Analysis of Some Pharmaceuticals in Surface Water in Jordan

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Overview

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INTRODUCTION

- Jordan's total population of 9.5 million, 6.6 million Jordanians, 2.9 million non-Jordanians representing 30.6 per cent of overall population (2016).
- The country is facing a future of very limited water resources, among the lowest in the world on a per capita basis.
- Wastewater reuse is being increasingly seen as the main long term strategy for conservation of limited freshwater resources.
- In Jordan, the reuse of treated wastewater for irrigation is being practiced since the eighties of last century to overcome the severe water shortage.

INTRODUCTION

- There are fourteen dams in Jordan with total reservoir capacity of about 336 MCM, including the desert dams.
- Stored water from these dams is used for drinking water, agriculture activities and groundwater recharge.
- Some of these dams are collecting surface runoff and treated wastewater while other dams are collecting only runoff.
- Treated wastewater is mixed with freshwater at the dams and then used for unrestricted irrigation in the Jordan Valley.

INTRODUCTION

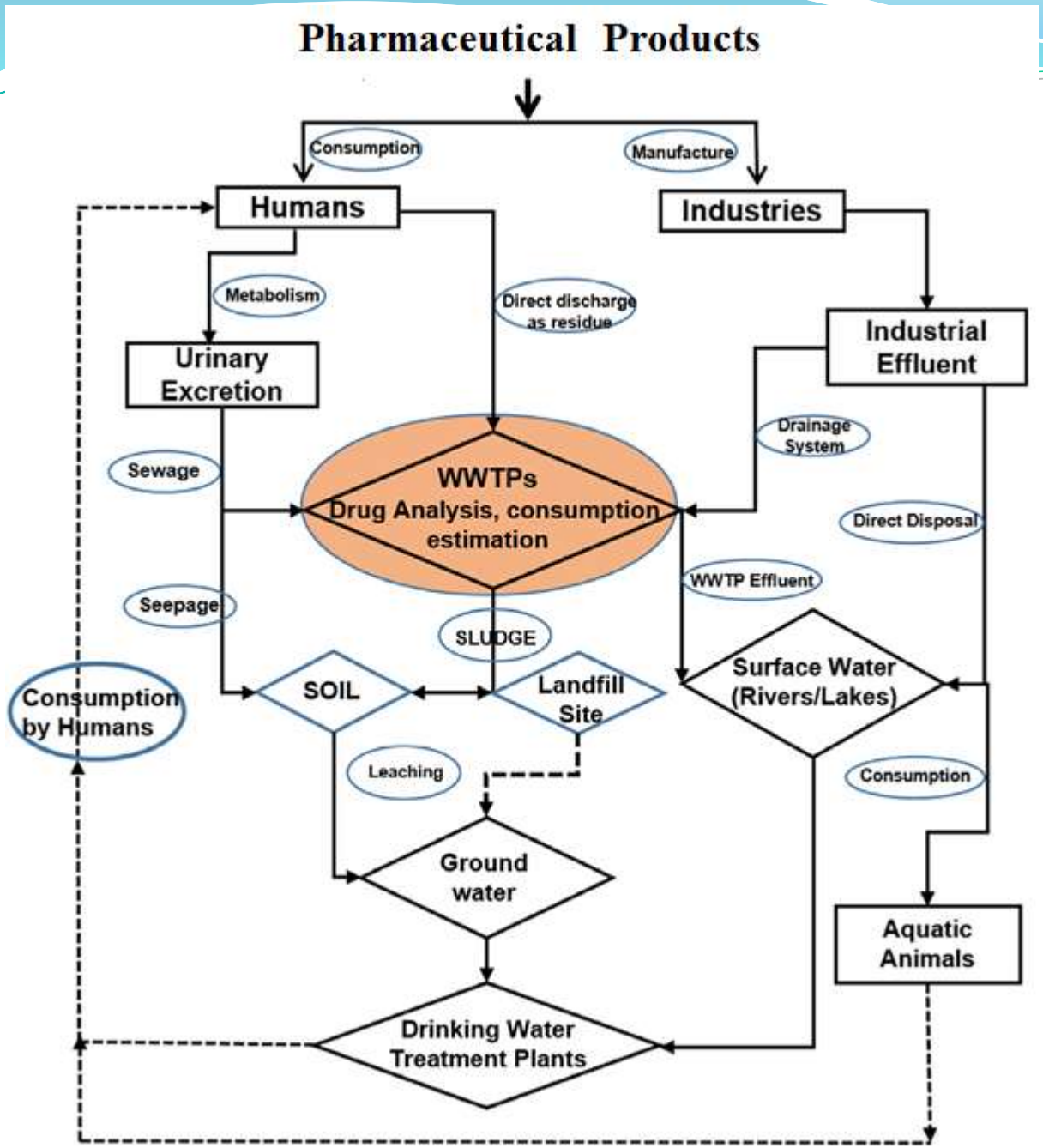
- Emerging contaminants are components of organic matter originating from wastewater treatment plant effluents. These substances enter the environment via wastewater treatment plants effluent discharges, land application of sewage sludge and agricultural animal wastes
- The current conventional secondary waste water treatment plants operated in many countries (such as Jordan) are unable to effectively remove most of the emerging contaminants investigated in the literature.
- The main sources of these contaminants in the wastewater are pharmaceuticals and personal care products (PPCPs), endocrine disrupting chemicals (EDCs), plasticisers (e.g. bisphenol-A), flame-retardants, fuel additives and other industrial organic.

