COUNTRY ENVIRONMENTAL ANALYSIS (CEA) OF JORDAN

Water Quality Component

Status of water quality; costs of water quality degradation; alleviation measures

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presented by:

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CEA Jordan: Water Quality

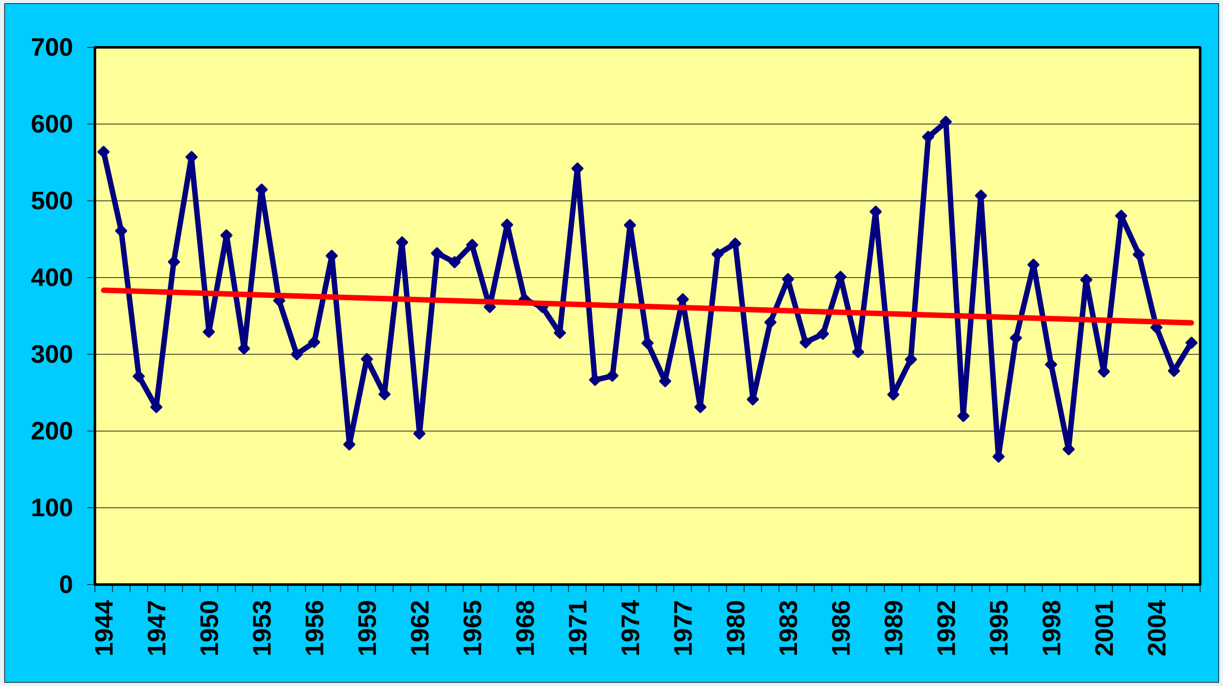
Contents of the presentation:

1. Water quantity an water budget
2. Groundwater quality; costs of degradation; measures
3. Surface water quality; costs of degradation; measures
4. Urban wastewater; health impacts; measures
5. Industrial wastewater; impacts; measures

Water quantity / water budget

Rainfall over the last 60 years

Consolidated average of 22 stations (WAJ, JMD) with long records



Water quantity / water budget

Water uses per source and water use category

Year 2005 [Source: Ministry of Water and Irrigation]

	municipal	industrial	irrigation	others	total
surface water	74.7	4.5	265.2	7.0	351.4
groundwater	209.6	33.8	254.8	7.9	506.1
treated wastewater	0.0	0.0	83.5	0.0	83.5
total	284.3	38.3	603.5	14.9	941.0

