Water treatment processes and plant in Iraq a review

Basim S. Yousif

aaairaq@yahoo.com

Abstract:

This review paper intends a monitoring scope for treating waste waters. Reusing of treated wastewater effluent, which is normally discharged to the environment from municipal waste water treatment plants, is receiving an increasing attention as a reliable water resource. The volume of this resource may be worthily taken into consideration in the planning and implementations of water resources projects, however, Iraq has many tape of the wastewater resource and the treatment process activities were low efficiency ratio due to technical and administrative reasons. Uses it under environmental and health respects caused increasing the agricultural production and cultivated area. There are relationship between the wastewater treatment quality and crops quality in addition to the state international and local market and movement of international trade. The wastewater treatment in Iraq contain high value of EC & TDS. Moreover, in this paper, we suggest several recommendations for recycling wastewater usage in Iraq.

Introduction

Large amount of water is being consumed in agriculture, industry, domestic and municipal use which imposes a further demand on this resource. Agriculture is the single largest sector that can use about 85% of fresh water in Iraq, accounting for nearly 85%, During the last two decades, the reuse of treated wastewater for agricultural irrigation has expanded, especially in arid and Semi-arid regions, helping to relieve water scarcity and improving the means for local food production. In recent years, the amount of wastewater produced from several activities has increased as a result of the rapid improvement of living standards. Although some communities treat their wastewater in a suitable way, others lack convenient treatment systems. Pollutants (e.g. Heavy metals) enter aquatic systems via numerous pathways, including effluent Discharge, urban and agricultural run-off (Jalal & Jumaily,2012). Contaminants present in sewage commonly include a wide range of metallic and organic compounds. Wastewater treatment technology needs to be appropriate and sustainable. It also needs to be less costly, easy to operate and maintain, and very efficient in removing both organic matter and heavy metals.

Non-conventional water resources are becoming of great importance, especially in countries located in arid and semi-arid regions. Non-conventional water resources comprise desalinated brackish and seawater, treated domestic wastewater, and treated industrial wastewater. Wastewater can be used directly or indirectly; direct reuse means using treated wastewater for irrigation, aquaculture, industrial, and recreation. Indirect reuse means using treated wastewater after mixing with freshwater from a river, a lake or from an underground aquifer (Fahmy et al.2011).

Using macrophytes can be good method to treated wastewater and reduce pollution or discharge wastewater to the environment. The wastewater treated by using macrophytes depend on the treatment design and the uptake of plants (Ali & Sabti, 2010). The macrophytes have other sitespecific Valuable functions, such as providing a suitable habitat for wildlife, and giving systems. Nowadays, climate change and subsequently drought is the real challenge faces all life forms on our planet (Gango & Khwakaram, 2010).

The aim of this review is to focus on the present and future situation of waste water in Iraq, and the problems that face the management of waste water treatment and plants in Iraq.

The unnatural water resources in Iraq

Recently, water resources in Iraq experienced deterioration in both quantity and quality. Moreover, the existing centralized wastewater treatment plants is unable to follow the increasing load due to high rate of population increase. This situation necessitates a new wastewater treatment and water reuse management strategy based on small scale decentralized wastewater treatment plants, the resources are :

1. the wastewater (as **municipal water**) treatment, for irrigation purpose for green lines(belts) or vegetative crops that not eating.
2. the **salty ground water** or sea water are used after treatment (limited uses). Saline and sea water treatment in Iraq by using reverse osmosis technique.

3. Iraqi agriculture sector has a lot of quantity of **drain water** about(15%) from the grand water supply for irrigation , this kind of wastewater contain a lot of compound as nutrient and fertilization elements. This case can enhance the O_2 , NH_4 ratio, then starting the hazard character on plants, water, fish ..ect. Also, the drain water contain a lot of quantity of industrial and wastewater not treatment , but locally we can used this water after mixed it with river water under drain system.

Chemical characters of drain water in iraq (2009)

NO3	Mg	Ca	K	Na	SO4	HCO3	CO3	Cl	EC(ds/m)	PH	Indicator
mg/ L	Cmol/L										
6.2	24.2	14	0.16	29.7	40.1	2.84	0.48	27.5	6.3	8.1	value

ACSAD (2009)

4. **Industrial water** that contain large compound from heavy materials and organic maters. This water quantity are 79.8 m^3/d, including about (59%) industries wastewater from chemical industry sector, it is drained towards (almost) to river and drain network.

