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REGIONAL SYMPOSIUM ON WATER USE AND CONSERVATION

28 November - 2 December 1993
Amman - Jordan

POTENTIAL AND EXISTING TREATED WASTEWATER REUSE IN SELECTED ESCWA COUNTRIES

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Organized by the
Economic and Social Commission for Western Asia (ESCWA)

and the

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in cooperation with the
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and

United Nations Environment Programme (UNEP)

Potential and Existing Treated Wastewater Reuse in Selected ESCWA Countries*

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Potential and Existing Treated Wastewater Reuse in Selected ESCWA Countries

Abstract

Water pollution and its scarcity become a major concern in most ESCWA countries which is attributed to extensive withdrawal of renewable water resources, and hence resulted in hindering the sustainable development of the region, by the year 2025, almost all countries in the region will not be able to meet their water requirement for different purposes. Efficient water resources management can help considerably to overcome this critical situation. Hence, the purpose of this study is to identify potential uses of reclaimed water, to review the types of wastewater reuse applications, treatment processes and it appropriateness for present and future reuse. The study also discussed in detail the regulations and guidelines for wastewater reuse in ESCWA countries. It also covers the economical and social aspects for wastewater reuse in the region. It includes : 1) importance of wastewater reuse to augment to the conventional water resources and contribute to the economic development in the ESCWA region; 2) potential uses of reclaimed water in WA: the reclaimed water will have significant importance in agricultural economy qualitatively and quantitatively; 3) types of wastewater reuse applications in most WA countries: reclaimed water provides a convenient and economical source for irrigation. In Egypt, Iraq, Lebanon, Syria , Yemen, and occupied Palestinian territories wastewater is used through discharging it to irrigation canals or rivers; and at least six out of thirteen countries of the region are currently practicing wastewater reuse in unplanned, uncontrolled, direct reuse for irrigation, causing pollution to groundwater and the soil; 4) treatment processes and its appropriateness for present & future reuse: there are four wastewater treatment processes that can achieve complete removal of helminth eggs namely: i) conventional sewage treatment with effluent upgraded in polishing ponds, ii) conventional secondary treatment followed by slow sand filtration. iii) waste stabilization ponds, iv) combination of treatment and effluent storage; 5) regulations & guidelines for wastewater reuse in WA countries: most guidelines and government regulations in WA were set as effluent standards to control the quality of the discharge the major criticism of effluent standards has been that the application of a uniform effluent standard can be uneconomical and inappropriate. Moreover, the effluent standard is too stringent and environmentally unsound. This is due to the great variation in the final beneficial usage. It is suggested that stream standards be imposed in case of indirect reuse and they must be based on using the total assimilative capacity of the rivers or waddies and on the minimum water-quality level for the predominant water reuse downstream; 6) economical and social aspects for wastewater reuse, almost always, the wastewater reuse is economical and feasible in WA countries. Therefore, it must be mandatory to eliminate the costs of supplementary water supply;

Abbreviations and Acronyms

Abbreviations for Units Measure

CM	Cubic meter (264 US gallons)
CM/sec	Cubic meter per second (22.8 Mgd)
Dunum	1000
ha	1 hectare (2.469 acres) = 10 dunums
km	Kilometer (0.621 miles)
l	Liter (0.264 US gallons)
l/c/d	Liters per capita per day
l/d	Liters per day
MCM	Million cubic meters
mg	Milligrams
ml	Milliliters

Acronyms

AGTP	Ain Ghazal Treatment Plant
AL	Aerated Lagoon
AS	Activated Sludge
BOD	Biochemical Oxygen Demand
CDM	Camp, Dresser & Mckee International, Inc.
CEHA	Center for Environmental Health Activities (WHO)
COD	Chemical Oxygen Demand
CWWTP	Conventional Wastewater Treatment Plant
DO	Dissolved Oxygen
EC	Electrical Conductivity
ESCWA	Economic and Social Commission for Western Asia
EPA	U.S. Environmental Protection Agency
FAO	Food and Agriculture Organization
FC	Fecal Coliform
KTD	King Talal Dam (Jordan)
MCL	Maximum Contaminant Level
NA	Not Available
NTU	Nepheometric Turbidity Units
O3	Ozone
OP	Oxidation Ponds

OPT	Occupied Palestinian Territories
O&M	Operations and Maintenance
PCB	Polychlorinated Biphenyls
POTW	Public Owned Treatment Works
PP	Polishing Pond
RAS	Return Activated Sludge
RBC	Rotating Biological Contractor
RO	Reverse Osmosis
RSF	Rapid Sand Filtration
SAR	Sodium Adsorption Ratio
SS	Suspended Solids
SSF	Slow Sand Filtration
TDS	Total Dissolved Solids
TF	Trickling Filter
THM	Trihalomethane
TKN	Total Kleldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TOH	Total Organic Hydrocarbons
TP	Total Phosphorus
TSS	Total Suspended Solids
UN	United Nations
UNEP	United Nations Environmental Programme
WA	Western Asia
WAS	Waste Activated Sludge
WB	World Bank
WHO	World Health Organization
WPCF	Water Pollution Control Federation
WSP	Waste Stabilization Ponds
WWTP	Wastewater Treatment Plant

Potential and Existing Treated Wastewater Reuse in Selected ESCWA Countries

I. Introduction

1. Necessity of the Use nonconventional Water Resources to Augment Conventional Ones:

The member countries of the Economic and Social Commission for Western Asia (ESCWA) are all situated in arid and semi-arid zones. The region is characterized by land and soil degradation. desertification water scarcity, salt intrusion and coastal degradation and over-population. Table 1 shows in detailed information about climatic classes and soil constraints in Western Asia (46).

More than 90 per cent of the total area of the ESCWA region is arid, 6 per dent is semi-arid; 3 per cent is humid. 15 per cent of the land with soil not affected by one or more of the following constraints:- steep slopes, shallow soil, poor drainage, low nutrient retention, aluminum toxicity, acid soil, phosphorus material, vertic properties, low potassium reserves, calcareous soil, soil salinity, excess sodium, and acid sulfate (48).

Desertification is a serious problem facing most of the Western Asia countries. Syria is given as an example in UNEP's report entitled "Status of Desertification and Implementation" (48). The following was stated in this regard:

"Also in ESCWA report in 1987 (25), Yemen case was mentioned as":

a) An area of some 500 thousand hectares in the anti-Lebanon range north of Damascus was studied recently to assess the change in land use patterns from 1958-1982. It was found that the rea of rocky shrub land and bane skeletal land has increased from 50 thousand hectares or 10 per cent to 80 thousand hectares or 16 per cent of the total, an average annual rate of desertification of 0.25 per cent for this area"

b) "Existing statistics show that the average annual rate of cultivated land abandonment due to soil degradation has increased from 0.6 per cent in 1970-1980 to about 7.0 per cent in 1980-1984". (25).

c) Concerning sedimentation indicators, an estimated 2500 hectares of Jordan's soil resources have been lost annually during the past fifty years. Particularly, in view of the fact that 99 per cent of the Jordan-land area is subject in variable degrees to different processes of desertification (25).

Table 1 Climatic Classes and Soil Constraints

Country	Total land area 000ha	Percent of total area			Percent of the total land with no inherent soil constraints
		Arid	Semi-arid	Humid	
Bahrain	68	100	0	0	18
Egypt	99545	100	0	0	25
Iraq	43737	73	9	18	6
Jordan	8893	85	7	9	5
Kuwait	1782	100	0	0	2
Lebanon	1023	0	2	98	6
Oman	21246	100	0	0	18
Qatar	1100	100	0	0	26
Saudi Arabia	214969	97	2	0	14
Syria	18406	49	34	16	4
U. Arab Emirates	9360	100	0	0	44
Yemen	52797	72	21	7	12
OPT	593	NA	NA	NA	NA

NA : Not available

Source: The World Resources Institute, 1992.

The demand for arable land and water resources is increasing to satisfy the expanding population and rising standards of living. The limited resources in WA have resulted in over-exploitation and degradation of the natural environment have led to serious modification or depletion of these resources. This was clear on land and soil; but the spectrum in renewable water resources which in case of thie availability can combat the soil and land deterioration is more somber as shown in Table (2.2). The resources cannot assure the quantities necessary for human subsistence.

Bahrain, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Yemen, have been undergoing a withdrawal exceeding the total internal renewable water resources and they depend mainly on water desalination and/or an overpumping of ground aquifers and tapping of non-rechargeable aquifers (48).

2. Treated Water Reuse in the ESCWA Region:

Hence, to the limited water resources available in most member States of ESCWA, the augmentation of conventional water supplies by non-conventional sources has become an important activity for developing such resources in the region.

Desalination of salt water or brackish water is an intensive source of fresh water; and become a significant portion of total supply in Western Asia region.

According to the Atlas of the Environment (28) countries with under 2000 cubic metres of fresh water per capita per year are considered to be chronically short of water and according to this definition; mostly ESCWA countries belong to water-short region.

