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# Wetland System as a Sustainable Alternative for Traditional Sanitation in Rural Egypt

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**Abstract:**

*Most rural Egyptians suffer the absence of proper sanitation. They use alternatives like cesspits and direct discharge into water canals. These acts cause serious pollution in groundwater and irrigation systems. Polluted groundwater is heavily used as a drinking source in absence of proper and clean water supply. All these factors led to the spread of diseases like renal failures and cancers. This bad life contributes in demographic changes because of rural-urban immigration. This paper aims to find a proper and sustainable alternative for traditional sanitation in rural Egypt. It was found that wetland systems can treat wastewater with high removal efficiency and minimum cost. Applying this technology can improve the quality of life for rural people and provide additional source of income.*

. **Keywords: Rural Egypt – Sanitation – Wetland systems – Groundwater contamination**

## 1. Introduction:

**The rapid population growth in Egypt has resulted in a large escalation of demand for new infrastructure. Installing the traditional sanitation grid systems demands huge capitals and investments which exceed the abilities of the Egyptian economy. Rural areas are the less fortunate in having infrastructure utilities. This problem affects the health of rural people and cause environmental problems.**

## 2. Sanitation coverage in Rural Egypt:

There are conflict statistics about the sanitation coverage in Egypt. Egyptian water Association (EWRA) annual report 2010/2011 confirms that only (49.7%) of all Egyptian families are connected to central sewage network while the rest either have self-installed systems (11.89 %), or completely deprived from any system (26.93 %) as shown in fig(1).

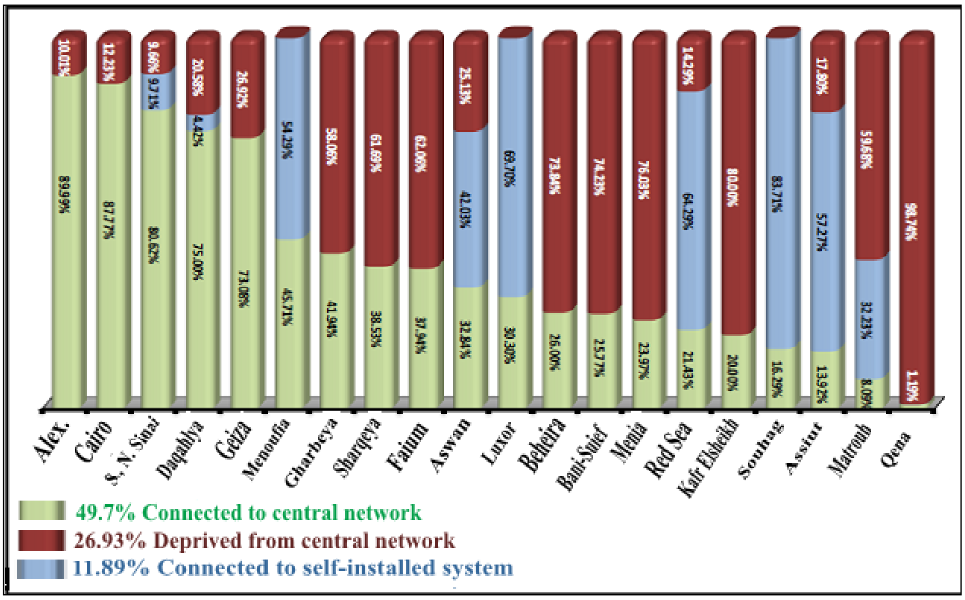


**Fig.1 Central Sewage network availability in Egyptian Governorates**
Source: EWRA Annual Report, 2010/2011

For rural areas, Central Agency for Public Mobilization and Stastics (CAPMAS) showed in its 2012 census that only 24.3% of rural houses were sewered **(1)**. The National Water Quality Monitoring (Nawqam) 2012 report states that these ratios do not represent the actual sanitation coverage, as many of these networks are not connected to wastewater treatment plants but are constructed by the inhabitants and most probably discharge untreated wastewater to agricultural drains or even a waterway in some cases; i.e. they are a pollution producer not a pollution prohibitor **(2).**

2.1 Sewers alternatives in deprived areas: People differently react towards the absence of central sewer system in rural Egypt. Some houses discharge their waste directly into nearest canal, while others install vaults and cesspits which need regular evacuation. Others who are the poorest among the inhabitants, carry on their liquid waste and walk in daily trips to pour it in the nearest drain, see fig (2),(3).