5. **Gray water** treatment limited uses in Iraq.

Treatment system in Iraq

Natural treatment systems are considered one of the best treatment options, particularly in warm climates. Constructed wetland is one of the many types of natural systems that can be used for treatment and pollution control. constructed wetland is defined as a wetland specifically constructed for the purpose of pollution control and waste management, at a location other than existing natural wetlands.

Constructed wetlands have many unique benefits as a wastewater treatment process, including the ability to operate on ambient solar energy, self-organize and increase treatment capacity over time, create wildlife habitat, produce oxygen and consume carbon dioxide, and achieve high levels of treatment with minimal maintenance (Ibrahim, et al. 2012, Al Rawi & Al Naggar, 2009, Abbas, et al, 2012).

The efficiency ratio for wastewater treatment(biological method in Iraq) are very low (about 50.4%), and usually there is amount of drained water goes to river or drainge system (Table 1,2).

Using treated wastewater without consideration to environmental impacts can cause accumulation of salt and heavy metals in the soil. This can lead to the soil pollution which affects on crops, human health, surface and ground water resources (Al Nasrawi, 2003).

Table(1) Number of wastewater treatment units in iraq (2011)

Number	43	
quantity of wastewater (1000	input	1938
	output	976
%	50.4	
type of treatment	biological	
ways of drain	river& draine system	

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Table(2) ways of drain industiral wastwater in iraq (2011)

ways of drain	number of factary	%
storge	27	9.9
drain	38	13.9
river	49	17.9
Minicipal system	98	35.8
treatment units	10	3.6
other near lands	16	5.8
other way	36	13.1
total	274	100.0

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Treatment process for wastewater in Iraq

1- Primary Treatment

The principal step is plain sedimentation of settle able matter , there is (8) ponds which will removed heavy solids present in raw sewage in this stage about 40% of (BOD5) and 55% of suspended soil will be removed . The retention time is usually (2-4) hours approximately 30% of some organic nitrogen, phosphorus and heavy metal reduced**.**

2- Secondary Treatment

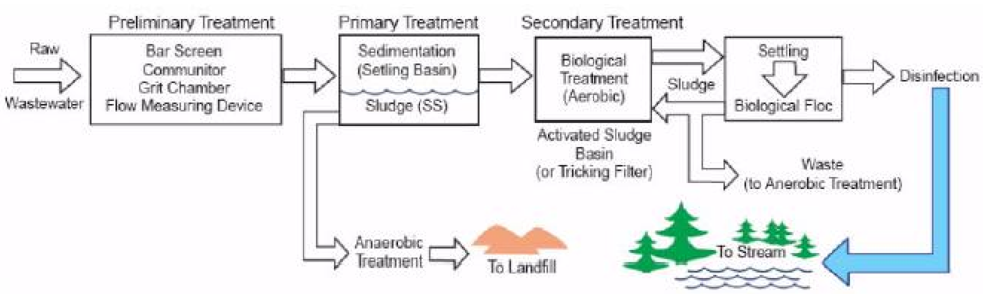
There is (6) aeration ponds where the degradable organic matter is consumed as food by bacteria in the presence of oxygen. The Bactria uses some of the organic material for growth. The remainder is oxidized to carbon dioxide and water. Some of the combined nitrogen and phosphorus present in the waste water and absorbed by the Bactria at the same time. During the primary and secondary treatment pathogenic organisms are largely removed. Disinfection is the last process against any pathogenic organisms remaining in wastewater .In chlorine contact until chlorine is the most generally used disinfection in the prevention of water-borne disease.

