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REUSE OF LOW QUALITY WATER IN EGYPT

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ABSTRACT – In Egypt, the reuse of the drainage water can be natural, official and non-official reuse. Natural reuse of drainage water occurs where rivers or canals act as a drain for hydrologic basin aquifer systems. Official reuse is the practice of including part of drainage water flow in the quantity of irrigation water delivered by the irrigation system. Non-official reuse is practiced by individual farmers who decide when and how much drainage water will be used for supplementing their irrigation water supply. In addition to these issues, the present article discusses the three national projects of drainage water reuse (Al- salam canal, Omonm drain and drain No 1 and 2) as well as the factors that may adversely affect the drainage reuse in the Delta region, including pollution, irrigation improvement program implementation, rice area reduction, and the main health risks caused by discharges of insufficiently treated wastewater to rivers and drains.

Key words: Egypt, drainage water, impacts, Al-Salam Canal project, Omoum Drain project, Drain No.1 and 2

1. INTRODUCTION

Conventional water resources in Egypt are limited to the Nile River; groundwater in the deserts and Sinai, and precipitation. Each resource has its limitations on use. These limitations relate to quantity, quality, space, time, and/or use cost.

The Nile is the main and almost exclusive source of fresh water in Egypt. The Nile inside Egypt is completely controlled by the dams at Aswan in addition to a series of barrages between Aswan and Mediterranean Sea. Egypt relies on the available water stored in Lake Nasser to meet needs within its annual share of water, which is fixed at 55.5 Billion Cubic Meters (BCM) annually by agreement with Sudan in 1959.

Groundwater aquifer in the Western Desert stores about 200,000 BCM of fresh water. However, groundwater occurs at great depths and the aquifer is generally non-renewable. The utilization of such water therefore depends on pumping costs and its depletion rate versus the potential economic return on the long run.

Rainfall on the Mediterranean coastal strip decreases eastward from 200 mm/year at Alexandria to 75 mm/year at Port Said. It also declines inland to about 25 mm/year near Cairo. In addition to the conventional water resources there are some other non-conventional resources that include renewable groundwater aquifers in the Nile valley and Delta, agricultural drainage water, and treated wastewater. The groundwater aquifer underlying the Nile valley and Delta is recharged only by seepage losses from the Nile, the irrigation canals and drains, and deep percolation of water from irrigated lands. It can be considered as a reservoir in the River Nile system with a small rechargeable live storage. This aquifer can be used as a source of water to meet part of the water demands at peak periods and then recharged again during low demand periods. The total available storage of the Nile aquifer is estimated at about 500 BCM but the maximum renewable amount (the aquifer safe yield) is around 7.5 BCM. The existing rate of groundwater abstraction in the Valley and Delta regions is about 4.8 BCM/year, which is still below the potential safe yield of the aquifer.

2. AGRICULTURE DRAINAGE SYSTEM

In Egypt, the total agriculture land amounts to 8 million feddan (1 feddan = 1.04 acre), which represents 3.8% of the whole area of the country. There are two major crop seasons, namely, the winter season (November-May) and the summer season (May – October). The most important crops are wheat and berseem in winter, cotton, rice and maize in summer.

Among the main constraints to agriculture production in Egypt is the rise of the water table causing water logging and salinization. Therefore, drainage becomes obvious to control water table level and soil salinity. A system of open main and branch drains has been constructed since the start of the 20th century. This network of open drains helps in dealing with the problem of water logging and salinity partially.

The implementation of the National Drainage Program started in 1970. It included the widening and deepening of the existing main open drains, the excavation of new main drains, the construction of appurtenant structures, the construction of new pumping stations and the rehabilitation of old ones. It included also, the installation of subsurface drainage systems of laterals and collectors in gridiron layout. The average field drainage depth is 1.35 m and the minimum depth of water levels in the main drains is 2.5m.

The total target of the surface drainage is 7.2 million acres, of which 4.9 million acres are in the Nile Delta and 2.3 million acres in Upper Egypt.

3. AGRICULTURE DRAINAGE REUSE

"Agricultural drainage water reuse" is defined as the use of drainage water discharge repeatedly, *Source "Nevada's Water Dictionary"*.