**Fig.2 Woman disposing her household waste--water in the village's drain in ElMenya, Egypt.**
www.cbm.org


**Fig.3 Household outlets discharging raw-wastewater into waterbody in Tersa, AlFaium.**
www.mobtada.com/news.details.php-retrieveMarch,2014

Vaults and cesspits are prominent in many Egyptian villages and are considered a main contributor in groundwater pollution in Delta Region. Vaults need regular evacuation which commonly doesn't occur properly because of the high cost of evacuation tanks which may lessen the frequency of the process. If not regularly evacuated, vaults overflow and flood the surrounding area.

But even if regularly evacuated, and in absence of any practical alternative, evacuation products are regularly discharged into neighboring waterways, and sometimes by the municipalities own tanks, see fig(5) **(3).**

**Fig.4 Left: Sewage evacuation tanks in Met Nama, Qaliubeya, Egypt. Right: Discharging wastewater in the Nile in Monshat El-Qanater, Egypt –** source: www.almasryalyoum.com

Some people dig wastewater wells which directly discharge wastewater to the ground water. This act highly pollutes groundwater and raises water table which is already 3 to 5 meter high in Delta region. This contaminated water is commonly used for drinking when municipal water access is not available.

## 2.2 Contamination of groundwater:

As a result for wastewater discharge into ground wells and water drains without proper treatment in rural regions, groundwater contamination has reached very high levels in last two decades. The total dissolved solids of groundwater in Egypt have significantly increased from 800 (mg/L) in 1997 to more than 1700 (mg/L) in 2009, which means more than 200% of augmentation in less than 12 years, see fig (5) **(4).**

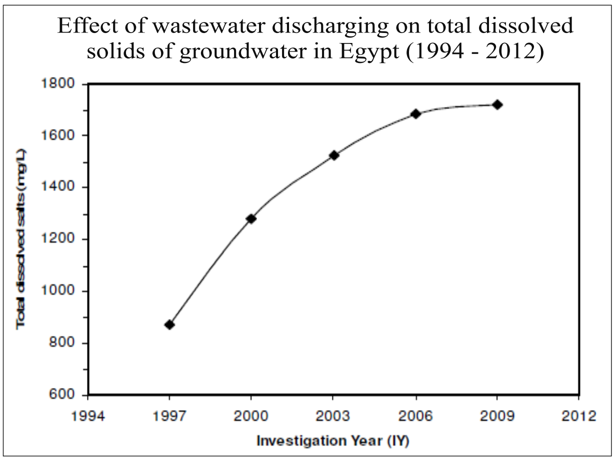


**Fig.5 Left: Effect of wastewater discharging on total dissolved solids of groundwater in Egypt (1994 -2012) – Right: Wastewater treatment municipal plant in Mehallet Hassan, Gharbeya, discharging poor treated wastewater into open drain.** Source: Easa & Abou-Rayan, 2012.

In absence of clean municipal water, groundwater is a main source of water consumption in rural Egypt. People commonly dig wells and install pumps for ground water extraction. Even if available, municipal water is less favorable because of its low quality. Many rural people think that well water is healthier and cleaner. There are millions of private artesian wells and pumps installed allover Egypt. See fig (6).

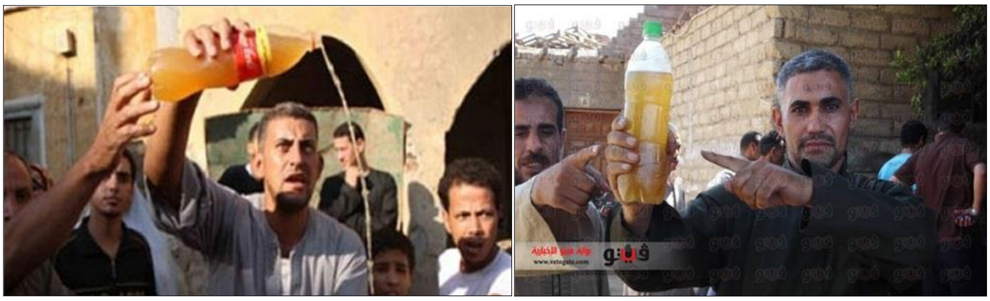


**Fig.6 Left: Demonstrations about bad municipal water in rural Egypt –** www.hoqook.com- **Right: Private groundwater pumps being very common as a good alternative. Assiut, Egypt.** (Water Management, Building on Fluid Availability, 2009).

