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Pollution Sources to Zarqa River: Their Impact on the River Water Quality as a Source of Irrigation Water

Online Workshop , 16 December 2020

Prof. Abbas Al-Omari
Water, Energy and Environment Center
The University of Jordan

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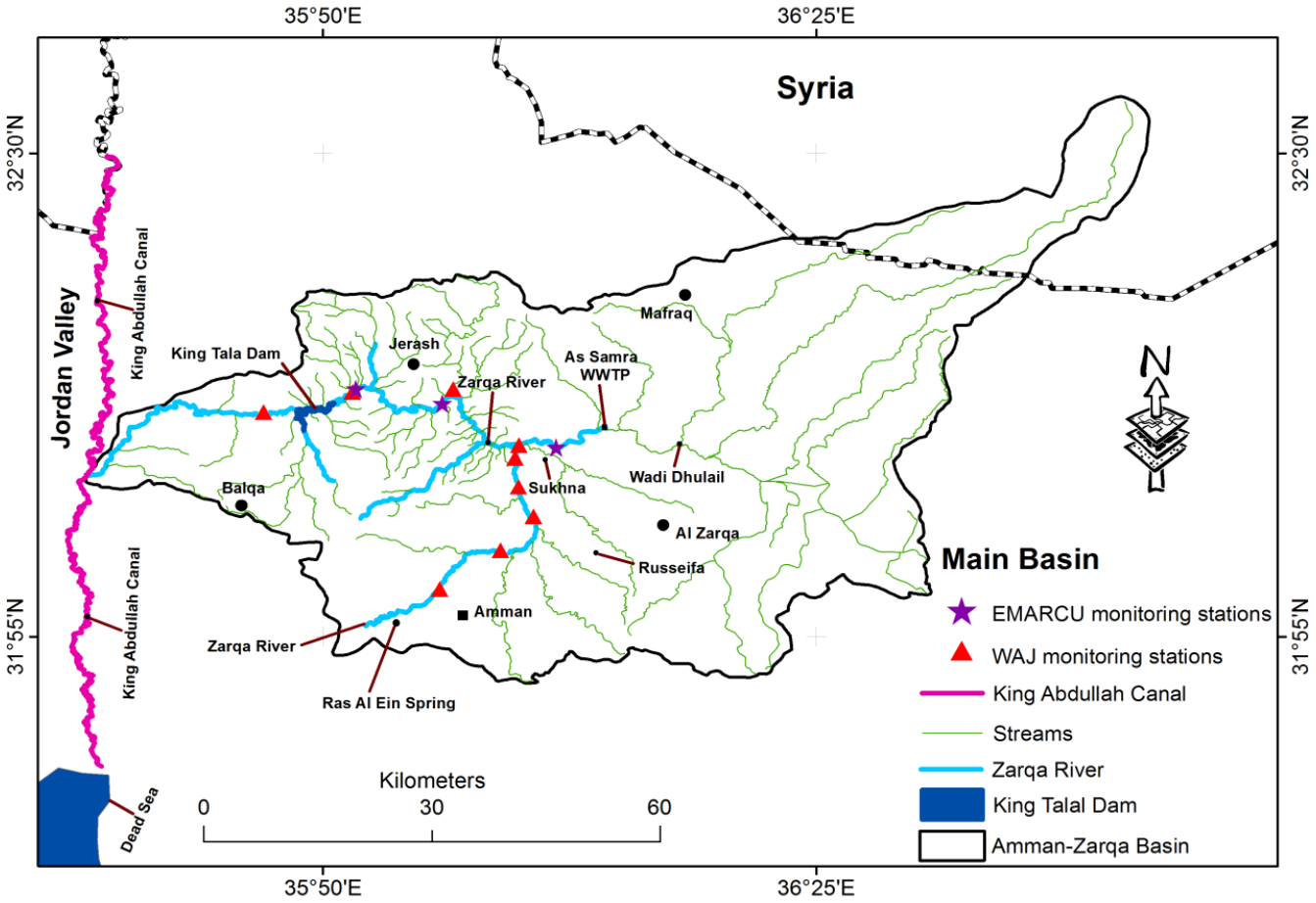
STUDY AREA
AMMAN ZARQA BASIN