3.1. Background

The irrigated agriculture of Egypt is sustained through provision of adequate land drainage systems. They were developed over the past four decades to mitigate the hazards of water logging and salinity resulting from perennial irrigation that widely practiced since the Aswan High Dam (AHD) construction (1970). Efficient drainage systems are not only needed due the perennial irrigation, but more importantly due to the fact that Egyptian agriculture is one of the most intensive irrigated agriculture in the world (cropping ratio is almost two).

The drainage water in Upper Egypt is pumped or flows by gravity back to the Nile. In the Delta, the network of open drains discharges their flows mainly into the Northern Lakes or the sea. The total length of Nile Delta drains is over 16,000 km long.

Three types of reuse practice can be distinguished: natural, official and non-official reuse. Natural reuse of drainage water occurs where rivers or canals act as a drain for hydrologic basin aquifer systems. Natural reuse is largely non-controllable except by modifying the amount of recharge that occurs, i.e., reduction of deep percolation from irrigation. Official reuse is the practice of including a part of drainage water flow in the quantity of irrigation water delivered by the irrigation system. Physically, official reuse occurs through lifting specific amounts of drainage water from drainage canals and blending the water with better quality canal or river water. Non-official reuse is practiced by individual farmers, who decide when and how much drainage water will be used for supplementing their irrigation water supply.

Drainage water reuse projects in the Nile Delta started as early as the 1930's alongside the construction of the drainage projects. In 1930, the additional Serw pumping station in the Eastern Delta was constructed to support the main Serw station (constructed in 1928). When it was discovered that the lifted water by the additional station was of a reasonable quality, it was separated from the main station and the pump drainage water was diverted into the Damietta Branch (El Quosy, 1989).

Beside the above reuse projects, unofficial reuse is taken place in many locations. Field observations and simple mathematical analysis show drainage water is intensively reused from South towards the North and then towards fringes of the Delta both to East and to West. Estimates differ but it is believed that a quantity of the unofficial reuse is as high as 2 bcm every year for the Nile delta (EL Quosy, 1989).

3.2. Reuse as a Policy

Dr. Mahmoud Abu Zeid, Minister of Water Resources and Irrigation, Egypt, stated that*" In terms of increasing the overall system efficiency, the drainage reuse pays back much faster and at much less cost than the irrigation improvement. This justifies the adoption of the drainage reuse strategy on the short term"*

3.3. National Agriculture Projects that Depend on the Reuse of Drainage Water

Planning for re-use projects in the late seventies and early eighties was marked by the desire to use the water of "drain" catchments rather than that of isolated "drainage" catchments. The purpose was to use as much drainage water as possible especially for the irrigation of large land reclamation projects in the eastern and western parts of the Delta.

Three projects of this kind were designed and they will be described in brief in the following sections.

3.3.1. Al-Salam Canal Project

Al-Salam Canal is designed to be fed from the Damietta Branch upstream of Farskour Dam with fresh water while supplemented with drainage water from the Lower Serw pumping station and Bahr Hadous drain near its outfall. At this point, the drain contains the collection of drainage water from all the catchments served namely Nizam, Beni-Ebeid and Erad.

The average yearly discharge of the Lower Serw pumping station is about 600 Million cubic meter (MCM), and that of Bahr Hadous drain is about 2 Billion cubic meter (BCM). These bring the available drainage water total to 2.6 BCM / year.

The average salinity measured at Lower Serw pumping station is around 1 000 ppm, and that measured at Bahr Hadous outfall is about 1 400 ppm. The weighted average of both waters is 1300 ppm. When this is mixed with fresh water at a ratio of 1:1 the salinity of the mixture is expected to be in the neighbourhood of 800 ppm, which is reasonable, given that the water is going to be used for the irrigation of sandy sois.

It is planned to use 1.50 BCM /year of this quantity in the first and second phases of the project in addition to a similar quantity of fresh Nile water. The mixed water will be used to irrigate the land reclamation projects in Port-Said Plateau, South Husseinia, and South Salhia, the total area of which is about 200 000 fed, in the first phase. The second phase covers the irrigation of 400 000 feddan extending along the northern coast of the Sinai Peninsula from Al-Arish westward.