I. Also waste-water resuse has been practiced in some ESCWA member States for a considerable period of time; however, its application has been limited, and plans have been formulated for the large-scale development of this non-conventional supply source. Lack of knowledge of the long-term effects of treated sewage effluent use for various purposes and the unavailability of other water resources have limited the reuse of treated waste water on a wider scale. The development of new technologies and the rising costs of desalinating water have led to increased waste-water reuse during the last decade in the ESCWA region. Water reuse, whether in agriculture or for other purposes, still entails certain risks to humans, and must therefore be carefully monitored and controlled and its overall cost considered.

Jordan, the Gulf States and Egypt have practiced the application of waste-water reuse in agriculture and public gardening. Table 2.1 below shows the present and future (projected) treated sewage effluent use in these countries.

Table 2.1 Future treated sewage effluent in some ESCWA countries

Country	Volume of waste-water reuse (MCM)		Use
	Present	Future	
Bahrain	9	67	Gardening
Kuwait	40	..	"
Oman	25	..	"
Qatar	120	..	Irrigation
Saudi Arabia	400	..	"
United Arab Emirates	62	..	Gardening
Egypt	600	1 000	Irrigation
Jordan	35	116	"
Total	1290	1141	

Source: E/ESCWA/ENR/1992/5, "Progress Achieved in the implementation of Mar der Plata", October 1991.

Table 2.2 Freshwater Resources and Withdrawals in WA (UNEP 1991)

Country	Renewable water resources 1990		Withdrawal from renewable and non-renewable resources[a]			
	10^3 Total MCM a^{-1}	Per Capita 10^3 m^3 a^{-1}	Year of data	Per Capita m^3 a^{-1}	Per Capita for domestic L/cap/day	Per Capita for domestic m^3 a^{-1}
Bahrain	0.0	0.00	1975	.735	1208	441.0
Egypt	58.3[b]	1.11	1985	1.08	207	75.6
Iraq[d]	100.0[b]	5.29	1970	4575	501	183.0
Jordan[d]	1.1	.027	1975	173	138	50.2
Kuwait	0.0	0.00	1987	238	417	152.3
Lebanon	4.8	1.78	1978	271	82	29.8
Oman	2.0	1.33	1978	561	46	16.8
Qatar	0.0	0.05	1978	234	396	144.5
Saudi Arabia	2.2	0.16	1978	321	396	144.5
Syria[d]	35.5[b]	2.83	1976	449	86	31.4
UA Emirates	0.3	0.19	1987	393	52	18.2
Yemen	2.5	0.22	1980	429	129	47.2
OPT	0.7	0.19	1990	152	88	32[c]

(a) Calculated from sectoral percentages usage given in the reference
(b) Includes a contribution from river flows from other countries.
(c) Occupied Israeli Authorities have full control over water resources in Occupied Palestinian territories (OPT). (49)
(d) Not firm figures, because upstream use of river water can dramatically alter the potential downstrea.

The major challenge which will face ESCWA region will be to provide enough water for human subsistence and sustainable agriculture in keeping with the growing demands for domestic and industrial needs which, usually, come as first priority. the question is how and from where the required water supply to sustain life in this region can be found.

The high-income countries within ESCWA region will continue to depend on desalination. Nowadays, Saudi Arabia is the world leader in this field and has 27 per cent of the total global capacity. Kuwait has 11 per cent; the United Arab Emirates has 10 per cent. Desalination is 3-4 times more expensive than conventional source of fresh water and the cost is from 40-60 US cents per M^3 of brackish water and 1.05-1.60 US$ per M^3 of sea water (44). This cost is too high to pay back by agricultural production. Improved and efficient water resources management can help considerably to overcome this critical situation. Wastewater reuse, recycling, harvesting, and water conservation have a good potential.

3. Potential Use of Water in the ESCWA Region:

The range of the quantity of water required to produce food for one person varies; but in WA it appears to be in the range of 750-900 cubic metres (45). According to this limit, and, if it is assumed that 70 per cent of renewable water resources will be available for agriculture production, only four countries within their range of population growth in 1990 (Iraq, Lebanon, Oman and Syria) can theoretically produce food to satisfy their population needs. However, by the year 2025, Iraq will be the sole country capable of satisfying the food needs of its population, provided that the Euphrates and Tigris rivers maintained their annual flows uninterrupted.

II. Water Reuse Practices in Western Asia

1. Uses:

In the region the reclaimed water is the side product of urban and rural sanitation service by sewer systems. At the end of the International Drinking Water Supply and Sanitation Decade, sewer services coverage in WA was as shown in Table 3. Fig. 2 shows the percentage of wastewater to be produced in the year (2025) compared with renewable water resources. In Saudi Arabia, Jordan, Yemen, the percentage is 142, 28, and 18 respectively and all of the quantities in Kuwait, Bahrain, Qatar are totally produced through desalination. From the chemical point-of-view, this means that the reclaimed water will have good quality for agricultural production. The water quantity to be produced in (2025) would be sufficient to produce food enough for 17 million people which would be equivalent to 6 percent of the population in 2025.

Table 3 Wastewater production in WAR

Country	% Urban population	Sewage generation L/cap/d			% population served			Sewage generation MCM/4r		
	2000	1995	2000	2025	95	2000	2025	1995	2000	2025
Bahrain	87	415	430	450	58	65	90	53	69	148
Egypt	55	130	187	200	45	55	65	1264	2353	4287
Iraq	79	110	115	125	40	50	75	360	558	1710
Jordan	74	80	85	100	52	60	85	76	102	307
Kuwait	97	200	210	250	85	90	95	146	190	328
Lebanon	87	150	155	165	50	55	75	33	47	142
Oman	35	192	200	250	15	18	32	26	73	139
Qatar	91	220	225	235	65	70	92	23	29	68
Saudi Arabia	82	200	225	235	70	72	85	875	1219	3263
Syria	68	150	155	165	55	65	80	451	650	1642
UAE	78	200	210	225	70	85	90	91	127	196
Yemen	50	40	55	65	30	35	55	61	116	451
W + G	80	70	75	85	30	35	70	12	18	66

Source: This table was set up upon reviewing the following references.
1. The World Resources Institute 1992. (44)
2. ESCWA 1990. (24)
3. UNEP 1991. (48)
4. SAMED 1993. (37)
5. WHO 1990. (52)
6. WHO, UNDP, UNEP 1990 (45)
8. WHO/CEHA 1992. (54)
9. UN 1991. (49)

2. Types of Wastewater Reuse Application in Application in ESCWA Countries:

The reuse opportunity potential in WA is very high due to the following conditions (Table 2.1):

- Extreme water scarcity which affects economic development with little chance to create feasible alternatives for a water supply having excellent quality and competitive price as in the case of reclaimed water.

- Wastewater is a good reliable source and if there is a good design for reuse, there will be no health problems ahead.

- The reuse in irrigation is the most environmental and economic sound alternative for wastewater disposal.

- The reuse capital investment can be paid back with a reasonable profit for both suppliers and users.

- The socio-cultural acceptance is there.

Under these conditions, reclaimed water has been used in the whole region whether on a planned or unplanned, direct or indirect application for centuries.

In Egypt, Iraq and other countries, the wastewater is used through discharging it in to irrigation canals or rivers. (21)

In most WA countries sewage effluent provides a convenient and economic source of water for irrigation. In the last decade there has been a significant move to formalize health risks and use the treated effluent with the highest possible efficiency. In addition to wastewater being reused, nutrients can be recycled through irrigation as well. This will protect water bodies from eutrophication and will at the same time use the fertilizer value in the reclaimed wastewater to meet the fertilizer requirements of a wide range of crops; but care needs to be taken that the fertilizer value should not be too high for some supplementary crops. Noteworthy is that at least eight of WA countries operate these days modern wastewater reuse facilities to yield agricultural products; and a great effort is being made to expand these facilities to bring more land under cultivation. This will also contribute to combatting desertification by irrigating green belts, roadside trees, public greenery in parks, landscaping, forestry, ornamental trees and bushes to beautify cities.

All countries are practicing wastewater reuse for irrigation, and at least six out of the thirteen countries in the region are currently practicing wastewater reuse in an unplanned, uncontrolled, direct reuse for irrigation. In Yemen, Lebanon, Palestine (OPT) Syria and Egypt, raw sewage is being applied to farms including those producing salad vegetables; this practice, of course, has been condemned by the health officials in these countries. As has been stated previously, this practice will produce adverse effects on public health; and the continuity of these methods of disposal will lead to a very dangerous deterioration in an already critical environmental and public health situation.

At least three countries discharge raw wastewater to the surface water without considering the management of reclaimed water as a resources. Unless early measures are soon applied, many of the drinking water sources will be heavily polluted and may have to be abandoned for far away sources, if any such sources can be found.

