Wastewater Management Overview in the Occupied Palestinian Territory

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Abstract The Palestinian wastewater treatment sector in Palestine is manifested by inadequate management due to insufficient infrastructure, unsafe disposal of untreated or partially treated effluent and unplanned use of low water quality. The current wastewater treatment plants, established during 1970–1980 under the Israeli occupation, are overloaded and badly maintained with aging equipment, thus posing serious environmental and public health hazards. The challenges behind this unsustainable wastewater sector are exacerbated by the lack of institutional coordination reflected by multiple stakeholder involvement leading to institutional fragmentation and lack of coordination. By law, the Palestinian Water Authority (PWA) is responsible for all regulatory, planning, monitoring, research, and training functions. Despite the current valid Palestinian effluent quality standards, urgent efforts pertaining to effluent monitoring and regulations enforcement are needed. To promote feasible wastewater treatment facilities (WWTFs) crucial strategic regulatory and planning policies were stipulated. Wastewater should be collected, treated, and reused where feasible and the design of WWTFs should be

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modular and community-based with effluent use options. The institutional capacity for implementing and enforcement of water-related rules and regulations should be enhanced. WWTFs including reuse schemes form a key element of an integrated water management strategy with coordinated institutional cooperation. The PWA is committed to sanitation services enhancement in the Palestinian communities to protect public health and the aquatic environment, where the reclaimed effluent must be used for various applications. Effluent reuse practices protect not only the limited water resources, but also enrich the quality and quantity of groundwater and the receiving water bodies; groundwater and surface water.

Keywords Effluent reuse, Palestine, Sanitation, Wastewater, Wastewater treatment

Contents

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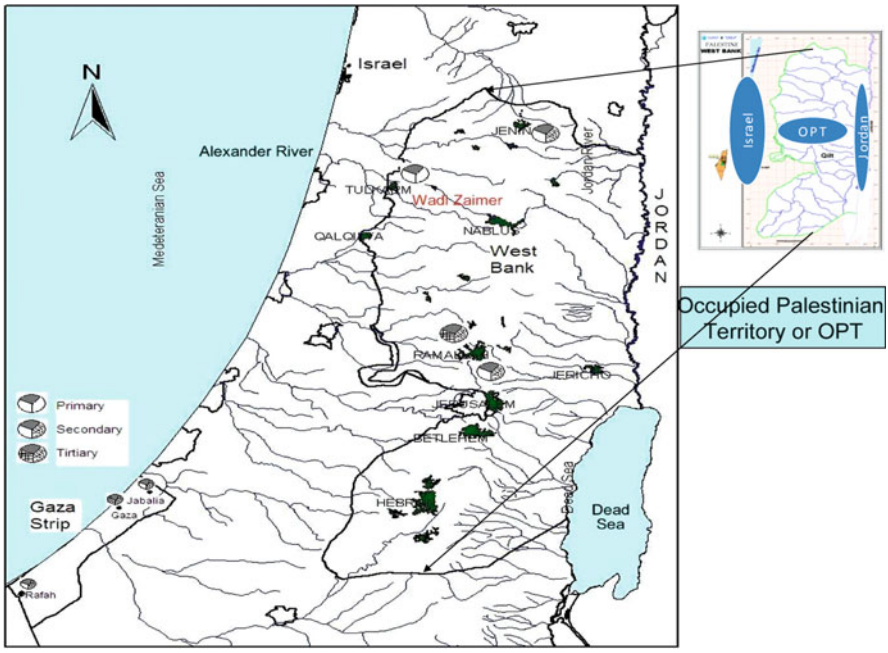
1 Introduction

Palestine (the West Bank and Gaza Strip) is one of the most water-poor countries of the Middle East due to natural and artificial constraints. At present, water needs exceed the available water supply; the gap between water supply and water needs is growing and is calling for the adoption of the integrated water resources management approach and the mobilization of any additional conventional and non-conventional water resources. Treated wastewater is seen as one of the promising solutions that can assist in partially filling the gap of the growing needs for water. The wastewater sector in the West Bank and Gaza (WBG) is characterized by poor sanitation, insufficient treatment of wastewater, unsafe disposal of untreated or partially treated water and the use of untreated wastewater to irrigate edible crops. Currently, only a few treatment plants (Fig. 1) are serving urban centers in the WBG, where most of them were built in the 1970s or 1980s under the Israeli occupation. The majority of the treatment plants are currently overloaded, badly maintained, poorly equipped, and thus represent a serious environmental and public health hazard in urban or rural areas. The reuse of treated wastewater is practiced on a small scale and this option has been generally absent from wastewater treatment plants (WWTPs) after treated or partially treated wastewater [1].