3.3.2. Omoum Drain Project

Its objective is to collect the drainage water from the three catchments of Omoum drain, Abu-Hommos (the biggest in the Western Delta), Shereishra and Truga. This collection of water will then be mixed with the fresh water of Nubaria Canal at km 46.0. At this point, the canal serves an area of reclaimed lands of about 500,000 fed and passes a discharge of 5.0 BCM / year. The quantity of drainage water to be used in the project is about 1.0 BCM / year and has an average salinity of 1 800 ppm. The expected salinity of water after mixing will be in the margin of 800 ppm.

3.3.3. Drain No. 1 and 2

Those drains are located on the far north of the Middle Nile Delta region. It is planned to pump part of the water delivered by those drains to kalabsho and Ziean areas. The collective discharge of the two pumping stations is about 900 MCM / year at an average salinity of 1000 ppm. The project is now completed and the water delivery to the area is in progress.

Following the completion of the construction of the above three projects, an extra quantity of 3.40 BCM of drainage water will be used for irrigation which brings the total to 7.60 BCM (4.2 BCM are already re-used every year at different other drains in western / eastern / middle delta and Fayoum).

3.4. Monitoring Network

One of MWRI major goals is to develop an effective long term drainage water quality monitoring programme aiming at providing better knowledge of Egypt's drainage water and giving answers to decisions and policy makers about drainage water reuse potentials.

A monitoring network of 90 measuring sites on the main drains in the Nile Delta and Fayoum was established in the early 1980's providing flow, salinity and macro-ions data. The current monitoring network in the Nile Delta and Fayoum consists of 158 sites (Fig. 1). Drainage Research Institute (DRI) monitors the Delta and Fayoum regions on monthly basis. An additional part is monitored by Nile Research Institute (NRI) twice a year (February and August), including forty-three locations for Upper Egypt drainage system. For the collected samples, a set of parameters are analyzed including physical, biological, microbiological, macro and micro ions. Integrated databases and information systems are being used with interpretation tools and prediction models meeting water quality objectives.