Two thirds of the population of Lebanon reside in the coastal settlements and are presently polluting the Mediterranean thus causing health hazards by discharging raw sewage to the coastal front. All sewer networks serving about fifty per cent of the population have not been maintained for the last eighteen years. Sewers have been blocked and damaged; they are overflowing and leaking, thus polluting ground and surface domestic water causing health risks. A survey carried out in 1991 (19), shows that 70-80 per cent of water resources throughout Lebanon are polluted, mainly due to sewage disposal practices.

A similar condition exists in the West Bank and the Gaza Strip. Cesspits are flooding the surface and creating marshes within residential areas, where children find a place to play. Even wastewater from sewer systems flow to nearby wadis; this is the case in Nablus, Bethlehem, Hebron and all refugee camps, where wastewater is used to irrigate trees and vegetables, which are consumed in nearby areas causing the spread of helminthic infection.(33).

In the Gulf States, however, the aim is to achieve a high quality standard effluent for green yard irrigation through secondary and tertiary treatment.

Modern operational wastewater reuse facilities are currently functioning in seven countries of the region; namely Bahrain, Jordan, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. Egypt was the first country to use primary treatment sewage in a direct and planned manner. This operation was started in Cairo city in 1911 and has been used ever since to irrigate Jabal Al-Asfar covering an area of about 1260 hectares. (1). The earliest planned and monitored reuse facility in Kuwait started operation in 1970.

In Jordan the major indirect reuse scheme was started in 1969 when the sewage treatment plant at Ain-Ghazal was established. Later the activated sludge system at Ain-ghazal was replaced by the largest waste stabilization pond system (WSP) in the region. The effluent from Al-Samra WSP treatment plant is blended with rainwater in King Talal Dam (KTD). The proportion of treated effluent is above 30 per cent of the total yield from the Zarqa river feeding KTD. The water from KTD is released through a network to irrigate parts of land in the Jordan Valley without any restrictions on crop selection or types of irrigation systems. The cropping pattern of these lands is 70 per cent vegetables, 18 per cent cereals, and 12 per cent fruit trees. In addition, a portion of water from Zarqa River upstream of KTD is used for restricted irrigation of about 500 hectares. (10) and (5).

Using reclaimed wastewater in urban areas is not practiced so far, but it appears that reclaimed wastewater reuse in urban area for toilet flushing and street-cleaning is feasible, especially because the majority of countries in WA region face an increasing growth of high-

Using reclaimed wastewater in urban areas is not practiced so far, but it appears that reclaimed wastewater reuse in urban area for toilet flushing and street-cleaning is feasible, especially because the majority of countries in WA region face an increasing growth of high-rise buildings, where reuse for toilet flushing is a promising option, since it is the most economic application method for highly-populated urban areas, if a nearby agricultural area is not available. In the ESCWA region there are three cities of over three million people, according to 1992 statistics, where this method can be applied.

Another method of reusing reclaimed wastewater in the region is by recharging the groundwater resources directly or indirectly. This method involves injection or surface spreading thus permitting the water to percolate into the unsaturated ground water zone. By this method ground water supply may be replenished in the vicinity of metropolitan and agricultural areas, where ground water overdraft i severe, or where sea-water intrusion exists. This method is an effective barrier; but intensive precautionary measures should be taken to prevent health hazards and the contamination of the aquifer.

The Isma'iliyah and Suez cities in Egypt, have waste stabilization pond systems with a capacity of 90,000 cubic metres per day; also the city of Aqaba in Jordan, has a pond system with a design capacity of 9,000 cubic metres per day. The final disposal system for all these cities is to the aquifer via rapid infiltration basins. In Oman recharge via infiltration is also planned. It is anticipated that, withdrawal will be made from the aquifer for agricultural use. (34).

Table 4 summarizes current types of reuse in the WA region and describes the level of treatment and restriction regulations on the crop selection and whether or not there is a discharge to the sea of raw or treated wastewater.

Table 4 Main features of wastewater use in WA

Country	Type of effluent	Crop restriction	Planned direct use	Unplanned non-direct	Marine discharge
Bahrain	T	+	+	-	+
Egypt	S & P	-	+	+	+R
Iraq	S	-	-	+	+R
Jordan	S	+	+	-	- R
Kuwait	S & T	+	+	-	-
Lebanon	W & P	-	-	+	+R
Oman	S & T	+	+	-	+R
Qatar	S & T	+	+	-	-
Saudi Arabia	S & T	+	+	-	+R
Syria	W, P.S	-	+	+	+R
U. Arab Emirates	S & T	+	+	-	+
Yemen	W, P, S	-	+	+	+R
W + G	W + P	-	-	+	- R
%		53	77	38	70

\+ YES

\- NO

W. wastewater

P. primary

S. secondary

R. river discharge

T. tertiary treatment

Table five summarizes methods of reuse, types of treatment, quality of available treated effluent.

3. Appropriateness for Present and Future Reuse

The main objectives of wastewater treatment plants (WWTP) is to prevent the speed of diseases and to protect the environment. Many serious outbreaks of communicable diseases have been traced to direct contamination of drinking water or food supplies by the body wastes from a human diseases carrier. some known examples of diseases which may be spread through wastewater discharges are typhoid, cholera, dysentery, polio, hepatitis, giardiasis, intestinal parasitic (11).

Table 4 shows that reuse practice is still uncontrolled, non-monitored and unintentional. This turns to be one of the main causes of the spread of disease in the WA Region.

Several studies have shown that wastewater reuse in irrigation increases the prevalence rate of parasitic infection. They emphasize the fact that wastewater reuse has to be managed carefully to reduce or eliminate effects on public health. If health is not protected, the disadvantage of wastewater reuse will overweigh its advantage.

3.1 Prevalence and Intensity of Helminthic Infection in The Region (II).

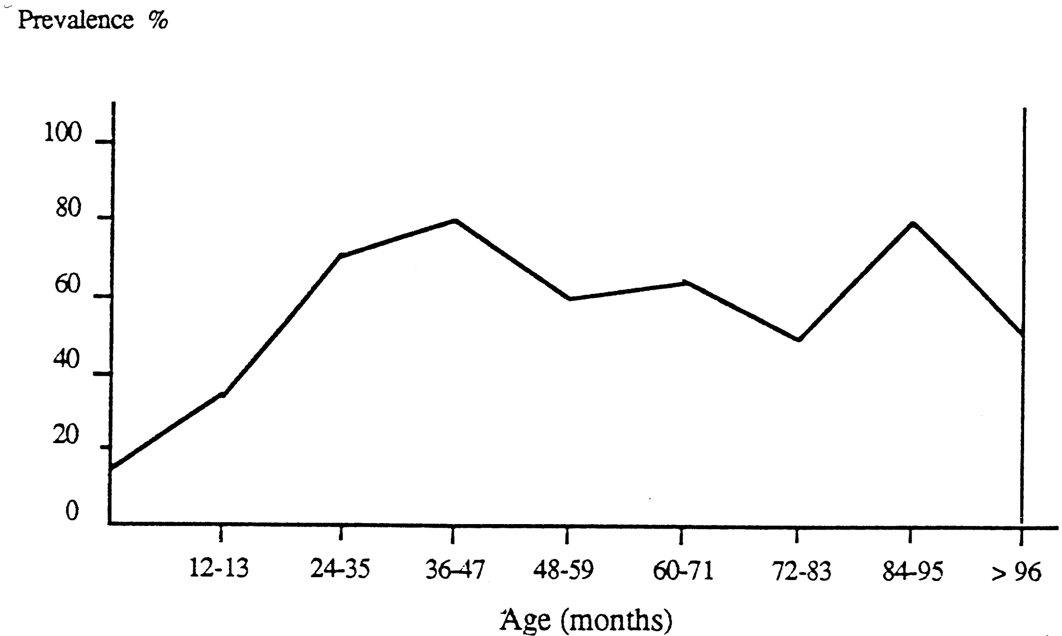
The major source of child morbidity in the occupied West Bank of Jordan is the intestinal Protozoa and Gastro-intestinal infection. A study(40) shows that under the one-year of age group in infancy has a double relative frequency of any other age in the group of gastro-intestinal diseases Ascariasis and Hymenolepis nana were predominant. A study carried in a refugee camp on children in selected West Bank localities shown that children aged between 6-12 years have revalence of hymenolepis nana 11 percent, trichuris trichiura 6 per cent, Ascaris lumbricoides 2 per cent. Enterobius vermicularis, 1 per cent; trichostrongylus sp. 0.6 per cent. The prevalence of T. trichiura was higher in older children rather in boys than in girls, which may reflect their more frequent contact with contaminated soil areas, possibly through their outdoor playing activities (38).

A study (12), summarizes six years of accumulated data on 22970 specimens in Nablus, West Bank: Scaris 177 per 1000, Trichuris 13 per 1000.

