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# Restoration of coastal wetlands and management of wastewater disposal

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## Abstract

A study has been conducted to arrive at the most cost-effective and environmentally acceptable solution to the discharge of partially treated wastewater into coastal wetlands, lakes and offshore waters, where funding for complete conventional treatment plans has either been severed or inadequate.

Field data of water-quality parameters for effluents discharged out of wastewater oxidation ponds and constructed wetlands have been reviewed and analyzed.

The case studies reported herein are those of natural treatment plants in the USA (California) and in the Middle East (Jordan). The results of the extensive work conducted at the natural treatment plant in Jordan and on the effluents discharged into the Zerka river indicate the viability of using treated wastewater for irrigation in the Jordan valley. The findings of the study suggest an appropriate and alternative solution to Alexandria's current disposal of primary-treated wastewater into Lake Maryout. The recommended scheme comprises an integrated system of oxidation ponds and a constructed wetland in the Maryout Valley prior to disposal in the lake or reuse for irrigation. This integrated system would provide a solution to cope with water scarcity and river basin management.

## Introduction

Since the beginning of last century, there have been numerous cases of wastewater reclamation, reuse, and ocean disposal projects. Pollution control regulations have become more stringent in developed countries and billions of dollars have been spent on the construction of wastewater treatment plants. Problems pertaining to wastewater disposal in coastal industrial regions are particularly acute. Population growth and development in coastal regions are especially rapid in developing countries, but the same problems appear in

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developed countries [1]. In addition, many are facing water crises and the problem is likely to become more serious and to continue well into the 21st century. With the rising costs of wastewater treatment plants and the limited resources of fresh water supplies there is an increased demand for the use of natural methods for treatment prior to disposal into the coastal zone, simultaneously giving rise to the need for reuse or safe irrigation, depending on the level of treatment received.

Despite social, political, cultural and economic differences in many regions around the globe, when it comes to the fate of water resources in semiarid environments, many similarities actually exist. (Fig. 1)

Concerning the Arabian Peninsula and Egypt, limited amounts of treated wastewater effluent are being used. The total volume of treated effluent used in 1992 represents only 21% of the total wastewater volume, estimated at 2.2 billion $m^3$. According to the U.S.A. national survey on wastewater reclamation and reuse projects, most of the wastewater reuse sites are located in the arid and semiarid western and southwestern states, including, California, Arizona, Colorado and Texas. The current estimate of wastewater reuse is about 5.5 Bgal/d.

## Disposal and reuse of treated sewage

The World Health Organization (WHO) has recommended that crops that will be eaten raw should be irrigated with treated wastewater only after it has undergone biological treatment and disinfection to achieve a coliform level of not more than 100/100 ml in 80 percent of the samples [2]. However the state of California requires that reclaimed wastewater used for landscape irrigation of areas with unlimited public access must be "adequately oxidized, filtered, and disinfected prior to use," with median total coliform count of no more than 2.2/100 ml. The criteria recommended by WHO for irrigation with reclaimed wastewater have been accepted as reasonable goals for the design of such facilities in many Mediterranean countries and in some Middle East countries such as the existing wastewater treatment facilities of Al-Hassa area, in Saudi Arabia [3].

An overview of different schemes used for natural treatment of domestic wastewater is shown in Fig. 2 for projects located in Saudi Arabia [3], the U.S.A.[4] and Jordan [5]. The schemes shown in the figure illustrate several alternatives for the use of the sewage effluent by applying various types of additional treatment needed to render the water free of health hazards, and suitable for agricultural use. The selection of a particular scheme should be based on climate, irrigation method, crop type, health and economic considerations [2].

## Jordan valley wastewater reclamation project

In 1985, the Khirbet es Samra (KS) natural wastewater treatment plant started to discharge its effluent into the Zerka River through Wadi Dhuleil (Fig. 3).