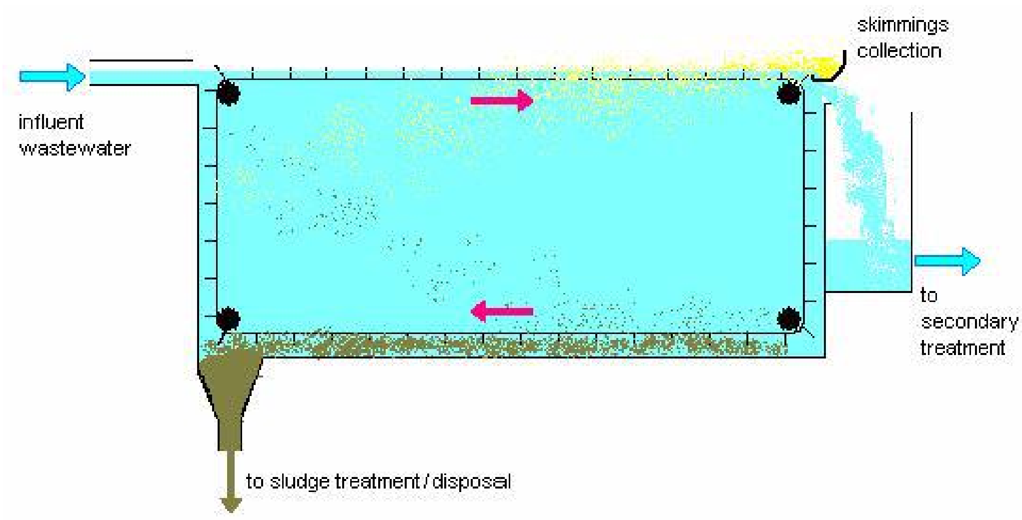
3- Disposal of wastes sludge

A digester units for sludge, The residence time in a digester is about (45) days anaerobic Bactria are analyzer the organic matter to methane and carbon dioxide. Sludge which is produced as a byproduct of most treatment processes are spreading in drying beds.

Utilization of wastewater at special irrigation system

One of the main progressive methods of natural biological treatment of wastewater is their use in agriculture at special irrigation system (SIS).the use of wastewater for irrigation would ensure full treatment of wastes. Where absorption of dissolved matter makes 70 – 100% deficit of water resources in future makes the use of wastewater in agriculture especially promising. In Iraq most of non treated wastewater used by farmer to irrigate some food crop like (lettuce, cabbage, peppers, tomato, peans) also the raw sewage used for nonfood crop like, (Alfalfa, clover. maize, cotton, sunflower) most of treated wastewater from Rustumiya and Karkh treatment plants discharged to Diyala and Tigris river if the treatment not following national environmental it will increased river pollution. In Iraq some farmer used drainage water to irrigate wheat and Barely more than (1.5) million hectare of reclaimed lands discharged drainage salty water to main outfall drain.





The importance of using treated wastewater in agriculture (agronomic aspects)

Treated domestic wastewater is a valuable water resource that can be augmented with conventional sources to satisfy agriculture and industrial demands in arid regions. Its most advantageous use seems to be irrigating newly reclaimed lands due to its fertilizing effect (Yaseen, 2011). Nevertheless, the use of wastewater even after treatment imposes serious threats to surface and groundwater sources. It also involves hazardous effects on public health (Killidar, *et al.,* 2010). Therefore, several criteria should be considered when planning for the use of treated wastewater in irrigation. Different alternatives, such as treatment plant capacity, type of treatment, cultivated area, irrigation method, cropping pattern and mixing ratio with fresh water have to be considered in the planning process. These alternatives must be evaluated and ranked based on their socio-economic and environmental impacts, before implementation. Some post construction problems, like violation of physical system constraints, farmers' acceptability, health, and environmental risks, could be avoided if good strategies for treated wastewater had been formulated and analyzed carefully before implementation, therefore the agronomic aspects are:

1. Uses it under environmental and health respects caused increasing the agricultural production and cultivated area.
2. Increasing the fresh water for drinking usage.
3. Increasing the farm economic .
4. Improvement the soil fertilization.

The problems of using the wastewater treatment in Iraq

1. Deterioration the efficiency treatments units, due to several technical and administrative conditions such as Reduction in the number of technical workers.
2. Unused almost wastewater treatments quantity because not founded the irrigation systems near this projects and return the output water to the river directly.
3. Incontinence the farmers for using this kind of water because the heavy usage for it in agriculture caused injury economic and health characters.
4. The existence of illegal cases for use the wastewater treatment network (canals) units.