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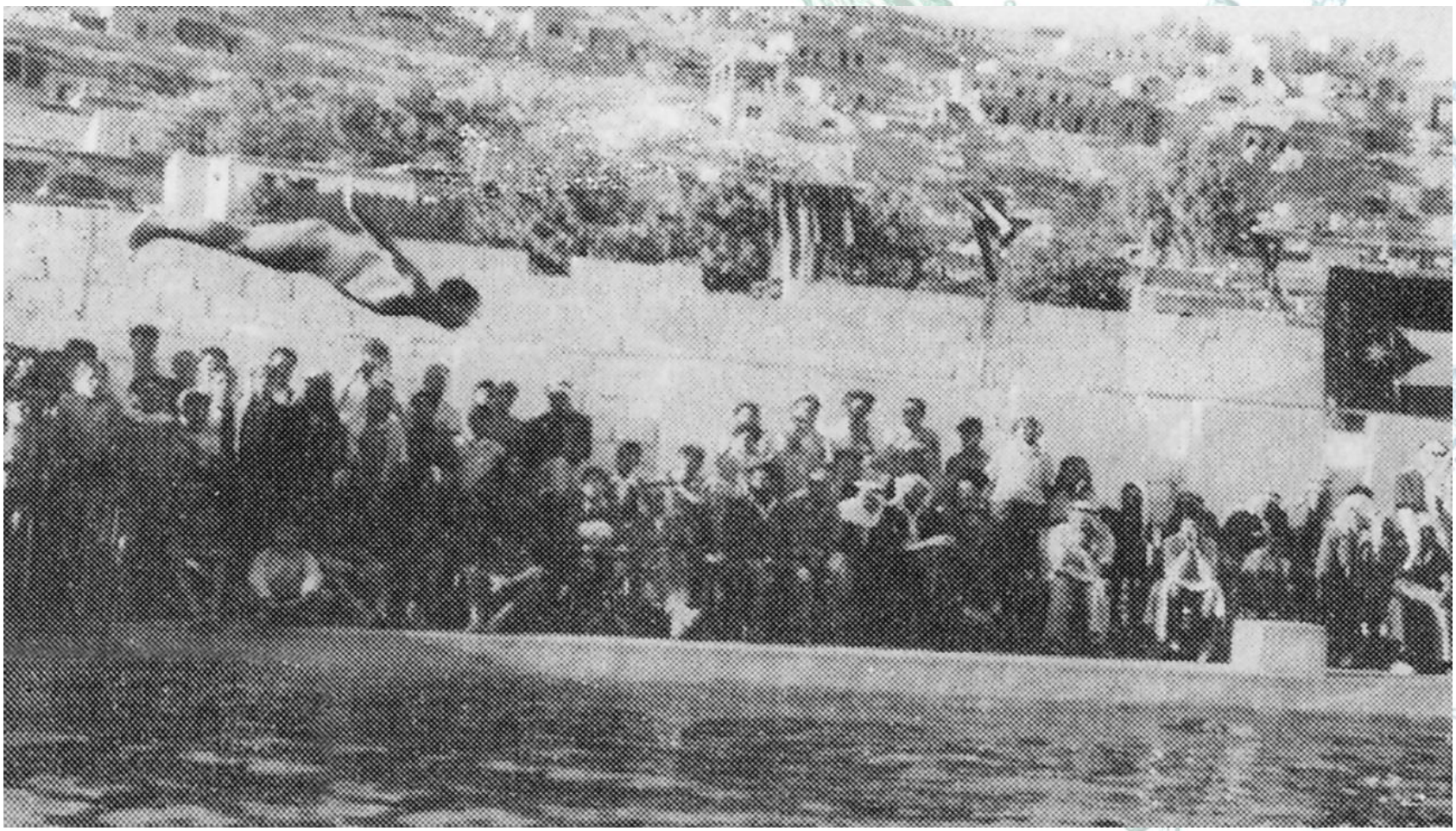
ZARQA RIVER IN THE PAST



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OBJECTIVE

- To identify pollution sources to the river and assess their impacts on the river water quality and to observe river flow

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METHODOLOGY

- River survey
- Zarqa River water quality data collection
  - Environmental Monitoring And Research Central Unit (EMARCU)
  - Water Authority of Jordan (WAJ)
  - Grab sampling
- Analysis of the collected data
- Conclusions