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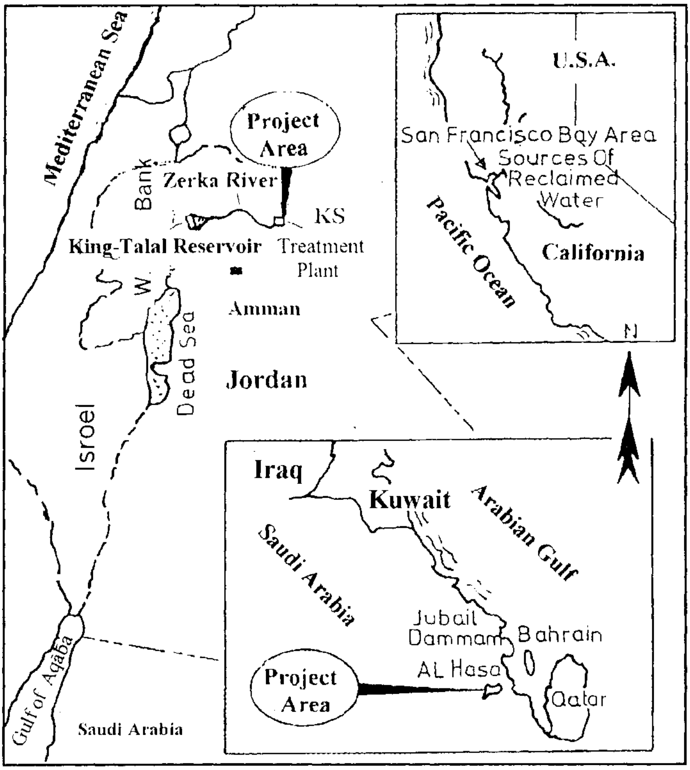


**Figure 1:** Location map of wastewater reuse projects.

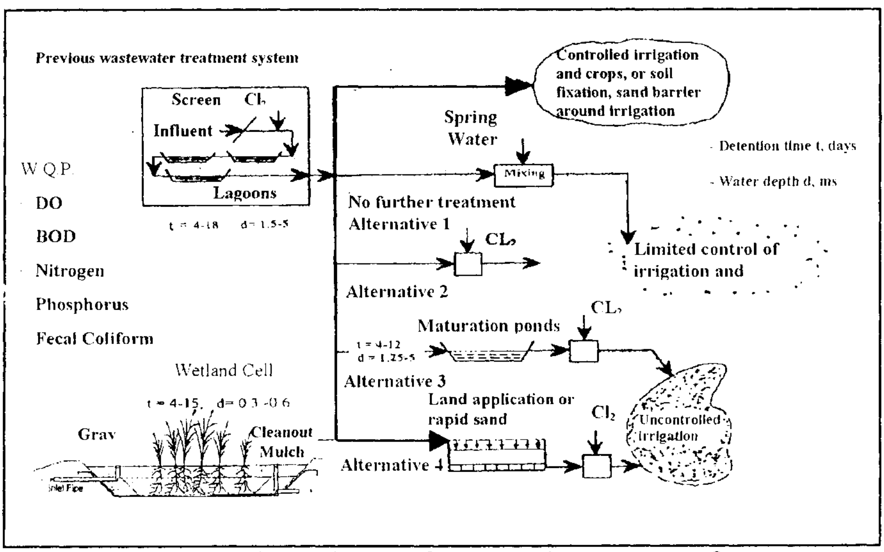


**Figure 2:** Alternative schemes for natural treatment of domestic wastewater for irrigation use.

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The KS plant receives its raw wastewater inflow from the capital Amman by a pipeline system at a rate of $30\chi\ 10^6$ gal/day [6]. The Zerka River is a natural water stream located in the main urbanization center in Jordan. Domestic as well as industrial wastewater, whether treated or untreated, are being disposed of along the Zerka River, which flows into the King Talal Reservoir (KTR). The inflow of water into the reservoir as well as the water accumulated from rainfall are being stored and used for irrigation of land in the Jordan Central Valley Zone (Fig. 3).