Effects of wastewater treatment on economic development sector:

Treated water is a valuable resource that should not be wasted. Humans have always realized the importance of water to life have given top priority to using it wisely. The rapid urbanization increase the pressure on the resources, leading to increasing costs of water supply and emphasizing on the need for appropriate water management practices. Approximately 30% of the populations in Iraq are connected to sewerage system. it is a common practice to discharge untreated sewage directly into bodies of water causing significant health and economic risks. The reuse of treated municipal wastewater for purposes such as agricultural and landscape irrigation reduces the amount of water that needs to be extracted from natural water sources as well as reducing discharge of wastewater to the environment, In Iraq, most of it connected to sewerage system and then conveyed and received primary and secondary treatment, the rest disposed to the Tigris river without any treatment, and the using of treated wastewater for irrigation is still not experienced yet (Khathi, et al., 2010, Patterson, 2011). the effective are:

1. There are relationship between the wastewater treatment quality and crops quality in addition to the state international and local market and movement of international trade.
2. The costs of seawater treatment units is vary high.
3. Effects the wastewater quality on the rivers and sea environment then on value of fishes quantity and tourist activities.
4. Effects this kind of water on animal and human health.
5. Human faces contain pathogens when escapes in water lead to water pollution.
6. Sewage treatment plan consider as a key factor for possibility of infection by *E.coli* ,the main source of diarrhoeal diseases .

The characters of wastewater treatment in Iraq

Reusing of treated wastewater effluent, which is normally discharged to the environment from municipal waste water treatment plants, is receiving an increasing attention as a reliable water resource. The volume of this resource may be worthily taken into consideration in the planning and implementations of water resources projects. For the time being, it has been detected that about 1 million cubic meters\day in Iraq to rivers after getting secondary treatment, which (if treated) may irrigate the industrial crops, or to be used for planting a green lines of trees surrounding the cities, this could help in damping the dust storms which became a predominant phenomena in the last few years. the concept of decentralization sewage treatment plants and separation of gray water in source(Paranychianakis & Chartzoulakis, 2005). The characters are:

1. State of the chemical water deferent from place to others depend on population ratio, human living methods, climate condition.
2. It is contain high value of EC & TDS, Fig(1\a,b,c), Table (4).
3. It is contain high value of heavy mental as Hg, Cd, Gr, Pb, As , the recourse of this elements the industry waste water.

Phytotoxicity & threshold levels of heavy trace metal for crop production

Heavy metals	Phytotoxicity (ppm)	Threshold level for crop production (ppm)	Damages to crops
Cd		0.01	Toxic to beans, beets & turnips at concentrations as 0.1 ppm in nutrient solutions. Conservation limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Cu	60 -125	0.2	Toxic to a number of plants at 0.1 to 1.0 ppm in nutrient solutions.
Ni	100	0.2	Toxic to a number of plants at 0.5 to 1.0ppm; reduced toxicity at normal or alkaline pH .
Pb	100- 400	5	Can inhibit plant cell growth at very high concentrations.
Zn	70 - 400	2	Toxic to many plants at widely varying concentrations: reduced toxicity at pH > 6.0 and in fine texture or organic soils.

4. It is contain high value of microbial and toxicological indicators.
5. It is contain high value of NH4 and NO3, recourses this compounds the drain water because the farmers uses a lot of quantity of fertilization elements.
6. It is contain high value of BOD, this is refer to level of aeration condition in water, recourses it from aquatic plant and fungi also the water movement and wind, this value depended to degree of temperature (the value are very low at summer session).

Table (3) avarage value for lap testing for wastewater projects (units) in iraq (2011)

	PH		TSS		BOD		COD		Cl		SO4		PO4		NO4		NO2		NH4		TDS	
	(6-9)		(60mg/l)		(40 mg/l)		(100 mg/l)		(600 mg/l)		(400 mg/l)		(3 mg/l)		(50 mg/l)		NIL		(10 mg/l)		(1500 mg\l)	
governorate	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Ninawa	6.9	7.5	193	35	106	11.4	149	47	103	90.3	117	116	11	5.8	20	109	0.1	1.5	21.5	3.3	524	528
Baghdad	7.3	7	310	30	241	20	383	37														
Babil	7.2	7.3	311	96	149	21	195	76	473	462	868	891	12	7	12	22	0	1	21	4	2314	2306
Karbala	6.8	7.2	166	51	170	8	236	38	269	251	460	519	9	4	14	131	0	8	21	0	1384	1468
Salah addin	7.1	7.3	266	79	172	40	225	137	138	140	204	228	18	8	19	54	0	0	34	20	1329	1273
Najaf	7.1	7.4	323	126	110	20	214	108	335	320	881	902	8	8	18	83	0	1	32	23	2594	2673
Qadisiyyah	7	7.2	213	116	198	49	184	69	364	317	489	518	13	8	14	17	0	0	22	20	1544	1481
Maysan	7.2	7.5	374	290	198	143	295	191	1050	1019	546	547	11	10	14	17	0	0	21	18	2537	2589
Basrah	7.3	7.6	230	287	152	48	163	184	2641	2348	2641	2348	8	5	15	18	0	0	30	26	3556	3780

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According to Table (3) :

1. The value of TDS, EC, *T.coli* in Euphrates and Tigers rivers increased in summer months (with increasing the evaporation ratio) , also there are increasing with flowing the river inside country.

