Obstacles to enhance groundwater aquifer by reclaimed water using artificial recharge as a reuse option in West Bank / Palestine

Mediterranean Workshop on New Technologies of Recycling non Conventional Water in Protected Cultivation Opportunities and New Challenges for Arid and Semi - Arid Areas

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INNOVA-MED: Innovative processes and practices for wastewater treatment and re-use in the Mediterranean region

Groubwater protection framework in Palestine

POLICY

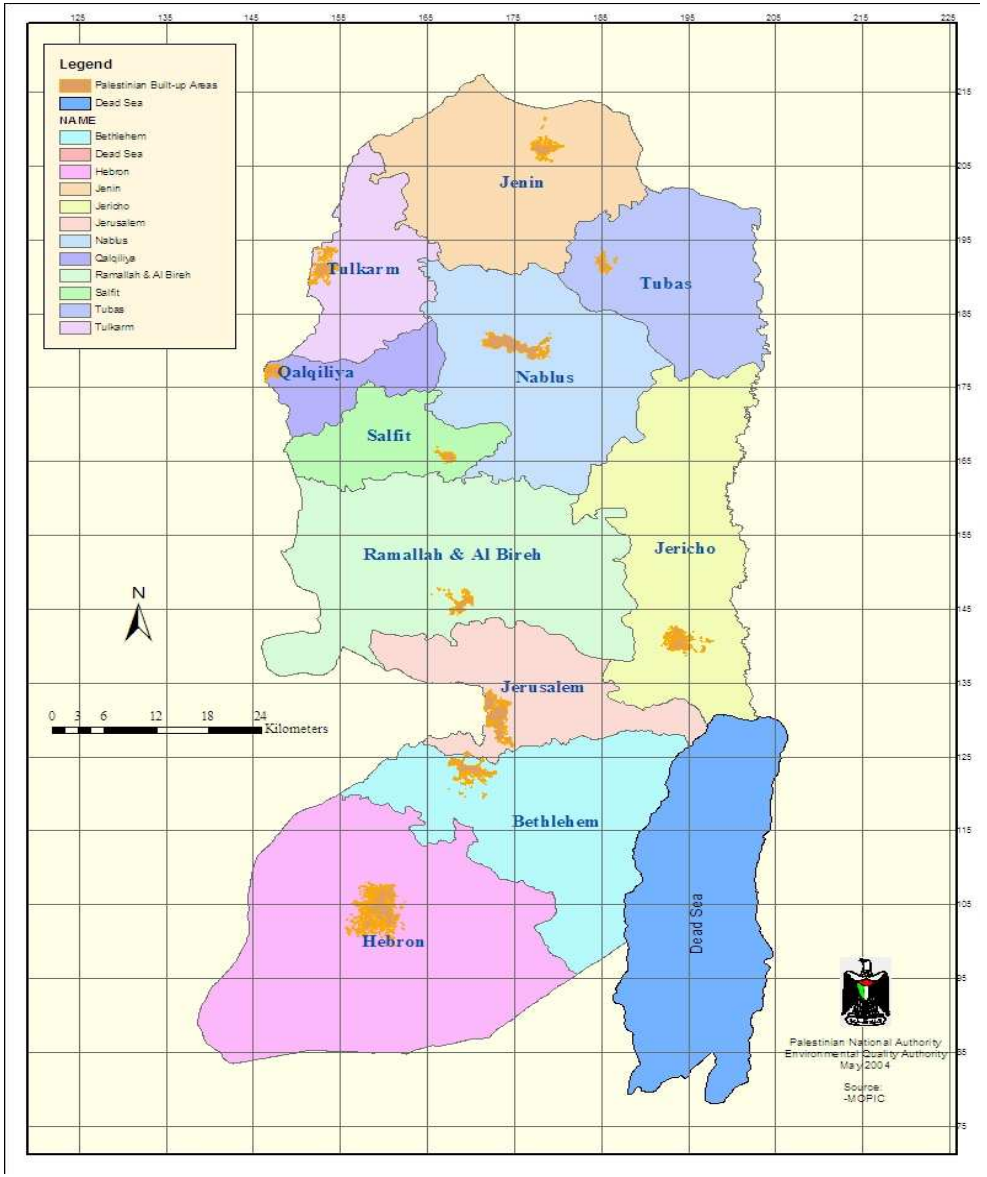
Groundwater development, planning and management both quantity and quality.

RESEARCH

- **Groundwater resources assessment**
- **Groundwater potentiality assessment**
- **Groundwater vulnerability assessment**
- **Pollution load assessment**
- **Pollution risk assessment**
- **Monitoring**

IMPLEMENTATION

Regulations
Remedial measures (land use restriction, artificial recharge, WWTPs)
Protection zones
Public awareness and human resources development
Monitoring



West Bank governorates.

Demography:

- The population of West Bank is about 2.35 million (2004 senses) and it's area about 5615Km2.
- Annual Population growth is 3.5%.
- 30 communities with population > 20,000.
- 70 communities with population <10,000>5000.
- 463 communities with population <5000.

Introduction:

• Wastewater generated estimate by 60-70 MCM/2006 in West Bank. Of this only about 36.5 MCM is collected by sewage network.