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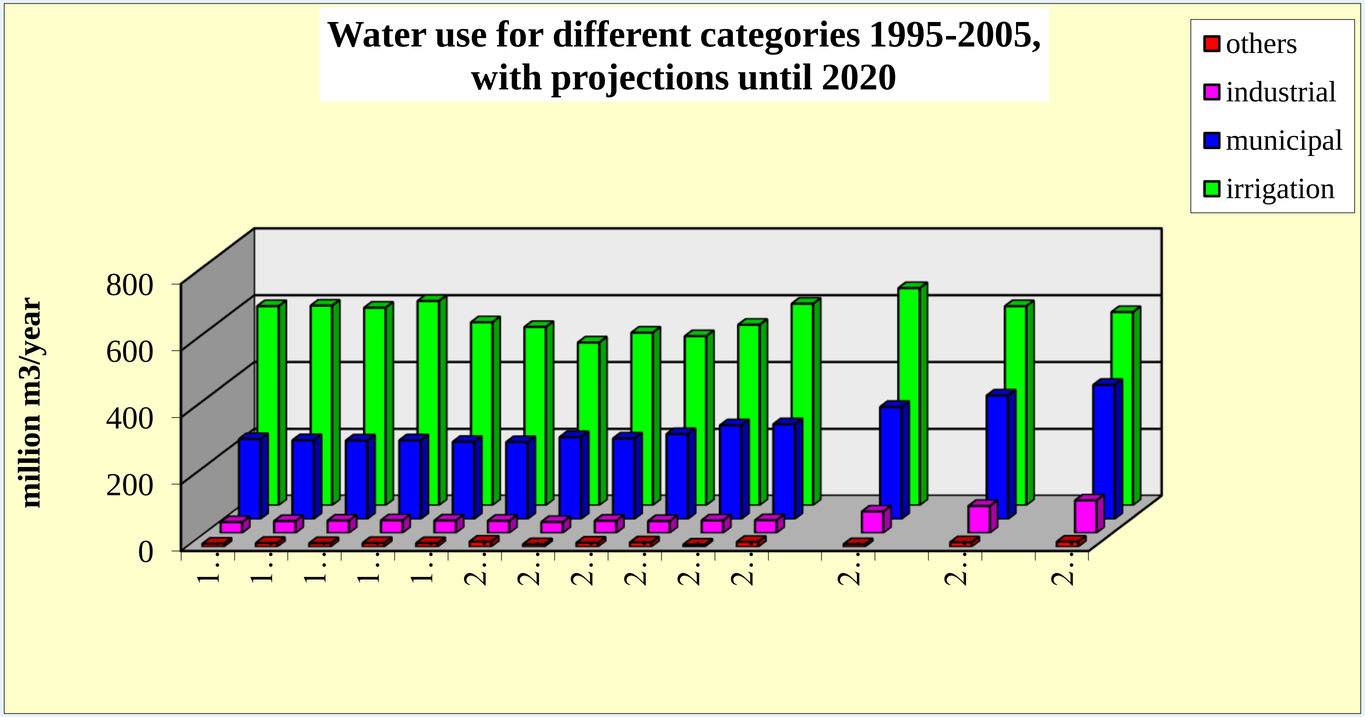
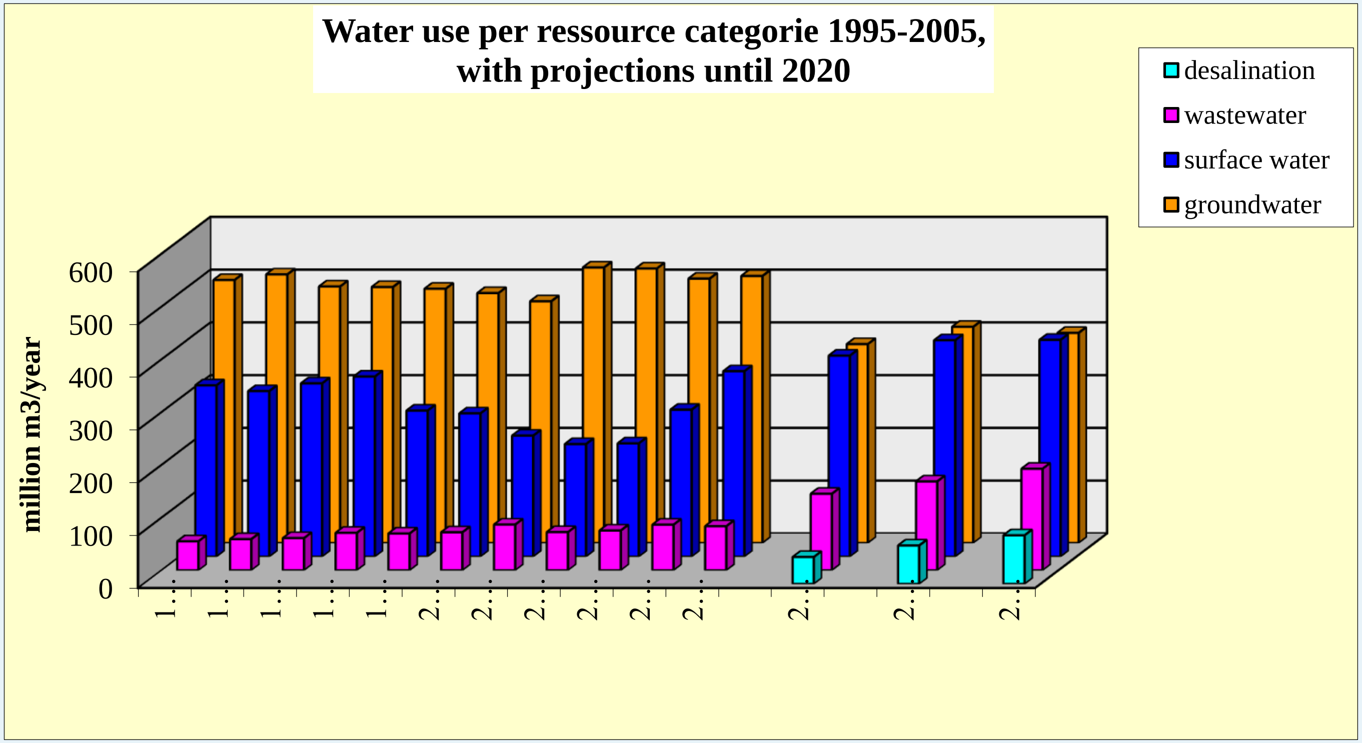
Water uses for different categories

[Source: Ministry of Water and Irrigation]



Water uses from different sources

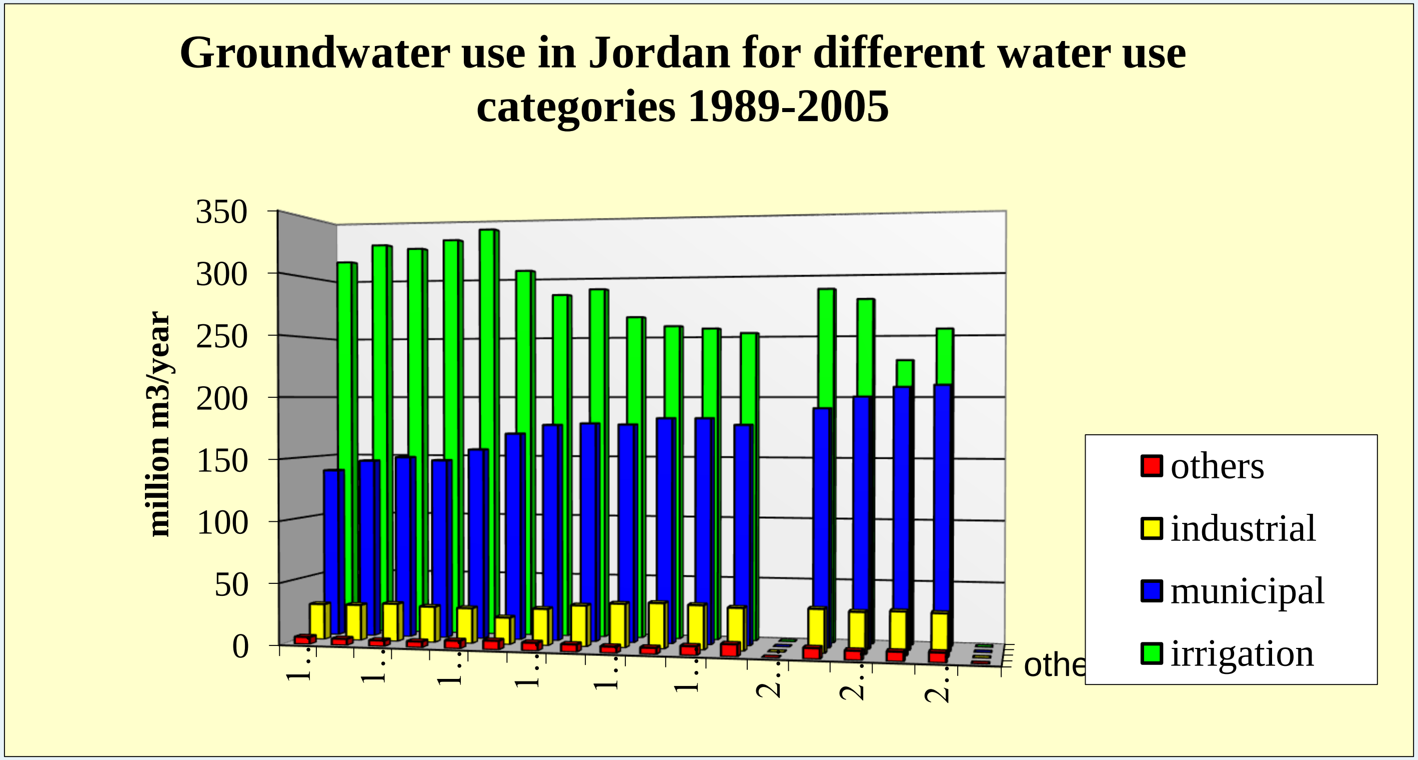
[Source: Ministry of Water and Irrigation]



