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Environmentally Friendly Wastewater Treatment in Egypt: Opportunities and Challenges

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***Abstract*- The uncontrolled and untreated discharge of significant amounts of wastewater into water bodies, including lakes, rivers, and streams, as a result of population growth, has resulted in a number of environmental and health problems. At the local and municipal levels, many processes are traditionally used for wastewater treatment. It is essential to comprehend all accessible methods and assess their effectiveness because of the growing demand for and development of newer technology. Reusing various agricultural, municipal, and industrial wastes is a workable solution to Egypt's water needs due to the country's limited water supply and gradually rising water demand. The Egyptian irrigation system is regarded as a closed system and a mixed system, with various water losses returning to the drainage system. This caused the drainage water to become more polluted, which makes its reuse a significant issue. In the present review, all the important methods involved in the treatment of wastewater and its monitoring have been comprehensively discussed and compared along with their advantages and disadvantages. Information will not only help in understanding the treatment of wastewater but it will also help in developing procedures for the reuse of treated water for various alternative purposes. Wetland is a strong candidate to address this issue. The technique was applied in Egypt on two different scales. While some subsidiary drains (in-stream wetlands) were utilized on a smaller scale, the northern lakes were utilized on a bigger scale. In-stream wetland development is a practical solution to Egypt's water quality problems. The technique does not require greater surface areas and uses an easy-to-understand technology.**

***Keywords*- Wastewater treatment technologies, Secondary treatment, Tertiary treatment, reclaimed water uses, water resources management.**

I. INTRODUCTION

Water pollution is a problem that is getting worse and impacts water quality, which makes it harder to get water that is genuinely usable [1]. Humans use water primarily to ensure their biological survival [2]. A significant volume of water is also needed for industrial and agricultural processes. Water is utilized in daily life for many other things besides drinking, including cooking, washing, flushing, bathing, and using toiletries, all of which enter the sewage collection system from both urban and rural regions [3]. Despite the fact that industrial wastewater is typically handled separately from sewage, this does happen on occasion [4]. Due to the presence of dangerous chemicals and pathogenic organisms, water treatment helps to (i) prevent the spread of water-borne illnesses, (ii) reduce environmental pollution, and (iii) reuse the treated water for a variety of uses [5-7]. Sewage is treated using a variety of techniques. The quantity and makeup of sewage have changed as a result of increased urbanization and industrialization, necessitating the standardization of diverse procedures and the creation of novel treatment techniques [8]. Trickling filters (TF) [8], activated sludge systems (AS) [9], waste stabilization ponds (WSP) [10], rotating biological contractors (RBC) [11], constructed wetlands (CW) [12-15], fluidized aerated bed reactor (FAB) [16], and aerobic lagoon (AL) [17] are wastewater treatment methods that have demonstrated their effectiveness. Egypt has a water scarcity, and as the population grows quickly, the difference between the amount of water available and the amount needed for consumption widens [18]. Since the ability to expand actual water resources from the river Nile has become very constrained, relying on the reuse of agricultural drainage water and municipal wastewater is the most practical way to fill this gap [3,6]. The vast bulk of the farmed area is irrigated using gravity, which is typically linked with low water efficiency. All agricultural water losses enter the system again, where they are combined with sewage and industrial wastes that also do the same. Water contamination has become a major issue due to the rise in municipal and industrial waste and the requirement to reuse such losses [19-20]. Egypt’s capacity to collect and handle all municipal garbage is affected by the country's limited economic resources [21,22]. About 40% of rural regions lack sewage services at this time. Sewage wells located beneath the homes are where they collect their sewage, which leaks into the nearby shallow aquifer [23,24]. Farmers use portable tanks to deposit trash into the irrigation or drainage system once these tanks are full. Sewage effluent from numerous treatment facilities in the cities surpassed their capacity, and some of this effluent is discharged directly into various watercourses [25]. In many locations, industrial waste is also discarded after basic treatment, and it would be difficult economically to enhance all of this garbage. With the rapid growth in population and the quick change in living standards, it is crucial to study several options in order to produce a solution that is technically and economically feasible and could be implemented quickly. The present review has covered the features of wastewater, its treatment technologies, evaluation, and permissible standards. Egypt’s water resources and wastewater treatment challenges and solutions are discussed. In that aspect, the wetlands method is a promising one. Such a method is one of the potential remedies for the poor water quality issue due to its reasonable cost, which is around one-tenth of that of conventional treatment facilities, and the successful outcomes that have been obtained in several studies. The task now is to look at the possibility of spreading the idea and include non-governmental organizations in creating and maintaining these sites. The technique has already been tested in limited areas.