2. Drained the wastewater (municipal, industrial ..ect) directly to rivers and daring system, this caused states of pollution and increasing the organic microbial compound, then increased the toxicological health risks (Hussain, 2009).

3. the value of TSS, TDS, BOD, COD, Cl, SO4 and NH4 are exceed the limited wastewater Iraqi standard (NO. 25, 1967), because of effectives the none industrial, drain and municipal wastewater from the treatment projects.

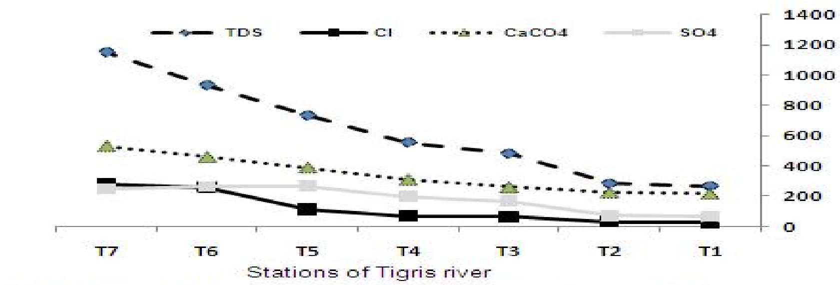

Fig.1A : that shown the CaCO3,Cl, SO4 & TDS concenretion increased with flowing the river inside iraq, because effected the wastewater.

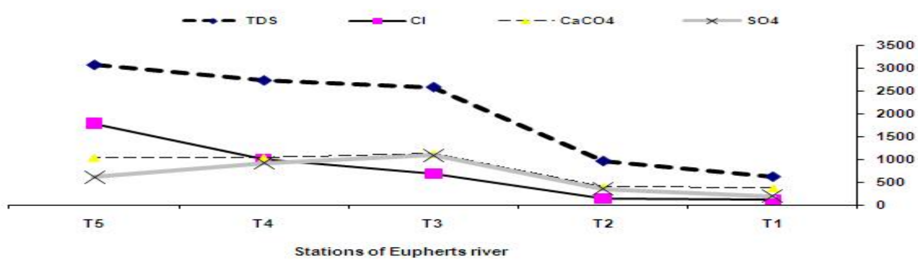

Fig.1B: that shown the TDS, Cl, SO4 & CaCO4 value increased with flowing the river inside iraq, because effected the wastewater.

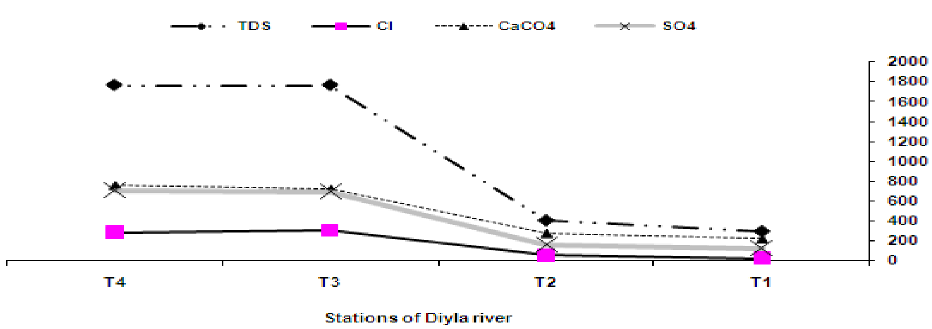

Fig.1C: that shown the TDS, Cl, SO4 & CaCO4 value increased with flowing the river inside iraq, because effected the wastewater.

Conclusions

1. Treated wastewater from (drain water, industrial wastewater, municipal water and salty ground water) are important resource of abnormal water in Iraq.