Groundwater quality

Groundwater uses per category

[source: Ministry of Water and Irrigation]



Groundwater quality

Actual main quality characteristics of 10 representative observation wells scattered over all groundwater basins

[source: Ministry of Water and Irrigation]

Electric Conductivity: 700-5400 µS/cm; average 1660 µS/cm (30 years ago it was 400-1100 µS/cm and 760 µS/cm resp.)

Nitrates: 0-140 mg/l; average 30 mg/l (30 years ago it was 0-80 mg/l)

E-coli has been observed to surpass 100 MPN/100 ml in about half of the springs; no problem in deep wells

POP (persistent organic pollutants) have been measured but are consistently under the limit of detection

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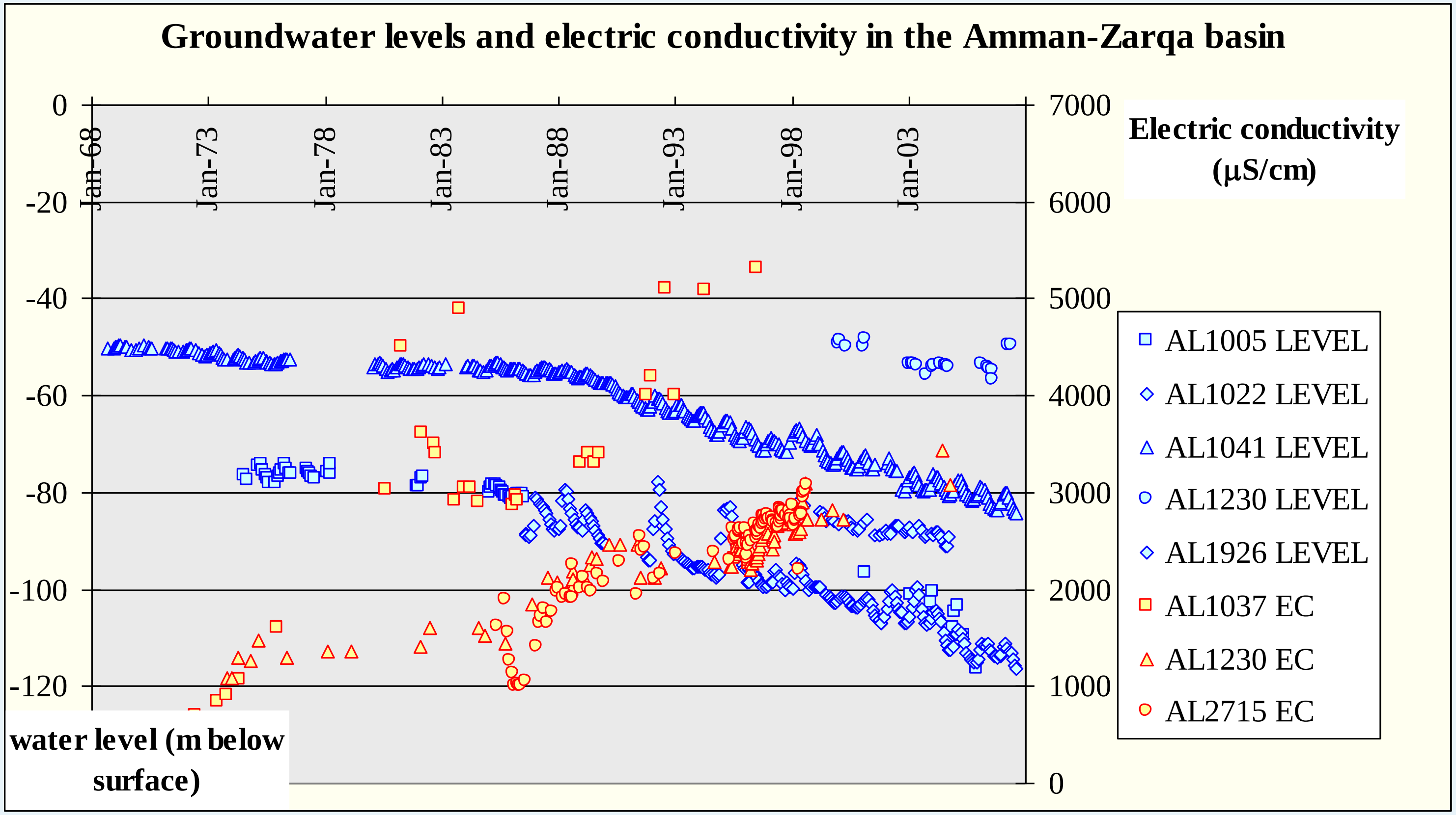
Groundwater quality