Ramallah wastewater treatment plant (Left) and its effluents (Right) and then to Wadi

Al-Bireh wastewater treatment plant and its effluent (left), and Tulkarem wastewater lagoon (right).

Fig. 1 Wastewater treatment plants in the OPT



Map 1 Location of Palestinian WWTPs and receiving surface water bodies

At present, the Occupied Palestinian Territory (OPT) has eight large urban WWTPs including almost 300 onsite treatment plants (Map 1). These wastewater treatment facilities (WWTFs) serve mainly urban communities covering an approximately 1.5 million population equivalent (PE), where the current total population of the OPT is slightly more than three million. The technology type applied for treatment processes is conventional using the activated sludge system with its process modifications. Most of the existing WWTPs do not function very well, with effluent quality exceeding the prescribed national effluent standards. This is due to overloading, but it can often be the result of the various factors associated with improper physical design, faulty construction and insufficient system maintenance [2, 3].

A recent study made by Al-Sa'ed [4] revealed that about 20% of the total population that are served by central sewer networks reside in urban communities and the wastewater is discharged into seasonal Wadis (Fig. 2). Among these major Wadis in the West Bank are Wadi Mugata (Jenin district), Wadi Zaimer (Nablus-Tulkarm districts), Wadi Zhor (Qalqilia district), Wadi An-Nar (Hebron district), Wadi Mahbas (Ramallah district), and Wadi Al-Qilt (Jerusalem and Jericho districts). About 33% of the annual collected urban wastewater (73.7 mcm/year) from Palestinian communities is being treated in Israeli WWTPs (Table 1). The treated effluent from this Palestinian wastewater is then even further reclaimed for various applications within Israel (not for the benefit of the OPT), mainly for unrestricted

Al-Bireh wastewater treatment effluent (left) and Qalandiah wastewater not treated discharged and all run towered Al-Qilt.

Nablus wastewater discharged West to Wadi Alzumer (left) and East to Wadi Al-Fara' (right).

Fig. 2 Wastewater effluent discharged treated or not treated to Wadis

Table 1 Population served by WWTFs and effluent reuse [4]

Total PE WB & GS (PE)	3,761,646		Annual WW collected	73.70 mcm
Urban PE served (PE)	1,513,214	40%	Annual treated WW	59.5 mcm
Daily sewage collected (m^3)	175,580		Potential WW reuse	81%
Daily WW treated (m^3)	141,748	81%	20 mcm/year are used in Israel	

agricultural irrigation and water for nature purposes, for example, river rehabilitation and landscape recreation [4].

In the OPT areas, most of the existing WWTPs are not functioning well, e.g., the three malfunctioning WWTPs in Jenin, Tulkarem and Ramallah and the non-operating one for Hebron. This is without mentioning the WWTP in the Gaza Strip that is facing the same problems, but more acute, since it has a direct impact on the water resources stored in the fragile geological structure mainly composed of sandstone formations that characterize the area [5]. The wastewater effluent is flowing into small wadis in the OPT (Map 1) and Fig. 2, with the worst situations found in Jabalia, Gaza, and Rafah since their problems are not only the fact that the WWTPs are not functioning well, but the discharge of the effluents and its usage [6].

The conditions of the sewage systems vary, depending on the age and material of the pipes. Approximately 60% of the houses in the urban communities are connected to sewage systems. The connection rate in the major cities varies between 50% in Qalqiliya to 85% in Bethlehem. On the other hand, the wastewater collection system in both Nablus and Hebron are combined systems that collect both wastewater and storm water. Moreover, the situation in the refugee camps can only be classified as very poor as wastewater is channeled into open drains until it flows into either a sewage network in a nearby city or is simply transported to outside the camp boundaries. In most cities, rainwater is allowed to run off on the surface until it eventually reaches the Wadis. Also most of the Israeli settlements in the West Bank have sewage networks and discharge the wastewater into the nearest Wadis on Palestinian lands without any type of treatment or at times partially treated. The purpose of this paper is to assess the wastewater management in the West Bank with special emphasis on wastewater treatment and effluent reuse. Various options for wastewater treatment and reuse have been proposed and investigated in several previous studies. However, few studies have examined the overall picture of wastewater treatment and reuse in the OPT.

This paper will present the wastewater status in the OPT in order to achieve the following objectives:

1. To review the current status of wastewater management in Palestinian communities and the constraining factors behind enhancing the progress of establishing sustainable WWTFs.
2. To present the past Israeli water policies that affect sustainable wastewater management in Palestine and discuss the needs for proper integration for the system to be sustainable.