• In West Bank about 56 communities are connected to sewage network, whereas 513 communities use cesspits to dispose their sewage without any type of treatment.

• About 93% of the generated wastewater in the West Bank discharged untreated into the environment and run in wadis.

• Settlement rate of consumption were 6-7 times for those living in the West Bank. they generate about 35 Mcm/yr of untreated sewage which cause catastrophic effects on the Palestinian water resources and environment.
• Solid waste production in West Bank estimated to be 0.4-1.2 kg\day household solid waste produced in the West Bank is 1,728.2 tons. This volume is estimated to cover between 100-200 hectares. Their is lack of waste separation implies that hazardous and medical waste disposal is also uncontrolled. Batteries, liquid wastes, and potential hazardous wastes are mixed in with solid (household) wastes, sources for all ARIJ, 2007

• 123 type of pesticides used in the West Bank, 14 of these pesticides were internationally suspended, cancelled or banned by WHO from usage and still use in agricultural activity, In West Bank about 302 ton of pesticides, 30,000 ton of fertilizers and for soil disinfections Methyl Bromide were used in the cultivated area (ARIJ, 1998).

• CAMP,2001 study revealed that the overall water total demand 629 is millions m3 (Mm3)/ yr, where the overall supply for domestic and agriculture is only 170 (Mm3)/yr. This means that there is a deficit of about 459 (Mm3) every year. This deficit led to continuous discharge from groundwater this deteriorates groundwater quality.

• As a policy in water resources management, there is attitude to get other non conventional water resources such as treated wastewater as artificial recharge of groundwater from both storm water and treated wastewater.

Requested for wastewater management and reuse In West Bank to work in:

• There is no routine monitoring for wastewater, neither at treatment plants, nor at the end-uses.

• There no insufficient data available on wastewater quality and quantity, the quality of existing data is unclear and available sets are inconsistent.

• The agencies responsible for wastewater monitoring have insufficient capacity to fulfil their tasks.

• The existing laboratories cannot perform relevant analyses for routine waste water samples.

Interest in reuse has accelerated significantly in the Palestinian Territories for many reasons:

• Depletion of groundwater resources.

• Production of large quantities of wastewater which makes its use for a viable and reuse alternative options.

• The reuse is a safe disposal of wastewater which will reduce the environment and health risks.

• The treatment of wastewater to be used is cheaper than that needed for protection of the Environment (UNEP, 2000).

Palestinian practice of reuse of reclaimed water produced

Palestinian water Authority (PWA) considered the key regulator and guardian of water resources in Palestine. A number of strategies are being developed by PWA on 2003 concerning the artificial recharge usage; these strategies are:

• Co-operation must be established with different relevant bodies.

• Flexible reuse plans should be developed to be able to utilize treated wastewater and possible mixing with rainfall, urban run off and storm water.

• Establish planning tools (regulations, standards, guidelines, etc) for reuse and recharge.

• Discharge to surface water may be considered as an interim action for infiltration, or if reuse are not feasible.

• For better water quality and reuse efficiency, consider (1) mixing of treated effluent with urban and surface runoff, (2) artificial recharge of groundwater with treated effluent **wherever possible** and (3) establish surface storage for treated effluent with or without harvested runoff.

To reuse in aquifer recharge

1. The factors that governing the infiltration capacity and the type, size of the infiltration basin are:

- Infiltration capacity at the soil surface (the soil at the bottom of the infiltration basin),
- Hydraulic capacity of the soil profile and the geologic information below the bottom of the infiltration basin,
- Property of the water to be infiltrated which may lead to pollution of groundwater,
- Clogging of the basin and that will affect the infiltration capacity of the basin.

