Community participation and local regulations for sustainable sanitation and water reuse in Anza village, Palestine

This article presents the practical experience gained while conducting the feasibility study on technology selection for wastewater treatment and effluent reuse schemes in Anza village, Palestine.

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Abstract

Free access to water and agricultural land, and sustainable sanitation can reduce food insecurity and enhance economic development in Palestine. This paper presents initial findings of an EU funded project to erect sustainable wastewater treatment and effluent recycling schemes for food security in Anza village. The project aimed at the erection of affordable and environmentally sound sanitation infrastructures considering community consultation and local regulatory rules. The feasibility study showed that low cost treatment options were neither sustainable nor cost effective compared with mechanised biological systems. Results of scoping sessions revealed that major stakeholders (village council members, women and farmers) are willing to accept and pay for environmentally sound and cost effective sanitation facilities. The study recommends the need for coordination between regulatory institutions, funding agencies and community to oversee and coordinate planning activities. Early community participation in the planning process facilitated proper technology selection considering the socio-political, financial and environmental aspects.

Introduction

The growing tendency in reclamation of treated wastewater and reuse of recycled water (treated wastewater) worldwide urges water policy makers in Palestine to integrate water recycling practice as a core element of water resource management. The widespread of water reclamation and reuse for agricultural purposes in Mediterranean countries is driven by water scarcity, water resources protection, environmental security and sustainable sanitation as well as safe and affordable recycled water (Friedler, 1999; Angelakis et al., 1999).

The agricultural sector is a major element for a viable Palestinian economy. Therefore, the availability of freshwater is crucial to achieve food security and sustainable life. Despite the fact, the agriculture is

Key messages to ensure sustainable recycled water use for food security in Palestinian rural communities:

- In Palestine, land scarcity, local environmental issues and stringent effluent quality rules constrain the application of natural and low cost treatment systems;
- Early participation of community and local authorities in the decision making process facilitated proper choice of wastewater treatment technology and use of recycled water;
- Public perception and cultural issues are crucial and need to be evaluated and improved when recycled water use in agricultural irrigation is considered. Thus, public consultations help promote acceptance and pre-detection of future misconceptions.
- Flexibility and availability of a given treatment system, safe and environmentally sound recycled water, public awareness, OM and repair, affordable costs for recycled water should early be considered in the planning process;
- Practical management strategies with clear responsibilities and cost recovery dictate the future sustainability planned wastewater treatment facilities;
- Establishing sustainable sanitation facilities entails technology selection that is financially affordable, socially adequate, technically practical, institutionally suitable and environmentally sound.

the greatest water consumer (65% of the available water) in Palestine, only around 11% of the total Palestinian agricultural land is irrigated. This is mainly due to the Israeli control over the main Palestinian water sources, climate conditions of the region and mismanagement of irrigation water. The political well and commitment, as well as limited access to available water resources and agricultural land exacerbate the urgent needs for effluent reclamation and recycled water use in Palestine (Al-Sa`ed, 2005). In addition, the variable and unbalanced distribution of annual rainfall and seasonal drought periods have endorsed water restrictions in irrigated agricultural lands which use more than 70% of Palestine's available water resources (Nassar et al., 2009).

The provision of environmentally viable and cost effective wastewater treatment facilities in Palestinian rural communities is an overwhelming challenge for decision makers, community leaders and environmental professionals (Al-Sa`ed 2007a). Most rural communities lack adequate sanitation facilities, where domestic sewage is stored in cesspits posing health and environmental hazards through leaking, infiltration and uncontrolled disposal practices. Current installed low-cost onsite treatment systems in rural areas are unsustainable and causing annual environmental degradation, due to overloading, faulty design and implementation, absence of monitoring, maintenance and repair, poor public awareness, lack of administrative and legal control measures (Al-Sa`ed, 2007b, Al-Sa`ed and Mubarak, 2006). Nitrate is one of the most common pollutants in Palestine's ground water and is associated mainly with human activities such as percolation of nitrate-rich water from irrigation, leachate, cesspits and wastewater treatment plants (Almasri, 2008). In the West Bank, several groundwater wells showed nitrate content, which exceeds WHO`s maximum contaminant level (11 mg N/l) for potable uses. In Gaza strip, excessive nitrate concentrations (300-500 mg N/l) in water supplies pose serious public health risks causing 'blue-baby' syndrome and still-birth in both humans and livestock (Shomer, 2011).