2 Sanitation Features

The main feature of sanitation in the West Bank is that there are very few sewage collection systems in the rural and suburban areas and therefore very few centralized treatment plants where the effluent is treated. Furthermore, where no collective sewage network is available, each house collects all its sewage in a cesspit with a capacity of 15–25 CM, where they can store the sewage of 1 month. The average water use per inhabitant is between 50 and 80 l per day. A household is made of an average of eight to ten people and these sewage tanks are built close to the house by digging a hole in the ground. They can have concrete walls (septic tanks), or just be earth pools (cesspit) to allow wastewater to infiltrate in the ground. In most cases, cesspits become like septic tanks after a few years. Emptying these pits is done by private tank trucks with a capacity of 5 CM. The evacuation of one sewage tank is a rather heavy operation: the cost of a 5 CM truck is in the 50 NIS range (10€). So the monthly cost of sanitation is in the 200 NIS range (40€ for a typical house in the West Bank) [7]. Al-Sa'ed [4] made a comparison for the sanitation development in Israel for the period between 1948 and 2008 as presented in Table 2. It is clear that

Table 2 Historical development of sanitation service coverage under various regimes (Israeli occupation period and under the Palestinian Authority rule)

Responsible party	Population served	Years	%Year
Israel (1948–2008)			
Sewerage networks	95%	60	1.6
Centralized WWTPs	90%	60	1.5
OPT-WB (1967–1995)			
Sewerage networks	20%	28	0.7
Centralized WWTPs	5%	28	0.2
Mekorot (Israeli Water Company): 1937		Israeli Water Law 1957	
Palestinian Authority (1995–2008)			
Sewerage networks	+20%	13	1.5
Centralized WWTPs	+76%	13	5.8
Palestinian Water Authority (PWA): 1995		Palestinian Water Law (2002)	

the wastewater management in the OPT was fully neglected during the Israeli occupation period prior to the establishment of the Palestinian Authority in 1995, where only 20% of the total population were served centrally by sewer networks and only 5% of collected sewage experienced physical and partial biological treatment.

The neglect of Israel to provide access to safe sanitation services and the adverse impacts associated with this decision by Israel were recently explored by a World Bank report. This report stated that during the periods of peace and proposed stability conditions the Palestinian Water Authority (PWA) was able to erect only one urban sewage works in Al-Bireh city, with pre-conditions that the nearby Israeli settlements must be connected to the sewage treatment facility [8].

There are three main strategies which the PWA applied in order to promote wide sanitation services coverage and to enhance the performance of current WWTFs in order to comply with national prescribed effluent quality standards, i.e., (a) new erection, (b) retrofitting, and (c) upgrading WWT schemes. Table 3 illustrates the efforts made by the PWA to plan, upgrade and rehabilitate the existing WTPs for municipal wastewater treatment in Palestine. In all the efforts, emphasis was made on integrated pollution control in the upgrading schemes, in which all aspects such as effluent quality standard, sludge disposal, level of technology, upgrading, land availability, maintenance, cost-effectiveness, and other non-financial factors were considered [4].

The challenges facing the sanitation sector are further compounded by the existence of a multitude of governmental and non-governmental institutions involved in the water sector, leading to institutional fragmentation and lack of coordination. Moreover, there is an unclear understanding as to the roles and responsibilities of each institution in the treatment and reuse of wastewater. Today, most of the municipalities are in charge of supplying water and collecting wastewater, but these institutions suffer from limited financial and managerial capacities to perform their functions. In order to achieve a more coherent institutional framework, the PWA is therefore pushing for the establishment of strong

Table 3 PWA efforts made to enhance Palestinian sanitation services [4]

District	Capita(#)	Served (%)	Capita (#)	WW (m3/d)	Treatment system	Year	Status	Activity type
Al-Bireh	50,000	85.8	42.900	4,719	Extended aeration	2000	Operational	Upgraded 2008
Ramallah	35,000	74.6	26.110	2,872	Aerated lagoons	1973	Overloaded	Rehabilitated 2003
Nablus	150,000	82.9	124,350	14,300	Extended aeration	2000	Tendering 09	New WWTP/2020
Hebron	257,000	82.1	210,997	24,265	Conventional ASS	2001	Pending	Hold on
Tulkarem	93,000	68.3	63,519	6,352	Aerated lagoons	1975	Pending	Upgraded 2000
Salfit	25,000	65.6	16,400	1,394	Planned ASS	2000	Pending	No funding
Qalqilia	20,000	70.5	14,100	1,199	No WWTP		Pending	No funding
Jenin	52,000	66.5	34,580	3,458	Aerated lagoons	1972	Pending	Upgraded 1994
Beit Lahia	299,000	68.5	204,845	16,341	Aerated lagoons	1979	Overloaded	
Gaza city	545,000	79.0	430,550	48,243	Parallel TFs/EA	1977	Overloaded	Upgraded/86/98
Rafah	184,000	95.3	175,335	20,000	Aerated lagoons	1978	Overloaded	Upgraded 2008
Bethlehem	84,000	91.2	76,608	8,810	No WWTP		None	
E. Jerusalem	115,000	80.8	92,920	10,686	No WWTP		None	
Khan Yunis	120,000	75.0	90,000	10,350	No WWTP		None	
Total PE	1,710,000		1,513,214	175,580				