In the East Bank of Jordan, the only available statistics (for 1988) report on cases of Ascaris found in samples from patients who were visiting the hospital for non-parasitic medical care and whose stool samples were tested for helminth eggs. One percent positive samples were found in the patients whose stools were tested at the Central Laboratories of the Ministry of Health. In Amman city the concentration of intestinal nematodes was 297 eggs per liter, of which 245 eggs per liter were A. Lumbricoides (7).

A study from the Gaza Strip (40) showed that more than 50% of the children under the age of 10 are infected by Ascaris. Figure 3 shows the Ascaris prevalence according to age.

Fig. 3 Ascariasis Prevalence x Age, Beach Camp, Gaza Stip 1989 (13)



A study from riyadh, Saudi Arabia (2) on 5,737 stool specimens from three hospitals during 1986 showed: Ascaris 30 per 1000, Trichuris 25 per 100, Hookworm 4 per 1000.

In a study conducted in Yemen Arab Republic by Rodenko (1980) (36) nematodes found in 69%, Schistosomiasis in 22% and tapeworms in 8% of the population examined.

A study of parasitic infestation and the use of untreated sewage for irrigation of vegetables in Syria (14) shows that the domestic sewage of Aleppo contained 3340 Ascaris eggs/liter, which represents an Ascaris infestation rate of 42% of the total Aleppo population excreting an average of 800,000 eggs daily per person. The correlation between the number of parasites in Aleppo and the irrigation of vegetables with sewage is that irrigation completes the cycle by returning the parasites back to the community. On the other hand, a sample of untreated sewage from the syrian coastal town of Lattakis contained 460 Ascaris eggs/lter. Untreated sewage is not used for irrigation in Lattakia and this is reflected in the lower parasite count of Latakia sewage.

In Egypt a village with an improved water supply, latrines and refuse collection had a lower prevalence (50%) and intensity (4200 eggs/gram) of ascariasis than a village without improved sanitation (prevalence of 76% and intensity of 6900 eggs/gram) (17).

Strauss(1987) (43) estimated that the concentration of Ascaris eggs in Oman was 100-200 eggs/liter and the Ascaris prevalence in the total population was 2.5%. The estimated morbidity and mortality in developing countries from helminthic diseases as shown in Table 6.

Table 5 Summary of Existing and Proposed Re-use Installation in WA

Location	Reuse Application						Level of sewage Treatment			Policies	BOD :
	Roads	Parks	Industrial	Aqua-culture	Agricul-	Aquifer recharge	Primary	Secondar	Tertiary		
Bahrain					*				*	O_3 + restrict	10:10
Egypt				*	*	*	*	*		Not decided	--
Iraq							*	*		To river	40:60
Jordan					*	*		*		Restricted	30:30
Kuwait					*			*	*	Restricted	10:10
Lebanon					*		*			Not decided	--
Oman	*				*	*		*	*	Restricted	10:10
Qatar	*	*							*	Trickle irrigation	10:10
										with public access	
Saudi Arabia	*		*		*			*	*	Restricted; O_3	10:10
Syria					*		*			Not decided	--
U. Arab Emi-	*	*						*	*	O_{3}+	10:10
rates					*		*	*		Not decided	--
Yemen					*		*				--

O_3 - Ozonation

Table 6 Morbidity and Mortality of some Helminthic diseases in Africa, Asia, and Latin Amercan 1977-1978

Source, Global Freshwater Quality, WHO, UNEP, 1992 (54)

Disease	Infection 000/year	Death 000/year	Average No. of Days lost per case	Relative Disability
Ascariasis (roundworm)	800,000-100,000	20	7 - 10	3
Trichuriasis	500,000	Low	7 - 10	3
Hookworm	7,000,000	50 - 60	100	4
Shistosomiasis	200,000	500 - 600	600-1000	3 - 4

(3) Sufferer is able to work.
(4) Sufferer experience minor effects.

The transmission of most of the intestinal parasites reflects the local level of sanitation and the availability and quality of water. A high level of ascariasis is a good indicator of improper faecal disposal and the need to monitor the effectiveness of the sanitation projects in the area. A high level of giardiasis reflects the lack of water or its poor quality.

The Regional Director of the WHO/EMRO Office (53) reported the major diseases in the region:

1. Schistosomiasis is a priority public health problem in some countries of the region.

2. Diarrheal disease continues to be the leading cause of death of infants and children in most countries of the region.

3. Intestinal parasitic infections remain among the most widespread diseases in the region. Amoebiasis, giardiasis, ascariasis and hookworm are public health problems in countries with large areas under agriculture and with inadequate water supply and unsanitary conditions.

All data about the prevalence of ascariasis where there is a low percentage of people with adequate sanitation and an assessment of the existing types of wastewater treatment have shown that technologies being used are inadequate.

Table 4 Main featurs of wastewater use in WA

Country	Type of effluent	Crop restrection	Planed direct use	Un planed un direct	Sea discharge
Bahrain	T	+	+	-	+
Egypt	S & P	-	+	+	+R
Iraq	S	-	-	+	+R
Jordan	S	+	+	-	-R
Kuwait	S & T	+	+	-	-
Lebanon	R & P	-	-	+	+R
Oman	S & T	+	+	-	+R
Qatar	S &T	+	+	-	-
Saudi Arabia	S & T	+	+	-	+R
Syria	R,P.S	-	+	+	+R
U. Arab Emrates	S & T R,P,S	+	+	-	+
Yemen	R + P	-	+	+	+R
W + G		-	-	+	-R
%		53	77	38	70

\+ YES
\- NO
R. raw sewage
P. primary
S. secondary
R. river discharge
T. tertiary

The existing and planned sewage TP through the region in a few cases has a comprehensive strategy for wastewater reuse been formulated as shown in Table 7.

Most of the treatment plants in the area use the activated sludge process, followed in some cases by rapid sand filtration. They were developed to reduce the suspended load and the oxygen demand of the discharged water but these sophisticated technologies are not efficient in removing pathogenic microorganisms and were never intended to achieve a high removal of excreted pathogens. Their use in WA countries, where excreted infections are endemic and where the wastewater must be used for agricultural irrigation, is justifiable only in special circumstances, as there is now an alternative treatment process (waste stabilization ponds) that is vastly superior in obtaining low survival of excreted pathogens and even complete elimination from effluent. Less than one third of the existing and planned treatment plants in the region use waste stabilization ponds.

Guidelines for wastewater treatment to achieve these criteria must be established. Bacteria are not suitable diagnostic organisms to indicate environmental faecal pollution. For waste stabilization ponds, as discussed below, retention time in the pond system is the appropriate design criterion. For noneffluents such as night soil, the contents of pit latrines and septic tanks, and conventional sewage treatment works, it is reasonable to assume that, if ascariasis is endemic and there are no Ascaris eggs present in the wastes analyzed, then other pathogens are absent as well, since Ascaris eggs are so resistant. The viable eggs of A. lumbricoides would seem to be the best pathogen indicator available for noneffluents (26).

According to Kagei and others (32) rather than examining for every pathogenic organism that might still be present, the most practical and reliable indicator for monitoring the effectiveness of night soil treatment is observing the presence or absence of the eggs of A lumbricoides. As Ascaris eggs in night soil are more tenacious than other helminth eggs, it is generally presumed that if ascariasis is end emic and there are no viable Ascaris eggs in the waste after treatment, then other pathogens must have died already. This indicator has been accepted in China, where a standard of 95% Ascaris mortality has been adopted for agricultural reuse of excreta (35).

Table 7 Charactistics of Major Operational Planned Municipal Sewage Treatment Plants in WAR.

Location	Number of	Design capacity	Type of secondary	Type of tertiary	Status	Reference
Bahrain						(Charleworth 1992) (18)
Tubli	1	125	AS	Dual Filters + O_3	Over loaded	
Egypt						UNDP/FAO WD WHO 1990 (45)
Cairo east bank	3	4200	Conventinal treatment (CT)	--	Under construction	
Cairo west bank	2	1330	Activated Sludge (AS)	--	Under construction	
Alexandria			Activated Sludge (AS)		Under construction	
Helwan		850	A.S	--		
10 of Ramadan			Oxidation ponds (OP)			
Sadat			O P			
Port Said		150	Primary	Out fall to Lake Manza-la	Design	UNDP/FAO/WB 1990 (46)
6 october			O P			
Burg ElArab			O p			
Esmailia		90				
Suez		200				
Damietta government	8	3000 year 2000	AS		under construction	
Jordan					Over loaded 1992 (12000- m^3 d^{-1})	Al Salem 1985 (5)
Amman-Al samra	1	68 (120)	Oxidation ponds			
Aqaba	1	9 (4.2)	O P			
Ramtha	1	2.3 (1.1)	O P			
Mafraq	1	1.8 (0.9)	O p		Over loaded	Number in brackets is the actual load in 1992
Madaba	1	2 (1.8)				
Maan	1	1.2 (1.5)	OP			
Irbid	1	11 (6.5)	AS + TF		Operational	
Tafilah	1		TF	Polishing Pond (PP)	Operational	
Al-Karak	1	0.8 (0.8)	TF	(PP)	Operational	
Kufranja	1	1.8	TF	(PP)	Over loaded (understudy)	
Al Baqa'a	1	6 (5)	TF	(PP)	Under Expansion	
Salt	1	2.4 (3.9)	TF	(PP)	Under Expansion	
Jaresh	1	1.1 (1.5)	AS	(PP)	Operational (under study)	
Abu Nuseir	1	4 (1.4)	AS		Under construction	
Wadi Esser	1		Aerated lagoon (AL)		Under construction	
Fahis Mahis	1		AS	(PP)		