Groundwater is already a basic source for municipal water utility in Egypt. More than 14% of water stations in Egypt depend on artesian wells, especially in rural areas (5). These stations depend on building a water tower besides pumps which simply draw deep ground water and lift it to the tower where water simply flows by gravity to the village's grid. See fig(7). Almost every village in Egypt has a water tower for water reservoir and supply (6).

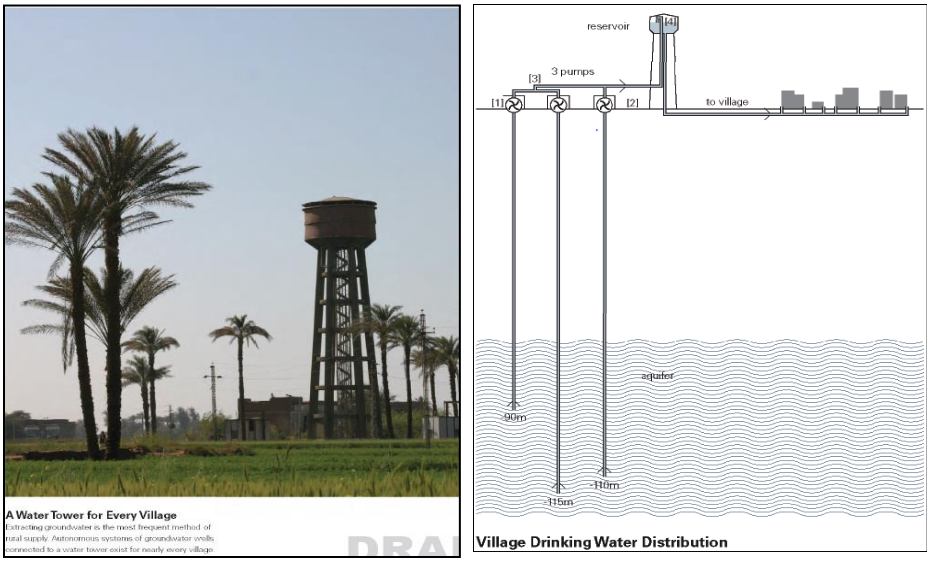


**Fig.7 Left: A view and a Cross section for Water Towers system which are almost installed in every Egyptian village.** (Water Management, Building on Fluid Availability, 2009).

An example for the reliance on groundwater in municipal water supply is the Governorate of Assiut. Although located directly on the Nile bank, Assiut basically depend on groundwater for supplying all its villages. Only one station in the Governorate is supplied from the Nile. The main reason is that digging beneath the village is much cheaper than transporting Nile water to these villages. See fig (8).