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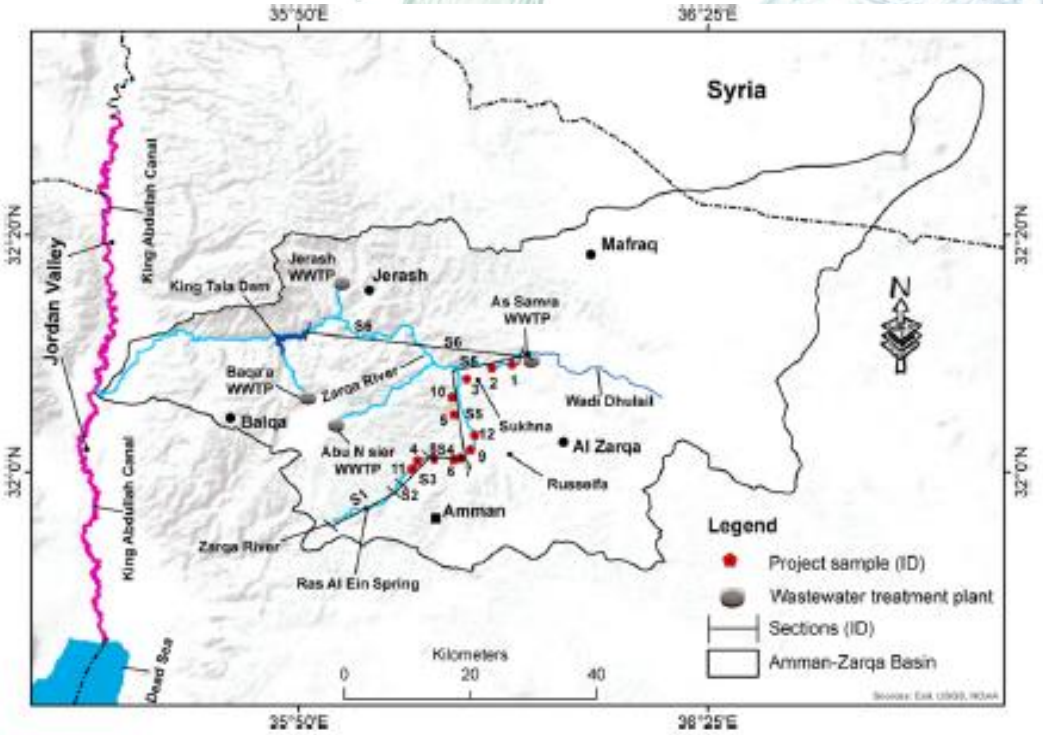
RIVER SURVEY

A field survey has been conducted to identify pollution sources to the river and to observe the river flow. Based on land use/cover and the prevailing anthropogenic activities, the river was divided into six sections (Fig. 3). For each section, the sources of pollution and pollutants released by these sources have been identified.



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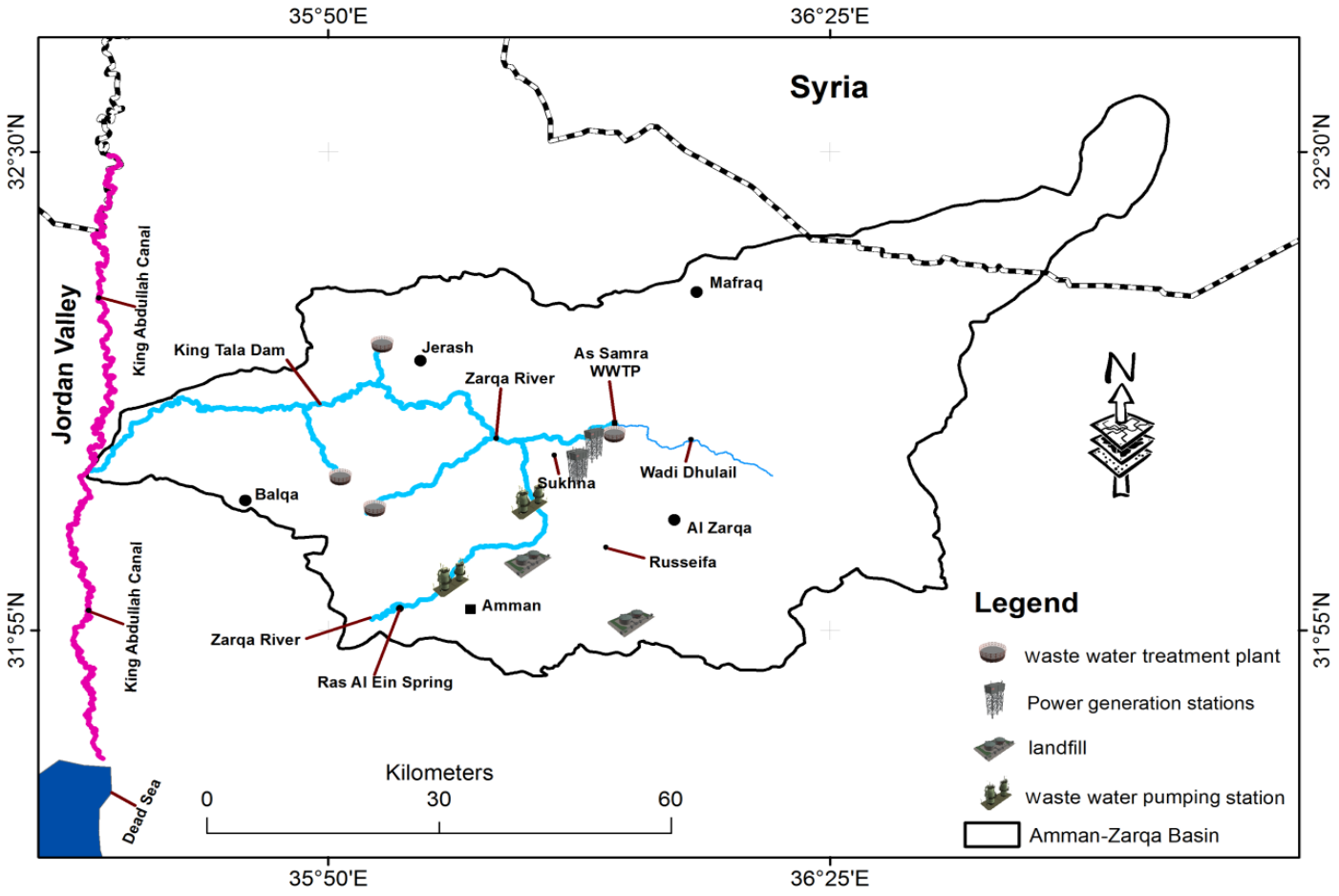
POLLUTION SOURCES TO THE RIVER