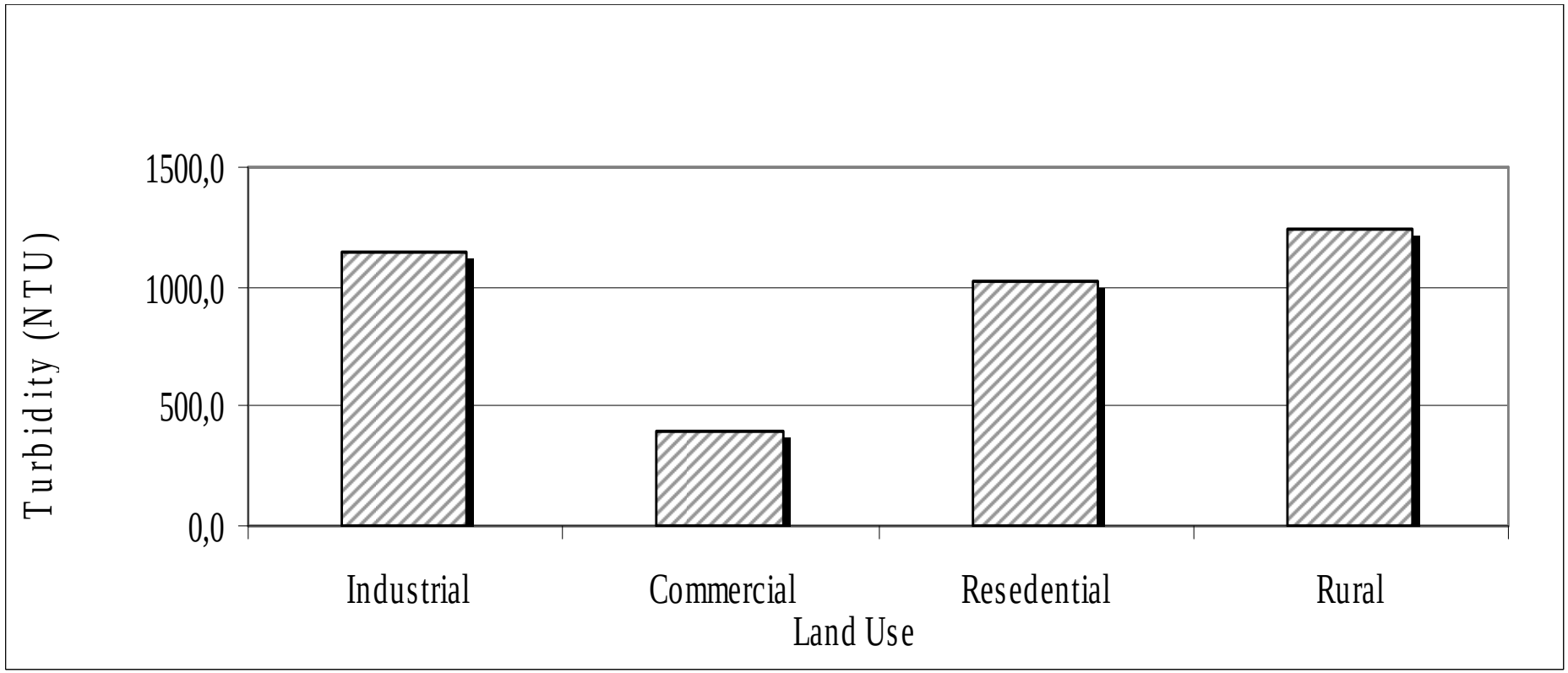
2. Treated wastewater could usually infiltrate to groundwater with high risk to polluting the aquifer. Therefore, several measures should be considered regarding the quality of the treated wastewater and the type of the recharging system.

3. Recharging the aquifer by injection type system (wells/boreholes) is excluded because this type of system is much more subjected to clogging and will not have a purifying effect on the residual pollution in the treated water.

Summary of urban runoff pollutants according to EPA, 1993

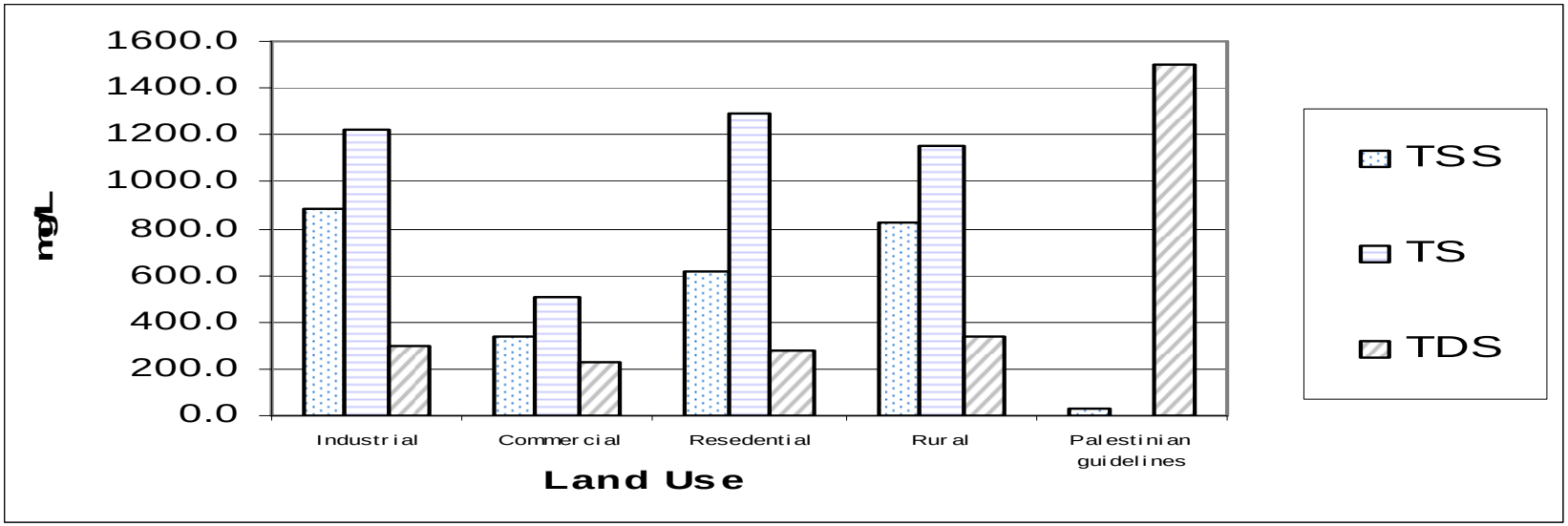
Category	Parameters	Possible Source	Effects
Sediments	Organic and inorganic: Total suspended solids (TSS) Turbidity Dissolved solids	Construction sites Urban/agricultural runoff Landfills Septic fields	Turbidity Habitat alteration Recreational and aesthetic loss Contaminant transport Navigation/hydrology Bank erosion
Nutrients	Nitrate Nitrite Ammonia Organic nitrogen Phosphate Total Phosphorus	Urban/agricultural runoff Landfills Septic fields Atmospheric deposition Erosion	Surface waters Algal blooms Ammonia toxicity Ground water nitrate toxicity
Pathogens	Total coliform Fecal coliform Fecal streptococci Viruses E. Coli	Urban/agricultural runoff Septic systems Boat discharges Domestic/wild animals	Ear/intestinal infections Shellfish bed closure Recreational/aesthetic Loss
Organic enrichment	Biochemical oxygen demand (BOD) Chemical oxygen demand (COD) Total organic carbon (TOC)	Urban/agricultural runoff Landfills Septic systems	Dissolved oxygen depletion Odors Fish kills
Toxic pollutants	Toxic trace metals Toxic organic	Urban/agricultural runoff Pesticides Underground storage tanks Hazardous waste sites Landfills Industrial discharges	Bioaccumulation in food chain organisms and potential toxicity to humans and other organisms
Salts	Sodium chloride	Urban runoff Snowmelt	Vehicular corrosion Contamination of drinking water Harmful to salt- intolerant plants