II. TYPICAL WASTEWATER TREATMENT TECHNIQUES

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In the secondary treatment process, dissolved organic debris in the sewage is broken down by aerobic and anaerobic bacteria [21]. The degradation is carried out by these bacteria, who also produce carbon dioxide and other byproducts. Secondary treatment techniques can be divided into old and current categories according to technology. A combination of physical, chemical, and/or biological procedures is used in the majority of sewage treatment facilities to remove colloids, organic matter, nutrients, and soluble pollutants [22]. The various conventional techniques include:

1. Trickling filters (TF).
2. Activated sludge systems (AS).
3. Waste stabilization ponds (WSP).
4. Rotating biological contractors (RBC).
5. Constructed wetlands (CW).
6. Fluidized aerated bed reactor (FAB).
7. Aerobic lagoon (AL).

A. *Trickling filters (TF)*

A biological filter that works under aerobic conditions and has a fixed bed is known as a trickling filter. The filter is "trickled" and sprayed with pre-settled wastewater. Organics are broken down by the biomass that covers the filter material as water passes through its pores [8]. Rocks, gravel, shredded bottles, prefabricated filter material, or other materials with a high specific surface area are used to fill trickling filters (Figure 1). The surface of the filter is "trickled" with the pretreated wastewater. The organic load in the wastewater is converted to carbon dioxide and water while new biomass is produced by organisms that develop in a thin bio-film on the surface of the media [26,27].

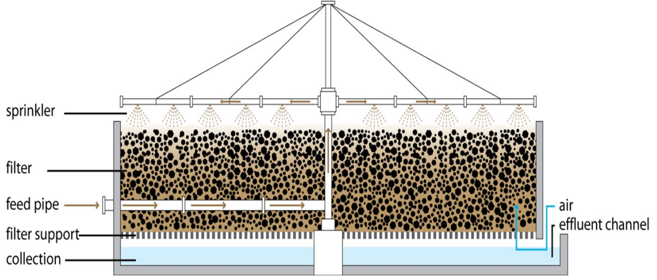

Figure 1. Trickling filter schematically.

B. *Activated sludge system (AS)*

A multi-chamber reactor called activated sludge uses aerobic microorganisms to break down the organics in wastewater and create high-quality effluent [21]. To maintain aerobic conditions and keep active biomass suspended, an adequate and timely supply of oxygen is necessary. As a result of the microorganisms oxidizing the organic carbon in the wastewater, new cells, carbon dioxide, and water are produced. Although facultative anaerobes are also engaged in the process, aerobic bacteria are the most frequent. The bacteria gather into little groups called flocs during aeration and mixing. The mixture is moved to a secondary clarifier once the aeration process is finished so that the flocs can settle and the effluent can either be discharged or sent for additional treatment. The cycle then restarts when some of the sludge is recycled back into the aeration tank [23] (Figure 2). A number of biological and physical factors, such as organic and hydraulic loading on the aeration tank, dissolved oxygen in the aeration tank, biosolids wasting rate, return activated sludge rate, clarifier loading, solids settling and compaction characteristics, etc., affect how effectively an activated sludge plant operates.