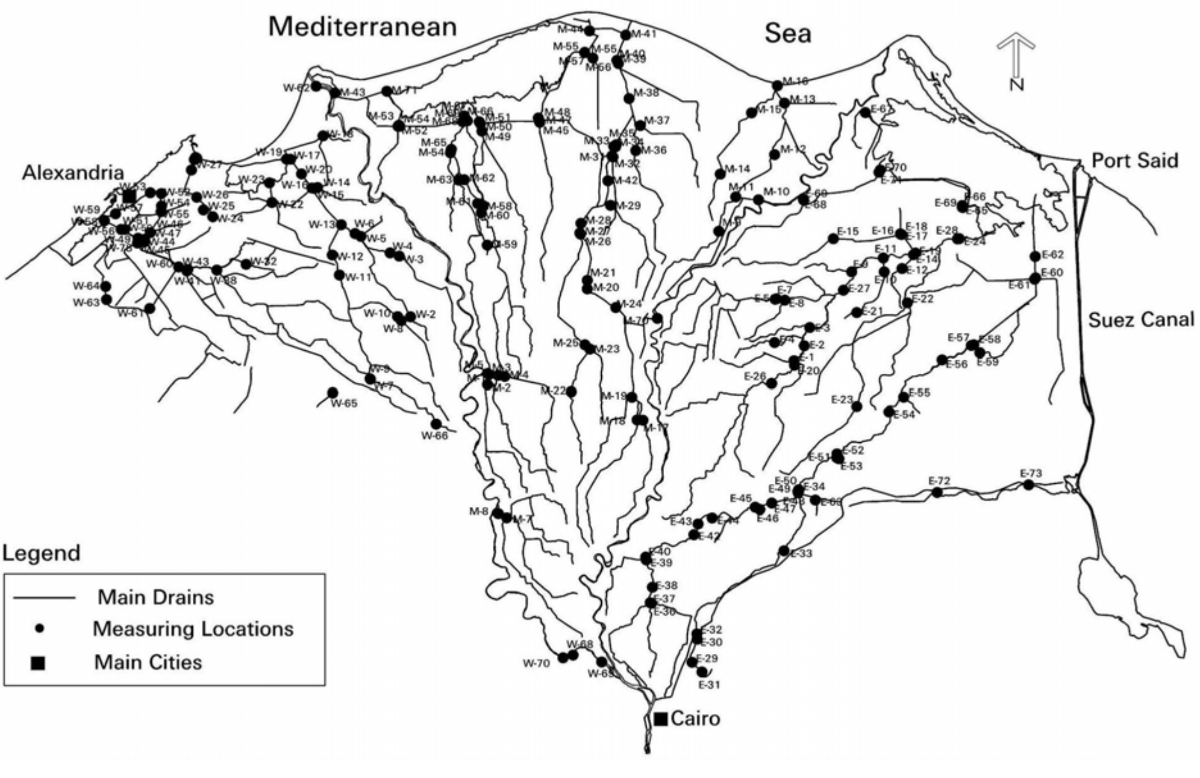

Figure 1. Monitoring network at the Nile Delta region

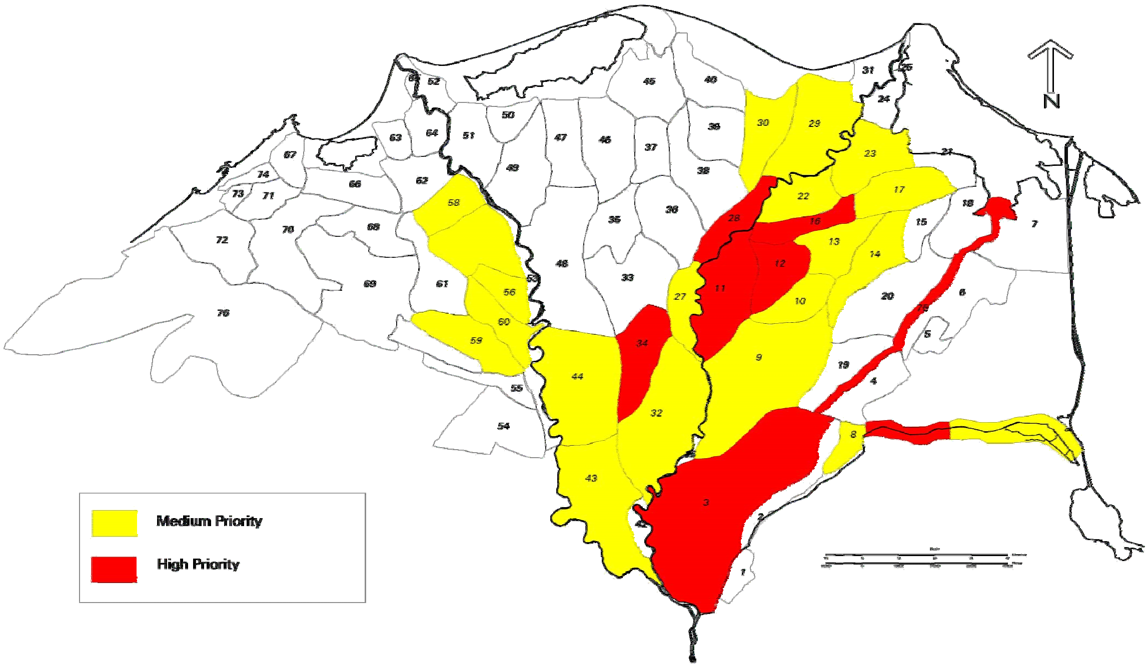

Figure 2. Priority areas in the Nile Delta based on the official reuse criteria

3.5. The Current Status of Reuse of Drainage Water

3.5.1. Official and Unofficial

Table 1. Reuse of drainage water in the Nile Delta during 1995/2003

Year	Eastern Delta		Middle Delta		Western Delta		Total Reuse	
	Q	EC	Q	EC	Q	EC	Q	EC
1995-96	1745.9	1.89	1814.6	1.79	705.9	1.42	4266.3	1.77
1996-97	1843.2	1.94	1947.9	1.85	642.5	1.31	4433.6	1.81
1997-98	1736.3	1.66	1801.3	1.77	632.4	1.35	4170.1	1.66
1998-99	2126.9	1.48	2168.3	1.52	738.3	1.07	5033.5	1.43
1999-00	1661.8	1.64	1891.4	1.64	1183.6	1.97	4736.8	1.72
2000-01	1830.2	1.57	1958.8	1.76	1058.3	1.92	4847.3	1.72
2001-02	2026.5	1.74	2199.8	1.67	1062.8	1.76	5289.1	1.71
2002-03	2329.3	2.00	2082.4	1.90	875.6	1.76	5287.4	1.92

Q: Drainage Water Discharge (million m^3/month)
EC: Drainage Water Salinity (ds/m)

Table 2. Reuse of drainage water in the Nile Delta during 2002/2003

Month	Eastern Delta		Middle Delta		Western Delta		Total Reuse	
	Q	EC	Q	EC	Q	EC	Q	EC
Aug	254.82	1.91	294.63	1.89	97.81	2.34	647.26	1.97
Sep	197.54	1.29	404.00	1.90	94.75	1.64	696.29	1.69
Oct	154.89	1.50	140.86	1.89	62.76	1.84	358.52	1.71
Nov	181.85	2.26	121.82	2.55	69.54	1.59	373.21	2.23
Dec	161.56	1.51	118.52	1.94	66.86	1.72	346.94	1.70
Jan	129.47	1.68	114.57	1.65	65.70	1.69	309.74	1.67
Feb	105.21	2.68	95.10	2.20	48.26	1.92	248.57	2.35
Mar	154.09	1.57	128.42	1.83	72.61	1.67	355.11	1.69
Apr	146.98	1.85	120.32	1.76	54.08	1.64	321.38	1.78
May	197.85	2.62	129.37	1.70	66.02	1.82	393.25	2.18
Jun	298.64	2.56	201.52	2.16	81.99	1.56	582.15	2.28
Jul	346.40	2.14	213.32	1.56	95.26	1.57	654.98	1.87
Total	2329.31	2.00	2082.45	1.90	875.64	1.76	5287.41	1.92

Q: Drainage Water Discharge (million m^3/month)
EC: Drainage Water Salinity (ds/m)

3.5.2. Drainage Pollution Mitigation Measures

- Intermediate reuse