(Cont.) *Table 7 Charactistics of Major Operational Planned Municipal Sewage Treatment Plants in WAR.*

Location	Number of	Design capacity	Type of secondary	Type of tertiary	Status	Reference
Kuwait						
Ardiyah	1	250	AS	Rapid sand Filtration	Operational	UNDP/FAO/1990 (45)
Jahrah	1	65	AS	Rapid sand Filtration	Operational	
Rikka	1	96	AS	Rapid sand Filtration	Operational	
Failakah	1	10	AL		Operational	
Lebanon						
Beirut, Chadir	1	170	Preliminary treatment		Not completed	DAR Al-Handasah 1991 (19)
Biktaya	1				Not completed	
Marjayoun	1		AS		Disabled	
Oman	10	385	AS	Rapid sand Filtration	Operational	Douglas 1992
Qatar	8	100	AS	Rapid sand Filtration	Operational	UND FAO, WB 1990 (46)
Saudi Arabia						
Jeddah	1	50	AS		Operational	
Mecca	1	50		Reverse osmosis	Operational	UNDP/FAO/WB/1990 (45)
Riyadh stage II, III	1	300	AS	Lime softening	Designed	
Riyadh	1	200	Trickling Filter	Filtration	Operational	
Al-Khafji	1	20	AL	PP	Operational	
Syria						
Damuscus	1	500	AS		Under construction	Hinen Hadad 1991(30)
Aleppo	1	250	AL		Under construction	
Homs	1	140	AS			
Hama	1	51	AS		Under construction	
Lattakia	1	175	AL		Under construction	
Altakia	1	28	AS		Under construction	
Salamia	1	38	O P		Under construction	

(Cont.) *Table 7 Charactistics of Major Operational Planned Municipal Sewage Treatment Plants in WAR.*

Location	Number of	Design capacity	Type of secondary	Type of tertiary	Status	Reference
United Arab EM						CDM 1992 (1)
Abu Dhabi	1	200	A.S	R.SF + O_3	Operational	
Dubai	1	130	A.S + TF	Rapid sand Filtration	Operational	
Al Ain	1	80	A.S	Rapid sand Filtration	Operational	
Yemen	3	15	O P		Operational	UNDP/FAO/1990 (45)
	8		O P		Construction	
	2		CT		Construction	
West Bank	Not available (NA)		OP			Kuttab 1990 (33)
Jeneen		NA			Over Loaded	
Ramallah		3000			Over Loaded	
Gaza		NA			Over Loaded	
Rafeh		NA			Over Loaded	

3.2 Evaluation of Existing Wastewater Treatment Methods and their Suitability for Use in Irrigation

All types and levels of treatment technologies are compared in Table No.8.

Although not an accident, it is unfortunate that most of the existing methods in use in the region are not capable of achieving the helminth dimension of the 1989 WHO guideline.

Most of them use conventional treatment methods, followed in some cases by rapid sand filtration, the common tertiary treatment in the Gulf countries. This type of tertiary treatment can reduce the pathogen content of effluent most substantially, and probably insufficiently to justify the investment in filtration on the basis of health benefits it yields (27).

The evaluation in Table No.8 shows clearly that there are only four wastewater treatment processes that can achieve complete removal of helminth eggs. These are:

1. Conventional sewage treatment with effluent upgraded in polishing ponds.

2. Conventional secondary treatment followed by slow sand filtration.

3. Waste stabilization ponds.

4. Combination of treatment and effluent storage. (Al Salem 1993 11)

To achieve the WHO microbiological quality guidelines for wastewater use in irrigation of crops likely to be eaten uncooked and for irrigation of sport fields, public parks, cereal crops, fodder crops, pasture and trees, the treated wastewater should contain a mean number of < 1 egg/liter of intestinal nematodes (Ascaris, Trichuris, and hookworm) during the irrigation period (51).

There is now no doubt that the most efficient, safe and reliable process to remove the most difficult of the disease vectors, helminth ova (worm eggs), is through the retention period in waste stabilization ponds. (UNDP FAO WB WHO 1990) (45).

TABLE 8

EVALUATION OF APPROPRIATE ALTERNATIVES FOR WWT TECHNOLOGIES (AL SALEM 1993)

Criteria	Conv. WWT CWWTP	Conv. WWT Followed by RSF Cum.	Conv WWT Followed by SSF Cum.	Conv. WWT followed by PP	WSP with or without Annerobic Pond	AWSP	Primary or Sec. T. followed by Storage
Appropriate for Irrigation	Poor	Fair	Good	Good	Good	Good	Good
Helminth Egg Removal (%)	70-90	90-98	95-100	100	100	100	100
Sludge Volume Reductin	Poor	Poor	Poor	Poor	Good	Good	Variable*
Sludge Usage Adequacy	Poor	Poor	Poor	Poor	Good	Good	Poor
Land Requirement	Good	Good	Fair	Fair	Poor	Fair	Variable*
Cu.m/sq.m	0.5-1.0	0.5-1.0	0.2-0.5 **	6-8	20-25	Variable	Variable*
O & M Cost	Fair	Fair	Poor	Fair	Good	Variable	Good
Construction Cost	Fair	Fair	Poor	Fair	Good	Variable	Variable*
Ease of Operation	Poor	Poor	Poor	Poor	Good	Fair	Variable*

WSP : Waste Stabilization Ponds.
CWWTP : Conventional Waste Water Treatment Plant (Trickling Filters; Activated Sludge).
RSF : Rapid Sand Filtration.
SSF : Slow Sand Filtration.
PP : Polishing Ponds
AWSP : Aerated With Mechanical or Wind-driven Aerator/Mixer.
Cum : Cumulative
Sec : Secondary.
T : Treatment.
* : Depends on level and type of Treatment in case of Low Cost Technology the criteria will rank good.
** : Additional Area Required Over the Previous Type.

III. Regulation and guidelines for Wastewater Reuse in Selected ESCWA Countries

Wastewater reuse was always a side benefit gained from sanitation projects. There were a few projects where reuse was considered from the beginning as an integral part of the sanitation project. Due to this fact, most of the guidelines were set as effluent standards to control the quality of discharge meeting a receiving water quality and are thus an indirect restriction of effluent discharges.

In most cases these guidelines to guarantee a minimum quality of water are easier to administer; but a major criticism of effluent standards has been that the application of a uniform effluent standard can be uneconomic, because of the great variation in the final beneficial usage.

The standards adopted in the most ESCWA countries are based blindly on the State of California standard. Their validity is not checked or reviewed according to the current situation int the country. They are, therefore, considered inappropriate, too stringent and not sound environmentally or economically (6).

Stream standards must be imposed, especially if a sizable population downstream from the wastewater discharge point depends on a river for their potable water or the water is used for recreation (with body contact) or fish-raising. The stream standards are applicable for Egypt, Lebanon, syria and to a lesser extent, in Jordan on both banks. However, these standards must be based on using the total assimilative capacity of the river or wadis as well as the minimum water quality level for the predominant water reuse. The regulation and guidelines to direct the reuse of reclaimed water were given the needed importance very lately, after realizing the health and environmental problems associated with the reuse of raw or improperly treated wastewater. As consequence, water reuse standards must protect the public and the environment. In general, they are based on indicators of pathogenic organisms like faecal coliforms and nematode eggs and/or fundamental reactions in pollution control affecting the quality of the environement. (e.g. BOD & SS).

1. Standard and Guidelines Existing in the ESCWA Region

The first regulation on wastewater reuse was issued and applied in California state, USA, in 1918, which has been modified and expanded over the years. the State of California current wastewater reclamation criteria were adopted in 1978 and have been used as guidelines are shown in Table 9.

TABLE 9 California Treatment and Quality Criteria for Reuse [a]

Type of Use	Total Coliform Limits	Treatment Required
Fodder, Fiber, and Seed Crops Surface Irrigation of Orchards and Vineyards	---	Primary
Pasture for Milking Animals Landscape Impoundments Landscape Irrigation (Golf Courses, Cemeteries, etc.)	23/100 ml	Oxidation & Disinfection
Sufrace Irrigation of Food Crops[b] Restricted Recreational Impoundments	2.2/100 ml	Oxidation & Disinfection
Spray Irrigation of Food Crops[b] Landscape Irrigation (Parks, Playgrounds, etc.) Nonrestricted Recreational Impoundments	2.2/100 ml	Oxidation, Coagulation, Clarification[c], & Filtration,

a Source: State of California (1978) (42).
b Exceptions may be made to the requirements for processed food crops.
c The turbibidity of filtered effluent cannot exceed an average of 2 turbidity units dueling any 24 hour period.