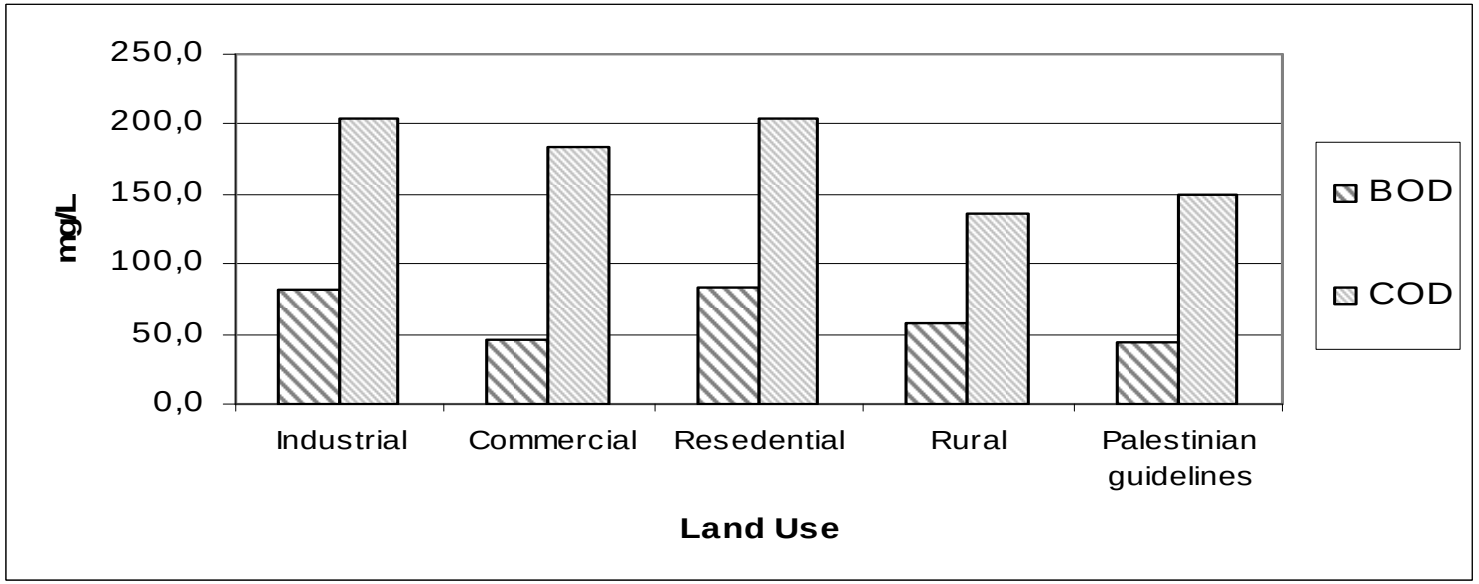
For Urban Run off investigation Mimi and et, al, 2006 study the urban runoff in Ramallah area their study revealed that Turbidity can be determined as physical parameters and related to Total Solids (TS),Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) among the analysis on the samples, as the turbidity depends directly on the time of the predominant rainfall during the time of analysis.