regional water utilities which would be responsible for all services, including water supply, wastewater collection, and reuse. The PWA would be responsible for all regulatory, planning and research functions. This institutional arrangement is reflected in the Palestinian Water Law of 2002. Efforts have been made by the PWA to adopt the effluent quality standards of WHO and USEPA, but more needs to be done in terms of monitoring the quality of effluent and the enforcement of regulations. In most of the OPT, there is wide use of individual sanitation systems that treat grey sewage on the plot occupied by the house, and the black sewage is collected in a specific tank. There are a lot of recommendations in a report done by the European Union [7] *as summarized in the following points below*:

2.1 Treatment of the Grey Wastewater

The PHG (Dr. Tamimi interview) case, for instance, consisted of filtration over two successive levels of porous material after storage in a septic tank and a settling phase. We consider this process technically well adapted. *The cost was said to be 2000*€. Moreover, in some cases (the PWEG case) (Munther Hind interview), the treated grey effluent is then used in green houses for drip irrigation of vegetables. This does not need any fertilizer, as the nutriments are already in the treated effluents. *This process brings a substantial income to the household of between 500 NIS (100*€*) and 1500 NIS (300*€*) per month*, which is more than enough to properly maintain the system and pay for the evacuation of the black sewage tank twice a year. Furthermore, ARIJ has developed a compact process (micro-station) treating the grey and black sewage with a reuse of the treated water for the drip irrigation of trees. *This process is expensive, being around 3600*€, and its performance has not been confirmed in the absence of measurements and analyses.

The above described situation has the following impacts on the environment as there are no sewage treatment plants; the wastewater is usually disposed in the nearby wadis, agricultural lands, road sides or on a karstic infiltration area. The raw domestic pollution is heavily disposed into the natural environment and generates heavy infiltration and pollution of springs, wells, and groundwater. Furthermore, the high cost of sewage evacuation for Palestinian families causes them to delay the emptying of their sewage tanks which generates overflows and flooding on the streets or neighboring properties. This causes problems between neighbors and public health threats. On the other hand, the flooding adds their effects to the chronic infiltration generated by cesspits and the many septic tanks which are leaking because of cracks in their concrete walls.

2.2 Type and Size of Collective Sanitation Systems

Most of the processes used are based on a first stage of anaerobic storage of the effluents for 8 days. The pre-treatment is just a simple rack at the entrance of the

anaerobic tank. This phase has two goals: to act as a buffer basin and to reduce the BOD value (by around 30%). The BOD concentration is very high in the raw effluents, close to 800 mg/l (only 300 mg/l in France), and due to the low water consumption per inhabitant (50–80 l/day versus 150 in France). The second stage is aerobic, either a bacterial filter or a small gravel filter, the last could be with reed beds. *In all cases, this stage, coming after a long duration anaerobic phase, seemed not enough aerated to allow a significant decrease in the BOD.*

The designers of the sanitation systems could not give us precise performance data of the different structures as there is no effluent quality analysis at the different stages of the process. These processes do not treat nitrogen, which is not a problem as nitrates are rather beneficial for the irrigated crops. Finally, the third phase is a sand bed filtration before sending the treated effluent into the irrigation network [7].

3 Regulatory Framework for Wastewater Reuse

The reuse of treated wastewater often disproportionately benefits the poor. It must be combined with strategies to prevent or mitigate health risks from pathogens, heavy metals, pesticides, and endocrine disrupters and environmental damage from heavy metals and salinity. Long-term institutional coordination among water, agricultural, environmental, and service providers and end users is a requirement for water reuse investments to pay off. Investments in urban water supply and sewerage coverage are raising, however, adequate treatment for agricultural reuse with acceptable risk mitigation for human health and the environment will require further investments.