The growing demands of Palestinian communities for food and freshwater require use of recycled water in agricultural purposes not only to abate food insecurity but also to protect natural water resources and improve land management. While the volume of wastewater is increasing, the safe disposal can be difficult due to lack of sustainable sanitation services. However, the use of recycled water (reclaimed effluent) for agricultural irrigation is the obvious solution, requiring building capacity and local expertise in the full range of technology involved (Abu Madi et al., 2008). Treated wastewater reuse is covered through a number of regulations and standards which are already established in the Palestine Authority (PSI, 2012). However, since treated wastewater reuse has not been implemented at large scale, enacting these regulations and standards have only been applied to issue permits for urban sanitation and effluent reuse schemes. Enacting these rules and standards for monitoring and control of recycled effluent (discharge and reuse) is still an ongoing debate within different ministries and relevant institutions in Palestine.

This article presents the practical experience gained while conducting the feasibility study on technology selection for wastewater treatment and effluent reuse schemes in Anza village. The focus is made on understanding the perceptions of stakeholders with insights to impacts of recent Palestinian regulations for the reuse of treated wastewater in agricultural irrigation.

Project Aim and Scope

Serving Anza village with a central sewerage network, wastewater treatment and effluent reuse scheme or Anza wastewater treatment facility [Anza WWTF] is part of the 'Food Security Thematic Programme' (FSTP) funded by the European Union [EU]. The project aims at improving the living conditions of the Palestinian inhabitants and economic development of Anza village. In addition to the design works and environmental impact assessment study performed for the Anza WWTF, the project entails safe disposal of the treated wastewater [recycled water] from the planned wastewater plant. The safe disposal of treated wastewater will be made beneficial through a planned reuse of recycled water in agricultural irrigation.

The feasibility study investigated several wastewater treatment alternatives including natural and mechanised treatment technologies. Vertical flow constructed wetlands and sequencing batch reactor (SBR) were analyzed. One major selection criteria was installing a system that has low-capital and affordable annual running costs with less environmental impacts. The recycled water is planned for restricted agricultural irrigation considering soil, climate, crops and socio-economic conditions in the community. A number of meetings and interviews were held with farmers and various stakeholders from the Ministry of Agriculture (MoA), Environmental Quality Authority (EQA), Palestine Water Authority (PWA), Ministry of Health (MoH), Palestinian Standards Institution (PSI) and Anza Village Council to investigate the feasibility of reuse. All of these institutions and Ministries are aware of the importance and need for the reuse of treated wastewater in the West Bank.

Materials and Methods

As mentioned earlier, the project entails design, implementation and operation of sanitation infrastructures including the sewerage networks, wastewater treatment plant (WWTP) and effluent reuse schemes in Anza and Bet Dajan villages. In addition, a baseline environmental and an environmental impact assessment for the wastewater treatment plant were also performed. For the accurate design of the WWTP, grab samples of domestic wastewater obtained from similar rural areas with central sewerage networks were collected and analyzed. Field questionnaires were developed, distributed and analyzed to gain knowledge on perception and understanding of municipal council members, farmers, women and school children. As of space limits, this paper presents the results for Anza village obtained from the environmental baseline report [reference], scoping sessions, personal interviews, lab analysis and feasibility study on proper wastewater treatment technologies.

Results and discussion

Baseline environmental profile

Anza, a Palestinian village situated in Jenin District in the Northern of the West Bank with 2,034 residents (2010), will reach 2,969 in the year 2022 and about 4,471 by 2035. Besides one kindergarten, Anza has two schools; one for boys (260 children) and another for girls (227 children). Furthermore, there is a functional healthcare clinic, a women centre, two agricultural societies, a charitable society and a sport club. Two olive presses work on full capacity during the olive fruits picking season. Since 1995, the village is administered by the village council having 9 members appointed by the Ministry of Local Government.