2. The efficiency ratio for wastewater treatment(biological method in Iraq) is very low (about 50.4%), and almost there is quantity of water drain to the river or drainage system.

3. Using treated wastewater under environmental and health respects can increase the agricultural production and cultivated area.
4. There are relationship between the wastewater treatment quality and crops quality, as well as to the state international and local market and movement of international trade.

5. The wastewater treatment in Iraq contain high value of EC & TDS.

Recommendation

1. Application new methods to reuse treated wastewater in irrigation system for crops, trees, frosty.
2. Protect the hazards factors when used this water in agriculture.
3. Increasing the public knowledge for uses this water.
4. Monitoring and evaluation for the wastewater treatment projects and units.
5. Application the sewage sludge as a organic fertilization.
6. Prevent draining the wastewater directly to the rivers without treatment.
7. Increased uses the wastewater treatment for irrigation purpose for green line , forest and the farms that produced plants not eating.
8. Increase the studies and research for this kind of water.
9. Increase agriculture extension activities for using treated wastewater in agriculture are crops production.
10. Use of treated wastewater recommended for the purposes, Municipal uses for street cleaning, gardens, watering of road sides, Agricultural uses for irrigation of forests, fodder crops, Industrial uses for cooling pipes of boiler

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Table (4) Cl, SO4, CaCO3, TDS CONCENTRATIONS IN MAIN RIVERS IN IRAQ

River	station	Indicators	2007	2008	2009	2010	2011	information
Tiger	T1	Cl mg/ L	28.2	30.17	29.7	27.44	27.3	first inpot point to iraq
		CaCo3 mg/ L	196.81	198.3	207.3	184.58	217.9	
		So4 mg/ L	55.89	56.2	46.3	49.72	65.5	
		TDS mg/ L	322.63	255.4	238.5	239.8	267.4	
	T2	Cl mg/ L		33.87	33.6	30.55	32	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L		233.3	226.6	203.33	226.2	
		So4 mg/ L		66.62	60.3	55.37	71.7	
		TDS mg/ L		293.5	248.5	265.77	283.7	
	T3	Cl mg/ L	66.33	100.1	72.5	60.29	65.2	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	250	383.3	320.8	262	260.9	
		So4 mg/ L	130.25	186.63	164.3	153.58	168.5	
		TDS mg/ L	492.6	584.3	494	472.36	481.5	
	T4	Cl mg/ L	68.43	101.16	138.8	61.92	69.7	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	317.77	424.1	326.6	298.64	310.6	
		So4 mg/ L	172.7	210.91	187.8	181.55	199.3	
		TDS mg/ L	526.88	618	468	531.2	556.1	
	T5	Cl mg/ L	98.57	106.8	103.2	78.61	112.4	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	386.27	443.8	381.2	324.8	388.7	