A guideline to direct the reuse of reclaimed water has been given necessary importance with regard to the associated health and environmental impacts. The first draft for proposed guidelines for effective wastewater management and wastewater reuse in Palestine was prepared by Birzeit University through a MEDA project named efficient Management of Wastewater (EMWTER). This project was a part of a regional project which included Egypt, Jordan, Tunis, and other European countries, where Birzeit University was awarded to implement it at the national level. To this end, a steering committee from different stakeholders (encompassing Ministries such as PWA, EQA, and the Ministry of Agriculture, in addition to Birzeit University and other stakeholders at the community level) was formed to steer the project's progress (www.medawater-rmsu.org and INVENT project (Birzeit University, IWES).[1]

[1]Invent project (Birzeit University – WSI) Efficient management of wastewater treatment – guideline for reuse of treated wastewater.

The Palestinian wastewater and reuse sector strategy calls for adequate institutional capability to manage resources and infrastructure and to regulate wastewater sector activities. This necessarily implies substantial capacity building actions in the areas of wastewater reuse management, operation and maintenance, and development of service utilities. Some of the main current institutional bottlenecks include:

- Lack of adequately trained human resources.
- Unclear designation of responsibilities between stakeholders with a tendency of insufficient delegation.
- Low level of enforcement – due in particular to the insufficient number of inspectors, the lack of monitoring data and equipment, and conflicts in allocation of regulatory responsibilities, plus a culture of producing data without analysis. Legislative change will not have any effect if enforcement is not improved.
- Insufficient awareness of issues related to wastewater.
- Lack of a separation of governance functions from service delivery.

4 Treated Wastewater Quality Standards

The wastewater quality achievable in practice depends on the treatment processes provided at any particular treatment plant and it is essential to match the use of the final water requirements with that level of quality. From the point of view of wastewater reuse in agriculture, however, additional quality characteristics important for health and agronomic reasons are necessary, including bacteria, viruses, helminthes, protozoa, and physical/ chemical parameters such as conductivity and the sodium absorption ratio. Primary treatment of municipal wastewater will remove primarily settled solids together with any adsorbed or entrained materials, such as heavy metals which might be associated with the solids. The effect of primary treatment on health and agronomic parameters is of minor significance, except that there may be a high level of toxic heavy metals accumulated in the sludge. Conventional secondary treatment of sewage in biological filters or activated sludge plants is designed to remove more of the biologically degradable organic material, and typically removes up to 80–90% of the BOD_5 remaining after primary treatment. Again, the health and agronomic parameters are little affected by conventional secondary treatment processes. Further upgrading of secondary effluent is possible in tertiary treatment processes but complex combinations of unit processes are required to achieve a high quality of effluent for unrestricted use in agriculture. Stabilization ponds can achieve high quality effluent standards with low cost, easily operated systems, but the land take is high. In order to meet the need for high quality treated wastewater, new technologies are being developed and studied throughout the world.

4.1 Current Practices of Effluent Disposal into Receiving Water Environment

Almong [9] explored stream restoration and wastewater treatment standards among five main Israeli/Palestinian water[2] challenges and analyzed the actual capability of current Israeli laws and regulatory tools to resolve them. Among the main Israeli water pollution control laws and orders are the following:

- Orders
- Water Law (1959, 1971, 2002, 2004, 2008 and [10])
- Water Commissioner
- Clean Up, Allowing, and Stopping Orders related to water pollution
- Water Council
- Water Drilling Control Law, Drainage and Flood Control Law
- Streams and Springs Authorities Law
- Local Authorities Sewage Law
- Public Health Ordinance
- Licensing of Businesses Law

The 1992 Sewage Effluents Standards (Public Health Ordinance) were set without scientific evidence and were based on European standards assuming a considerable degree of dilution in receiving surface water bodies. The standards unfortunately did not take into consideration the site specific vulnerability of groundwater and the existing water quality of many streams, i.e., that most of these streams have seasonal water flows, if any, or are comprised entirely of wastewater. With almost 95% sewerage coverage, Israel utilizes annually about 300 MCM (75% of treated effluent) in agricultural irrigation and has the status of a "world leader" in reclaimed effluent reuse. The present "20/30" rule for BOD_5 and TSS, respectively, required for effluent discharge into receiving waters and reuse for agricultural irrigation is still effective in health risk reduction. In a recent effort to update the current effluent disposal standards [11] (Table 4) lists selected major parameters highlighting the severe variations between Israeli and Palestinian Standards for Effluent Disposal for agricultural irrigation and discharge into surface water bodies.