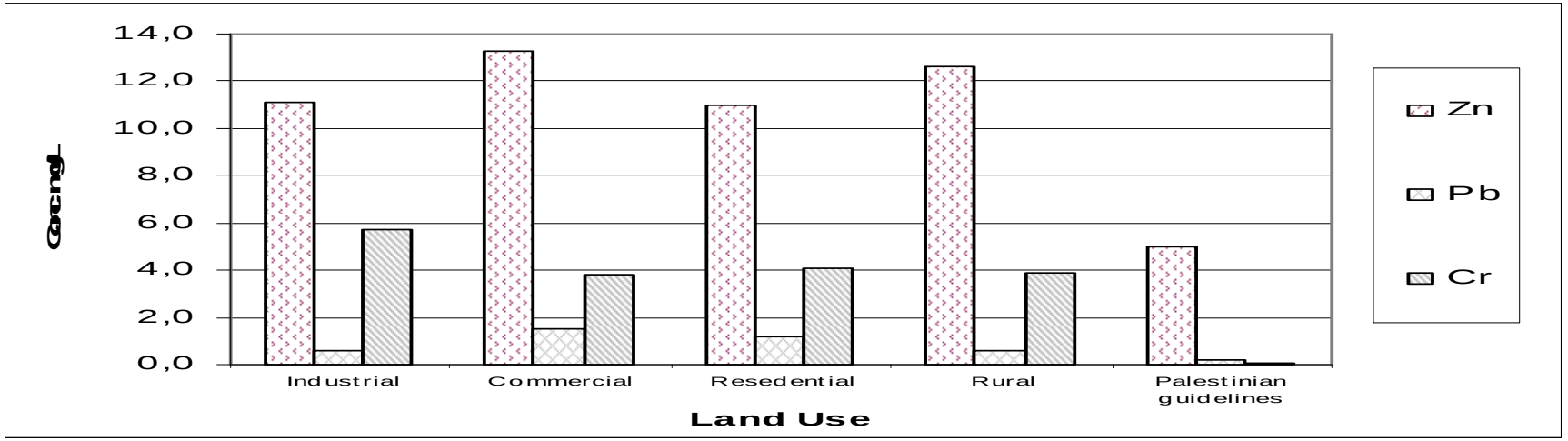
Results for the Turbidity analysis

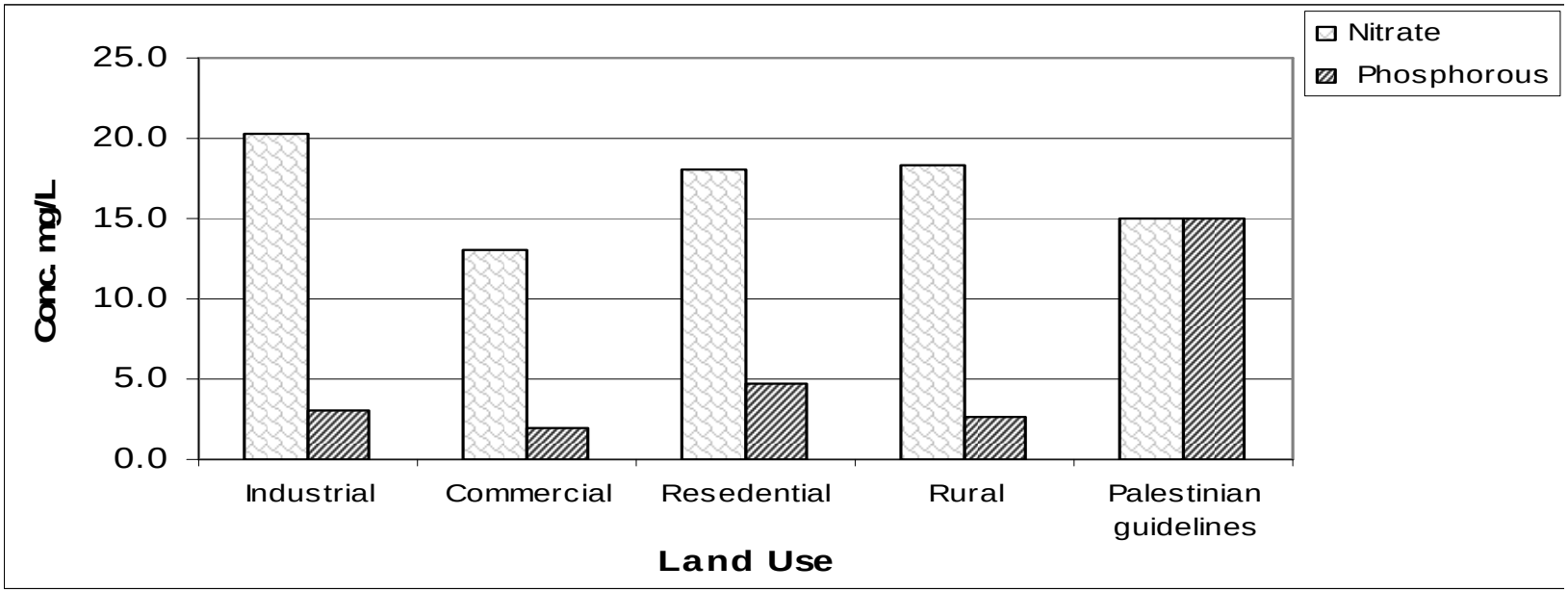
Result for Total Solids (TS), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) and Biological and Chemical as COD and BOD and compared to Palestinian guideline.





Trace Metals and Nitrate and Phosphorous





In West Bank there is no separation between the rain water runoff and sewerage system

Gray wastewater stream discharged through open channels from Al-Fara Refuge Camp.

Storm water and mixing wastewater that run in wadis Al-Qilt, 2003.

For Water and wastewater discharge in Wadi Al-Qilt (June, Julay, Auguset, 2007) by PWA.