The wastewater treatment facilities at KS plant consist of a series of anaerobic and facultative pond systems followed by maturation ponds. The total detention time for sewage in the pond system is 40 days. The outflow of the treated wastewater runs through a steep man-made concrete channel into the natural channel of Wadi Dhuleil (Fig. 3). The width of the river in the study area ranged between 2 to 3 m, and the average water depth was about 0.5 m. The maximum dilution of treated KS sewage effluent water by the Zerka River water ranges between 25% in winter and 60% in summer. In 1996, surface aerators were added to the maturation ponds.

## Water quality data of treated sewage

### Jordan Valley Project

Water quality of the Zerka River, as represented by different physical, chemical, and biological parameters, was analyzed for several samples taken at the KS plant, downstream the discharge channel, and along the river (Fig. 3).

### Dissolved Oxygen (DO)

The DO content of KS effluent at the plant exit ranged during the study period from zero to 3.3 mg/l. From site "a" downstream, it increased gradually to site "d" where concentration ranged from 6 to 12 mg/l, and decreased thereafter. After the addition of surface aerators in 1996, there has been significant improvement in the DO data, as illustrated in Fig. 4.

### Chemical Oxygen Demand (COD)

There has been gradual decrease in the COD values from KS and further downstream along the river from 550 to 20 mg/l [5].

### Biological Parameters

Until the early years of the last decade, treated water leaving KS treatment plant contained numbers of fecal coliform in the range of $10^2$ - $10^3$/100 ml for short distance downstream of the concrete channel. Thereafter the fecal coliform number continued to increase up to $10^4$/100 ml before the entrance to the

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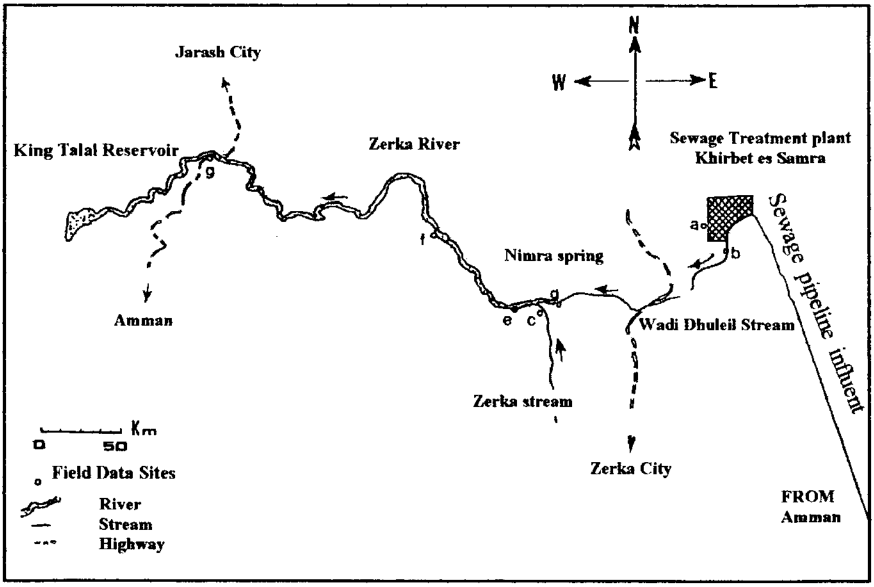