Most countries have established national committees and focal points to evaluate and update regulations and standards concerning the quality of effluent used for irrigation or disposal to the water bodies. The development in legislation is not going parallel with the growing needs for wastewater treatment and reuse. Some countries use standards and specifications applied in the most developed countries like those of California, while others modify the WHO guidelines according to their own conditions. There are *Palestinian Standards* for the Treated Wastewater – *PS-742-2003 – and an* industrial effluent discharge Standard *PS-227*–June 1998 which

[2]Palestinian-Israeli Joint Water Committee, 1996–2006, Minutes of Meetings.

Table 4 Israeli and Palestinian standards for effluent disposal in various applications

Parameter	Unit	Israeli Standards 2002		Palestinian standards 2002	
		Unrestricted irrigation	Rivers	Unrestricted irrigation	Rivers
BOD	mg/l	10	10	20	–
TSS	mg/l	10	10	30	
COD	mg/l	100	70		200
Ammonia-N	mg/l	20	1.5	50	5
Total-N	mg/l	20	10		
Total-P/PO_4-P	mg/l	5	0.2	30	5
SO_4	mg/l	–	–	500	1,000
Chloride	mg/l	250	400	500	–
Sodium	mg/l	150	200	200	–
Fecal coliforms	CFU/100 ml	10	200	<200	<1,000
Boron	mg/l	0.4	–	0.7	2
Hydrocarbons	mg/l	–	1	0.002	1
Anionic detergents	mg/l	2	0.5	15	25
Total oil	mg/l	–	1	5	10
pH	[–]	6.5–8.5	7–8.5	6–9	6–9
Dissolved oxygen	mg/l	<0.5	<3	>0.5	>1

have been prepared by a special committee and accredited by the Palestinian Standards Institute.

The Israeli stringent effluent quality standards are being forced upon the Palestinians where the 20/30 rule is required from the Palestinian operators during the first phase of implementation of any new WWTF. However, the WWTPs effluent should comply with the stringent level of standards (10/10) during the second phase of implementation, given a period of 5 years as a construction phase to erect an advanced filtration stage. This is evident from the approval protocol for Tulkarm and Nablus-West WWTPs. The debate over the adequacy of the standards remains controversial as even the less stringent "Inbar Standards" remain debatable, due to the huge financial burdens associated with their implementation and the objections to their adoption by the Ministries of Finance and Interior. Only Al-Bireh sewage works comply with international effluent standards, where local studies revealed that treated effluent is biologically safe for restricted agricultural use [2, 3, 12]. At present, the current valid 20–30 standard is still valid as the level of treatment required for wastewater treatment in Israel. However, before Israel can begin to force new stringent effluent standards on the Palestinian wastewater management facilities, it must first enact those on its own treatment facilities [9, 13].

5 Status of Wastewater Treatment Plants

About 40% (1.5 million) of the total urban population in the OPT have access to central sewer networks, however, only 48% of the total annual collected wastewater is being partially treated (secondary treatment) in Palestinian-owned sewage works,

whereas about 33% of the annually collected sewage is being treated within Israel. Under the Status column in the Table 2, it is obvious that the current sewage works are either overloaded or under the "waiting" for Israeli final approval. It is worth while to mention that if a WWTP proposal is technically approved by the JWC, this does not automatically mean direct implementation. The final approval must obey the "military" orders granted by the "Civil" Administration, which takes years to receive-exceeding 10 years for Nablus and Hebron, as examples [4, 8].

Improving WWTP and reuse issues in the West Bank and the Gaza Strip is a high priority because these are highly water-stressed areas and water quality suffers from pollution and over-abstraction. WWTPs are overloaded, so some effluent is discharged without treatment. There is currently some limited interest in wastewater reuse, but it is carried out in an unsustainable manner. The situation has not been helped by the existing weak institutional capacity for wastewater reuse, an incomplete legal framework, very low cost recovery and the continued political conflict. However, rural Palestinian areas in the WBG Strip are subject to serious environmental threats. These threats stem from gaps in the institutional and policy measures available. Therefore, discharge of untreated wastewater, unregulated agricultural practices, and a general lack of infrastructure lead to adverse environmental impacts – such as deterioration of ground and surface water quality. According to EU reports recommendations, the following points should be taken into consideration.

5.1 Maintenance of the Centralized Treatment Plants

This was the most obvious problem, unfortunately. Most of the plants show clearly that there is almost no maintenance which even makes it sometimes difficult to reach the site. The pre-treatment racks are often blocked. The gravel filters feeding is never properly set thereby generating strong preferential pathways for the effluent, which means that some parts of the filtering bed are dry and others overflowed. However, this problem could be easily solved by avoiding the blocking of the pipes and checking the equal flow of the effluents on the filters. When there is a pump in the process (lifting the effluent on a bacterial filter for example) one could wonder about its lifetime and on its maintenance.