		So4 mg/ L	169.65	240.31	182.2	185.55	267.7	
		TDS mg/ L	619	675.8	580	550.6	733.2	
	T6	Cl mg/ L	287.22	453.2	293.4	273.3	258.7	because effected the wastewater (miniciple , industrail , drainge water)from cities.
		CaCo3 mg/ L	461.18	540.3	459.1	421.4	459.8	
		So4 mg/ L	173.5	209.6	257.8	309.13	264.8	
		TDS mg/ L	986.09	1641.7	714	905.3	933.5	
	T7	Cl mg/ L	437.7	840.7	454.4	359	278.8	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	711.36	836.5	726.4	505	530	
		So4 mg/ L	263.64	567.9	379.3	291.58	247.1	
		TDS mg/ L	1440.9	2187.9	1889.4	1362.64	1152	
Eupherts	E1	Cl mg/ L	74.6	213.2	187.3	151.8	130.9	first inpot point to iraq
		CaCo3 mg/ L	208	203.7	363.2	382.48	382.9	
		So4 mg/ L	113.8	208.8	337.1	203.8	203.3	
		TDS mg/ L	351	691.3	805.3	633.93	626.5	
	E2	Cl mg/ L	147.9	0	340	238.84	152.3	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	419.4	435.18	617.2	463.44	417.3	
		So4 mg/ L	172.46	227.9	438	382.76	363.7	
		TDS mg/ L	651.9	728.2	1091.4	1035.1	970.2	
	E3	Cl mg/ L		659.98	1114.2	1004.1	703.5	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L		1050.8	1895.1	1488.9	1140	
		So4 mg/ L		394.6	1311.9	1255.6	1102.9	
		TDS mg/ L		2010.1	3291.7	2004.2	2592.6	
	E4	Cl mg/ L	256.5	596.21	997	716.3	1015	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	355.6	308.4	960	936.3	1050	
		So4 mg/ L	873.28	0	0	664.2	928.9	
		TDS mg/ L	1618	1886.1	3792.7	2560	2739	
	E5	Cl mg/ L		827.3	1143.3	729.2	1799	because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L		840.2	1309.8	926.7	1051	
		So4 mg/ L		613.02	674.7	629.58	623.6	
		TDS mg/ L		2319.1	3103.2	2583.7	3080	
	E7	Cl mg/ L	946	1581.5	1500			because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	1034	1352.2	1340.4			
		So4 mg/ L	618	1153	845.3			
		TDS mg/ L	2658	4170.9	3367.6			
Diyla	D1	Cl mg/ L	29.3	32.66	30.4	28.4		first inpot point to iraq
		CaCo3 mg/ L	285	236.42	228.8	223.4		
		So4 mg/ L	195	145.65	135.1	125.6		
		TDS mg/ L	450	388.3	319.9	301		
	D2	Cl mg/ L	577	65.31	32.39	53.9		
		CaCo3 mg/ L	296.5	421.8	243.2	281.2		
		So4 mg/ L	134	185.86	147.1	161.3		
		TDS mg/ L	373	807.45	331.5	410		
	D3	Cl mg/ L	270.65	351.75	314.2	308.1		because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	714.5	840.75	879.3	723.5		
		So4 mg/ L	432	407.6	624.6	694.3		
		TDS mg/ L	1513.6	1694.3	1951.2	1766.4		
	D4	Cl mg/ L	238.4	355.41	309	289		because effected the wastewater (miniciple water)from cities.
		CaCo3 mg/ L	743.16	899.25	864.3	762.7		
		So4 mg/ L	438	412.4	594	707.1		
		TDS mg/ L	1433.3	1702.1	2049.3	1766.3		
Shat al arab	SH1	Cl mg/ L	800					mixed point area
		CaCo3 mg/ L	1000					
		So4 mg/ L	500					
		TDS mg/ L	2250					
	SH2	Cl mg/ L	550					
		CaCo3 mg/ L	800					
		So4 mg/ L	550					
		TDS mg/ L	1600					