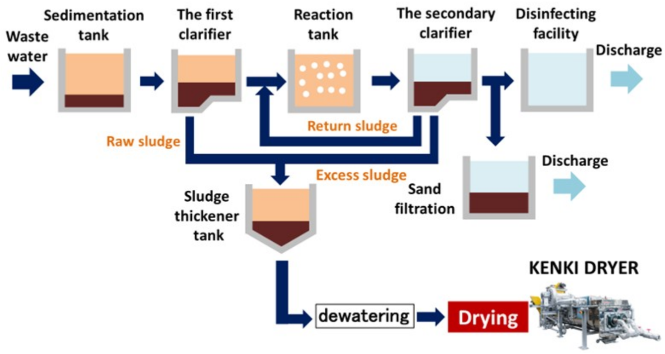

Figure 2. Conventional activated sludge process

C. *Wastewater stabilization ponds (WSPs)*

Due to the high running costs and large energy consumption of wastewater treatment plants, only 38% of the urban and industrial wastewater produced in poor nations receives any form of treatment [10, 28]. Waste stabilization ponds (WSPs) are man-made earthen basins that are used to treat wastewater using a single agent or a combination of physicochemical and biological agents with the goal of reducing various contents like nutrients, micro- and micropollutants, and also removing pathogens from wastewater. Despite being utilized all over the world, WSPs are particularly well suited for poor nations with warm temperatures due to their affordability, high efficiency, complete naturalness, and high sustainability. The ponds can be utilized singly or linked together to form a succession of anaerobic, facultative, and maturation ponds, depending on the final effluent quality that is required. The effluent's intended use determines this in turn. Whether it will be utilized for groundwater or surface water outflow, restricted or uncontrolled irrigation, or aquaculture.

D. *Rotating biological contractors (RBC)*

It is efficient to treat challenging wastewater, including coke wastewater, employing biological wastewater treatment using biofilm systems. Regarding the effectiveness of treatment and the biochemical potential to remove different contaminants, knowledge of the structure and dynamics of the microbial population in the biofilm that is in charge of treating wastewater is important. However, physicochemical variables might have a major impact on the biofilm population, impairing performance. A number of rotating discs make up the RBC. A biological slime similar to the slime on the rocks in a healthy stream is applied to these discs. This slime is circulated through the wastewater and subsequently, the air to absorb oxygen from the air and degrade B.O.D. in the wastewater (Figure 3). RBC has a solid media on which static biofilms of bacteria can develop [29]. Bacterial growth on RBC and wastewater biomass are combined in the treatment to oxidize nutrients by using

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airborne oxygen. Ammonia, phosphorus, and other nutrients can be fully removed by it [11].

Figure 3. Rotating biological contractors.

E. *Constructed Wetlands (CW)*

Leachate from homes, businesses, and landfills is frequently treated using constructed wetlands because sophisticated wastewater treatment is not practical from an economic standpoint. Activated sludge can be replaced with this practical option [7,12]. Utilizing wetlands, plants, and microbes, it uses natural processes. Since no chemicals, power, or great treatment efficacy are needed, it is cost-effective. The thing is, its anaerobic reactions predominate, which slows down the healing process [13,15]. The wetland system is a complex interconnected process that involves (i) chemical reactions like oxidation, reduction, and hydrolysis, (ii) physical actions like sedimentation, flocculation, volatilization, and adsorption, (iii) biological activities like assimilation and uptake (iv) biochemical reactions like transformation and degradation, and (v) ecological processes like substance and energy exchange among bio-species, as well as between the system and the surrounding environment [30]. According to the direction of the water flow and the type of vegetation, there are two types of constructed wetlands: (i) free surface flow wetland, which contains emergent plants, submerged plants, free-floating plants, and floating plants (Figure 4A); and (ii) sub-surface flow, which includes constructed wetlands with the vertical flow (tidal flow, up flow, and downflow) (Figure 4B), horizontal flow (Figure 4C), and hybrid constructed wetlands (vertical and horizontal-flow). Since their inception in 1970, the technology knowledge related to the design and maintenance of artificial wetlands has undergone significant changes [31].

F. *Aerobic Lagoon (AL)*

Turbulence and other variables can occasionally prevent normal algae from growing in the WSP, which affects oxidation and the effluent's quality. To get around this, people employ aerobic lagoons, where the sewage is aerated by a mechanical or subtle aerator to stabilize the oxygen inside the sewage, avoid the settling of the suspended biomass, and make the process quicker. The facultative