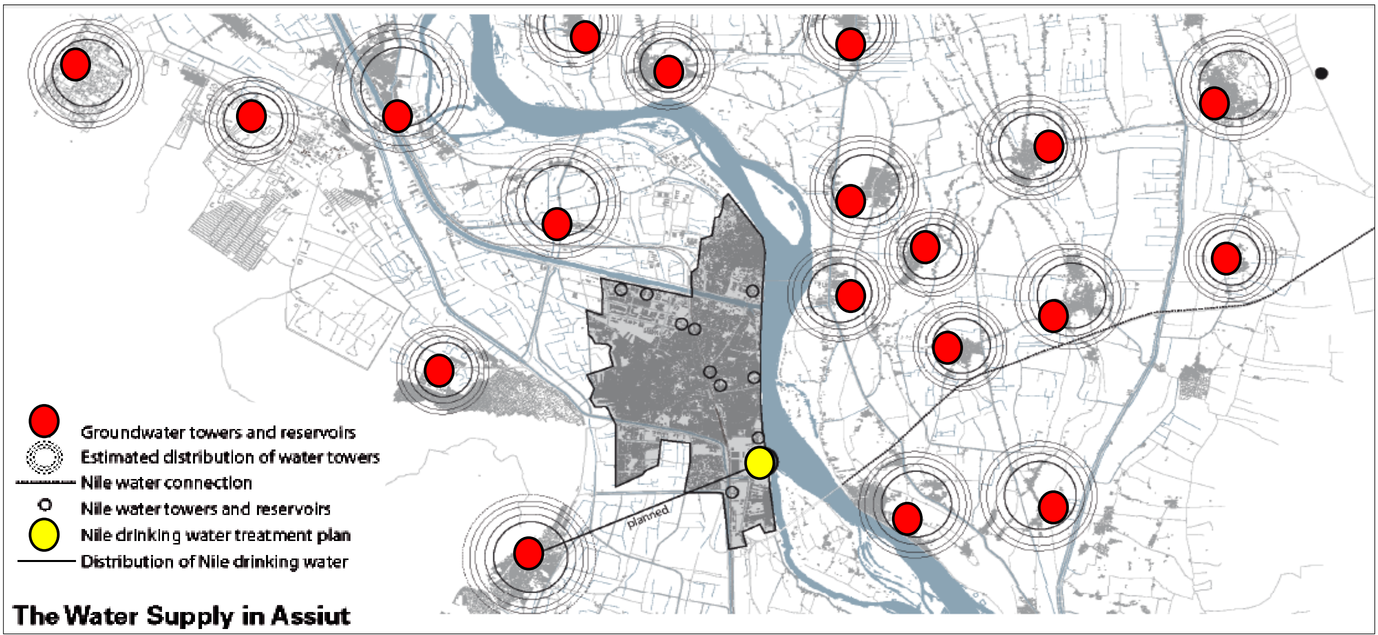


**Fig.8: Water supply stations in Assiut Governorate according to source of intake**
- Water Management Building on Fluid Availability, Sep.2009

## 2.3 Contamination of Agricultural Drains:

Egypt has 323 wastewater treatment plants (WWTP's) commonly located nearby agricultural drains as seen in map below. **(7).** With poor removal efficiency and a massive daily flow of 12 million m3/day, **(7)** drains are heavily polluted with human-waste-related bacteria like Faecal Coliform and Escherichia coli. The concentration of Faecal Coliform in some agricultural drains has exceeded 100000 - 500000 (MPN/100ml) while the Egyptian Environmental Standards are not to exceed 5000 (MPN/100ml), see fig (9).

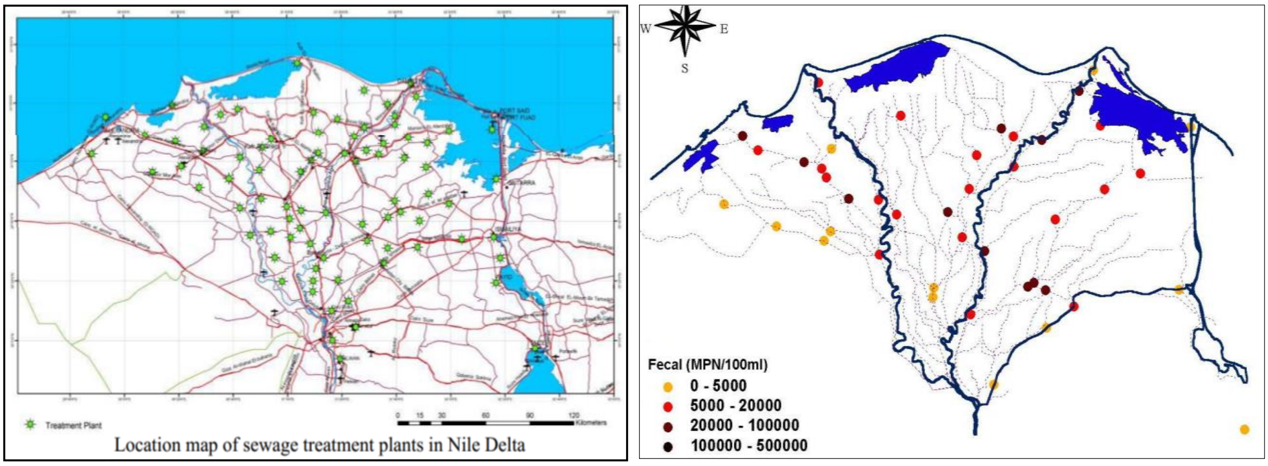


**Fig.9: Left: Location map of sewage treatment plants in Nile Delta. – Right: Faecal Coliform Bacteria in Delta Monitoring Points (2002/2003) -** (ESIAF) -2010

The level of water pollution in agricultural drains in some areas has reached limits preventing the reuse of this water after mixing it with canal water, which is considered a serious waste of an important water resource (8).

With wastewater plants pouring wastewater without proper treatment, and with increasing scarcity of irrigation water in many villages, heavily polluted drains are used for direct irrigation in many governorates as seen in fig (10). These irrigated crops form a serious threat to the public health and may cause liver failure and sometimes cancer.

**Fig.10: Left: Polluted drains used in irrigation in Kafr El- Sheikh- Right: Crops irrigated with sewage in Alsaff, Giza-** www.youm7.com

2.4 Health Impact: Due to bad sanitation in rural areas, groundwater is heavily polluted with pathogens and heavy metals. According to a UNICEF study, the incidence of Diarrhea in rural children is three times more than their peers in the city, see table (1).