No	Flow (m^3/d)	pH	TDS (mg/l)	NO_3 (mg/l)	NH_4 (mg/l)	Anionic Surfactant (mg/l)	COD (mg/l)	BOD (mg/l)	DOC (mg/l)	F.coli CFU/100ml	E. Coli CFU /100ml
1	4800	7,41	900	25	3,58	0,89	214	62	22,54	6000	3500
1	4500	7,65	795	21	8,25	1,12	180	46	19,55	8800	5500
1	4750	7,85	890	27	6,25	1,35	225	120	29,88	6800	4800
2	3450	7,78	1120	30	5,55	0,95	300	130	28,31	$600x10^2$	NM
2	3120	7,85	950	38	12,25	1,25	430	195	25,51	$300x10^2$	NM
2	3356	7,65	880	29	10,25	1,65	385	160	32,3	$400x10^2$	NM
3	730	8,85	1550	22	10,25	2,35	325	208	16,18	$40x10^2$	NM
3	895	8,23	1000	17	8,44	2,11	490	308	32,15	$80x10^2$	NM
4	785	7,23	880	75	8,25	2,11	195	75	18,19	$60x10^2$	2850
4	650	8,55	785	55	6,35	2,45	252	135	16,95	$80x10^3$	NM
5	1130	8,12	301	21	1,15	0,12	70	51	6,75	80	30
5	995	7,55	260	27	2,12	0,52	95	44	4,62	101	40
5	1120	7,66	195	16	0,95	0,23	65	29	9,23	75	20
6	2560	6,85	850	23	9,95	0,65	175	65	15,95	$140x10^2$	NM
6	2495	7,15	1220	35	12,35	1,15	205	85	14,93	$640x10^3$	NM
6	2400	7,95	750	29	11,23	1,98	95	52	19,55	$840x10^3$	NM
7	11452	7,06	550	39	0,52	1,15	82	35	8,95	$40x10^2$	1850
7	13895	7,55	640	28	1,12	1,35	100	40	11,25	$84x10^3$	NM
7	12585	8,1	480	26	0,89	0,95	65	38	10,58	$29x10^2$	1250
8	15485	8,15	520	31	0,11	0,18	62	15	4,55	980	350
8	14360	7,59	385	22	0,25	0,25	75	18	3,95	700	225

Wastewater wadis survey and monitoring program done by CH2Mhill (1999):

	pH	ORP mv	NH3-N*	Antimoy **	Arsenic **	Berylium **	Cd **	Ca *	Cr **	Cu **	Fe **	Pb **	Mg *	Hg **	Ni **	K *	Se **	Ag**	Na *	Thallium **	Zn *
Q1-1T	7.8	-34	131	148	28	86	31	8.2	102	157	3020	125	36	0.77	116	29.3	ND	48	33	13.6	79
Q1-1D				ND	22	81	ND	2.4	ND	154	111	ND	29	0.77	87	24.5	ND	45	80	10.9	0.2
QA-1T	7.8	-38.1	89	ND	63.1	99.5	20	3.1	ND	208	648	ND	89	0.76	121	33.4	17.1	70	386	27.4	0.2
QA-1D				ND	30.8	95.8	20	3.1	ND	186	137	ND	32	0.76	113	30.4	12.8	70	260	20.5	0.1
QA-2	7.8	-39.4	127																		
QA-3	8.6	-81.4	46.3																		
QA-61			53.8	ND	ND	ND	ND	76	3.3	7.9	726	6.7	33	0.58	6	35.3	ND	0.86	167	ND	0.8
MQ-1T	7.6	-26.4		184	15	ND	23.7	40	ND	ND	1311	128	35	1.01	ND	37	14.6	ND	145	77.9	0.5
MQ-1D				129	13	ND	15.5	35	ND	ND	115	ND	36	0.8	ND	38	ND	13	133	57	ND
MQ-2	7.7	-29.7	58.5																		
MQ-3	8.1	-51.4	58.5																		

For water and wastewater run into Wadi Al Qilt (Ghasan, 2006)

Parameter	Min	Max	Average
Na^{+}(mg/L)	24	277.0	97.15
Ca^{2+}(mg/L)	15.0	86.8	53.73
Mg^{2+}(mg/L)	20.0	33.0	25.0
K^{+}(mg/L)	1.6	33.0	12.07
Cl^{-}(mg/L)	24.0	270.0	104.33
SO_4^{2-}(mg/L)	16.0	37.0	28
NO_3^{-}(mg/L)	0.6	60.0	28.518
HCO_3^{-}(mg/L)	165.0	172.0	169.25
NH_4^{+} (mg/L)	0.1	2.3	16.6
DOC (mg/L)	1.87	29.86	9.343
COD (mg/L)	38.0	479.0	130.78
BOD_5 (mg/L)	9.0	136.0	44.58
EC (µS/cm)	458.0	1940.0	866.68
Turbidity (NTU)	2.0	162.0	41.0
TDS (mg/L)	296.0	1069.0	624.86
TSS (mg/L)	7	350	43.6
pH	6.57	8.40	7.72
Flow m^3/h	38.5	1984.7	400.0

For Industrial wastewater consumption and generated as wastewater the West Bank (MENA, 1999)

Type of industry	Water Consumption (m3/yr)	Wastewater Generation (m3/yr)
Textile dyeing	1533600	1533600
Tanning Industry	410400	410400
Food & Beverage	1723680	689472
Construction	854000	256200
Stone processing	1116640	1116640
Chemical industry	112520	36608
Metal working & furniture	76358	76358
Wood working and furniture	12048	12048
Olive mills	375300	375300
Non-metallic	15240	6096
Plastic, rubber, sponge	5076	5076
Printing, paper and carton	4680	4680
Clothes, shoes & textile	43236	43236
	6282778	**4565714**

Wastewater characteristics for influent, effluent and removal efficacy from Al-Bireh WWTP. Results as an average value in mg/l for Master Thesis done from March to September (Samhan, 2005).