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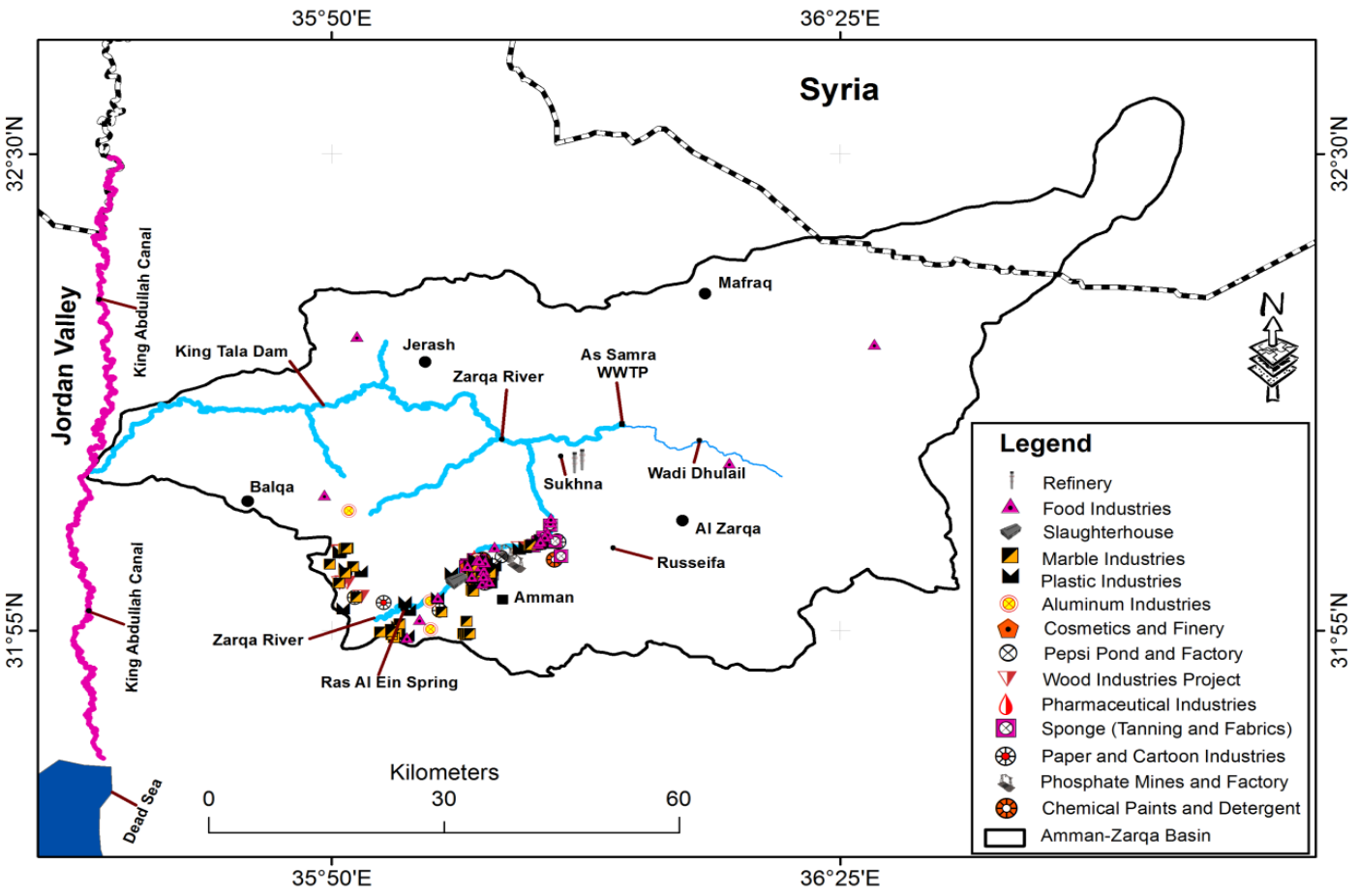
INDUSTRIES ALONG ZARQA RIVER