The first proposed guideline for wastewater reuse in the ESCWA region was issued in Kuwait in 1976, seven years after starting operation of the first treatment plant and one year after putting into operation the first reuse schemes. These standards are shown in Table 10. Moreover, wastewater is used in a controlled remote area with no public access; and crops are restricted.

The first proposed guideline for wastewater reuse in the WAR was issued in Kuwait in 1976, seven years after starting operation of the first treatment plant and one year after putting into operation the first reuse schemes. These standards are shown in Table 10. Moreover, wastewater is used in a controlled remote area with no public access; and crops are restricted.

Table 10 Reclaimed Waster standards in Kuwait (CDM 1992) (16)

Parameter	Irrigation of Fodder & Food Crops not Eaten Raw, Forest land	Irrigation of Food Crops Eaten Raw
Level of Treatment	Advanced	Advanced
SS (mg/1)	10	10
BOD (mg/1)	10	10
COD (mg/1)	40	40
Chlorine Residual (mg/1), after 12 hrs @ 20 C	1	1
Coliform Bacteria (count/100 ml)	10,000	100

However, in Jordan, a standard was introduced in april 1982, thirteen years after starting the reuse of reclaimed wastewater and one year after the cholera outbreak in the year 1981, (because of uncertain beliefs that the cholera outbreak as due to irrigating some crops eaten raw with improperly treated secondary level treated effluent from the old Amman activated sludge treatment plant). The 1982 Marital law No. 2/1982 prohibits cultivation of plants which are irrigated by wastewater or reclaimed water or any area that reclaimed water passes by or has an effect on it. Excepted are trees, fruit trees and fodder.

In September, 1989, a new version of the martial law was issued, which is considered to be more advanced in comparison with the old version, because of the following reasons:

(a) The new version relates the types of crops to be irrigated, with the quality of effluent to be used in irrigation.

(b) It allows irrigation of cereals and vegetables eaten cooked, under certain conditions.

(c) It allows the use of exposed water (exposed to contamination) in irrigation except on vegetables eaten raw and greenery in sports fields and public parks.

Table 11 compares the September 1989 marital law with the WHO Guidelines for wastewater reuse in agriculture. However, the 1989 marital law has some disadvantages which are as follow:

Table 11 Microbiological Quality Comparison of WHO Guidelines and Jordanian

Standards (Al Salem 1992) (10)

Reuse Type	WHO		JORDANIAN	
	Faecal Coliforms	Nematodes	Faecal Coliforms	Nematodes
<u>UNRESTRICTED</u> Irrigation Of crops to be eaten uncooked Irrigation of sports fields and public parks	< 1000 /100 ml	< 1/L	not allowed	not allowed
<u>RESTRICTED</u> Irrigation Of Cereal Crops Industrial Crops, Fodders, Trees	No Guidelines Recommended	< 1/L	< 1000 /100.ml	< 1/L
<u>LOCALISED</u> Irrigation of Cereal Crops Industrial Crops, Fodders, Trees with no exposure of workers and the public	Not applicable	Not applicable	Not allowed	Not allowed
Frequency of Testing	No Guidelines Recommended		> 2 per month	> 2 per month

(a) Specification of the number of samples to be tested in a month is not a useful criterion as two grab samples do not represent the quality of water during a whole month. Instead, it is preferable to specify a sampling programme which will disclose will disclose the real quality of the water tested.

(b) The martial law did not allow irrigation of crops eaten uncooked by any type of effluent, regardless of its microbiological quality, whereas it allows irrigation of sports fields and public parks by an effluent having faecal coliforms at 200 per 100 ml and nematode eggs at < 1 per litre of sample which will have more or less the same potential risk as crops eaten uncooked.

(c) The martial law did not even allow localized irrigation of industrial crops and trees by raw wastewater. This means that wastewater treatment is a must.

In Saudi Arabia regulation for wastewater reuse require secondary and tertiary levels of treatment for unrestricted irrigation with the standard as shown in table 12.

Table 12 Reclaimed Water Standards for Unrestricted Irrigation in Saudi Arabia [c]

Parameter [a]	Maximum Contaminant Level
BOD	10.0
TSS	10.0
pH	6 - 8.4
Coliform (Count/100 ml)	2.2 (7 day average [b])
Turbidity (NTU)	1.0
Aluminum	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.5
Cadmium	0.01
Chloride	280
Chromiun	0.1
Cobalt	0.05
Copper	0.4
Cyanide	0.05
Fluoride	0.2
Iron	5.0
Lead	0.1
Lithium	0.07
Manganese	0.2
Mercury	0.001
Molybdenum	0.01
Nickel	0.02
Nitrate	10.0
Selenium	0.02
Zinc	4.0
Oil &Grease	Absent
Phenol	0.002

Reference CDM 1992 (16)

(a) In mg/1 Unless Otherwise Specified.
(b) No Value above 23/100 m in any sample
(b) In 1987 the total coliform limit was relaxed to 100/100 ml. and intestinal criteria of less than one egg per litre was added.

Crop restriction is enforced and no crops (cocked or uncooked types) are to be irrigated by wastewater from treatment plants (Abou Khaled 1991).

Some wastewater treatment plants were designed to meet the equivalent of drinking water standards by advanced treatment which includes reverse osmosis desalination, filtration and disinfection.

2. Government Regulations for Water Reuse in selected ESCWA Countries

In 1982 (one year earlier than starting irrigation with treated water), the Ministry of Agriculture and Water in Riyadh put forward a proposal for Guidelines to be followed by farmers who are using the water. The guidelines were basically for a proposal for Guidelines to be followed by farmers who are using the water. The guidelines were basically for a "restricted use to irrigate non-vegetable crops-wheat, fodder, data palms, fruit trees. This action aimed at assurance of public health protection against any adverse effect from contaminants and disease transmission during water reuse.

The following points summarize the Guidelines:

* No vegetable crop could be irrigated with this treated water, both vegetable eaten fresh or cooked ones.

* Farmers who wish to grow vegetables on the same farm where waste water is in use are obliged to have a separate irrigation network for the vegetables, and preferably an underground piping network.

* If surface irrigation is adopted on the farm then a band of land 30m wide should separate the vegetable plots from those plots irrigated with treated water.

* The farmer signs a document that he understands these rules, and any violations from his side would lead to the cut-off of the treated water for his farm until the vegetable crop is removed.

* The treated water is distributed to farmers free of charge and the farmer is expected to cooperate with Ministry officials by giving information on cropping patterns on the farm and any changes that might take place.

The Egyptian Water Law 48/1982, and Ministerial Order No. 8/1982 for the protection of the River Nile provides the legal framework for treated wastewater guidelines. The code prohibits the use of raw sewage in agriculture and in irrigation of vegetables eaten raw. The Ministry of Irrigation is authorized to impose discharge standards for discharge into the river and canals. Moreover, there are limits that specify the maximum allowable effluent discharge to unpotable water canals as follows.

Faecal coliform of 5000/100 ml and BOD, SS, TDS, NO_3 (60,80,200,50)mg/L, respectively.

In the Sultanate of Oman, effluent requirements are set in the regulations for wastewater reuse and discharge as outlined in Table 13.

Table 13 Parameters for reuse and discharge of waste-water in Oman

Parameter	Limits [not greater than]	Maximum Monthly av. over any 4 consecutive weeks
Physical : T.D.S.	1500	1000
Total Suspended Solids	15	10
Turbidity [NTU]	5	2
Chemical : Aluminium	5	1
Ammoniacal Nitrogen [as N]	5	1
Arsenic	0.2	0.05
Barium	2	1
Beryllium	0.3	0.1
BOD [5 days}	15	10
Boron	2	1
Cadmium	0.03	0.01
COD	100	50
Chloride	350	250
Chlorine, Free Residual [After 60 min. contact time]	0.5	0.5
Chromium	0.5	0.1
Cobalt	0.5	0.1
Copper	0.3	0.2
Cyanide	0.1	0.05
Dissolved Oxygen	2.0	2.0
Fluoride	2.0	1.0
Iron	5	1
Lead	0.5	0.1
Lithium	10	2.5
Magnesium	150	30
Manganese	1	0.2
Mercury	1	0.2
Molybdenum	0.005	0.001
Nickel	0.5	0.2
Oil & grease	5	2
pH [pH units]	6 - 9	6 - 9
Phenols	1	0.1
Phosphorus [total as P]	30	20
Selenium	0.05	0.02
Sodium	200	70
Sulphate	400	200
Sulphide	0.1	0.05
Organic Nitrogen [Kjeldahl]	10	5
Total Nitrogen	50	30
Total Organic Carbon	50	20
Vanadium	1	0.1
Zinc	5	2
Bacteriological		
Total Colifirms [MPN/100 ML]	23	2.2
Viable Pathogenic Ova & Cysts	(None detectable)	

- All units are mg/l unless otherwise stated.