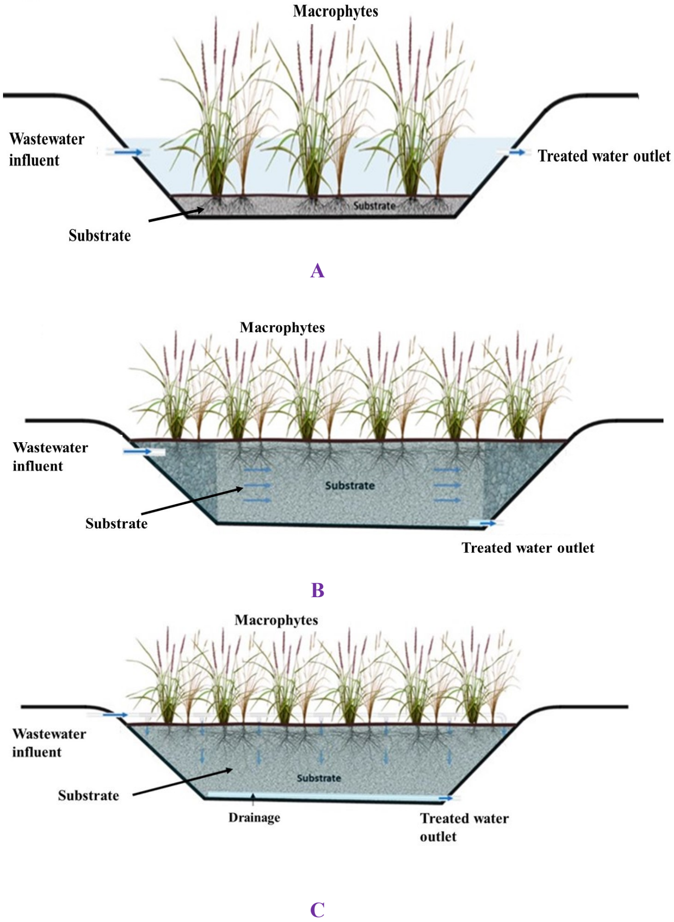

Figure 4. Constructed wetlands types A: free water surface, B: horizontal flow subsurface, and the vertical subsurface flow.

G. *Fluidized aerated bed reactor (FAB)*

An advanced hybrid biological system is the fluidized aerated bed reactor. This involves moving wastewater through a bed of particles quickly enough to fluidize the particles. The particles form a biofilm around the surface by adhering to the fluidized media. It promotes wastewater recirculation (Figure 5) [32].

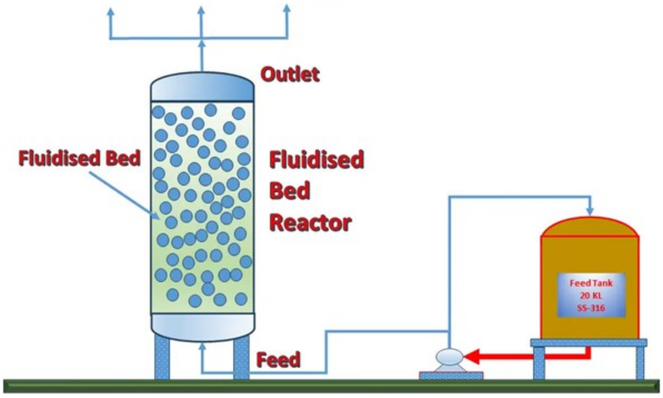

Figure 5. Fluidized bed reactor- working

III. EGYPT WATER RESOURCES

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Egypt is experiencing a water shortage; its only source of freshwater is the Nile River, which provides 55.5 km^3 of surface water annually [33]. The Mediterranean Sea costal regions provides 1.6 km^3 of annual effective rainfall in Egypt's northern region. Additionally, 6.4 km^3 of shallow groundwater and 2.4 km^3 of deep groundwater are produced annually in the western desert, respectively. In 2018, there will be a total water supply of 66 km^3 and a total water demand of 79.5 km^3 [6]. Egypt currently has 105 million people living there [34]. The 13.5 km^3 of water needed annually to meet Egyptian water demands should come from non-confidential water sources including indirect recovered water reuse and good-quality drainage water in drainage networks. About 80% of all freshwater demands are met by the agriculture sector, and the amount of drainage water used for agriculture is 11.7 km^3/year [6]. Currently, the purifying facilities produce 10 km^3/year of drinkable water year [29]. For the new reclamation lands projects, which cover 315000 hectares, a total water scarcity of 26 km^3/year is anticipated in 2037 [35]. Therefore, non-confidential water resources, like indirect reclaimed water reuse and high-quality agriculture drainage water reuse, are the future's most important remedies to water scarcity. The disposal of recovered water to groundwater and watercourses by MWRI is governed by Egypt Law 48 [36]. If the effluents meet specific criteria and other requirements, sanitary sewage treatment facilities, industrial workshops, and riverboats are granted licenses to discharge reclaimed water into fresh watercourses. Unauthorized discharges that exceed license limits are prohibited by fines, detention time, or both. In accordance with further legal requirements, permits may be revoked if pollution-causing discharges are not reduced within three months. A number of initiatives are included in the national water plan [35], including the 10^6 m^3/day El Mahsama plant project in Ismailia to treat, recycle, and reuse agricultural wastewater, which has won numerous international prizes. This project was finished in a record-breaking 10 months, and the water produced by the station will help 70,000 feddan be grown as well as the 6.5 million m^3/day Bahr El Baqar agricultural wastewater treatment plant to reclaim 200,000 feddan at the North of Sinai. In order to carry out the government's objective to develop the Sinai region and build sustainable urban neighborhoods, it is used to irrigate about 600,000 feddan. Future work will be done on The New Delta. Along the brand-new Rod El Farg-Dabaa Axis Road is where the project is situated. With a daily capacity of 7.5 million m^3/day, the New Delta Treatment Plant is a sizable wastewater treatment facility now under construction (https://www.arabcont.com/english/project-624).