Example of water level decline and salinity increase



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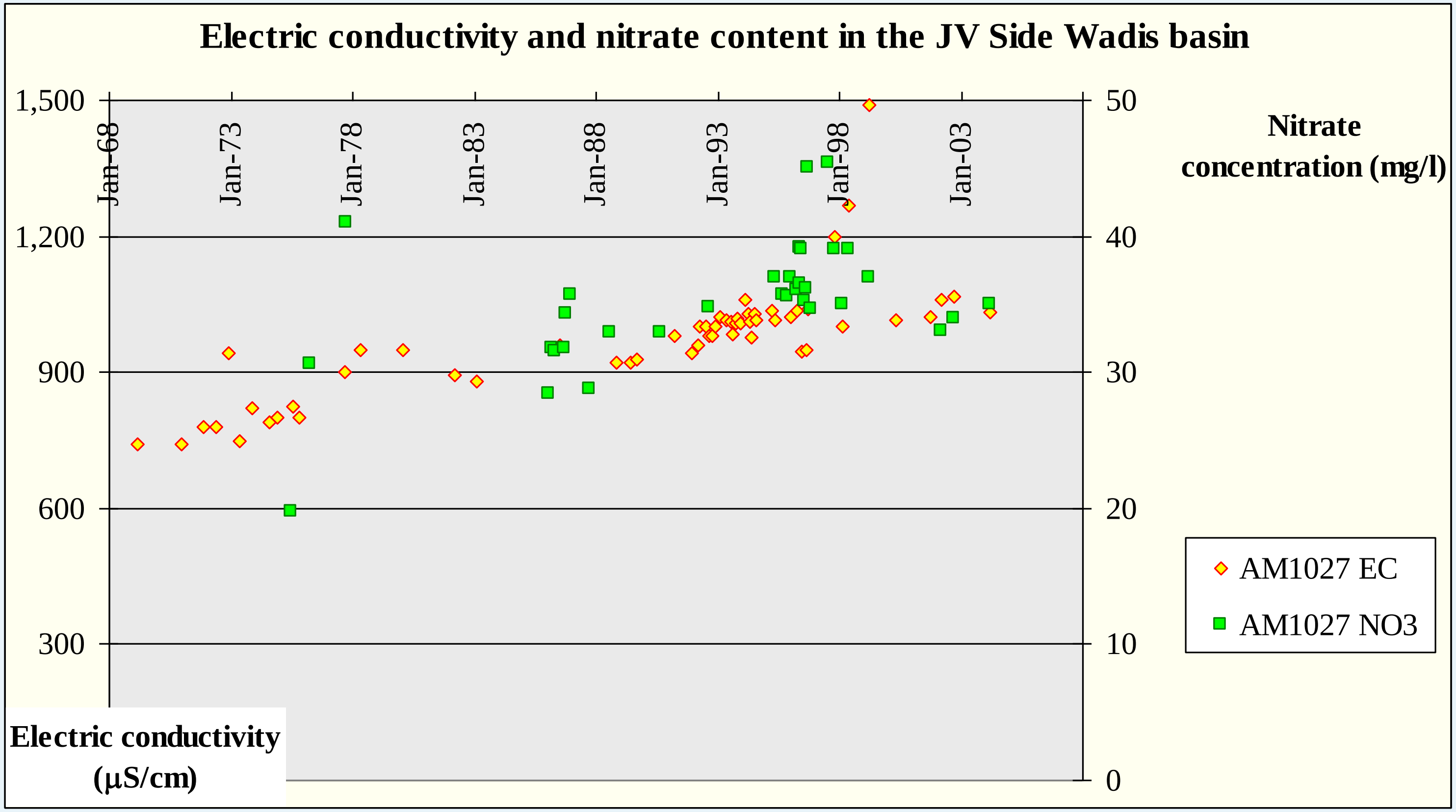
Groundwater quality

Example of increase in nitrate concentration



Groundwater quality

Future developments, consequences

Without change in policies, the groundwater table will continue to decline at probably a higher rate and aquifers will dry out, severely diminishing available groundwater resources

The water quality, particularly salinity will further deteriorate and groundwater will become too saline to use without extra treatment (desalination)

Some damage to the water quality may already be irreversible

High costs for more pumping, desalination, loss of agricultural productivity, increasing opportunity costs

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Cost of groundwater degradation

Extra pumping costs

To pump one m3 of water one meter extra, we need 9.81 kJ which is about 0.0027 kWh

The total GW abstraction at the highlands (without counting Disi and Mudawara aquifers) is about 414 million m3

Decrease of water level is on average 1.13 m per year

Pump efficiency is 0.60

kWh price is 0.08 JOD

Total extra costs (accumulating everyt year) are 0.17 million JOD.

In 2007 (average 30 meters of water table drawdown since 1970), the extra pumping costs were almost 5 million JOD)

Cost of groundwater degradation

Replacement of drying-out wells

According to WAJ, about 100 new private wells are drilled each year and about 10 new wells fro drinking water supply

For the private wells it is estimated that 75% of these are drilled because of wells falling dry; for government wells this is 100%

One private well costs 50,000 JOD, one government well (deeper and larger) 120,000 JOD

Total yearly costs are 4.95 million JOD

Cost of groundwater degradation

Loss of resources due to increasing salinity

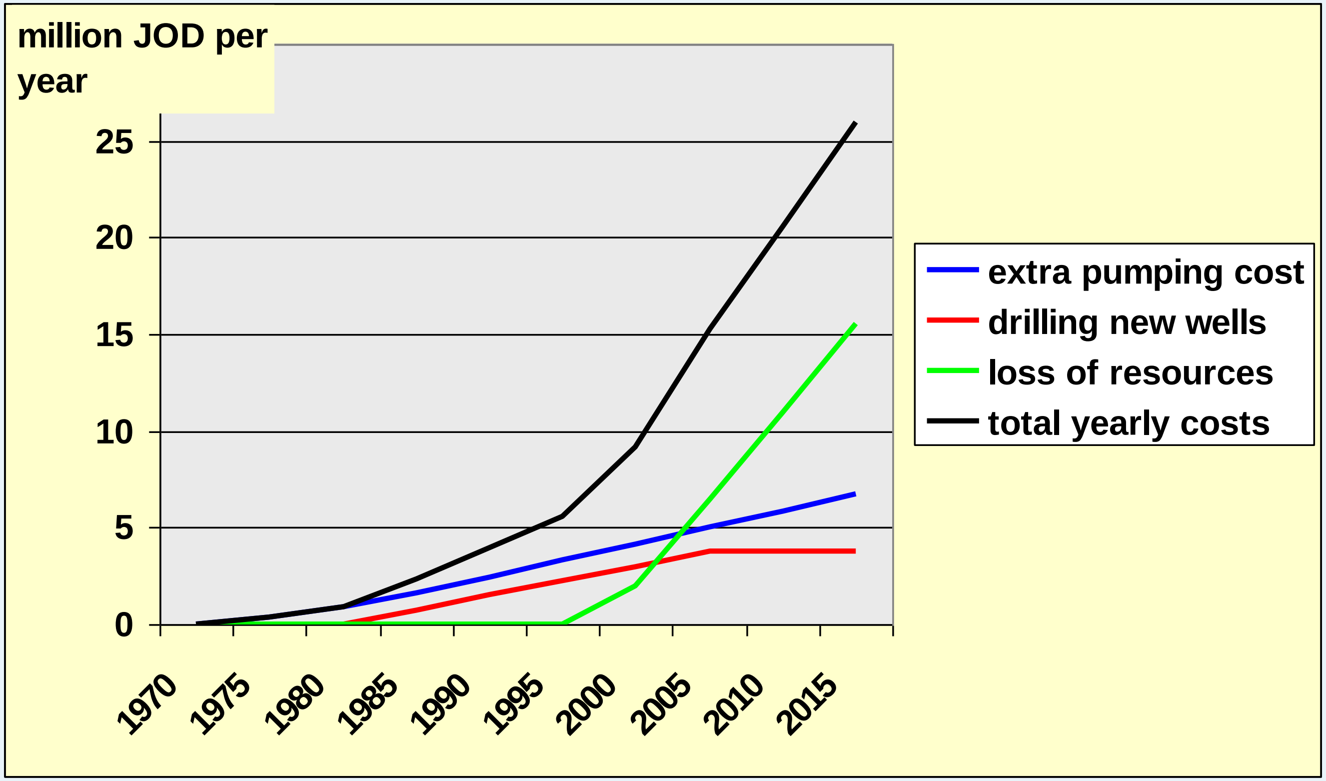
When we estimated such losses at 2% per year, the cost will be 4.3 million JOD per year, accumulating, and assuming the opportunity cost for water of 0.50 JOD/m3.