INTRODUCTION

- A recent studies conducted in Europe, USA and Canada have showed that wastewater (treated and untreated) is contaminated by pharmaceutical compounds which has caused a serious contamination to the water resources (ground water and surface water) by these compounds
- EPA and USGS have recently reported that 80 percent of the streams tested were found to be contaminated by pharmaceutical drug, at least 46 million Americans are drinking water contaminated with trace amounts of pharmaceuticals and more than 270 million pounds of Pharmaceutical compounds is dumped every year into waterways nationwide. These studies have recommended that there is a need for more restricted legislation to regulate pharmaceutical drug disposal.

INTRODUCTION

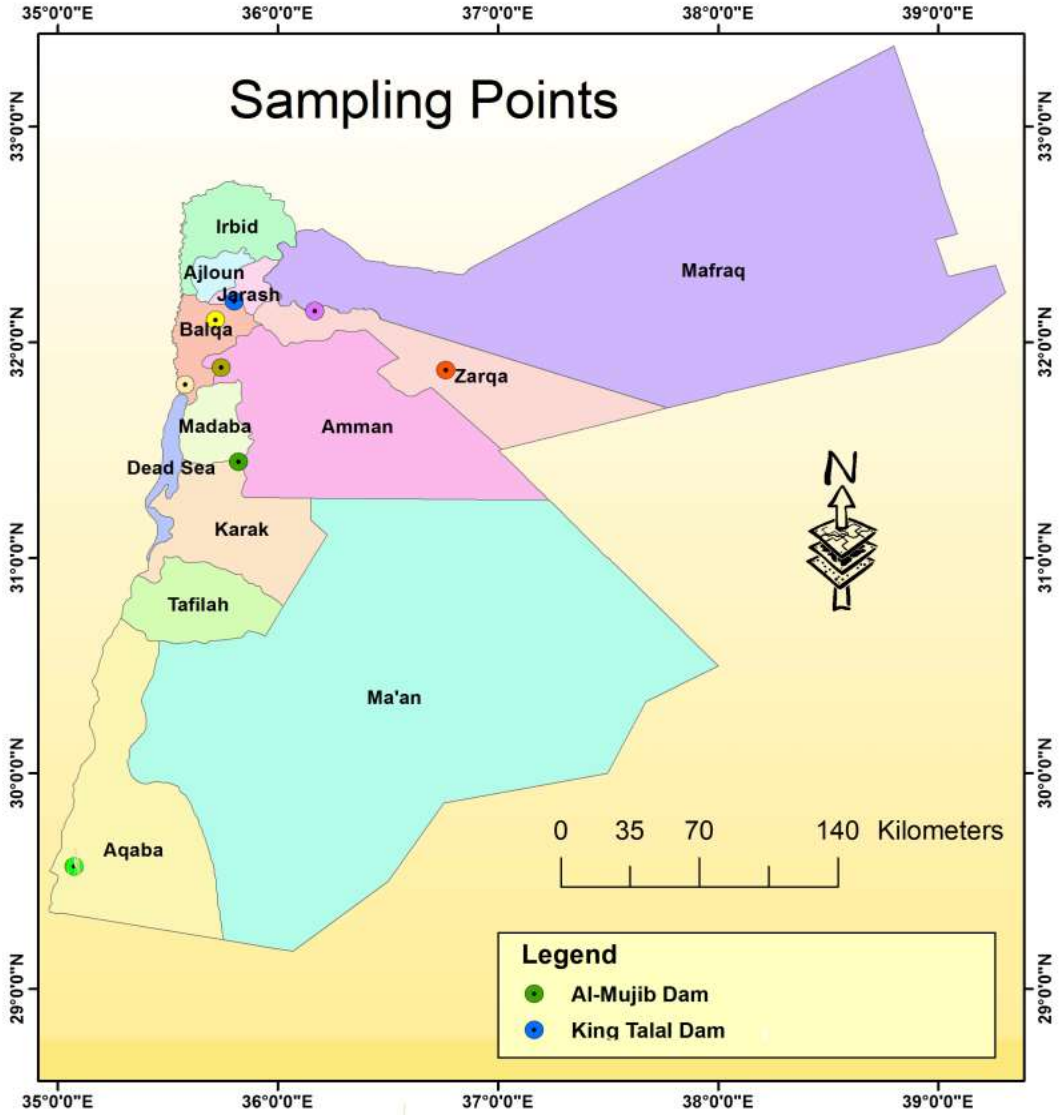
- PPCPs have been detected in all environmental compartments, such as water, soil, air, Biota and in wastewater at concentrations ranging from sub-ng/L levels to µg/L.
- The presence of these compounds in the environment has been shown to result in adverse ecological and health risks for the exposed biota or humans, even at very low concentrations (ng/L range).
- Municipal WWTPs are considered as a main source for the discharge of PPCPs into surface waters. The literature indicates that currently employed conventional wastewater treatment processes (primary and secondary treatment) cannot effectively eliminate all PPCPs in the raw wastewater.