IV. EGYPT'S WASTEWATER TREATMENT CHALLENGES AND SOLUTIONS

A. *Irrigation and drainage network characteristics*

The majority of Egyptians reside in the Nile Valley and Delta, which make up around 3.5% of Egypt's total land area (or about 35,000 km^2). Thousands of smaller organizations (called ezba) and more than 4,600 communities are dispersed throughout this region. The majority of Egyptian cities are also located here. The landscape appears to be one large plot of arable land connected by thousands of nested irrigation canals at various levels. This region is covered by a system of extremely dense irrigation and drainage canals totaling more than 50,000 km. The majority of rural communities lack sewage services, so the sewage in this rural area is gathered and discharged in drainage and irrigation systems. Figure 6. Shows the drainage system in the Delta and Figure 7 shows the reuse of drainage water in Egypt's Delta.

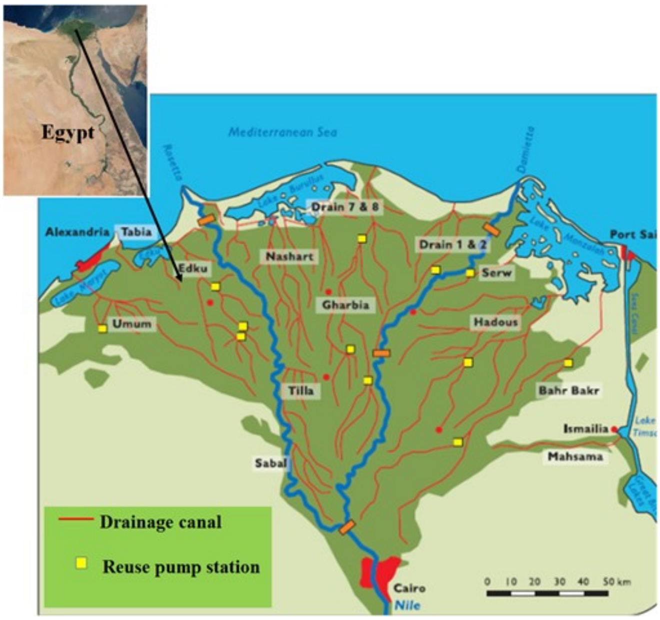

Figure 6. Drainage system in Delta

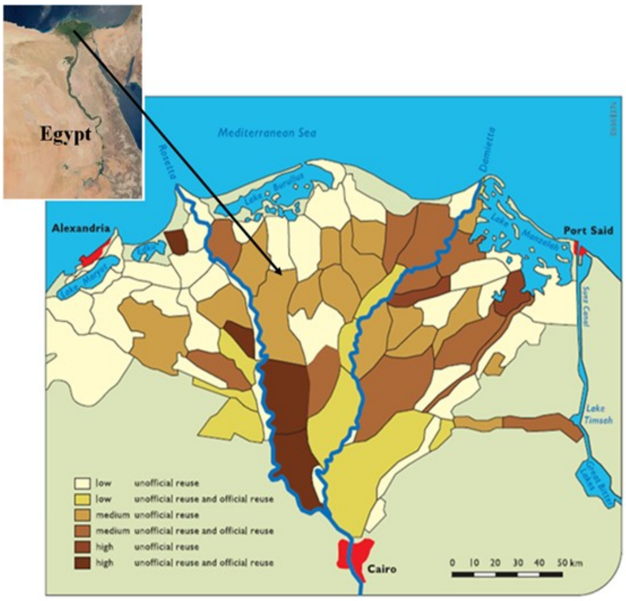

Figure 7. Reuse drainage water in Egypt's Delta.