As an alternative one could desalinize the newly formed brackish water; this will cause about the same costs

(under discussion, not yet included in the COED study!)

Cost of groundwater degradation

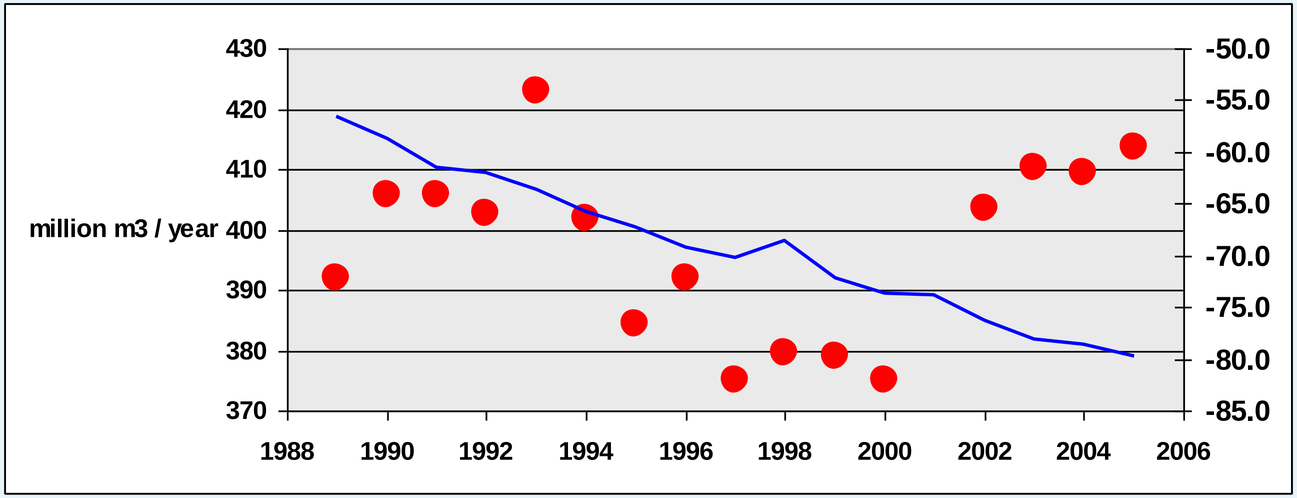
Summary of costs



Cost of groundwater degradation

Alleviation measures

To avoid accumulating costs, groundwater policy should change rapidly. To remind:

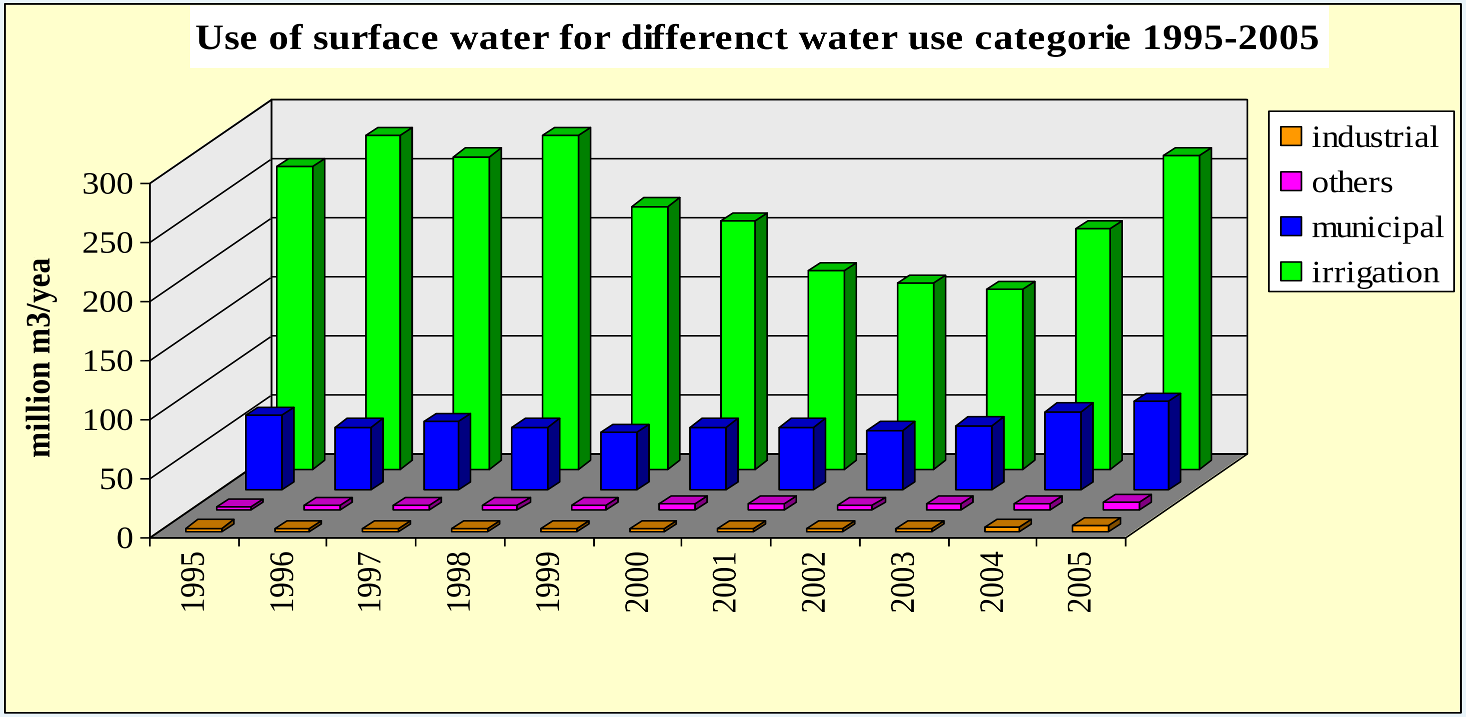


Alternatively new water resources (desalination?) could be developed more rapidly