Pharmaceutical Products
Consumption
Manufacture
Humans
Industries
Metabolism
Direct discharge as residue
Urinary Excretion
Industrial Effluent
Drainage System
Sewage
WWTPs
Drug Analysis, consumption estimation
Direct Disposal
WWTP Effluent
Seepage
SLUDGE
Surface Water (Rivers/Lakes)
Consumption by Humans
SOIL
Landfill Site
Leaching
Consumption
Ground water
Aquatic Animals
Drinking Water Treatment Plants

INTRODUCTION

- The research efforts made to address this issue in low income countries (i.e. Jordan) is still lag behinds developed countries due to lack of monitoring of PPCPs compounds in water resources as well as lack of availability in the analytical instruments and methods needed to identify PPCPs at low concentration levels (ng/L).
- Very little data are currently available in Jordan on the occurrence and fate of PPCPs in Surface water.
- The objective of this study was to determine some PPCPs compounds in two dams in Jordan during summer season.

Methodology: Sampling Sites



Methodology: Sample Collection

- King Talal Dam (KTD) is located in Amman-Zarqa basin (AZB) which comprises several cities (Amman, Zarqa, Mafraq, Jerash and Balqa).
- The total area of the basin 3860 km^2 where around 95% of the area is within Jordan and 5% is in Syria reaching to the Syrian city of Salkhad in Jebal al-Arab the Syrian boarders.
- The Zarqa river is the main watercourse passing through AZB and discharge into KTD.
- KTD is currently receiving surface flow including surface runoff from AZB and treated wastewater discharged by the four wastewater treatment plants (As Samra, Al-Baqa, Abu Nusair and Jarash). Therefore, KTD water is being only used for agriculture activities in Jordan valley.

Methodology: Sample Collection

- Mujib dam is located in southern Jordan at Mujib basin (90 kilometres south of Amman). The Mujib watershed covers an area of 6571.4 km^2.
- Five dams have been constructed across the catchment. The most important is Mujib dam with a capacity of 16.8 MCM per year.
- The Mujib dam is currently receiving only surface runoff from Mujib catchment. Therefore, its water quality is being used for drinking supplies water for the southern Ghor and Amman.
- The water samples for this study were collected from the discharge of dam.

Sample Collection: King Talal Dam

Sample Collection: Mujib Dam

Methodology: Analytical Methods

- The water samples for this study were collected from the effluent of the dam.
- All extracted samples were then shipped to WSL/UNL for elution and analysis.
- The pharmaceuticals compounds (18 compounds) were analyzed by LC–MS/MS.