Parameter	Influent(mg/l)	Effluent(mg/l)	Removal efficacy (%)
COD_{tot}	**1224**	**234**	**81**
COD_{sus}	**640**	**NM**	
BOD_{tot}	**605**	**56**	**91**
Turbidity (NTU)	**598**	**9.38**	**98**
pH	**7.43**	**7.60**	
TSS	**574**	**24.5**	**95.5**
TDS	**1056**	**896**	**16**
TS	**1606**	**929**	**42**

Al-Bireh wastewater reuse demonstration project:

Al Bireh WWTP is located in Wadi Al-Ein (south of Al-Bireh city) over 2.2 ha area; it was constructed in 2000. The connected population to sewers system in Al-Bireh city is about 60%, which amount to 50,000 inhabitants and designed to serve more than 100,000 inhabitants. The treatment system is extended aeration as activated sludge. The plant was designed to treat 5750 m3/day with an overall retention time of 20 days (the present total inflow is 3200 m3/day).

Al-Bireh wastewater treatment plant

Fresh water, raw and treated wastewater characteristics (WESC, 1997)

Property	Unit	Raw WW (Rang)	Activated sludge+TF (Range)	Fresh water
EC	(ms/cm)	0.9-6.73	0.36-3.79	7.5
pH	Value	6.75-8.82	7.5-8.98	0.8
BOD	mg/l	350-1374	10-720	55.2
COD	mg/l	909-3500	18-2000	50.1
TSS	mg/l	190-800	2-660	25
NO3	mg/l	2.8-5	15-55	10.2
PO4	mg/l	0.6-11.62	0.86-10	15
CL	mg/l	165-2044	48-1000.2	2.7
HCO3	mg/l	500-592	180-421.3	17.5
SO4	mg/l	32-34.25	15-23.75	70
Ca	mg/l	60.1-100	57.7-93.8	272
Mg	mg/l	25-46.2	15.3-51	0.0
Na	mg/l	200-667.7	31-724.5	1.3
K	mg/l	6.5-10.11	1.4-8.83	0.0
SAR	$(mmole)^{1/2}$	6.48	5.46	0.0
B	mg/l	0.11	0.13	***
Cu	mg/l	0.9	0.92	
Zn	mg/l	2.1	2.25	

An overview of secondary, tertiary effluent and soil characteristics of Al-Bireh reclaimed wastewater reuse demonstration project Source: CH2 MHILL, 2003a

No.	Item	Sampling Dates	Parameter	Results
1	Secondary treated water	Continuously	BOD	25-15 mg/l
			TSS	35-25 mg/l
			EC	1.7-1.5 DS/m
			pH	7.5-7
			N	40-30 mg/l
2	Tertiary treated water	01 June, July, August, 2003	Residual chlorine	1.0-0.5 mg/l
			Turbidity	1-2 NTU
		24 June,2003	Fecal Coliform	0 CFU/100 ml
3	Soil	07 July, 2003	pH	7.5
			ECe	0.5 dS/m
			Na	1.0 meq/l
			Ca	63.4 mg/l
			Mg	13.2 mg/l
			Cl	48 mg/l
			HCO3	195 mg/l
			SO4	43 mg/l
			NO3	6.2 mg/kg
			NH4	35 mg/kg
			P-Olsen	3.0 mg/kg
			K	6.1 mg/l
			Mn	39.2 mg/kg
			Zn	1.6 mg/kg
			B	0.08 mg/l
			CaCO3	6.4 %
			Sand	16 %
			Silty	49 %
			Clay	35 %
			Saturation	64 %

PSI- Palestinian Standards Institute, First Draft, (PS 2003-742) of the reuse of treated wastewater guidelines (2003). (-): not specified

Parameters	Discharge into the sea-500m far	Artificial recharge of groundwater
TDS	-	1500
pH	6-9	6-9
NO_3	25	15
NH_4	5	10
Cl	-	600
Mg	-	150
Ca	-	400
Al	5	1
Ar	0.05	0.05
Cu	0.2	0.2
Fe	2	2
Mn	0.2	0.2
Ni	0.2	0.2
Pb	0.1	0.1
Se	0.02	0.02
Cd	0.01	0.01
Zn	5	5
CN	0.1	0.1
Cr	0.05	0.05
Hg	0.001	0.001
Co	1	0.05
B	2	1