Surface water quality

Surface water uses

[source: Ministry of Water and Irrigation]



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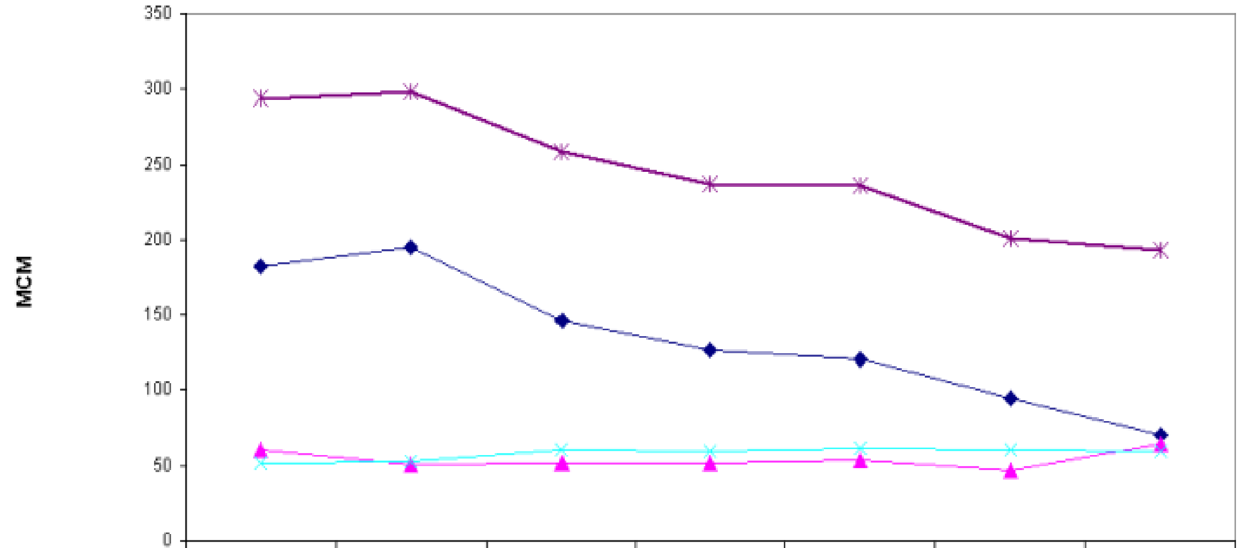
Surface water quality

Water quality characteristics of main sources

	1995		2007	
	EC	E-coli	EC	E-coli
Yarmouk River at Adasiya	-	3.4E+02	1,040	4.5E+02
King Abdullah Canal, Deir Alla	940	3.5E+03	1,110	3.0E+02
King Abdullah Canal, after mixing	1,460	7.9E+03	2,420	1.5E+03
King Talal Reservoir, outlet	1,980	1.9E+02	2,400	9.0E+02
Zarqa River, Hashemiya bridge	-	4.3E+03	2,210	4.8E+04
Kufrein Dam	930	-	1,060	2.8E+02
Wadi Arab Dam	-	-	1,040	1.0E+01
Mujib dam	-	-	790	1.9E+03
Jordan River, Majame bridge	-	-	6,090	3.8E+02

Surface water quality

Origin of irrigation water in the Jordan Valley



	1996	1997	1998	1999	2000	2001	2002
Surface water	182	195	146	127	121	94	70
Groundwater	60	51	52	51	54	47	64
Treated Wastewater	52	53	60	59	61	60	59
Total JRV	294	298	258	237	236	201	194

Courtesy: GTZ/JVA

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Surface water quality

Future developments, consequences

A further increase in surface water salinity is not expected in general

Fresh water resources of Yarmouk river will further decrease and drinking water supply will take a larger part of available fresh surface water resources

Treated wastewater will become the predominant resource in the Jordan Valley and will largely replace fresh water for irrigation

Costs of irrigation with higher salinity water (decrease of production, more leaching)

Cost of surface water degradation

Agricultural losses in the Jordan Valley

Quality class		1995	2005	2015
1: fresh water from yarmouk and other sources	EC	800	1000	1200
	percentage	54	36	19
2: fresh water mixed with KTR water	EC	1620	-	-
	percentage	46	0	0
3: KTR water	EC	1800	2100	2100
	percentage	0	64	81
from 1 to 3			18	35
from 2 to 3			46	46
from 1 to 3 average losses per dunum			24	47
from 2 to 3 average losses per dunum			35	35
total losses (210,000 dunum), million JOD		**0**	**12.27**	**17.02**

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Cost of surface water degradation

Summary

Assuming that there was no damage yet in 1995, total agricultural losses were 12.3 million JOD per year in 2005 and will be 17 million JOD per year in 2015. A slight increase is expected after 2015.

Additional damage may have occurred due to problems with the bacteriological quality of surface water/ treated wastewater; export opportunities may have been lost; difficult to estimate

Some health costs should be included here as well; these are discussed later.

Surface water degradation

Alleviation measures

Improvement of the quality of water treatment (urban and industrial!) may deliver water with 10-20% less salinity. The cost of such investments may be as high as 0.9 JOD/m3 and not pay for themselves if only the positive effects on water use are considered.

Mixing with fresh water resources should be maintained (as far as available). Cost benefit analysis of reduction of mixing is necessary.