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INDUSTRIES ALONG ZARQA RIVER AND POLLUTANTS RELEASED BY THEM

Industries along the Zarqa River and their pollutants based on literature

Industry	Number of industries	Typical pollutants
Tanning industries	2	TDS, TSS, BOD, COD, NH_4, SO_4, S^{-2}, P, Al, Cr, oil and grease (Bond and Straub 1974;Tisler et al. 2004)
Fabric industries	15	TSS, BOD, COD, NH_4, SO_4, S^{-2}, oil and grease, Cd, Cr, Pb, Zn, CN (Aydin et al. 2010; Hussein 2013; Mutamim et al. 2012)
Pharmaceutical industries	2	COD, BOD (Mutamim et al. 2012)
Abandoned phosphate mines	2	P
Paper and carton industries	18	TDS, TSS, BOD, COD, Ca, Na, Cr, Cl, color (Bond and Straub1974; Khansorthong and Hunsom 2009)
Wood-based industries	9	TDS, COD, polyphenols (Kaczala et al. 2012)
Marble industries	47	TDS, BOD, COD, HCO_3^{-1}, Ca^{+2}, Mg^{+2}, K^{+1}, Cl^-, NO_3^-, SO_4^{-2}, Na^+, Al^{+3}, Fe, Mn, Zn, Cu, Pb, Cr, Cd, Ni, solid waste (Aukour and Al-Qinna 2008)
Food industries	34	TDS, TSS, COD, BOD, oil and grease, P, H_2S, NH_4, SO_4^{-2}, Fe, Cl^-, fat and oil (Aydin et al. 2010; Bond and Straub 1974)
Cosmetics	3	TDS, TSS, BOD, COD, fat and oil (Bautista et al. 2007), B (EPA-OGWDW 2008)
Paints	4	TSS, COD, BOD, P, TKN, Cl^-, SO_4^{-2} (Aboulhassan et al. 2014)
Aluminum industries	4	TDS, TSS, BOD, COD, Fe, Zn, Cr, Cu, Cd, Pb, Ni, Mn (Tariq et al. 2006)
Petroleum refinery	1	BOD, COD, TSS, Al, As, Cd, Cr, Cu, Pb, Ni, Zn (Bond and Straub 1974)
Amman slaughterhouse	1	BOD, COD, VSS, N, TSS (Bond & Straub1974; Bustillo-Lecompte et al. 2016)
Pepsi factory and pond	1	BOD, COD, TSS, TDS, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn (Aboulhassan et al. 2014)
Battery factory	1	Pb, Cd, Cu, TSS, TDS, Hg, Ni, Fe, Al, Zn (Aydin et al. 2010; Arunlertaree et al. 2007)
Detergents	3	COD, BOD, oil and grease (El-Gohary et al. 1986; Remy et al. 2005), B (EPA-OGWDW 2008; HOWE 1998)
Petrochemical industries	49	COD, phenols, hydrocarbons, grease, sulfide (Dimoglo et al. 2004; Vaiopoulou et al. 2005), B (Ozturk and Kavak 2005)