The total area of the village is estimated at around 5,000 dunums (1 dunum=0.1 ha). Some 1,000 dunums are plain rain fed land. This area is usually cultivated with cereals like wheat, barley, corn, broad-beans, and lentil in addition to olive trees (Figure 1). About 4,000 dunums are mountainous and planted with trees such as olives, figs, and almonds. The plain land within the project area is dry land of low agricultural productivity as it relies totally on fluctuating rainfall seasons. Various vegetable types can be planted as open agriculture or in green houses if sufficient quantity and safe irrigation water is available.

Provision of drinking water supply for Anza village is secured by Jaba' agricultural well. The latter provides the village with about 4,000 to 5,000 m^3 of drinking water per month. Without prior treatment but disinfecting (chlorination), drinking water is elevated to a concrete water, from which further distributed via the network to households. From official records of the village council, the average daily water consumption per capita from the network (48 l) in addition to 41 l from rainwater harvested in household cisterns during winter months. Hence, the daily water consumption for potable uses per capita in total is about 89 l. The un-accounted for water (losses) in the network is estimated around 32%. Drinking water tariff is collected from the households based on monthly water bills at a fixed rate of 1.35 US$/$m^3$.

Before this project, domestic wastewater was stored in individual or collective cesspits, where the domestic septage from cesspits is frequently vacuum-trucked and disposed off uncontrolled on agricultural land and discharged into nearby wadi. Depending on the vacuum truck loading capacity, the average costs for septage evacuation and transport range between 3.85-5.75 US$/$m^3$ septage. It is worth mentioning that these costs exclude the safe treatment and disposal costs of septage.

Figure1: Overview of Anza village with olive trees orchards

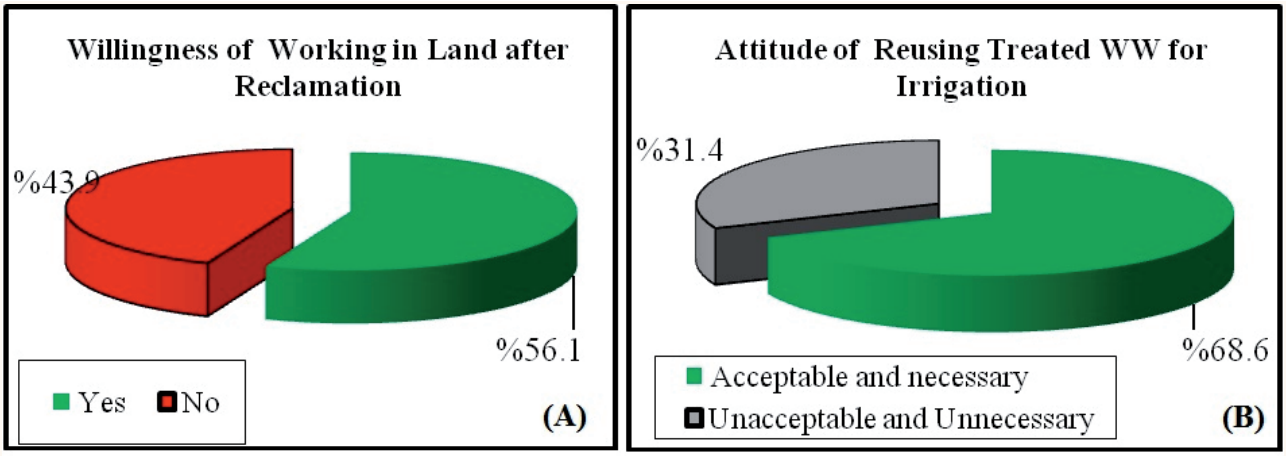

Figure 2: Willingness and attitude of households to use treated water in agricultural irrigation

Field questionnaires on community perceptions

Three questionnaires were distributed to explore the community perceptions related to public awareness, socio-economic situation, knowledge and attitude towards wastewater treatment and recycled water use in agricultural irrigation. Field surveys were performed via three separate questionnaires designed for households (61 questions), school children (22 questions) and farmers (46 questions) in the village. The total surveyed residents in the village included 70 households, 144 children, and 20 farmers. Due to space limitations, the results obtained from the surveys on households and farmers are presented.