Regular consumption of poor treated water may also cause Renal problems as well. A medical study conducted in rural and urban Egyptian regions showed that 58.6% of renal impairments patients were living in rural areas, and 12.6% of total patient drink directly from groundwater. 81.6% of them where with low socio-economic status, and 77% of them where under 12 years old, see fig(11) **(9).**

socio-demographic characteristics of patients presenting with impaired renal function

| Characteristics | (%) |
|---|---|
| *Age* | |
| Neonates | |
| 28 days > 1 year | (24.1) |
| > 1 year < 6 years | (34.5) |
| > 6 years < 12 years | (18.4) |
| | (23) |
| *Residence* | |
| Rural | (58.6) |
| Urban | (41.4) |
| *Drinking water* | |
| Treated | (87.4) |
| Untreated (direct from river/well) | (12.6) |
| *Socio-economic status* | |
| Low | (81.6) |
| Middle | (8) |
| High | (10.4) |

**Table 1: Renal imparities in rural and Egypt-** Hebatullah O. Tawfik et.al, 2002

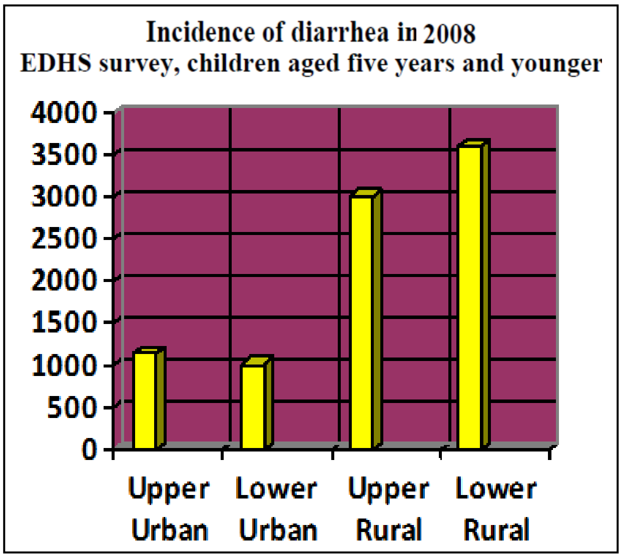


**Fig.11 Incidence of diarrhea in Egyptian children urban** in Rural and Urban Egypt -**Rania Roushdy, et.al, 2012**

**2.5 Demographic Impact:** The deprivation of proper utilities and the bad quality of life in rural areas have urged the viligers to move to cities seeking for better life. As rural-urban migration inclines, cities are overloaded and agricultural land declines, see fig(12). Inspite the fact that internal migration in Egypt has many reasons like searching for better jobs and better education, looking for better quality of life is a main contributer too.

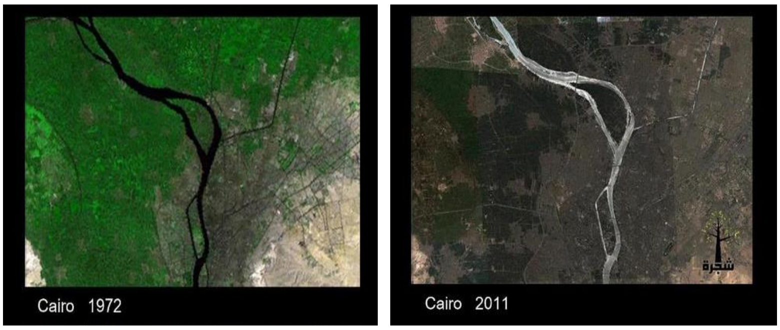


**Fig.12 : The decline of agricultural land around Cairo (1972-2011) due to expansion and rural-urban immigration** http://cairobserver.com

## 2.6 Land Use of wastewater plants:

Even if available, municipal sanitation requires land for building, installing and running the system. There is usually an inverse proportion between land requirements and construction cost of municipal wastewater treatment plants, because lower-cost technologies rely on exposure to sunlight for biological treatment, consequently this requires larger areas for treatment basins and more stay time in these basins. As technology used in Egypt is primitive, it requires vast areas to build and install wastewater plants, see fig(13). This may be suitable for coastal governorates and new settlements, but it may cause a problem in rural areas as vacant land is scarce and expensive (10).