**Figure 3:** Route map of KS sewage treatment plant, Jordan

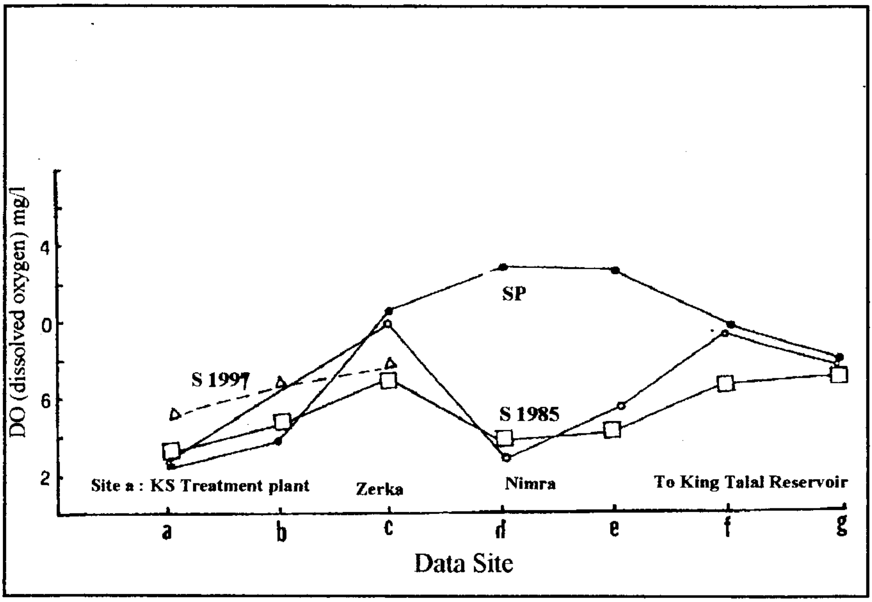


**Figure 4:** Fluctuations of dissolved oxygen along the Zerka River, Jordan

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reservoir [5]. The values of the total Biological Oxygen Demand ($BOD_5$) at the exit of the treatment plant (Table 1) are much lower than those observed further down-stream in the river. In addition, the high nitrate concentration detected along the Zerka river is attributed to insufficient microbial oxidation and unregulated waste dumping from farms and villages along the river course.

### Wetland performance observations

The field data of $BOD_5$ showed consistent decrease at a location (d) on the river where values of $BOD_5$ less than 100 mg/l were observed. This fortunate decrease of $BOD_5$ was attributed to the fact that the Zerka river reach between locations b and d has an aquatic environment which resembles a natural wetland where dense stands of water plants are grown.

Table 1: Operating characteristics of oxidation ponds
(KS Sewage Treatment Plant: Location b (Fig. 3), Jordan)

| Characteristics | Operating Sequence | | | |
|---|---|---|---|---|
| | Anaerobic I | Facultative II | Maturation III | |
| | | | w/o aerators | w/aerators years 96/97 |
| Depth, m | 5 | 1.75 | 1.25 | 5 |
| Ponds Size, ha | 3 | 7 | 6 | 3 |
| No. of Ponds | 6 + 2 | 7 | 12 | 2 |
| Deten. time,d | 4 | 18 | 12 | 4 |
| $BOD_5$, mg/l | 240 | -- | 150 | 28 |
| Fecal Coliform w/Chlorination, MPN/100 ml | -- | -- | 100-1000 | 30< |
| Fecal Coliform w/o Chlorination, | -- | -- | $10 \times 10^3$ | 300 |

## Alexandria wastewater treatment system

At present the primary treatment plants receive Alexandria's raw domestic wastewater which is discharged into the Lake Maryout main basin with a total flow rate of 7m$^3$ /sec. Lake Maryout is composed of four basins; main basin, fishery basin, north-west basin, and south-west basin. Levees and waterways separate the basins. The main basin of the lake also receives drainage water from the neighboring agricultural land. Water level in the lake is kept at its normal level which is below the mean sea level (-2.4m) using the El-Mex pump station

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located at the western harbor bay (Fig 5). The area of the main basin amounts to about 22 km$^2$ , approximately half of which is occupied by vegetation, mainly phragmites and floating hyacinths. The areas of Lake Maryout impacted by the primary treated wastewater discharges exhibit extremely degraded water quality[7]. Current government plans call for several alternatives, including upgrading the treatment to secondary treatment, with continued discharge into Lake Maryout.