Collecting and analysing the data gained from questionnaires distributed on households and farmers revealed the following main results:

Perceptions of households and farmers towards use of reclaimed water in irrigation

Our interviews with the various institutions in the area showed a good awareness regarding the need and importance to utilize treated wastewater in agriculture. The Ministry of Agriculture considers such utilization as very important and it is willing to guide farmers through reuse activities. From the contacts we had with officials in municipalities, with the experience of the systems they manage, it seems that a monthly cost of 15 NIS per household would be acceptable, which is around US$ 4, which would bring the cost per cubic meter of wastewater to US$ 0.35.

92.9% of households supported the idea of constructing a central WWTP in the village while 7.1% rejected. 88.2% of households expressed their willingness to pay money contribution for the construction of the wastewater sewerage network and treatment system and they can pay about US$ 75, whereas 11.8% refused to pay. 74.6% expressed their willingness to pay monthly fees for wastewater services after connecting their houses to sewerage network and they can pay about US$ 4 per month, whereas 25.4% rejected that. 73.8% of households expressed their agreement to reuse the treated wastewater to irrigate their lands, while 26.2% refused that.

Figure 2 shows that about 56.1% of households are willing to work in agriculture if their land is reclaimed and irrigated with recycled water, while 43.9% of respondents voted against. Pro-reuse of recycled water in agricultural irrigation (68.6%) and

Figure 3: Knowledge of farmers about reclaimed water irrigated cops

considered this practice as acceptable and necessary, meanwhile 31.4% represented the view of rejection.

Farmers interviewed in the area were willing to utilize treated wastewater in agriculture, although they had some concerns regarding marketing crops irrigated with treated wastewater. It appeared from the meetings and interviews that the difficulties (religious, psychological, hygienic safety) associated with reuse will be in marketing crops irrigated with treated wastewater. Thus, there is a need for public awareness and training regarding the conditions which make consuming crops irrigated with treated wastewater safe for use. All the questioned farmers underlined the necessity for routine laboratory testing of the treated wastewater to monitor the quality and ensure safety and suitability recycled water for irrigation. Fifty percent of the farmers expressed their knowledge that most of local agricultural products as well as those imported from Israel are being irrigated by treated wastewater while the other 50% denied their knowledge (Figure 3). About 40% of the latter group reported they will refrain consuming such products, if they would have known. However, 90% of the farmers are willing to use treated water for irrigation once an official religious decision (Fatwa) is issued regards suitability and safety.

Looking at previous activities in the West Bank regarding reuse, most of training and awareness programs were directed towards agricultural reuse. However, consumer awareness is essential to improve the marketing potential for crops irrigated with treated wastewater in accordance with standards. Thus, it will be recommended in the early stages to irrigate fodders and almonds which will not face marketing problems. It will be also possible to plant fodder crops in the open flat areas and among existing olive trees in the area within WWTP area. At later stages, other fruits could be planted especially tropical fruits.

Based on Palestine Standards for treated wastewater reuse and climatic conditions in the area, fodder crops, almonds and fruit trees were identified as potential crops to be irrigated with treated wastewater. Fodder crops such as alfalfa will be safely irrigated with treated wastewater and farmers there are familiar with such crop which is demanded by local markets. There are many fruit trees that could also be planted in the area and irrigated by treated wastewater. The fruit trees include:

- Tropical fruits (as citrus, guava, avocado, mangos and kiwi),
- Stone fruits (as almonds, pomegranate, peaches, plums and apricots),
- Other fruits such as grapes, apples, and date palm.

Despite the legal restrictions endorsed by the Ministry of Agriculture (MoA) regarding irrigation of vegetables and olive trees with recycled water, the latter can be utilized in supplementary irrigation of olive orchards. Figure 4 shows the willingness of farmers to cultivate fruit trees (53%) and their acceptance (84%) to eat recycled water irrigated fruits.