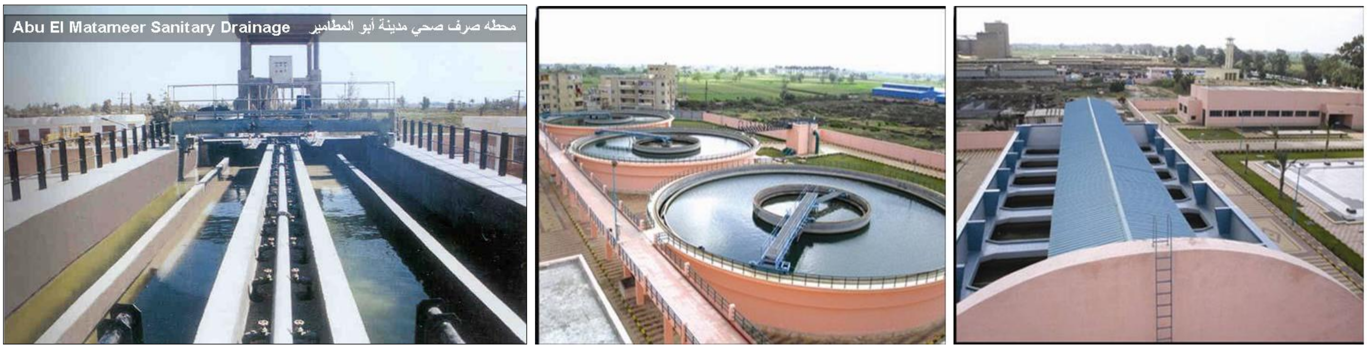


**Fig 13: Excessive land use by the treatment plants in Kom-Hamada and Abul-Matameer.**
www.ngcc-allam.com.eg

## 3. Wastewater treatment by Wetland system:

Wetland system is a well-known biotechnical system used in wastewater treatment around the world. In this system, wastewater runs through an aquatic environment consisting of aquatic plants. The plants' roots act as filters where the microbes thrive around the roots to do most of the work, breaking down nitrogen and phosphorous compounds, as well as toxic chemicals. The effluent water is usually clean and safe to be released into environment, see fig (14).

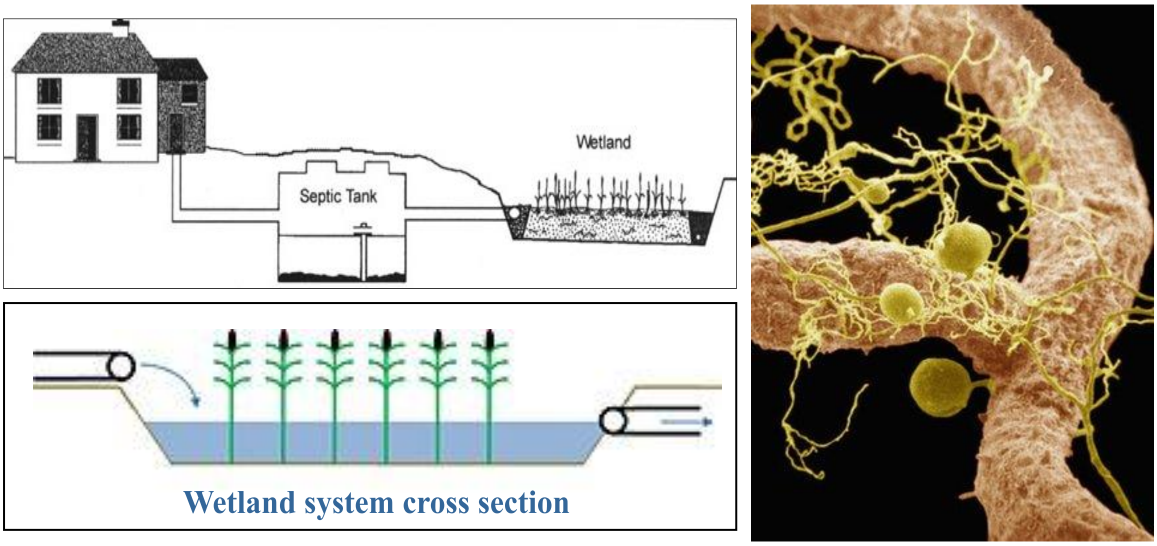


**Fig.14 Upper left: Diagram of Septic tank followed by wetland system-** J. S. Salvato: Environmental Engineering and Sanitation **– Lower Left: Typical wetland system cross section -**www.wikipedia.org**- Right: Microscopic image showing zinc oxide particles accumulated around plant's root-** Priester, J.H. et al. 2012

Although they don't break down heavy metals, the plants absorb them; they can then be harvested and incinerated or land-filled (11). Wetland systems are widely used as off-grid technology for domestic wastewater treatment in areas with no sanitation coverage around the world. Wastewater from the house is clarified through a regular septic tank and then passes through the wetland system as shown in fig(..).