Reference Abdel-Magid et al 1992 (3)

These regulations make no distinction between variations in disposal methods of locations, although marine disposal is subject to different regulations. The regulations do address the methods of reuse. the possibility of reuse is provided for as follows:

IV. Economic and Social Aspects for Wastewater reuses

1. Economic Aspects

The sewer systems in the Western Asia region have been built mainly for convenience of the urban population and for health and environmental protection. Hence, standards for effluent discharge are so strict, which is why the cost of treatment is high. Irrigation does not require this stringent standard the cost of treatment must not be added to the cost of reclaimed wastewater reuse. In other words when calculating the cost of reuse, one must differentiate between treatment for environmental protection and the supplementary treatment required for specific usage. The added price must be compared with the benefits gained from reclaimed reuse. This emphasizes that the cost of facilities which have been built for the sole purpose of reuse of reclaimed water must only be taken into consideration.

Most countries within ESCWA region are designated as a region with critical water supply problem areas. For this reason most of the time such reuse is economical and feasible. Consequently, wastewater reuse must be mandatory. this will eliminate the cost of supplementary cost of water supply, or at least will delay their implementation.

Reclaimed wastewater does not create additional quantities of water, but rather brings additional quantities of water, but rather brings additional quantities of water to satisfy specific standards compatible with various types of use. Thus the economic evaluation must be based on the benefits of wastewater reuse compared with drinking water, which has the highest value in the water sources allocation plan.

It is clear as well as logical to assume that the benefits of reclaimed wastewater reuse are equivalent to the economic value or long run marginal cost of drinking water. These statements do not need deep analyses for justification in a region where the rate of withdrawal of fresh water is higher than the repleinshment of the resources. The reuse in this case will protect and conserve the natural resources.

In addition to the quantities reclaimed and reused, there are a lot of other indirect benefits associated there and can be summarized as follows:

* To provide employment and settlement opportunities since a quantity of 11,000 M^3/year of reclaimed water can create one job opportunity if reused in agriculture, in addition to job opportunities created while collecting and treating these quantities.(29)

* To improve the nutritional status of the population. The income from 0.2 hectares of irrigated land can support one person by using about 2,000 M^3 of reclaimed water. (29)

* To increase soil productivity in addition to the reduction of the use of artificial fertilizers.

- * To increase crop production resulting from year-round availability of treated effluent.

- * To reduce of the use of chemical fertilizer imported from developed countries and to save hard currency.

In Jordan the average concentration of nutrients for the last six years (1986-1991) in the effluent was as follows:

Total N 95 mg/L. Total P 18 mg/L. equivalent to 40.5 mg/L. as P^2O^5 Total K 115 mg/L. equivalent to 138.6 mg/L. as K^2O.

The contribution per 1,000 M^3 of effluent is 95 KG N, which is equal to a value of about 69 US$ based on the average cost of fertilizer as $(NH_4)_2$ SO_4.

The value of 1,000 M^3 of P based on prices of super phosphate P_2O_5 (46%) is 14 US$, and the value of K is about 87 US$ based on the price of potassium sulphate 52% K_2O. so the value of NPK in 1,000 M^3 of reclaimed wastewater is 170 US$ (9).

Public Health and Hygiene

The British Wastewater Limited (1986) (15) summarizes the economic benefits of the Greater Cairo Wastewater Project East Bank Scheme as shown in appendix No.1.

2. <u>Social Aspects of Wastewater Reuse</u>:

The demand for water presents an increasing problems to many countries of the region, with the accelerating growth of population and the continuing expansion of industry and agriculture. In the WA a greater strain is frequently imposed on fast-diminishing water resources.

In order to maintain growth, it is necessary to investigate alternative water resources to satisfy this increasing demand and sustain economic and social development.

The sources appropriate to each usage of water must be classified in order to reserve, where possible, water from the least contaminated source for potable supplies and avoid squandering high-quality water on less demanding applications.

The practices of reclaimed wastewater reuse is not new in ESCWA countries. The disposal of sewage effluent to a river is frequently followed by abstraction from the same river at a downstream location for water supply purposes, the river having removed, ny natural purification, the majority of the contaminants discharged with the effluent. This type of indirect reuse is practiced in Iraq, Egypt, Jordan, Lebanon, West Bank and Gaza Strip. But in the Gulf Countries, where rivers are less common, this conditions would lead to use reclaimed water directly.

It is not known if there is any country in the region, where wastewater reuse is not acceptable, because the use of running wastewater in wadis is deeply rooted and widely acceptable as a cultural norm. However, the objections of residents in the locality of proposed wastewater treatment plants may be raised in the background of the approach (6).

The reason for that is mostly economical and environmental and is not based on social, or cultural norms, because the treatment plants will reduce the value of the land adjacent to the treatment site; and the owners, usually, do not have a fair compensation for the reduced value of the land or given priority either to use the final effluent or given priority in the employment at the project even though they are paying for the upset of the process and the deterioration of the aesthetic view of the area in addition to the inconveniences due to the odor and any other environmental nuisance.

The religious authorities have ruled that the use of reclaimed water is an acceptable practice in agriculture and in industry as well as for all other purposes excluding the following: drinking and Wadi (worshipping and bath for worshipping).

An opinion of the Head of the Department of Islamic studies at Sultan Caboose University, Oman, on religious and social opinion on the reuse (Shahata 1992) (39) is included in Appendix 2.

V. Summary of Key Findings and Recommendations

The following is the summary of findings and recommendations resulting from the investigation mission to most ESCWA countries undertaken by the author of this study and the review of the literature, especially those used in this study:

Findings:

1. The main problem in the region is the vast depletion of renewable resources and exhaustion of nonrenewable resources. Thus, the recovery of wastewater and its reuse will reduce undoubtedly, the rate of depletion of water resources and help in combatting land desertification and deterioration.

2. The existing wastewater treatment plants and wastewater collection system coverage and performance in the region are fairly inadequate.

3. Wastewater technologies are not properly selected to suit the end use. In a large number of cases the selection of wastewater treatment technologies prior to agricultural reuse was based on criteria for pollution control (such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and Suspended Solids (SS) of receiving waters. Little or no consideration was given to the ability of treatment processes to remove helminths, protozoa abd bacterial. Most countries rely on conventional, secondary or tertiary treatment for purification of wastewater prior to irrigation. These process would provide a very clear effluent, but are often inefficient in the removal of helminths eggs and the reduction of protozoa and other pathogenic organisms. (7)

4. Enteric and parasitic diseases are highly prevalent in most parts of the ESCWA region, especially where raw wastewater is used or where there is no adequate sanitation disposal. Schistosomiasis is reported to be on the increase. Enteric and parasitic disease in urban areas which are still without piped water supply are reported to be more than twice the incident rates in the areas supplied with piped drinking water.

5. The institutional aspects of wastewater collection, treatment and reuse need major strengthening. This includes setting proper legislation, guidelines, standards and monitoring, which, in some cases, do not exist.

6. In most countries there is a strong tendency to consider the economic aspects relating to reuse of wastewater for irrigation in terms of present irrigation systems and lower value cereal and fodder crops rather than more efficient and modern irrigation systems now available. This is also the case in the associated changes in the cropping pattern favoring high-value crops.

7. In many countries, data concerning disease transmission related to reuse is not reported nor collected.

8. The health protection measures based mainly on treatment as the only barrier and other methods such as minimizing the human exposure and the crop restrictions and the application measures are not given the necessary attention.

9. The chemical quality of the effluent in the most WAR countries is relatively saline, due to an increase in the dissolved solids from infiltration or increases in the dissolved solids in domestic water or due to industrial wastewater discharge.

10. ESCWA countries have the highest unit costs in the world for construction of urban sanitation, as a reflection of both difficult terrain and the number or richer countries in the region, which sometimes require effluent exceeding WHO standards for drinking water.

Recommendations:

1. The acceleration of planning for urban sanitation, including setting adequate, appropriate treatment priorities for construction. Treatment plant priorities should be given to the urban areas, where uncontrolled reuse or raw wastewater is dominant.

2. To promote political commitment and obtain the necessary funds and resources for provision of sewerage and wastewater reuse and their cost recovery.

3. Wastewater reuse must be considered as an integral part and an important component of water resources management and budgeting.

4. To monitor and to set a reporting system for enteric and parasitic diseases which is a vital issue for the right selection for the type of treatment plants and the reuse system and to establish guidelines appropriate to existing health conditions and suitable for effluent end-use.

5. The choice of treatment systems should be reviewed, as an important variable to be optimized simultaneously with the cropping pattern and irrigation technology to maximize private and social benefits, while minimizing public and private investment needs. Cost reduction is badly needed.