Ministry of planning , statical of environmental in iraq, 2011

PH (acidity & basicity) H+

EC electrical conductivity dS\ cm

TI (color) Turbidity (NTU)

Cl chloride (mg\l)

TH total hardness (CaCO4) (mg\l)

BOD biological oxygen demand (mg\l)

TSS total suspended solid (mg\l)

TDS total dissolved solids (mg\l)

COD chemical oxygen demand

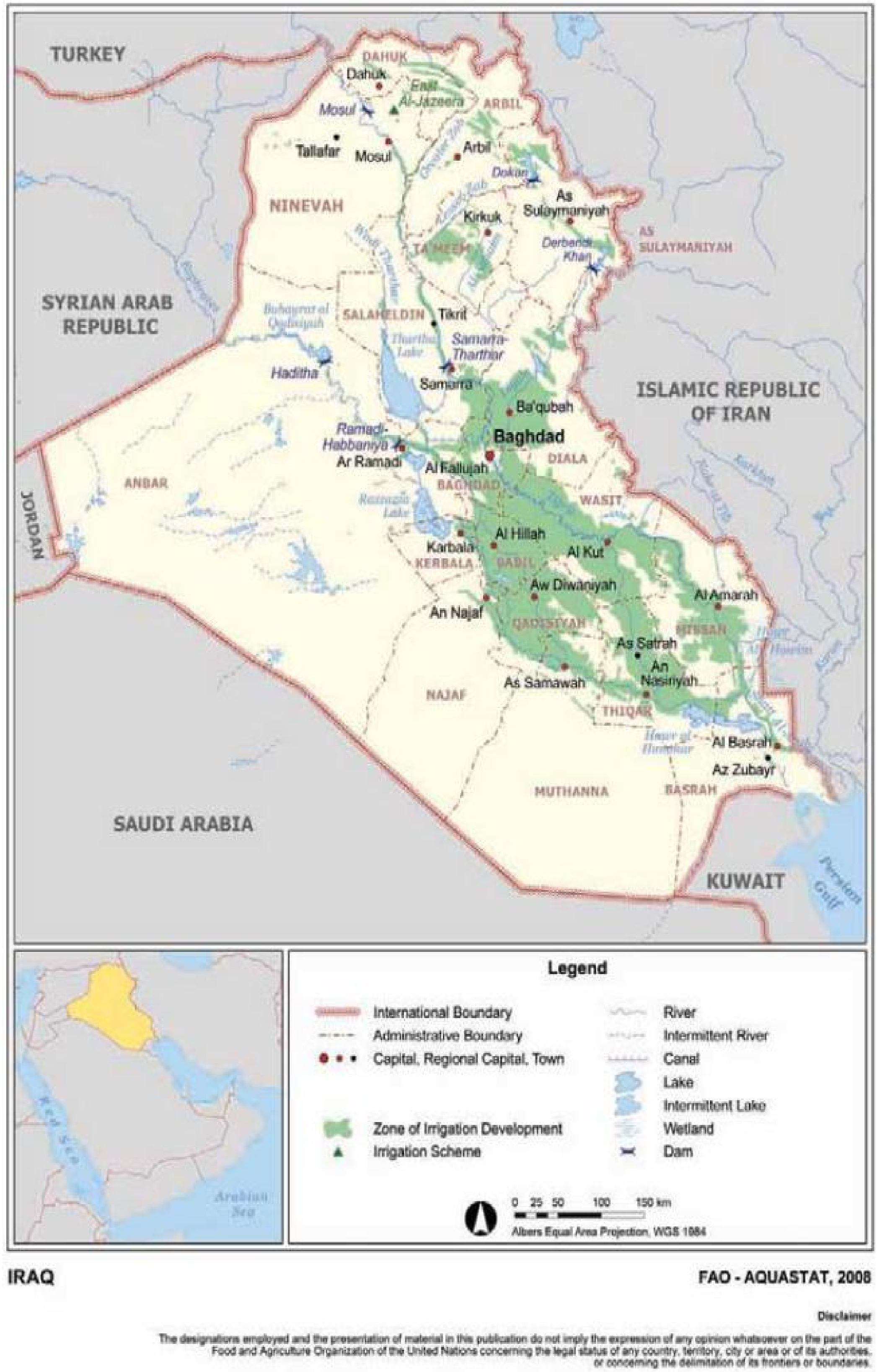
SO4 sulphate

NO4 nitrates

PO4 phosphate

Map of IRAQ


TURKEY
DOHUK
ERBIL
NINEVAH
SYRIAN ARAB REPUBLIC
TAMIM
SULEIMANIYAH
SALAHUDDIN
DIYALA
ISLAMIC REPUBLIC OF IRAN
BAGHDAD
ANBAR
JORDAN
WASIT
BABIL
KARBALA
MISAN
QADISIYAH
DHI-QAR
NAJAF
SAUDI ARABIA
IRAQ
MUTHANNA
BASRAH
KUWAIT


TURKEY
SYRIAN ARAB REPUBLIC
ISLAMIC REPUBLIC OF IRAN
JORDAN
SAUDI ARABIA
KUWAIT
Persian Gulf
DAHUK
Dahuk
Mosul
Tallafar
Mosul
Arbil
ARBIL
Dokan
As Sulaymaniyah
AS SULAYMANIYAH
Derbendi Khan
Kirkuk
TA'MEEM
NINEVAH
SALAHELDIN
Tikrit
Samarra-Tharthar
Samarra
Haditha
Ba'qubah
Baghdad
DIALA
Ramadi-Habbaniya
Ar Ramadi
Al Fallujah
BAGHDAD
WASIT
ANBAR
Al Hillah
Al Kut
Karbala
KERBALA
BABIL
Aw Diwaniyah
Al Amarah
An Najaf
QADISIYAH
MISSAN
As Satrah
An Nasiriyah
As Samawah
NAJAF
THIQAR
Al Basrah
Az Zubayr
MUTHANNA
BASRAH
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
Zone of Irrigation Development
Irrigation Scheme
River
Intermittent River
Canal
Lake
Intermittent Lake
Wetland
Dam
0 25 50 100 150 km
Albers Equal Area Projection, WGS 1984
IRAQ
FAO - AQUASTAT, 2008
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