Urban wastewater

Basic figures

The connection rate to centralized sewerage systems and secondary treatment is about 60%

There are 23 public wastewater treatment plants and at least 13 private WWTPs (Universities, Industrial Estates)

Rural sanitation uses mainly open bottom cess-pits, treatment is still in pilot stage

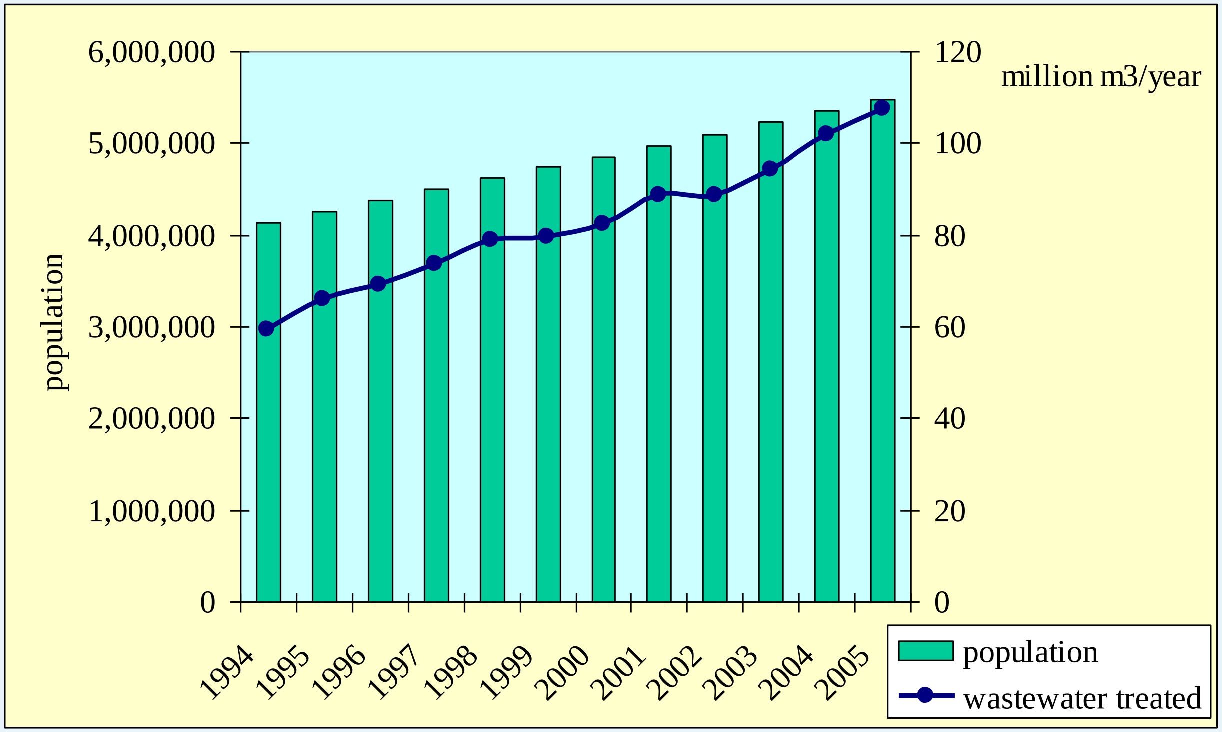
56% of the treated wastewater is not up to bacteriological standards

The BOD load is estimated at ~ 10,000 tons per year down from ~14,000 tons in 2007!

Urban wastewater

Growth of urban wastewater production

[Source: WAJ]



Urban wastewater

Quality of wastewater treatment

[source: WAJ, MoEnv]

	BOD$_5$ mg/l	EC µS/cm	phenol µg/l	TSS mg/l	total N mg/l	E-coli MPN/100ml
stabilization ponds	148	1,689	44	163	83	1.26E+04
activated sludge	32	1,641	40	56	49	8.72E+02
biofiltration	63	1,476	44	85	71	3.06E+05
extended aeration	6	1,364	51	15	7	7.20E+00

standards	BOD5	60	mg/l
	EC	1500	mg/l
	phenol	20	mg/l
	E-coli	1000	MPN/100 ml

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Urban wastewater

Future developments, consequences

The National Agenda 2008-2010 foresees 363 million JOD investment in networks and treatment plants.

This will connect 12% more of the population to centralized sewerage systems

It will also "create" 40 million m3 additional treated wastewater through more connected population and higher efficiency of WWTPs

Wastewater quality will further improve, alleviating some of the negative trends in groundwater and surface water quality

Urban wastewater

Impact of inadequate wastewater treatment

As wastewater quality has been improving steadily over the last 5 years, there is not calculable negative impact!

Wastewater collection and treatment is rather seen as an alleviation measure

Health impacts due to bacteriological quality

<u>Morbidity</u> due to waterborne diseases cost Jordan 3.91 million JOD per year

<u>Mortality</u> due to waterborne diseases cost Jordan 2.96 million JOD per year

Assumptions: 85% of the mortality of intestinal infections is caused by water and 100% of the morbidity is caused by water. This is meant as a upper limit.

Question: Are these assumptions valid? Or should they be lowered

Note that the quality of drinking water itself is good (~1.5% non-compliance), but the intermittent supply and use of tanker water may magnify the problem

Health impacts due to bacteriological quality

Alleviation measures

Wastewater treatment should respect bacteriological standards

Maintain present high quality standards of delivered product

Water supply should become permanent and 100% of the population in the cities should be connected to in-house piped water supply (= at present ~90%).

Strengthen management policies with regard to avoidance of "accidents"

Improve hygiene education

Improve access to medical services

Industrial wastewater

Main industries and treatment status

Industry	water consumption [million m3/year]	wastewater production [million m3/year]	treated [%]	discharged to [million m3]			
				sea	sewers	irrigation	others
Dead Sea Potash Company	10.8	10.8	0	10.8	-	-	-
Mining	9.6	4.8	0	-	-	4.8	-
Aqaba fertilizer complex	3.2	1.6	100	1.6	-	-	-
Zarqa industrial zones	15.0	7.5	65	-	6.0	1.2	0.3
Other industrial zones	2.3	1.2	80	-	0.2	1.0	-
Cement	0.4	0.2	0	-	-	0.2	-

Main unknown polluters are the Zarqa SMEs; they produce ~ 4 million m^3 industrial wastewater per year, largely untreated