In Egypt, the major problem regarding drainage water quality is not salinity, but chemical and bacteriological pollution. Where main surface drains pass through major urban and industrial areas, they invariably turn into major carriers of untreated wastewater. Ideally, most reuse of water should take place before flows reach major centres of contamination, which would mean that investment in irrigation and drainage is best concentrated upstream of metropolitan areas or industrial estates. Another set of operational measures concern mixing strategies. This is a matter of debate in Egypt where about 7 BCM of drainage water is re-used for irrigation. The proposal is to shelve the present centralized mixing strategy, where a limited number of big mixing stations pump drainage water from main drains back into main irrigation canals. The alternative is “intermediate reuse”. In this strategy mixing of drainage water and fresh irrigation supplies take place at lower level- with a drainage catchments coinciding with a number of secondary canals. The advantage of intermediate reuse is that it can isolate poor quality water and allow the reuse of relatively good quality with low levels of salinity and contamination, though even then it would still require careful integrated management of both fresh water and drainage water.

- Treatment technology

Treating drainage water is normally one of the last drainage water management options to be considered. This is due to the high costs involved and to uncertainty about the treatment level achievable. The treatment of drainage water should be considered where all other drainage water management measures fail to guarantee safe disposal or where it is financially attractive. For subsurface drainage water containing very high levels of salinity, selenium and other trace elements, the treatment objectives are: i) reduce salts and toxic constituents below hazardous levels; ii) meet agricultural water management goals; iii) meet water quality objectives in surface waters; and iv) reduce constituent levels below risk levels for wildlife.