5.2 Technical Staff and Training

There is a lack of maintenance because there is no follow up going with these projects. Only investment and implementation costs were considered. A sound technical support would be needed to have a sustainable and properly working system. Even when there is a motivated local technician in charge, which was the case sometimes, he is alone without enough training and without any external support.

5.3 *Involvement of the Local Authorities*

This is a major condition: the management and the sustainability of the future sanitation service will not be possible without it. This involvement has to be sought from the beginning of the design of the municipal sanitation. The municipality must be an actor when it comes to the choices to be made for this scheme and must contribute to the awareness and information campaign directed toward the population. *The most important point will be to build with the municipality the management rules of the sanitation service, including the tariff policy*. We have noticed that the relatively recent set up of local authorities in Palestine and the current political context has generated certain diversity in the organization of the municipalities and in their ability to manage the sanitation service.

6 Effective Management of Wastewater Across the West Bank and Gaza

The increased population growth rate and rapid expansion of industrial and commercial sites has caused an increased gap between water supply–demand balance, where treated wastewater as an alternative non-conventional water source can help bridge the imbalance. Due to the Israeli occupation in 1967, the Palestinian people have limited access to their land and water resources and are dependant on Israel's prior permissions and foreign donations to establish their water and WWTFs. Currently about 35% of the Palestinian population has access to adequate sanitation, World Bank [8]. On the other hand, there are risks from usage of cesspits and discharge of raw sewage over land or into wadis. Also, delays in project implementation contribute to serious public health and environmental risks, reduce availability of limited water resources as aquifers are polluted by wastewater, and reduce effective treated effluent use in agricultural irrigation, Isaak et al. [14] and Kramer [15]. Furthermore, there are negative impacts on surface water bodies and this can be related to the annual degradation in groundwater quality documented recently by Hareuveni [16].

Regional agencies like CEHA, EU, EC, UNEP, CPP, US AID, GTZ, FAO and others are playing a major role in the adaptation of new regulations and harmonizing existing laws among countries. They also encourage the establishment of regional standards for reuse of wastewater in agriculture, industry or artificial groundwater recharge. They recommend that regional experiences with effluent reuse should be made more widely available for other countries. They also recommend that legislation should be established to advance construction of sewerage systems and treatment of the industrial wastewater before disposal. Finding the proper financial incentives is critical to cover, at a minimum, the operation and maintenance costs of any reuse scheme. Capacity-building, awareness raising and assistance to farmers are also keys to achieving a rational pricing policy and to

encouraging farmers to use treated wastewater for crop irrigation. Farmers do not trust the monitoring of water quality carried out in the West Bank and the Gaza Strip and have a preference for reliable, inexpensive and better quality groundwater. However, there are indications that farmers are willing to pay and use treated wastewater for irrigation of crops. In addition to marketing skills training, they need to receive proper information about the impact of treated wastewater on crops. They also need to understand the more severe restrictions on the cultivation of high-value crops with treated wastewater. In addition, a reliable financial structure with cost recovery mechanisms and incentives for farmers to use the treated wastewater is lacking in the WBG. There is no comprehensive pricing policy or prices for reuse in the Palestinian Territory. Currently, farmers do not pay for the reuse of treated wastewater, if any, nor do they pay a penalty for irrigating crops with untreated wastewater [17].

Monitoring the performance of sewage treatment plants in Palestine is the responsibility of the Environmental Quality Authority, Ministry of Health, and the PWA according to their pollution prevention laws. However, all these ministries and entities are lacking a scheduled monitoring program, and neither has a data base. Never the less there is a modest initiative from the PWA main laboratory to build a data base in cooperation with the Al-Bireh Municipality, World Bank [18].

7 Reuse of Treated Wastewater in Irrigation as a Strategic Approach

In the *Palestinian Territories (the West Bank and Gaza)*, the untreated effluent has been used for irrigation of trees and vegetables in an uncontrolled manner. The situation will improve in the future with the heavy involvement of donor agencies and the PWA in reconstructing the whole water supply and sanitation infrastructure. The trend in other countries like Lebanon, Syria, Iran, Iraq, and Yemen is to expand the use of wastewater for irrigation. In Iran, for example, there is about 70 MCM of primary treated effluent that is used for irrigation. The new management reform action related to the water sector considers wastewater as a new source that should be used for irrigation. Artificial recharge of groundwater is another option for reuse of reclaimed wastewater either directly or indirectly. By this, the already over exploited aquifers in the region can be restored. A few cases of artificial recharge have been reported in the region, especially in Oman, Egypt, and Jordan. Recently, PWA in cooperation with PHG (an NGO) was involved in an assessment project to evaluate the potentiality and possibility of this technology taking the existing Beit Lahia WWTP as a pilot. In comparison with other neighboring countries, although Palestine is the less in terms of water consumption, nevertheless the share of treated wastewater in reuse is almost neglected and does not exceed the community level and small WWTP with low cost technologies. Table 3 gives an overview of the quantities of wastewater discharged through the sewerage network and the quantities that are being reused in seven countries. The quantities that are not being

reused are directly or indirectly discharged into the sea or evaporate from streams and reservoirs Gearheart et al. [19].

