with estrogens.
 - Efficient removal at WWTPs is the best control strategy.
- ❑ The main objectives of this study were to determine the fate of estrogenic compounds in Kuwaiti municipal WWTPs.

Materials & Methods

- Kuwait has four main activated sludge WWTPs



Materials and Methods Cont.

Design of Kuwait's Municipal WWTPs

Plant	Treatment Level	Design Capacity (m ³ /d)	Current Load (m ³ /d)
Kabd	Tertiary (Cl+UV)	250,000	160,000
Riqqa	Tertiary (Cl)	180,000	260,000
Sulaibiya	Advanced (UF+RO)	600,000	625,000
Um-Al-Haiman	Tertiary (Cl+UV)	27,000	23,000

Materials and Methods Cont.

- Estrogens concentrations of the influents and effluents streams of three WWTPs (Kabd, Sulaibiya and Umm-AlHaiman) were monitored for ten months.
- Concentrations of five estrogens (E₁, E₂, EE₂, E₃, DES) were determined by Solid-Phase Extraction (SPE) Gas Chromatography-Mass Spectrometry (GC-MS) method.

Results

Influent Concentrations of Estrogens (ng/l)

Estrogens Type	WWTP	Minimum	Mean	Maximum	Std.	C.V. (%)
E1	Kabd	0	4	14	5	147
	Sulibiya	0	72	372	148	205
	Haiman	6	11	14	3	29
E2	Kabd	0	3	9	4	128
	Sulibiya	0	32	160	63	195
	Haiman	0	5	10	4	83
EE2	Kabd	0	19	50	15	80
	Sulibiya	0	194	474	199	102
	Haiman	0	36	90	42	116
E3	Kabd	0	3	20	8	265
	Sulibiya	0	65	360	145	225
	Haiman	0	25	88	32	127

Results Cont.

Influent Concentrations Cont.

- ❑ Kabd, Sulaibiya and Um-Al-Haiman plants are located at 6 km, 25 km and 10 km, respectively, from the catchment areas.
- ❑ Higher E₁ at Sulaibiya can be attributed to biodegradation and transformation of E₂ and EE₂ into E₁ conjugates during transportation in the relatively long sewerage system.
- ❑ Concentrations of the synthetic estrogens, EE₂, were highest at Sulaibiya plant because it treats most of the urban wastewater of Kuwait.

Results Cont.

Effluent Concentrations of estrogens (ng/l)

Estrogens Type	WWTP	Minimum	Mean	Maximum	Std.	C.V. (%)
E ₁	Kabd	0	12	54	19	155
	Sulibiya	0	45	233	92	205
	Haiman	0	1	4	2	243
E ₂	Kabd	0	1	8	3	265
	Sulibiya	0	4	7	3	78
	Haiman	0	2	8	4	155
EE ₂	Kabd	0	10	28	12	124
	Sulibiya	0	14	70	28	200
	Haiman	0	16	40	15	96
EE ₃	Kabd	0	7	18	8	122
	Sulibiya	0	12	22	10	83
	Haiman	0	7	19	10	144

Results Cont.

Effluent Concentrations Cont.

- ❑ As expected, the highest concentrations of both natural (E₁, E₂ and E₃) and synthetic (EE₂) estrogens found for the Sulaibiya plant, which experienced the highest estrogens loading.
- ❑ Umm-Al-Haiman achieved much lower concentration of E₁ (1 ng/l) compared to Kabd plant (12 ng/l).
- ❑ Except for E₁ concentrations, there were no significant difference between the average concentrations of estrogens in the effluents of Umm-Al-Haiman and of Kabd plants.
- ❑ The very high variation (STD > mean) of effluent concentration indicates that the operation of the Kuwaiti WWTPs need to optimized/upgraded for the removal of estrogens.

Results Cont.

Removal Efficiency of Estrogens (%)

WWTP	E ₁	E ₂	EE ₂
Kabd	-234	66	49
Suliybiya	37	87	93
Um-Al-Haiman	94	52	56

- ❑ Highest removal of estrogens at the Suliabiya plant can be attributed to the advanced membrane treatment.
- ❑ However, the study did not investigate the contribution of the different stages of wastewater treatment (preliminary, secondary, tertiary or advanced) nor the effects of operational variables.

Results Cont.

Potential Impacts of Reused Wastewater

- ❑ Obtained results showed that wastewater treated in Kuwait contain significant concentrations of estrogens.
- ❑ Threats to human health arises from ingesting estrogens via drinking contaminated water or eating contaminated food.
- ❑ The likelihood of mixing treated wastewater with drinking water is zero in Kuwait. Further, treated wastewater is not allowed to be used for irrigating edible crops.
- ❑ Nonetheless, estrogens can reach humans indirectly via eating meat of animals fed on contaminated grass or drinking contaminated groundwater.
- ❑ Thus, regulations of estrogens discharges should be urgently developed, as has recently started in EU, USA, Japan and Canada.

Conclusions and Recommendations

- ❑ Concentration of estrogens in the influent streams ranged from 0.0 to 474 ng/l, while that in the effluent streams ranged between 0.0 to 233 ng/l
- ❑ Influent concentration of E1 seemed to increase with the distance of plant from catchment area.
- ❑ The average removal of total estrogens were 13%, 79% and 68% for Kabd, Suliabiya and Umm-Al-Haiman, respectively.
- ❑ Operations of WWTPs in Kuwait need to be upgraded/optimized in order to maximize estrogens' elimination.
- ❑ Kuwait needs to regulate estrogens discharges from WWTPs in order to prevent further pollution of marine areas and ground water by estrogens.

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