B. *Solutions for Egypt's water quality issues*

(I) Mega wastewater treatment projects in Egypt

(1) Bahr El Baqar Water Treatment Plant

The largest water treatment facility in the world is this one. Sinai's Port Said tunnels are 10 km to the south of this location. Approximately 155 feddans make up the plant's construction. The Sinai Peninsula is being developed in order to take advantage of its natural riches, and this project is regarded as one of the most significant ones. The project will assist in the reclamation of 400,000 feddans by recycling and utilizing wastewater from industrial,

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commercial, and municipal sources that will be transferred from the western to the eastern bank beneath the Suez Canal. It started to work in 2021 and the construction cost is 739 million USD (https://www.arabcont.com/english/project-624). Everything that has been treated will be released into Sheikh Jaber's Canal. Three drains, the biggest of which is the 106 km long Bahr El Baqar Drain that empties into Manzala Lake, collect sewage and agricultural effluent. 5.6 million m^3 (2 km^3/year) of irrigation water is thought to be the plant's daily capacity at Bahr El-Baqar Wastewater Treatment. It is made up of 4 identical units for the physical and chemical tertiary treatment phases, as well as 2 units for the treatment of sludge.

a) The water treatment line consists of two intake canals and an outlet canal, a building for water intake pumping, rapid/slow mixing basins, sedimentation basins, filters with discs, ozone basins, and chloride tanks (Figure 8).

b) The sludge treatment line, which consists of sludge thickening basins, mechanical drying structures, and solar sludge drying units, has a capacity of 490,000 tons per year at a drying level of 24%, which is reduced to 165,000 tons per year at a drying level of 75%.

c) Administrative and service buildings, including those for management, intelligent control, communication, and power, as well as internal road networks and landscaping projects.

(d) Water treatment line (physical and chemical treatment phase).

Phase 1- Pre-Treatment Phase:

Intake building, that consists of the refineries and intake pumps, where the coarse and fine refineries operate on removing all small and large planktons, where water will flow to the following phase of treatment;

Phase 2: Water Treatment:

Water is treated for first sedimentation by adding substances that will help balance pH levels and aid in the development of flocculants and sedimentation in the bottom of sedimentation basins. The process then went into the 11,600 m^2 lamella sedimentation tanks, which use pipes and sedimentation tanks for a more effective process. The project also uses 120 triple disc filters, each of which has a planned capacity of 1,992 m^3/h. To achieve the highest quality and standards of filtered irrigation water, 32,800 m2 of fine polyester membrane with a filter size of 10 microns is used as the filtering surface.

Phase 3—Post Treatment Phase:

It includes the chlorine or ozone injection method for water sterilization. Following that, created water is discharged into Sheikh Jaber Canal.

Sludge treatment facility (process)

Sludge collection in the initial phase

From sedimentation tanks to sludge thickening tanks, the sedimentary solids are moved.

Second phase: thickening of the sludge

The sludge proceeds to thickening and stabilization to become a thicker sludge, and then to mechanical drying and dewatering to achieve a greater dry rate of up to 24%.

Stage 3: Solar Drying

The dry sludge, which has a drying level of 24%, is transported by belt conveyors to solar drying units to be distributed and stirred continuously to produce a final product (sludge), which has a drying level of 75% and is used for construction materials like cement bricks and backfill, among other things, or for agricultural purposes like land reclamation.

Figure 8. A and B: Bahr El Baqar Water Treatment Plant

(2) New Delta Treatment Plant

With a daily capacity of 7.5 million m^3/day, the New Delta Treatment Plant is a sizable wastewater treatment facility now under construction (https://www.arabcont.com/english/project-624). Flexibility and dependability in operation define the station. Given that drip or sprinkler irrigation is used to rationalize the use of water in agriculture, the station will be at the beginning of the lands intended for cultivation, where the water produced by gravity—not pumping stations—will flow through a lined canal to ensure no seepage until the end of the agricultural land. The New Delta Treatment Plant seeks to cultivate a region characterized by high-quality arable land and the consequent production of food on a strategic scale while simultaneously removing pollutants from Alexandria's Mediterranean Sea coast and Marriout Lake. By rerouting wastewater and floods that contribute to the sinking of lands in Behira Governorate to the New Delta area, the New Delta Treatment Plant also effectively mitigates climate change in

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the existing Delta area, drains, and pumping stations. As the New Delta Project helps to absorb this extra water, irrigation water from the High Dam may be lowered during wet and flood seasons. The New Delta Treatment Plant is included in both the National Water Plan "2017-2037" and the State's strategy for water resources until 2050 since it is a key component of the creation of a New Delta and will enable truly sustainable development that will benefit the local population.