## 3.1 Removal Efficiency:

According to EPA, wetland system has very good potentials in removing pollutants from wastewater. Average wetland system can remove about 86% of Cr and 67% of Ni. It reduces the Zn concentration to below 50 $\mu g L^{-1}$ in most systems. The out-coming water is anoxic in most samplings while 70% and 60% of the incoming nitrate and nitrite are removed. Large denitrification losses occur due to root filtration. Cr, Ni and Zn are retained by the macrophytes in the larger wetland and in sediment in the small-scale one. Fig (15) shows the decline of fecal coliform, BOD, and total suspended solids (TSS) in wastewater sample after 6 days of Wetland treatment, measured by EPA, 1999.

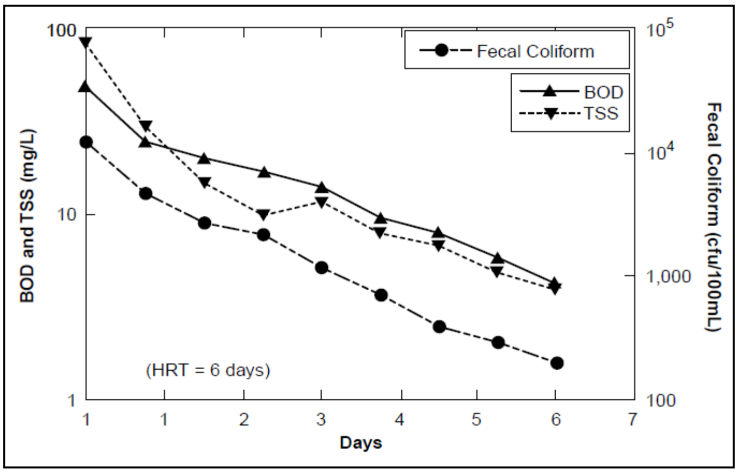


**Fig.15: Improvement of wastewater quality after 6 days of wetland treatment**-
EPA Manual of Constructed Wetlands 1999

### 3.2 Plants used:

Almost all aquatic plants suit the wetland system, but there are some species that perform even better in wastewater treatment, such as water hyacinths ورد النيل , bulrush, duckweed, water lilies اللوتس أو البشنين الأزرق and cattails البوط الدمياطي.

These species are abundant in Egypt and are considered as waste. In Burullus Lake, cattails are dominant and the fish-catchers usually burn it regularly to get rid of it, see fig(16). Water Hyacinth is also abundant in Egyptian waterways and is considered as a biological problem, as see in fig (16).

**Fig.16: Left : Water Hyacinth domination in agricultural waterways in Egypt, Middle and Right: Southern Cattail domination in Al-Burullus Lake, Kafr El-Sheikh, in a way that people burn it frequently -**www.youm7.com

### 3.3 Plants reuse:

Most users get rid of harvested plants by burial or incineration. Some use them as fodder, though many health concerns arise about animal health in this case. One of the best ways to use these plants is to reuse them as furniture. Some aquatic plants like hyacinths ورد النيل and reeds البوص have the potentials to be dried and used in making chairs and tables. In Indonesia, disabled men and women are hired to dry, process and weave stems of these plants as an economic investment, see fig(17)


**Fig. 17 : Disabled men & women processing dried water hyacinth stems for use as a material to make furniture in Sulawesi, Indonesia**

Wetland systems can be applied on big scale in open water courses. For example, if planted in agricultural drains in Egypt, these plants can improve the quality of water before it drains in the Mediterranean, solving a serious environmental problem.

## 3.4 Land Use:

Wetland system can have both maximal and minimal land requirements, depending on shapes and materials used. For example, perforated water pipes can be used as a wetland system. The main target of the system is to make wastewater come in contact with aquatic plants' roots as much and as long as possible. So, long paths are required which is achieved in vertical systems as seen in fig(18). Wastewater flows by gravity from the house or apartment to pass through wetland system. When it reaches the ground it become treated and safely disposed into soak pit or leach field.

**Fig.18: Left: Vertical hydroponic trays on rotating rail in a residential quarter in Canada-** http://eandt.theiet.org/magazine/2011/10/high-rise-hopes.cfm – **Middle : Horizontal wetland system-** www.solarcities.blogspot.com – **Right: Vertical wetland system suitable for apartments and small land areas -** www.pinterest.com

3.5 Affordability: Wetland technology is a comparatively cost effective method for wastewater treatment. The materials needed are inexpensive and can be locally provided. Plants of the system are abundant and easily obtained; in fact they are considered waste and given without price.