- Guidelines for safe reuse of drainage water

The reuse of drainage water in irrigated agriculture is primarily limited by the salinity of the water, which affects both the soil properties and crop production, and also by the substances in the water, which are toxic to crops. Furthermore, reuse of drainage water might be restricted in areas where drainage water is returned to irrigation canals, which provide drinking water to a population downstream. In that case the presence in the drainage water of substances toxic to humans becomes critical. When other user categories besides agriculture rely on the irrigation water supply, standards other than salinity have to be applied to determine the limits of water quality and hence the ratio of drainage water to irrigation water in the mixture.

3.5.3. Waters that Should not be Reused

There are some drainage waters that should not be blended or reused for irrigation. Waters that are highly saline, when mixed with fresh water may result in too large a volume of drainage water to be handled by the soil, i.e. requiring a very high leaching fraction and an intensive drainage system from to remove the excess water. Highly saline waters should be kept separated from the irrigation water supply, to be disposed of in a salt sink. Waters containing an excess of Sodium, Chloride, or Boron should not be used (Table 3).

Table 3. Drainage water quality criteria for irrigation purposes in the Nile Delta, Egypt

Salinity of drainage water (dS/m)	Restriction on use for irrigation
< 1.0	used directly for irrigation
1.0 - 2.3	mixed with canal water at ratio 1:1
2.3 - 4.6	mixed with canal water at ratio 1:2 or 1:3
> 4.6	not used for irrigation

Source: Abu-Zeid, 1988

3.6. Drainage Reuse Potential

There is obviously a limit on the amount of drain water available for reuse. A central issue in Egypt's water resources management is how much more of the drain water currently being discharged to the Mediterranean Sea can be conserved by increasing reuse. This section addresses this issue by establishing a better understanding of the maximum reuse potential based on drain water salinity and the minimum drainage outflow requirements for the maintenance of freshwater fish production in the northern lakes (APRP, 1998).

3.6.1. Maximum Drainage Water Reuse Potential

According to the recent drainage monitoring data (DRI, 2000), the average salinity of the reused drainage water in the Delta region was 1,076 ppm. For more drainage water reuse, pumping will need to be extended to drains containing higher salinity concentrations.

The reuse potential presented in Table 4 was estimated by 75% of the available drainage water in the Nile Delta can be reused. The presented table is based on the average of 5 years from 1997 to 2002.

Table 4. Maximum possible drainage water reuse in Nile Delta (MCM)

Region	Available Drainage Water	Currently Reused	Possible to be reused
Eastern Delta	4083.65	2049.89	1519.02
Middle Delta	5849.14	2007.73	2881.06
Western Delta	3819.15	1123.56	2384.33
Total	13751.94	5181.18	6784.41

It is not possible to reuse all 75% of the available drainage water where there are three factors limiting the implementation of drainage reuse expansion. Pollution of drains with untreated sewage and industrial effluent limits the reuse potential. Some of the already existing mixing stations are shut because their delivery outlets are on canals that serves drinking water treatment plants. Another limitation is minimum outflow of the system that has to go to the sea to maintain the salt balance and fragile ecosystem of the Nile Delta.

3.7. Future Perspective

3.7.1. Factors Affecting Future Drainage Reuse

There are many factors, that may adversely affect the drainage reuse in the Delta region, including pollution, irrigation improvement program (IIP) implementation, rice area reduction, and the Toshka project (DRI, 1998).

4. REUSE OF TREATED MUNICIPAL WASTEWATER

The first use of treated wastewater in Egypt was in 1915 in the eastern desert north east of Cairo. An area of 2500 acres is still under irrigation with wastewater, which receives only primary treatment. With the scarcity of water resources, it is planned to irrigate 150,000 acres with treated wastewater up to the year 2000.

All urban wastewater projects include facilities for treatment up to the tertiary level and allow re-use for irrigation. Many of the rural areas are still lacking such facilities. It is estimated that present amount of wastewater from major cities and urban areas are as given.