(3) Mahsama Water Treatment Plant

The largest facility of its kind in the world, Mahsama Water Treatment Plant, was built to address the lack of irrigation water in this region by supplying irrigation water to agricultural lands in the Sinai Peninsula east of the Suez Canal. It will irrigate about 50,000 hectares of land in North and Central Sinai. For the development of a 1,000,000 m^3/day agricultural wastewater treatment facility as shown in Figure 9 (https://www.hassanallam.com/projects/mahsama-water-treatment-plant).

Figure 9. Mahsama Water Treatment Plant

(II) Constructed wetlands

Constructed wetlands (CWs) are made up of shallow lagoons or channels (depths of less than 1 m) that are planted with local species that are typical of humid areas. The water, solid substrates, microorganisms, vegetation, and even fauna interact with each other to decontaminate the area [37]. Construction-related wetlands can be divided into surface and subsurface flows based on the characteristics of the water circulation [14]. Compared to surface flow wetlands, their underground correspondents allow for higher organic loads, lower contact risks with the populace, and no insect emergence [38]. Depending on the design employed, the wastewater travels either vertically or horizontally in the underground flow's wetlands, where a gravel bed acts as the substrate for plant development. The plants in such wetlands provide the perfect environment for decomposing the organic waste in sewage because of their roots, stems, and leaves. The method works well in small and medium-sized villages. El-Torkemany [38] listed this method's benefits as having inexpensive construction and maintenance costs and effective removal ratios. Additionally, after harvesting, the wetland's flora might be used to feed cattle. The main drawback of this method is that it takes up much more room than conventional treatment plants. The method was employed in two different ways in Egypt. The first type was used at the furthest end of the drainage network. The wetlands were constructed in Lake El-Manzala, which gets highly contaminated water from certain main drains, on Egypt's northern side. The other form (in-stream wetlands) was utilized in tiny drains at the beginning of the drainage network. The outcomes in both types were quite encouraging. A portion of the cleaned water was diverted into basins created for fish farming and used for irrigation and agricultural purposes. A total of 25,000 m^3/day was delivered to the marsh. The system has a much higher level of treatment while only costing 10% as much as conventional, chemical-heavy wastewater treatment systems.

In-stream wetlands

In-stream wetlands in two small drains—the Faraa Al-Bahow drain in the East Delta and the Edina drain in the West Delta—were studied by Rashed and Adbel Rasheed [39]. The first experiment is described in depth as an illustration of how to use an in-stream wetland to achieve high treatment efficacy. The Faraa Al-Bahow drain, according to [39], is a modest drain with a length of 1,710 m and a served area of 533 hectares. A tiny rural village of 3,000 people located inside the served area is supplied with potable drinking water. A small pipe network collects raw sewage effluent and dumps it untreated into the Faraa Al Bahow drain inlet. The Faraa Al-Bahow drain discharges its water into the 2,100 hectare-serving Al-Bahow drain. Farmers are compelled to rely on drainage water because the area has summertime water shortages. Therefore, the farmers are negatively impacted by the Al-Bahow drain's poor quality. The in-stream wetlands in the Faraa Al-Bahow drain include: a sedimentation pond (100×2×1 m); a wooden gated weir and a steel plants screen that govern a series of floating (150×3×0.5 m); emergent aquatic plants (150×3×0.5 m); and a control weir at the drain outlet, the purpose of which is to control drain water depth and treatment detention time according to pollutant loads. As described by the author, the system is made up of five different processes: sedimentation, filtration, biodegradation, plant uptake of nutrients, and pathogen eradication. Water disinfection and oxygen content are improved by sunlight penetration. Common reeds (Phragmites Australis) and floating water hyacinths make up the vegetative system. The findings reported [39] showed how various in-stream wetland components may remove various types of pollution. The sedimentation pond was where TSS was primarily eliminated, falling from 915 to 114 mg/L. TSS was 20 mg/L when it reached the drain outlet. Before wetland cells, BOD dropped from 550 to 32 mg/L, then rose to 7 mg/L at the drain outlet. Along the drain path, pathogens (TC and FC) received flawless treatment. From 4×10^7 TCU/100 ml at the intake to 2×10^6 TCU/100 ml after 800 m, 7×10^4 TCU/100 ml through in-stream cells, and finally 5×10^3 at the drain outlet, the total coliform was reduced. Similar effects are seen with fecal coliform and total coliform. These results are quite encouraging, with treatment efficiencies for TSS, BOD, TC, and FC of 97.8%, 98.7%, 99.9%, and 99.9%, respectively.