3.6 Using the system in massive scale: Wetland systems are also used in wastewater treatment plants. For example, big scale wetland system is constructed for massive flow in wastewater treatment plant in Anna Norström, Stockholm, see fig(19).


**Fig.19: Hydroponics used in central wastewater treatment plant in Sweden-Treatment of domestic wastewater using microbiological processes and hydroponics in Sweden-Anna Norström-Stockholm 2005**

## 3.7 Off-grid wastewater systems usage worldwide:

Using off-grid systems for treating domestic wastewater is not only common in poor areas but also in many developed countries. In the United States, the vast areas of domestic expansion made it very expensive to install central sanitation systems in all areas. EPA has approved many off-grid systems including wetland system as a proper wastewater treatment with minimal impact on the environment. Fig (20) shows the commonness of these onsite systems in the U.S. in year 2002 census.

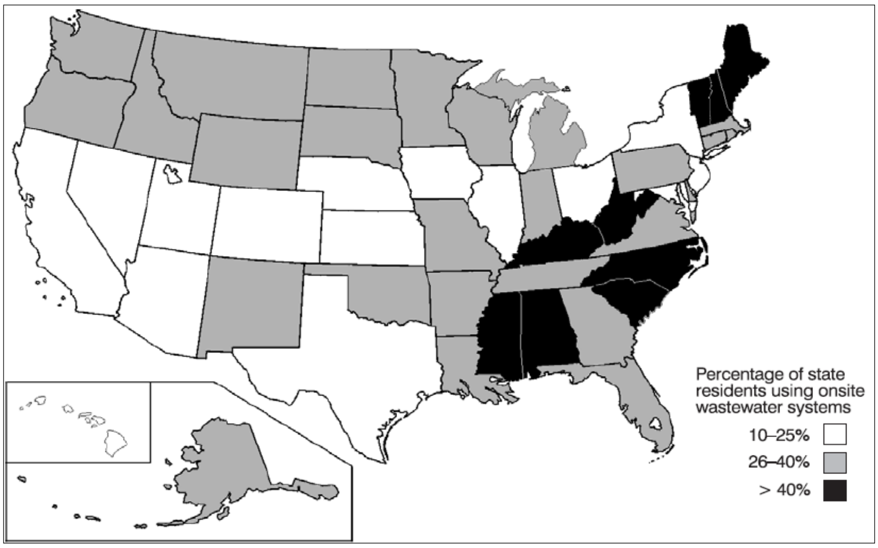


**Fig.20: Percentage of usage of onsite wastewater treatment in U.S.**
Onsite Wastewater Treatment Systems Manual , 2002

## 4. Conclusion:

Most rural Egyptians suffer the absence of proper sanitation. They use alternatives like cesspits and direct discharge into water canals. These acts cause serious pollution in groundwater and irrigation systems. Polluted groundwater is heavily used as a drinking source in absence of proper and clean water supply. All these factors led to the spread of diseases like renal failures and cancers. This bad life contributes in demographic changes because of rural-urban immigration. Using off-grid sanitation systems is widely common in many developed countries like the U.S. Wetland systems have the potentials of treating wastewater onsite with high removal efficiency and minimal cost. These systems may use small areas if installed vertically which can suit crowded areas with scarce land. Plants are available and can be reused as furniture for more economical benefits. Applying this technology can improve the quality of life for rural people and provide additional source of income.

### 4.1 General Findings and Outcomes:

- Rural areas suffer bad or absent sanitation which leads to major health problems.
- Bad utilities contribute in rural-urban immigration which leads to agriculture land diminish around big cities.
- Wetland systems are a good alternative for municipal sanitation and have an efficient performance in pathogen removal from wastewater.

- Wetland systems are economic, sustainable, easy to apply and needs minimal space for installation.
- Plants of wetland system are abundant in Egypt and can be reused as furniture raw material, offering job opportunities for rural people.
- Wetland is a good alternative for municipal sanitation in deprived rural areas.

## 4.2 Recommendations:

We recommend the applying of wetland technology in rural areas as a proper treatment system. Governmental entities can encourage this application by monetary incintives and technical assistance. This technology needs more development to minimize its space required and maximize the benefits and outcome. Researches and industrial pioneers are invited to resume the work to lessen the cost and make the system cheaper and easier to install to be commercially available in local market.

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