Table 5. Waste Water from Urban and major cities

Area	Year 1992	Year 2000
	Billion m^3/year	Billion m^3/year
Cairo	1.36	1.70
Alexandria	0.53	0.65
Other Urban areas	1.54	2.58
Total	3.43	4.93

Currently in Egypt, detailed criteria for wastewater reuse in agriculture are under review and preparation. Several pilot programs have started and under continuous monitoring for some refinements.

In an arid country such as Egypt, where water is scarce in general, wastewater reuse should be encouraged and promoted whenever, especially in terms of public health; it is safe and economically feasible. Every effort should be undertaken to safely make use of reclaimed water and encourage development of more treatment facilities. Treated wastewater is a valuable resource and has certain economic advantages. It is available close to urban areas where the demand for food and fuel wood crops in concentrated. With proper management, crop yield may be increased by irrigating with raw wastewater. Such nutrients inputs can reduce or eliminate completely the need for commercial fertilizers.

Reuse of sewage, after primary treatment in agriculture has been in practice since 1925 in the eastern desert area of Gabal Al Asfar outside (25 km. N.E.) Cairo. An area of 20.000 feddans of desert land is fully cultivated. Reuse of primary treated sewage was possible only during the first 20 years of operation at Gabal Al Asfar’s treatment plant, and therefore, only raw sewage has been used. The flow reaching the plant had then reached double the capacity of the primary treatment works. The productivity of the reclaimed land had originally increased but with continued use of untreated sewage in irrigation the soil began to suffer due to accumulation and retention of fat end grease in the top soil. Sampling of the subsurface and groundwater in the vicinity of Gabal Al Asfar sewage farm has proven this water to be extensively and extremely polluted with a broad variety of pathogens. In the mean time most of the sewage water drained to the agricultural drains is actually reused in one way or another (Eid, 1990).

4.1. Potential of Treated Sewage Reuse

The experience of large-scale and organized reuse of treated wastewater effluent is still limited in Egypt. However, there are a number of large-scale pilot projects, mostly irrigating trees beside some field crops, for example in Abu Rawash, Sadat City, Luxor, Ismailia, … etc. This situation is changing rapidly in the major cities of Egypt due to the installation of modern Waste Water Treatment Plants (WWTPs) that provide secondary treatment that offers an opportunity for water resources planners to fill the gap between supply and demand.

In Greater Cairo, there are six wastewater treatment plants, with a total capacity of approximately 27 MCM/day. All of which will eventually be treated to a secondary standard. With a current combined treatment capacity of this quantity of effluent is potentially sufficient to irrigate about 100,000 feddans.

The sewage system in this area also serves industries and commercial activities. Therefore, high levels of toxic substance in sewage have been reported. All treatment plants discharge into agricultural drains, where they act as point sources of pollution. In the desert areas, treated domestic water is used for irrigation.

4.2. Concerns Related to Treated Wastewater Reuse

While need for reusing wastewater for irrigation is evident in many developing countries, the efforts made so far have generally been ad-hoc. Countries under water stress release constraints in their wastewater development and reuse projects, as they believe that any additional water available for augmentation is a positive measure. Proper planning of wastewater reuse must support any measure that is being taken because the negative impacts of wastewater have to be considered carefully. This will ensure that cost-effective process can be designed and maintained in agreement with health, environmental and institutional constraints.

Wastewater is the general term applied to the liquid waste collected in sanitary sewers and sometimes to be treated in a wastewater treatment plant. Municipal wastewater is generally composed of domestic wastewater, industrial wastewater and infiltration inflow. The volume of wastewater generated in a community on a per capita basis excluding industrial wastewater varies from 50 to 500 litre/day. The wide range of per capita flows reflects differences in water consumption among communities and is largely a function of the price of water, the ability of the community to pay for it and reliability of the water supply.

Normal domestic and municipal wastewater is composed of 99.9% water and 0.1% suspended, colloidal and dissolved solids including organic and inorganic compounds. Untreated industrial effluents may add toxic compounds but often not in detrimental quantities (Pettygrove G.S., Takashi Asano, 1990).

The physical properties and the chemical and biological constituents of wastewater are important parameters in the design and operation of collection, treatment and disposal facilities and in the engineering management of environmental quality. The constituents of concern in wastewater treatment and wastewater irrigation are listed in Table 6.