V DISCUSSIONS

The official method now being used in Egypt to address the pollution issue is the direct approach, which relies on the collection of sewage and the construction of new treatment facilities. On a modest scale, pilot projects or research activities were used to evaluate other strategies. Here, we present a few of these concepts. One of these options was to build artificial wood using dirty water. There are two issues with this strategy. The first difficulty is the features of Egypt's irrigation and drainage networks as previously described. The second challenge is the potential transition to feeding crops. Low cultural levels and a sizable difference in crop yield from different agricultural techniques may cause such a change. A crystal-clear example of how to use contaminated water for cultivating common crops was found in the El-Saf canal. The canal also accepts wastewater that has undergone bilateral processing from a few treatment plants in addition to industrial effluent. Vegetables and plants that would thrive in the canal's water quality were planned to be planted there. Instead of planting forests of trees, more than 20,000 acres are currently farmed with conventional crops and vegetables utilizing the surface irrigation technique. This will probably lead to significant health problems. Instead of mixing it with unclean water in the main drains, the second alternative entailed recycling agricultural drainage water from farm drains and collectors. The idea was explored by the Ministry of Water Resources and Irrigation, but it has not yet been implemented. If farm drainage water is utilized proportionately before being discharged in the main drain will become more contaminated and hazardous to use. The third strategy, wetlands, was successfully applied in several regions of Egypt [41]. The strategy is quite promising, and more will be spoken about it. A wastewater treatment system by Gabr et al. [15] that consists of a sedimentation tank, a horizontal subsurface flow constructed wetland (HSSF-CW), a vertical subsurface flow constructed wetland (VF-CW), and a storage tank was suggested, designed, and estimated in terms of cost. The treatment system can be used as a cheap construction, maintenance, and operational solution for wastewater treatment in small populations in developing countries with dry and semi-arid climates. Additionally, Gabr [13] proposed a wetland system within a branch drain network was proposed and designed, consisting of a sedimentation pond followed by four vegetated bed cells of reed (Phragmites australis), and an open water disinfection zone, to treat degraded agricultural wastewater due to non-point pollution source in cultivated area (Tina Plain), Egypt. The wetland was designed using the relaxed tank in the series concept.

VI CONCLUSIONS AND RECOMMENDATIONS

Egypt has a serious pollution problem. The reuse of water losses has emerged as a workable approach to meet water demand due to the scarcity of freshwater resources. These losses include a variety of municipal, industrial, and agricultural waste. These losses are extremely polluted since the treatment level is so low. The savings from using these potential losses are the major issue. All municipal and industrial garbage must be collected and treated, which would involve significant financial investments that Egypt's economy cannot now support. Finding a solution that is both technically and financially realistic is crucial. Wetland is an excellent contender to deal with this issue. In Egypt, the method was used on two different scales. The northern lakes were used on a larger scale, while some subsidiary drains (in-stream wetlands) were used on a smaller scale. An effective method for addressing Egypt's issues with water quality is in-stream wetland development. The method uses a straightforward technology and does not need for larger surface areas. With the aid of any local non-governmental groups, isolated communities could take the initiative and work concurrently in several locations with the help of a proper capacity-building and dissemination strategy. The quality of the water could significantly improve as a result. Investigating the feasibility of involving non-governmental organizations in the creation and management of such locations is therefore of utmost importance. This needs to be based on a thorough comprehension of their circumstances and how to develop their capacities. These organizations should be led by water user associations, and one of their responsibilities in maintaining various irrigation and drainage properties should be operating such sites.

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