The areas identified for irrigation are mainly located along the nearby wadi where the treatment plant would be constructed. The slopes around the wadi will require some land reclamation activities to be used for irrigated agriculture. Thus, in the initial stages of the project, the more flat area of the wadi is proposed for irrigation of industrial crops in greenhouses, while highland with stone fruits. Farmers in Anza village cultivate rain fed areas with olives and field crops. Farmers understand the importance of irrigation and they are interested in reusing treated wastewater for agricultural production to improve their income.

For managing the proposed wastewater treatment and effluent reuse schemes, it will be possible to

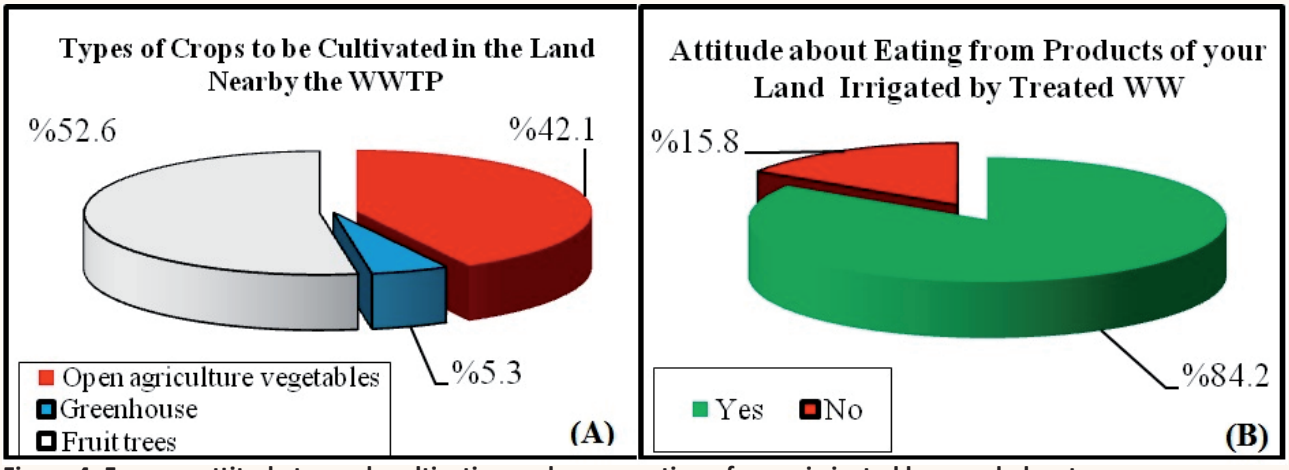

Figure 4: Farmers attitude towards cultivation and consumption of crops irrigated by recycled water

improve the organization and build capacity of the existing farmer associations in Anza village. Other possible management (administrative and legal coordination) form for the WWT facility can be administered and legally organized either through the Village Council or by establishing a new Recycled Water Association (RWA). However, housing the RWA in the village council lead to a better human capacity and organizational structure to manage and operate both the WWTP and the effluent reuse schemes. Alternative management options for the recycled water system should be analyzed before completing the construction of the WWTP.

Technology selection and local applicable regulatory requirements

The legal and institutional frameworks for the management of wastewater and effluent reuse have been expressed in the Palestinian development plans and under focus in the policies and strategies of the Palestinian Water Authority (PWA) and Ministry of Agriculture. Due to political, socio-economic and capacity building issues enacting of such ambitious policies and putting development strategies into practice are still lacking. However, the use of treated wastewater in agricultural purposes in Palestine is accomplished at pilot scale and the Palestinian farmers lack the practical experience in using this resource in a safe and an environmentally sound manner.

Seasonal drought periods, increased water demands in Palestine have forced water-related authorities, local councils and farmers to consider use of treated wastewater as a supplementary water source. As a consequence, there is a growing momentum favouring use of recycled water in agricultural irrigation. However, despite few successful pilot scale recycled water efforts, there has been a simultaneous increase in opposition against widespread of large scale agricultural reuse schemes (Al-Sa`ed, 2007b; Nassar et al., 2009). This is mainly due to public psychological issues and potential impacts of rest pollutants (mainly nutrients and pathogens) in the recycled water on human health and natural environment.