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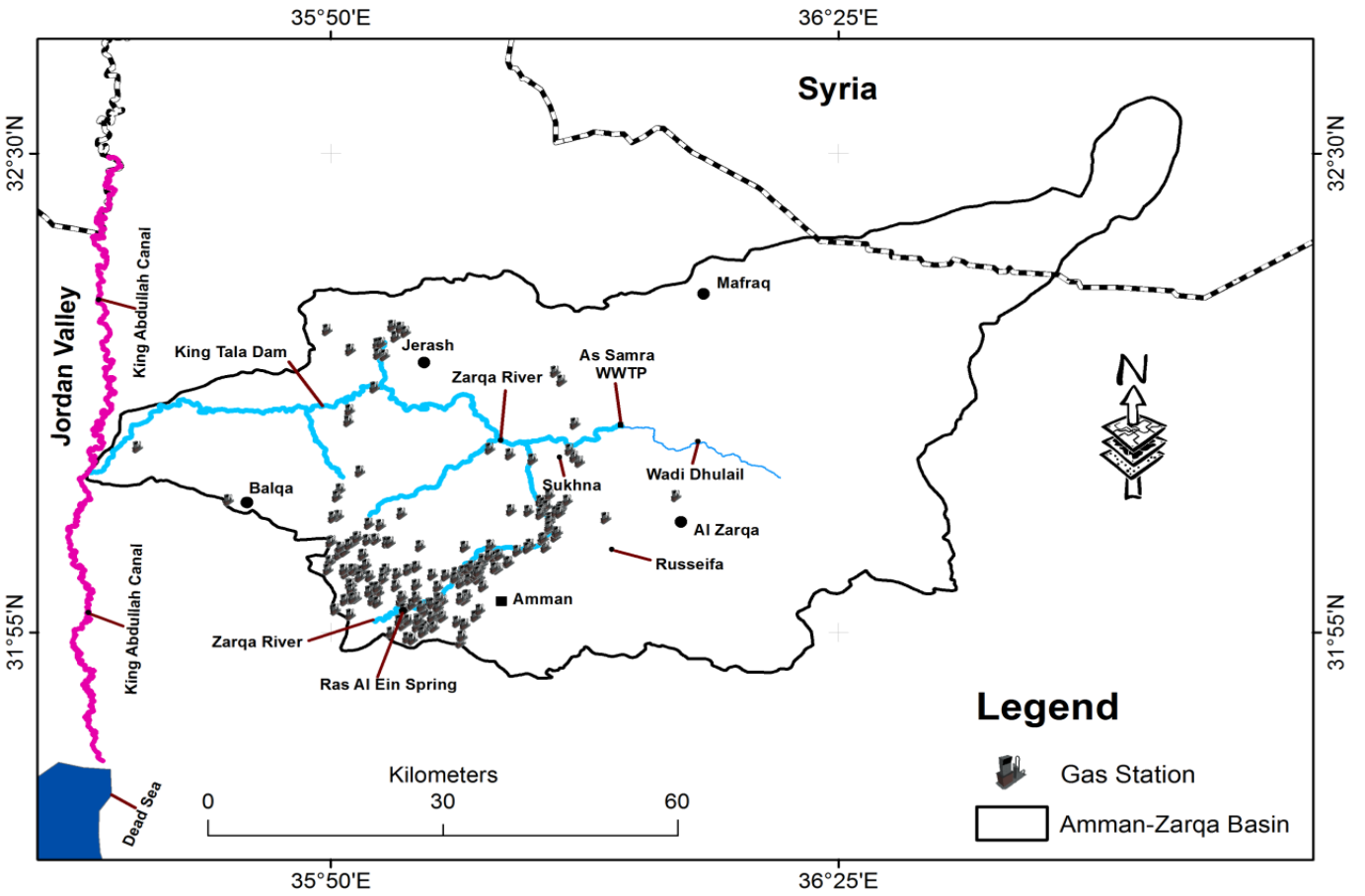
POLLUTION SOURCES TO THE RIVER



WAJ AND EMARCU MONITORING PROGRAMS

Parameters monitored and frequency of sampling for the Water Authority of Jordan and EMARCU monitoring programs

	Parameters	Frequency of sampling
Water Authority of Jordan monitoring program	pH, TDS, TSS, COD, BOD_5, TN, NO_3, NH_4, PO_4, *Escherichia coli*	Monthly from all sampling stations
	MBAS, nematode eggs, turbidity, FOG, B, SO_4, Na, Mg, CN, Ni, Ca, HCO_3, As, Be, Cu, Fe, Mn, Ni, Pb, Se, Cd, Zn, Cr, Cl^-, Al, V, Co, Mo, Li, F	Once every 3 months from selected locations provided that all locations are sampled twice yearly
EMARCU monitoring program	COD, temperature, turbidity, total nitrogen (TN)*, total phosphorus (TP)*, electrical conductivity (EC), and pH	TP and TN are sampled every 6 h All other parameters are sampled hourly