6. To determine a consistent pricing or an allocation policy to maximize technical and economic efficiency that would reflect socio-cultural norms, nutrient value and project financing requirements.

7. The evaluation of projects considering reuse of reclaimed wastewater should simultaneously be considered through system analysis: the level of treatment, alternative high-value cropping patterns and highly efficient irrigation systems.

8. The implementation of an integrated approach for health protection, by using different control measures in reducing health risks from wastewater reuse.

9. To introduce effective control to prevent toxic material and the dissolved solids from entering the sewer system from industrial discharge or through infiltration.

10. Priority in research in wastewater treatment should be given to find appropriate methods of removal of parasitic disease organisms from conventional secondary and tertiary treatment.

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Appendix 1
Case Study
The economic benefits of the Greater Cairo Wastewater Project

"The Project will provide benefits for Egypt in improved public health and hygiene, transfer of technology and skills, as well as in the irrigation and reclamation of desert areas which will also offer additional employment, and transfer of technology. Described below are the other benefits of which the dominant one is improvement in public health and hygiene.

"The current life expectancy of an Egyptian child at birth is 56 for males and 59 for females compared with 72 for males and 79 for females in the developed economies of the western world. Infant mortality in Egypt (the number of deaths from birth to the age of 1 year for each 1000 live births) is 102 compared with 10 for the developed economies. The child death rate (the number of deaths per 1000 children for each year from the age of 1 to 4) is 14 combated with a rate of less than 1 in the developed economies. The relatively short life expectancy common to developing countries is due largely to the high levels of infant mortality and child death rate. For each 1.000 live births in Egypt 144 infants/children will die before they reach the age of 5. In the densely populated areas of Cairo the available statistics show a more serious situation than that for Egypt as a whole. The report on Cairo Public Health Aspects by the late Dr. Ross Mackay, (formerly Deputy Director of the ross Institute of Tropical Hygiene), within the Taylor Binnie Master Plan Report indicates that infant mortality rates for the Cairo Governorate are of the order of one and a half times the national figures. The great killers of children in developing countries are not the exotic tropical diseases but rather the common diseases such as gastro-enteritis, measles and influenza which in effluent societies have now become minor illnesses. Dr. Mackay's researches indicate that 70% of early childhood mortality was caused by gastro-enteritis and that such infection was invariably fly-borne and its source was untreated sewage."

"The situation on sewage disposal in the city of Cairo at the time of the Master Plan Study (1978) was critical. Only 66% of the urban population was served by sewers. The system was grossly overloaded with intermittent flooding of central urban areas and residential areas with crude sewage. In answered areas there were few organized sanitary services, with the limited number of conservancy tanks available often overflowing into open drains."

"In some localities nightsoil and sullage water were deosited in the street with domestic refuse. The whole of the sewage flow from the city, much of it still in the crude state, was discharged to the main irrigation drains. Continuance of these methods of disposal would have led to a very dangerous deterioration in an already critical environmental and public health situation. In Dr. Mackay's words the underlying aim of the whole project, which should be accepted and appreciated by all concerned, is not simply to get rid of sewage. It is to dispose of a highly (and potentially explosive, in epidemiological terms) dangerous material in such a manner as to minimize the danger to the public in every possible way."

"The gravity of the health and environmental hazard through continuance of the existing system was compounded by the high projected rate of growth in Cairo's population. In the mid-1980s Egypt's population was 39.8 million. The projected population for the year 2000 is 60 million, an increase of 50.7%. In mid-1980s the Cairo East Bank Project area population was 7.71 million. The projected population for the year 2000 is 13.75 million, an increase of 78.3%. A major contributory factor to this high rate of growth in Cairo as combated with the national rate is the drift of the rural population into Cairo attracted by employment prospects and amenities in the city. this high rate of growth in urban population would also be accompanied by rising levels in water usage per capita, thus further increasing the pressure on the city's wastewater system."

"Removal of this environmental and public health hazard in the heart of the Middle East's most populated city constitutes an overwhelming developmental justification for the project. The system will provide for the conveyance of all sewage to the new treatment plant in covered sewers, the provision of sewerage facilities to those areas of Cairo at present answered, and a treatment plant which will produce a high quality effluent suitable for use in irrigating and reclaiming desert areas."

Land Reclamation

"Under the East Bank Scheme the discharge of wastewater to the drains will cease. Instead high quality treated effluent and sludge from the new Gabal el Asfa treatment plant willbe used for the irrigation and reclamation of desert areas. It is estimated in the Master Plan that the reclamation areas required to make million square metres. <u>This could provide employment for 100.000 people, and make a substantial contribution to the food supplies of the increasing population of Cairo</u>."

Employment

"Total employment of Egyptian personnel on phase I construction works, based on analysis of detailed returns from the Anglo-Egybtion joint venture companies engaged on the first six contracts, is projected at 21.000 man years with peak employment levels of 7,000 personnel."

Other Economic Benefits

"Other sectors of the economy are directly affected by standards of public health. This is particularly true in Egypt. Where a major role is played by the tourist industry on which the country already depends for a significant proportion of its foreign exchange earnings and which, it is planned, will make a growing contribution in the future."

Appendix 2

Example on the Religious and Social Opinion on Reuse

The National, Seminar on Wastewater Reuse
Muscat, 26-29 April 1992
Social And Religious Considerations
of Waste Water Reuse In Oman
by
Dr. Abdalla Mahmoud Shahata
Head of Department of Islamic Studies, SQU.
Translated by
Dr. Abdel Wahid Hago
Lecturer, Civil Engineering Department, SQU.

Religious And Social Opinion On the Reuse of Chemically Treated Waste Water:

1. Waste water after being chemically treated is useful in agriculture, industry, fisheries and other aspects of public welfare; which are part of the objectives of the Islamic legislation.

2. Scholars of the Islamic nation agree that all the rules of shari'a are based on the well being of people, and for their sake these rules have been set; and Allah, be He exalted, set the rules of Shari'a for the convenience and the benefit of the servants. Allah, be He exalted, said: "Allah intends every facility for you; does not want to put you to difficulty": 2-185.

3. Waste water in the Muslim world is abundant, because Islam has ordained purity of the body, purity of the place and purity of the dress for any act of worshipping. In fact, cleanness has great benefit in keeping the body healthy and in preventing diseases.

REMOVAL OF IMPURITIES

4. It has been stated by Muslim scholars that it is admissible to remove impurity from its place with one of the following:

a) Absolute water: that is the water which can be used for Wadi (i.e., washing specific parts of the body for worshipping), for Janaba removal (i.e., washing the whole of the body after a sexual intercourse), and for the removal of all impurities; such as rain water, river water, sea water and water from the wells.

b) Rubbing: that means rubbing the impure object, such as the shoe and the sock with the earth.

c) Drying: whether with the sun or with air, until any signs of impurity disappear: this applies to earth and such solid things on it such as trees and grass.

b) Gouging: that means the isolation of the impure part of the object from others: like when an impurity falls in a solid gee, the impurity can be lifted and part of the gee in its surround should be excavated out.

e) Transformation of the impure thing into another form that makes it pure: for example, transforming liquor (or any other strong drink) into vinegar makes it a pure, and similarly, an impure oil transformed into soap causes it to be pure, also if a corpse of a dead dog is buried in a saline and it transforms into salt, it becomes pure.

PERMISSIBLE TYPES OF IMPURITIES

5. Out of the concentrated or diluted impurities only a small quantity is allowed, which is less than a Darhim (equivalent to one twelfth of an ounce). The little quantity of the diluted impurities on dresses should be less than one quarter of the dress, and the reason for the allowance can be either a necessity, a general flection or a difficulty in avoiding the impurity.

6. Some inflexible people think that alcohol is impure, because it is a base of strong drinks, which is wrong; because the sour dough that we eat is Halal (admissible) according to unanimity of scholars, although what causes its sourness is fermentation. Accordingly, if whatever causes fermentation is Haram (inadmissible), the fermentation of the dough will cause it to become Haram, which it is not, by unanimity of scholars.

7. Impurity can be removed by water and by any other pure fluid that removes the body of the impurity and its effect; such as vinegar and rose water and a like. Sayed Rashid Rida the author of Manar Interpretation of Quran said: "purity from impurities occurs with anything that removes the impurity, such as rubbing or action of fire. And nowadays, there are some artificial fluids that are more potent in removing the impurities than water".

8. Islam is a religion that calls for the use of the mind, the use of modern technology and scientific excellence. In essence, it allows reuse of waste water in developing and improving the agriculture, so that we can eat from our production and not to import it from others. Religion is easiness and not hardness.

9. It can be concluded that: waste water can be used for agriculture and in industry and for all other purposes excluding the following:

   1) Drinking.
   2) Wadi and bath for worshipping.

This is because full impurity of such water is suspected, and accordingly, it can not be used in acts of worshipping, but can be used in other customary affairs, like agriculture and related aspects.

We ask Allah hel and success.