7.1 General Benefits of Wastewater Reuse

The reuse of wastewater reduces the demand on conventional water resources, and thus may postpone investment in a new mobilization of conventional water resources for developing new drinking water supplies. Additionally, the reuse of wastewater reduces the volume of wastewater discharged, resulting in a beneficial impact on the fresh water resources (surface and groundwater), the environment, and public health by protecting receiving areas against pollution. For certain types of reuse, constituents of the wastewater can be used for beneficial purposes such as, for example, nutrients in agriculture.

The situations are contrasted. In some municipalities of Palestine, there was not one farmer reusing treated effluent for irrigation. It was not possible to know if this was related to distrust toward the quality of the effluents (distrust justified taking in account what we mentioned above about maintenance), or if there was no need for this water, or if there was a lack of coordination [20].

During the same period, Al-Khateeb [21] reported some remarkable cases where the choice was made to irrigate fields on slopes. This is surprising owing to the energy cost reasons and the difficulties related to the maintenance of pumps and pipes in this context. Besides, there were land parcels available for gravity irrigation. More generally, it seems that the choice of the location of the treatment sites did not take into account the reuse of the effluents in agriculture in concert with the farmers themselves.

7.1.1 Planning of Wastewater Reuse Projects

Because there are risks associated with the reuse of treated wastewater and sludge in agriculture, any proposed wastewater reuse scheme must be carefully planned and strictly controlled through local and national institutions [21].

7.2 Government Organizations Involved in Treated Wastewater Reuse

The government organizations involved in treated wastewater reuse should be defined and their responsibilities clearly delineated. Status quo in Palestine indicates grand interference among the different institutions, including the NGOs and grass roots representatives. Each institution has developed its own regulations based on its own strategic plans, missions, and goals. EQA insists that all

wastewater should be controlled, regulated and managed under its auspices, and at the same time, the MoH underlines that all generated wastewater should be under its responsibility since one of its strategic goals encompasses securing the health of citizens and protecting them from being affected from wastewater-related diseases. PWA insists that all wastewater including its infrastructure should be under its total control and management. Also, this policy is included in PWA's Master Plans, assigning this mission to the wastewater strategic planning department within its organizational structure (Water sector in Palestine – PWA). This is justified based on the acute shortage that the country is facing including the unavailability of conventional water resources to fulfill the actual gap in demand and supply. Treated wastewater should be considered as a viable option to reduce the expected gap if it is addressed to agriculture taking into consideration the huge amount of fresh water consumed by agricultural practices [22, 23].

8 Conclusions

Wastewater treatment and reuse in the OPT of Palestine are still negatively affected by the Israeli military occupation. This practice had resulted in poor capacity building in the water and wastewater sector, limited rural development, poor if not negative economic growth, poor health and sanitation conditions, and physical and environment deterioration. As a result, the Palestinian Authority exists in a complex environment over which it has no control, because it is not officially recognized as the government of a state or a country. The implementation of development projects and plans require many years to be achieved and sometimes they are not achieved at all. There are some answers for wastewater reuse in the OPT, even when taking into consideration the many obstacles which are political, financial, social, institutional, and technical, summarized as follows:

- Technical capacities are not formulated to build on larger-scale reuse projects.
- Effluent reuse is a politically-tied issue with Palestinian water rights, where Israel considers reused wastewater as a part of the total Palestinian fresh water rights, and this calls for Palestinian awareness to wastewater issues.
- Non-availability of sewer networks and proper wastewater treatment systems is eliminating big jumps in reuse practices.
- Reuse standards are still not enforced. Israelis are asking for strict standards, while the Palestinians are not able to manage the presented standards.
- Institutional structure: Efficient financial and technical management of the treatment plants and associated facilities requires strong institutional support.
- Integrated vision: there is no integrated vision developed for the reuse issues; this includes among others political and institutional issues, water policy, and awareness.
- No work permits from the Israelis.
- Lack of funds for collection systems, treatment plants and small scale plants.

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