name	category	location	water consumption (m3/year)	treatment	discharged/reused
Arab Potash Company, Al Safi	Chemical Industry	Ghor Safi	10,600,000	-	Dead Sea
Jordan Phosphate Mines Company	Cement and Mining Industry	Shediya	6,000,000	-	?
Jordan Fertilizer Industry Company	Fertilizer Industry	Aqaba	3,200,000	yes	?
Jordan Phosphate Mines Company	Cement and Mining Industry	Al-Hassa	2,500,000	-	?
Jordan Petroleum Refinery	Chemical Industry	Zarqa	2,453,000	yes	irrigation
Jordan Phosphate Mines Company	Cement and Mining Industry	Wadi Al-Abyad	1,100,000	?	?
Jordan Ice & Aerated Water Co. (Pepsi)	Food Industry	Zarqa	630,000	pretreatment	sewer
Al Hussein Thermal Power Station	Other	Zarqa	438,000	-	sewer
EAM MALIBAN Textile Jordan (PVT) LTD	Weaving, Textile, and Cotton Industry	Zarqa	210,000	under construction	tanker to sewerage system
Arab White Cement Industries	Cement and Mining Industry	Fuheis	200,000	-	irrigation
Arab White Cement Industries	Cement and Mining Industry	Rashdiyah	200,000	-	irrigation
Jordan Paper & Cardboard Factories Co. Ltd.	Paper, Packing, Packaging and Printing	Zarqa	170,000	yes	recycled
Millennium Paper Mill (Hygiene Articles)	Paper, Packing, Packaging and Printing	Zarqa	164,000	yes	irrigation
Petra Apparel Factory	Weaving, Textile, and Cotton Industry	Zarqa	132,000	yes, partly	tanker to sewerage system
Yeast Industries Co. Ltd. ASTRICO	Food Industry	Zarqa	120,000	-	irrigation
Arabian Co. For White Cement I Manufacturing (Jordan White Cement)	Cement and Mining Industry	Zarqa	100,000	yes	irrigation
Kolaghassi Foam & Mattresses Factory Co.	Chemical Industry	Zarqa	79,000	-	sewer
Hammoudeh Brothers Co. Trade&Investment (slaughter House)	Food Industry	Zarqa	75,000	yes	irrigation
The United Co. for Creative Ready Garments & the Bee Line Co.	Weaving, Textile, and Cotton Industry	Zarqa	75,000	-	
Jordan Ceramic Industries Co. Ltd	Construction Industry	Zarqa	58,000	yes	recycled
Jordan Steel P.L.C	Engineering Industry	Zarqa	56,000	yes	irrigation
Soft Ready Garments Co.	Weaving, Textile, and Cotton Industry	Zarqa	54,000	-	tanker to sewerage system
Al-Hussein Iron Factories (Metal) or Jordan Steel Co.	Engineering Industry	Zarqa	52,000	yes	irrigation
Union for Agriculture Development & Slaughters (Tahoneh)	Food Industry	Zarqa	51,000	yes	irrigation

Industrial wastewater

Some data

Excluding the mining and potash operations and Aqaba fertilizer complex, Jordan produces about 24,000 m3/day industrial wastewater

About 86% of that (20,500 m3/day) comes from the Zarqa area

Some of the larger industries have their own WWTPs and about 50% of the Zarqa wastewater (11,000 m3/day) comes from SMEs

Over 80% of the wastewater of SMEs is still untreated

Database is not very good

Industrial wastewater

Future developments, consequences

The extend of the problem is not well known (no impact assessment)

Information on pollution with i.a. heavy metals, POPs, etc. is scarce and hinders proper development of industrial wastewater management

Enforcement of existing regulations is weak and has not improved over the last 10 years (discharge to the public sewerage system, directly or by tankers)

Investments in treatment have started (northern IWWTP, Zarqa IWWTP), but cover only 33% of the total needed

Experiences from other countries show that industrial pollution has always been underestimated !!!!!

Impacts of industrial pollution

Costs

There is no information on impacts

As an indicator of costs, we have calculated the annualized costs of treating the remaining industrial wastewater in the Zarqa area; this is 7.1 million JOD/year

With SME industries set to grow 300% by 2017, the cost of industrial pollution and necessary wastewater treatment may become much higher !

Impacts of industrial pollution

Policy aspects

Insufficient enforcement of existing regulation (30% non-compliance for industries connected to the sewers and no content control on tanker discharges)

There is no Integrated Pollution Prevention and Control

Jordan did not establish a minimum BAT

Control at the source maybe more effective than end-of the pipe treatment (which will cost > 3 JOD/m3 when not subsidized)

Impacts of industrial pollution

Alleviation measures

Thorough inventory of industries, products, processes, wastewater production and wastewater characteristics should be implemented.

Baseline survey of extent of pollution problem should be made

Industrial wastewater management plan should be produced based on aforementioned studies

Necessary legal system should be set-up and implemented (IPPC, licensing, control, etc.)

Necessary investments should be encouraged (incentives for own measures or centralized IWWTPs)

Summary of impacts

Groundwater table decline and pollution:

From 5 million JOD/year in 1995 to 13 million JOD per year in 2005; tendency sharply increasing

Surface water pollution:

From zero in 1995 to 12.3 million JOD per year in 2005; tendency moderately increasing

Health effects:

Up to 7 million JOD per year

Industrial pollution:

Probably considerable, not exactly known, indicator: 7.1 million JOD per year

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Priority measures

On top of existing policies!

Control of groundwater over-abstraction

Policy

Additional water resources

Control of industrial pollution

Enforcement of existing regulations

Introduction of IPPC and BAT

Build more industrial WWTPs

Measures to make drinking water supply more permanent

Additional water resources

COED study

In the COED study, the methodology allows only yearly costs to be included. For the water sector this leads to the following costs (compared to GDP)

	Low	High	Linked to water quantity?
Cost of illness	0.19%	0.27%	yes
Reduction in agricultural yields (Jordan Valley)	0.12%	0.12%	yes
Inadequate Water, Sanitation, Hygiene (bottled water)	0.11%	0.11%	yes
Pollution from Industrial Waste Water	0.09%	0.09%	no
Inadequate Water, Sanitation, Hygiene (water filtering)	0.07%	0.07%	yes
Morbidity due to inadequate water, sanitation hygiene (all ages)	0.04%	0.04%	yes
Overexploitation of groundwater (Private well replacement)	0.04%	0.04%	yes
Pollution of drinking water sources (springs and wells)	0.03%	0.03%	no
Overexploitation of groundwater (Cost of overpumping)	0.03%	0.03%	yes
Under five mortality due to inadequate water, sanitation, hygiene	0.03%	0.03%	no
Overexploitation of groundwater (Public well replacement)	0.01%	0.01%	yes
total		**0.83%**	
Linked to water quantity	82%		

COED study

Two remarks derived from the <u>National Agenda</u>

SME industry is likely to grow a factor 4 in the next 10 years; the cost of pollution will grow as well and may reach 0.36% of GDP

Agriculture will have a much higher added value of several dinars per m3; costs of higher salinity will therefore multiply as well and may be come as high as 0.60% of GDP unless further salinity increase can be stopped

Together these may become the most important factors with regard to water

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Final remarks

- Inadequate solid waste disposal may impact on water resources quality
- Land use (particularly degradation of rangeland) may have a negative impact on groundwater recharge
- Data and data collection and processing skills are insufficient to make proper analysis and set out policies