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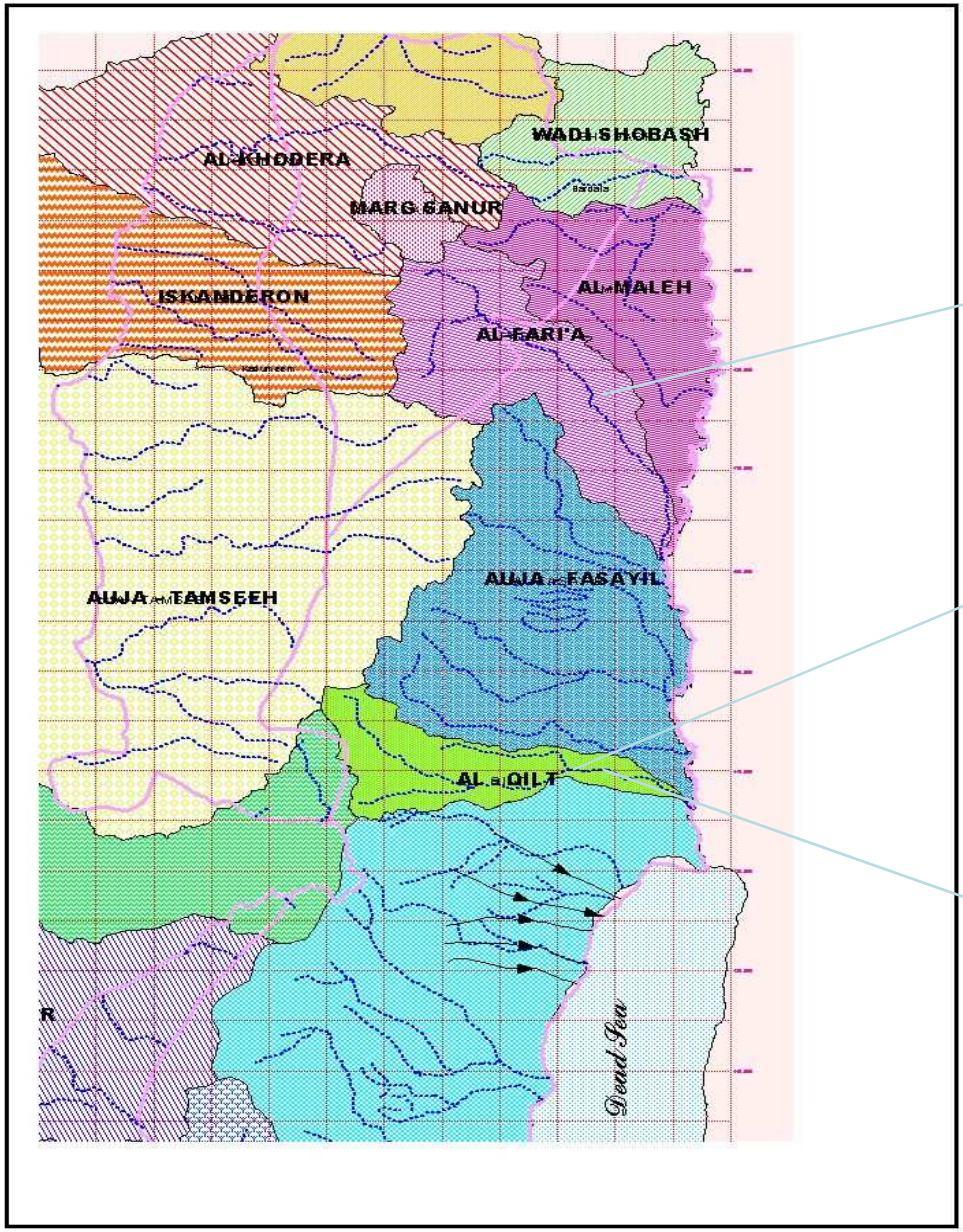
for wastewater treatment and re-use
in the Mediterranean region



Area for proposed sites

Proposed for pilot study

Upstream site (Existing partial flume) Reservoir of storm water

JICA

Downstream (slightly down stream of existing garbage dumping site as recharge pond

Obstacles and difficulties

Generally wastewater reuse projects associated with many obstacles in the West Bank classified by political, financial, social, institutional and technical ones.

• No work permits form the Israelis for treatment plants and lack of funds for collection systems.

•Reuse idea is still tied to the political issues concerned to the Palestinian water rights, since the Israelis ask to consider the reused wastewater as a part of the total Palestinians fresh water rights.

•Non-availability of sewer networks and proper wastewater treatment systems for reuse practices, moreover; there is a lack of expertise in the technical and O&M for wastewater systems.

•Technical capacities in the reuse projects are not formulated well to build on larger reuse projects.

• Week of networking system and information exchange for data available.

• Health monitoring systems is still week.

• Reuse standards is still not established, Israelis are asking for strict standards, while the Palestinians are not able to manage some kind of the presented standards.

• Institutional structure: Efficient financial and technical management of the treatment plant and associated facilities requires strong institutional support. At present, the institutional responsibilities for wastewater management in the West Bank are not well defined due generally to the overall absence of significant wastewater infrastructure.

• Integrated vision: no integrated vision developed for the reuse issues; this includes the political side, institutional, water policy, awareness, marketing and tariff, ext.

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Thank a lot

for your attention

and available time