Table 6. Technical and environmental risks of reusing treated wastewater

Constituent	Measures parameters	Reason for concern
Suspended solids	Suspended solids including volatile and fixed solids	Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment. Excessive amounts of suspended solids cause plugging in irrigation system.
Biodegradable organics	Biochemical oxygen demand, chemical oxygen demand	Composed principally of proteins, carbohydrates and fats. If discharged to the environment, their biological decomposition can leaf to the depletion of dissolved oxygen in receiving waters and to the development of anaerobic conditions.
Pathogens	Indicator organisms, total and faecal coliform bacteria	Communicable diseases can be transmitted by the pathogens in wastewater: bacteria, virus, parasites.
Nutrients	Nitrogen Phosphorus Potassium	Nitrogen, phosphorus and potassium are essential nutrients for plant growth and their presence normally enhances the value of the water for irrigation. When discharged to the aquatic environment, they can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, nitrogen can also lead to the pollution of groundwater.
Stable organics	Specific compounds (e.g. phenol, pesticides, chlorinated hydrocarbons)	These organics tend to resist conventional methods of wastewater treatment. Some organic compounds are toxic in the environment and their presence may limit the suitability of the wastewater for irrigation.
Hydrogen ion activity	pH	The pH of wastewater affects metal solubility as well as alkalinity of soils.

Constituent	Measures parameters	Reason for concern
Heavy metals	Specific elements (e.g. Cd, Zn, Ni)	Some heavy metals accumulate in the environment and are toxic to plants and animals. Their presence may limit the suitability of wastewater for irrigation.
Dissolved inorganic	Total dissolved solids, electrical conductivity, major ions (cations and anions)	Excessive salinity may damage some crops. Specific ions such as chloride, sodium and boron are toxic to some crops. Sodium may pose soil permeability problems.
Residual chlorine	Free and combined chlorine	Most chlorine in reclaimed wastewater is in a combined form which doesn't cause crop damage. Some concerns are expressed as to the toxic effects of chlorinated organics in regard to groundwater.

4.3. Management Tools of Wastewater Reuse

4.3.1. National codes and legislations

The national legislation on effluent reuse has also recently been revised by Decree 44/2000 to bring the standards for effluent quality and conditions of reuse inline with those adopted internationally.

The results should also give confidence to all the stakeholders that the measures under decree 44/2000, supported by the code of practice and specific extension advice that are appropriate and provide a secured framework for the sustainable reuse of the treated wastewater from Cairo east bank and other cities in Egypt.

Meanwhile, a National Code shall be issued to control the reuse of wastewater. Results suggested that irrigation of field crops with secondary treated effluent could be an effective means of reusing such wastewater safely for irrigation while maintaining the quality of field crops. Future reuse projects should depend on a better planning and management of reuse operation.

5. PRIORITY ACTIONS TO ENHANCE REUSE POTENTIAL

Identifying areas with health risks as a result of low drainage water quality is the first step towards identifying priority actions that will reduce the health risks. In some areas short term action may be required to change the contact mechanism, but always the longer term actions that will reduce the pollution levels are still required. The short term actions can be separated into pollution control actions and protection actions. Pollution control actions are measures to reduce the discharges of wastewater in areas that are already polluted. Protection measures are measures to prevent vulnerable areas to be polluted in the future.

Although it is known that there are still a number of industries that discharge either directly or indirectly (through a drain) to the Nile river, the main health risk is still caused by discharges of insufficiently treated sanitary waste to the river and drains.

The main problems seem to be related to the areas of Kom Ombo and Edfu, reuse of sewage in Luxor and Qena, downstream of Qena, downstream of Minya and around Greater Cairo.

Pollution control actions in these areas should be aimed at the provision of adequate treatment facilities to those communities connected to sewer systems and the provision of collection stations for the vacuum trucks. The collection stations could be connected to existing treatment plants by forced mains or could be equipped with small treatment units. Until these measures take effect the population living around the polluted drains, canals and river reaches should be made aware of the health risks involved with direct or indirect contact with the water.

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