## Discussion

Water quality data of the Jordan Valley project necessitate the need for enforcement of environmental control to deter dumping domestic waste along the Zerka River. Furthermore, the addition of a constructed wetland [8] prior to the reservoir would be a necessary step to reduce nutrients such as nitrogen and phosphorus and $BOD_5$ from the outflow discharged out of the KS sewage-treatment plant.

The deterioration of the water quality of Lake Maryout in the vicinity of Alexandria together with the rising costs of secondary and advanced treatment plants warrant the need to use natural treatment methods to upgrade the primary-treated sewage. Use can be made of the land availability in Maryout Valley to construct a series of wastewater treatment lagoons, which receive the primary treated sewage, by an inland pipeline. The Maryout Valley adjoins the lake from the west and its floor slopes from an elevation of 4.0m to an elevation of –1.0m below MSL. Thereafter the valley merges into the lake. The valley lies between two limestone ridges, which rise to a height of 20m, and runs parallel to the coastline. The nature of the soil at the floor of the valley is loose sandy clay. A constructed wetland could be created further along the downstream end of the pond complex to insure that the effluents produced have lower values of $BOD_{5,}$ SS and total N as demonstrated by Chen et al [9]. Figure 5 shows the Maryout Valley and recommended location of the pond system and the predicted total surface area of the ponds, which amounts to about 500 hectares as extrapolated from the data shown in Fig. 6.

## Conclusions

For safe and unrestricted use of the effluent of KS wastewater treatment plant for irrigation, the natural treatment processes along the Zerka River and maintenance of existing stabilization ponds should be further reviewed to insure optimum operation. Use of a constructed wetland system between the KS treatment plant and the KTR reservoir is recommended to reduce adverse effects of non-point source pollution. An integrated system composed of oxidation ponds and constructed wetlands might provide a low cost alternative to produce a polished level of secondary treated effluent for Alexandria primary treated wastewater.

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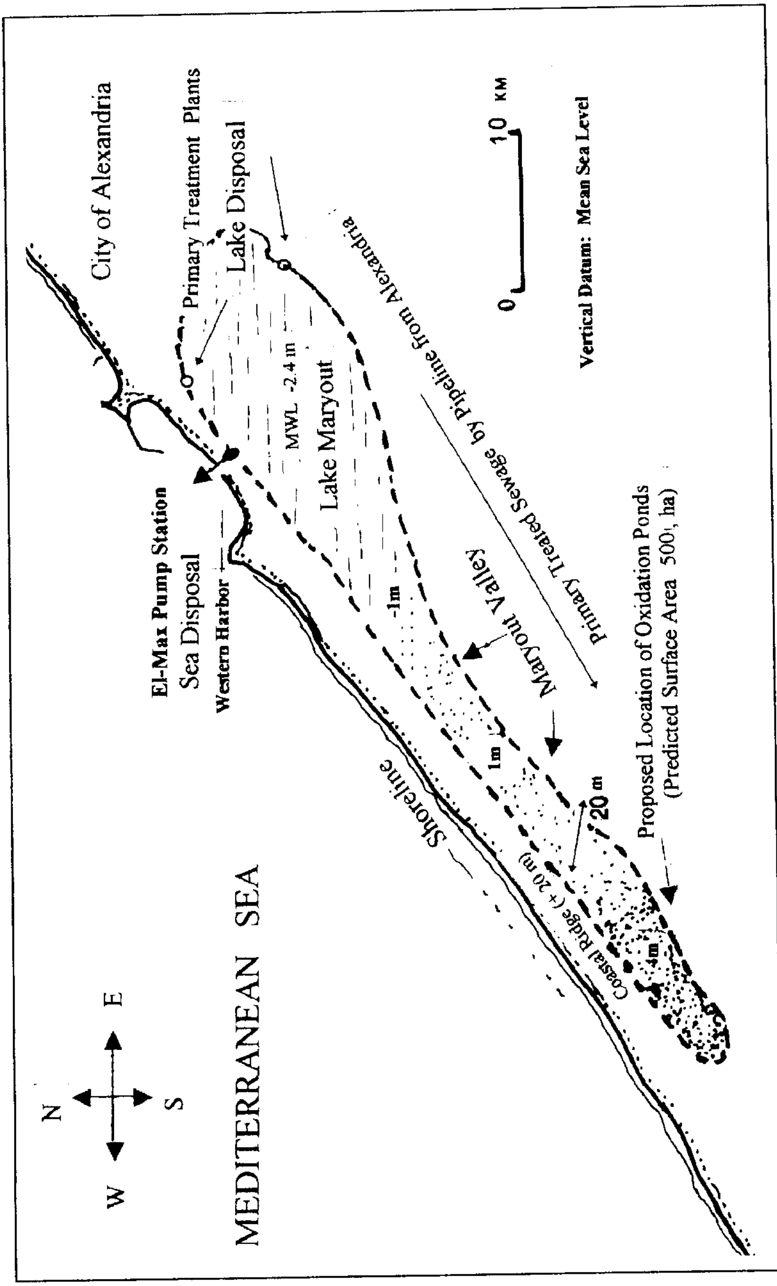