*TP and TN are not monitored at station 9

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GRAB SAMPLING

Table 2 Grab sampling events and parameters monitored

Sample no. (Fig. 3)	Grab sampling near EMARCU monitoring stations		
	Sampling date	Sampling location	Parameters analyzed
	December 18, 2011	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	December 28, 2011	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	January 23, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	February 27, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	March 5, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	June 17, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	October 21, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	December 23, 2012	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	February 4, 2013	Monitoring stations 8, 9, 10	Fe, Pb, Cu, Zn, Cd
	Grab sampling in the vicinity of certain industries		
2	October 23, 2013	Up- and downstream of pipeline factory	Zn, Cd, Cu, Fe, Cr, Mn, Ni
1		Downstream of steel factory	Zn, Cd, Cu, Fe, Cr, Mn, Ni
7		Downstream of fine tissue factory	Cr
9		Downstream of paper factory	Cr
8		Up- and downstream of yeast factory	Zn, Cd, Cu, Fe, Cr, Mn, Ni
3	November 17, 2013	Downstream of Jordan textile factory	Zn, Cd, Cu, Fe, Cr, Mn, Ni
6	November 26, 2013	Downstream of Arabic factory for soft drinks	Al
12	January 20, 2014	Downstream of food factory	TDS, TSS, COD, BOD, pH
5	February 20, 2014	Downstream of oil industry	TDS, TSS, COD, BOD, pH
4		Downstream of soft drink factory	TDS, TSS, COD, BOD, pH
11		Downstream of fodder factory	TDS, TSS, COD, BOD, pH
10		Downstream of food factory	TDS, TSS, COD, BOD, pH

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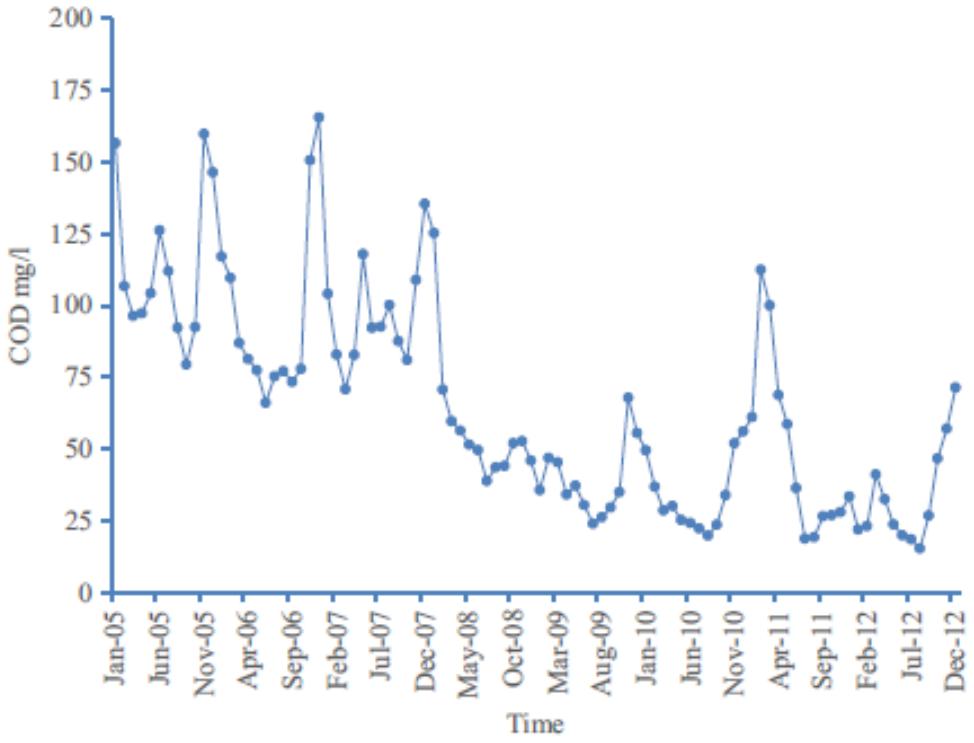
POLLUTANTS

- Solid waste
- Organics and solids
- Nutrients
- Heavy metals

ORGANICS

Fig. 9 COD concentration at the Zarqa River at EMARCU monitoring station 10 (Al-Omari et al. 2017)