Results: Pharmaceuticals compounds

Compound	Family and use	CAS number
1,7-dimethylxanthine	Stimulant	611-59-6
Acetaminophen	Analgesic	103-90-2
Amphetamine	Stimulant	300-62-9
Caffeine	(CNS) stimulant	58-08-2
Carbamazepine	Anticonvulsant	298-46-4
Cimetidine	Antiacid	51481-61-9
Cotinine	Stimulant	486-56-6
Diphenhydramine	Antihistamine	58-73-1
MDA	Abuse drug	101-77-9
MDMA	Abuse drug	42542-10-9

Results: Pharmaceuticals compounds

Compound	Family and use	CAS number
MDMA	Abuse drug	42542-10-9
Methamphetamine	Stimulant	51-57-0
Morphine	Narcotic Analgesics	57-27-2
Phenazone	Analgesic	60-80-0
Sulfachloropyradazine	Antibacterial	201-269-9
Sulfamethazine	Antibacterial	57-68-1
Sulfamethoxazole	Antibiotic	723-46-6
Thiabendazole	Fungicide and Parasiticide	148-79-8
Trimethoprim	Antibiotic	738-70-5

RESULTS: CONCENTRATIONS OF PHARMACEUTICAL COMPOUNDS

Pharmaceutical Compound	King Talal Dam (KTD) Effluent Concentration (µg/l)	Mujib Dam Effluent Concentration (µg/l)
1,7-Dimethylxanthine	0.053	0.010
Acetaminophen	0.036	<0.005
Amphetamine	0.018	<0.005
Caffeine	0.076	0.089
Carbamazepine	0.358	<0.005
Cimetidine	<0.005	<0.005
Cotinine	0.053	0.010
Diphenhydramine	0.036	<0.005

RESULTS: CONCENTRATIONS OF PHARMACEUTICAL COMPOUNDS

Pharmaceutical Compound	Influent Concentration (ppb) As-Samra WWTP	Influent Concentration (ppb) Wadi Al-Seer WWTP
MDA	0.015	0.015
MDMA	<0.005	<0.005
Methamphetamine	<0.005	<0.005
Morphine	<0.005	<0.005
Phenazone	<0.005	<0.005
Sulfachloropyridazine	<0.005	<0.005
Sulfamethazine	0.059	0.050
Sulfamethoxazole	<0.005	<0.005
Thiabendazole	0.041	0.008
Trimethoprim	0.039	<0.005

RESULTS: CONCENTRATIONS OF PHARMACEUTICAL COMPOUNDS

- For KTD, the results showed that carbamazepine was the pharmaceutical present at the highest concentration levels 0.358 µg/l, followed by caffeine 0.076µg/l, phenazone 0.059 µg/l, 1,7-Dimethylxanthine 0.053 µg/l, sulfamethazine 0.041 µg/l, sulfamethoxazole 0.039µg/l, acetaminophen 0.036 µg/l, amphetamine 0.018 µg/l, cotinine 0.015 µg/l, trimethoprim 0.015 µg/l.
- However, for Mujib dam, caffeine was the highest concentration levels 0.089 µg/l, followed by phenazone 0.050 µg/l, cotinine 0.015 µg/l and 1,7-dimethylxanthine 0.010 µg/l.

Results: KTD Catchment

Results: Mujib Dam Catchment

RESULTS: CONCENTRATIONS OF PHARMACEUTICAL COMPOUNDS

Compound	location	Worldwide Concentration (ng/L)	This study Concentration (ng/L)
1,7-dimethylxanthine	Lake Michigan-USA	25-75	10-53
Acetaminophen	Lake Michigan-USA	2.5-17	<5-36
Amphetamine	Pearl river- China	17.4-58.2	<5-18
Caffeine	Lake Michigan-USA	18-100	76-89
Carbamazepine	Lake Michigan-USA	0.5-10	<5-358
Cotinine	Lake Michigan-USA	1.5-11	15
Phenazone	Czech. Rep., Germany	35- 2500	50-59
Sulfamethazine	Lake Michigan-USA	0.5-1.5	8-41
Sulfamethoxazole	Lake Michigan-USA	1.5-220	<5-39
	Selangor River -Malaysia	84.31-114.24	
Trimethoprim	Lake Michigan-USA	2.5-18	<5-15

Conclusion

- 18 pharmaceutical compounds were screened in the water samples collected from KTD and Mujib dam
- KTD detected more pharmaceutical compounds compared to Mujib dam.
- Ten pharmaceutical compounds in the effluent of King Talal Dam, while four pharmaceutical compounds detected at Al-Mujb Dam.

Conclusion

- At KTD, Carbamazepine was the pharmaceutical present at the highest concentration levels, while Caffeine was the highest concentration at Mujib dam.
- Treated wastewater discharged by wastewater treatment plants might be the major source of the increase of these pharmaceuticals in the KTD.

ACKNOWLEDGMENT

The study was supported by the Partnership for Enhanced Engagement in Research (PEER) program administered by the National Academy of Sciences (NAS) and funded by the United States Agency for International Development (USAID), Project number: 5-91 (Cycle 5) “The occurrence and fate of pharmaceutical residues from their sources to water bodies and food chain”.

Thank you