**Figure 5:** Location map of proposed Alexandria wastewater treatment project, Egypt

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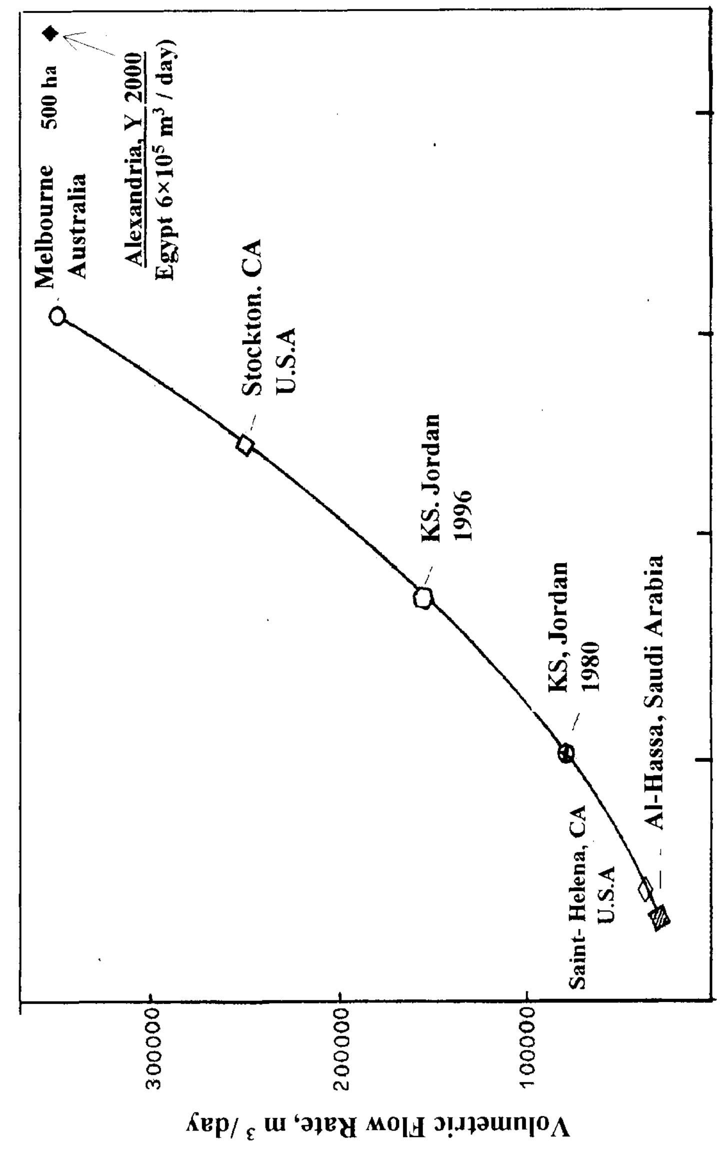


**Figure 6.** Correlation between ponds surface area and domestic sewage influent rate

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