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NUTRIENTS

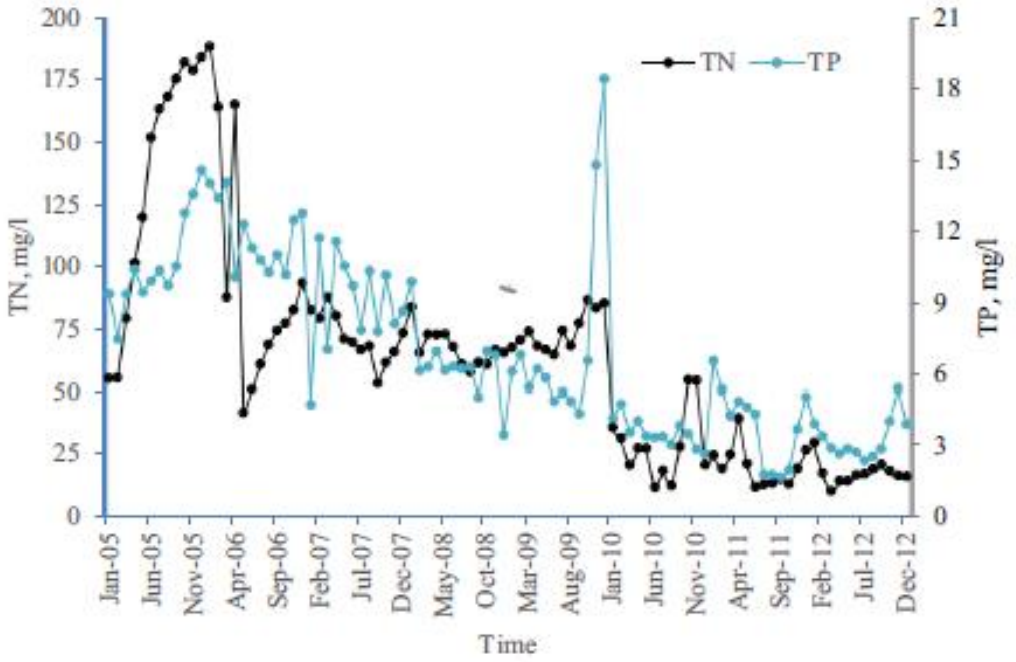

Fig. 11 TN and TP concentrations at the Zarqa River at EMARCU monitoring station 10 (Al-Omari et al. 2017)

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SOURCES OF HEAVY METALS TO ZARQA RIVER

Heavy metal	Source industries
Fe	Marble, aluminum, Pepsi, battery factory
Cr	Tanning, fabrics, marble, aluminum, paper, petroleum refinery, and Pepsi
Zn	Marble, fabric, aluminum, paper, petroleum refinery, Pepsi, battery factory
Cu	Marble, aluminum, paper, petroleum refinery, Pepsi, battery factory, fabric
Ni	Marble, aluminum, paper, petroleum refinery, Pepsi, battery factory, fabric
Pb	Marble, aluminum, paper, petroleum refinery, Pepsi, battery factory
Mn	Marble, aluminum, Pepsi
Cd	Marble, fabric, aluminum, petroleum refinery, Pepsi, battery factory
Se	Marble
Al	Marble, tanning, aluminum, petroleum refinery, battery factory
Hg	Paper, battery factory
As	Petroleum refinery
B	Detergents, petrochemical industries, cosmetics
CN	Fabric

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HEAVY METALS

Table 6 Spatial and temporal distribution of heavy metals exceedances in ZR

Name	Upstream of As Samra					Downstream of As Samra	
	Site no. 1	Site no. 2	Site no. 3	Site no. 4	Site no. 5	Site no. 6	Downstream of KTD
Boron	NV	NV	NV	W(1)	W(8) + S(4)	W(1)	W(7) + S(8)
Cadmium	W(1)	W(1)	W(1)	NV	W(1)	NV	W(1)
Chromium	NV	W(2)	NV	NV	W(2)	W(3)	NV
Copper	NV	NV	NV	NV	NV	NV	NV
Iron	NV	NV	NV	NV	NV	NV	NV
Lead	W(1)	NV	NV	NV	W(1)	NV	NV
Manganese	NV	W(2)	W(1)	W(2)	W(1)	W(4)	NV
Nickel	W(1)	W(1) + S(1)	NV	NV	W(1)	W(2)	S(1)
Zinc	NV	NV	NV	NV	NV	NV	NV

Summer months are April through October; winter months are November through March

NV, detected but has not exceeded the recommended limit; *W(i)*, exceeded the recommended limit during winter *i* times; *W (i) + S (j)*, exceeded the recommended limit during winter *i* times and during summer *j* times; *S (j)*, exceeded the recommended limit during summer *j* times; *KTD*, King Talal Dam

RIVER FLOW

It was observed that Zarqa River flow has diminished. Upstream of the confluence of the river with As Samra WWTP, river flow is intermittent, i.e. the river is almost dry except during winter storms. Downstream of the confluence of As Samra with the river, river flow consists mainly of As Samra effluent during the dry season and of As Samra effluent and flood water during the wet season. reasons advanced for the diminishing of the river flow is the gradual abstraction increase from the underlying groundwater to satisfy the increasing domestic and agricultural demands in the basin

IMPACT ON WATER QUALITY FOR IRRIGATION

Zarqa River water is used for restricted irrigation between As Samra and King Talal Dam, and for

Unrestricted irrigation downstream of KTD after mixing with King Abdulla Canal fresh water

Upstream of As Samra WWTP other water sources are used for irrigation as the river flows during winter only.

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