In this study, we argue that proper selection of treatment technologies considering community consultation and local environmental rules for treated effluent is one core element for achieving sustainable wastewater treatment and effluent reuse schemes. A comprehensive one year study was conducted to investigate the proper wastewater treatment system considering process reliability, treatment efficacy, capital and annual running costs, environmental impacts, and effluent quality. The ultimate goal is to reduce food insecurity in Anza village through planned use of recycled water in restricted agricultural irrigation. The treatment applied consists of pre-treatment (screening, grit removal) and biological units (vertical flow constructed wetlands and sequencing batch reactors) followed by disinfecting unit. Initially, detailed design was made for the constructed wetland system based on EU requirements related to installing natural treatment systems due to low energy and running costs.

The consequences of inadequate sanitation facilities in Palestine are awful. Therefore, planning and design of use or non-use oriented sanitation services should aim at the selection of robust wastewater treatment alternatives that reliably protect both public health and the environment. The selection of process technology focussed heavily on the environmental, health and safety aspects of recycled water alternatives. Thus, mechanised treatment alternatives, health and safety issues, public acceptance and costs were among the issues analyzed and evaluated in the feasibility study. In doing so, the planning team has considered the effluent requirements regards recycled water of safe and environmentally sound quality and the recently published technical regulations set for nitrogen contents in treated wastewater (Table 1). Valuing those rules and guidelines with detailed analysis of treatment alternatives revealed that the sequencing batch reactor (SBR), a modified activated sludge system, was the most reliable process technology. Table 2 illustrates the technologies evaluated with potential recycled water use purposes.

More stringent rules and guidelines for treated wastewater are becoming increasingly required. Combined with limited financial and human resources, lack of public awareness, increasing pollution loads, limited access to available land and

Table 1: Palestinian effluent quality guidelines (PSI, 2012)

Parameter	Agricultural reuse (class B)	Stream discharge*
BOD (mg/l)	20	10
TSS (mg/l)	30	10
Total-N (mg/l)	30	10
Total coliforms (CFU/100 ml)	1000	1000

* According to recent Israeli standards for treated wastewater reuse.

Table 2: Technology selection based on potential recycled water use purposes

Recycled Water use Purposes	Mechanised WWTP	Natural WWTP
• Restricted agricultural irrigation (pasture irrigation, stone fruits, industrial crops)	Screening, grit	Screening, grit, UASB
	SBR systems	Vertical flow constructed wetland
• Discharge into nearby stream (during winter season and/or failure of recycled water use	Disinfecting unit (chlorination)	Disinfecting unit (chlorination)
	Centrifuge (sludge dewatering	Sludge drying beds

freshwater sources, public health and environmental protection, periodic seasonal drought periods call for the establishment of sustainable wastewater treatment facilities in Palestinian communities. Inbar (2006) reported on the new Israeli regulations for treated wastewater reuse in agricultural purposes and discharge into streams. Those rules and guidelines are also applied for the approval of Palestinian wastewater facilities according to signed memoranda of understandings. The type of wastewater treatment technology dictates the quality of treated effluent. Restricted or unrestricted use of treated effluent for irrigation of agricultural crops is affected by the soil type, receiving water bodies' quality, irrigation type, crop patterns, and the acceptance of farmers to use and willingness to pay, if any. The choice of wastewater treatment technology should take into consideration qualitative and quantitative selection criteria, where the selection should based solely on financial aspects (low capita cost) but should reflect best practical option, foot print and preserve natural resources. Furthermore, optimized process control strategies should be possible to improve the biological process performance and reach a proper water quality and energy consumption.

Irrespective of the planned use of recycled water, public health risks and the potential environmental damages (soil, plant, water) are issues of paramount importance while analysing wastewater treatment alternatives (Al-Sa`ed 2007a; 2007b). According to Fatta et al., (2004) health considerations tackle fate of pathogenic organisms that are, or could be, present in the treated effluent and the build-up of toxic materials within the soil, and subsequently within plant and animal tissues which might eventually reach the human food chain. The leaching of materials such as nitrates and toxic-soluble chemicals into the groundwater is also a matter for concern. Environmental risks involve the effects of the use of

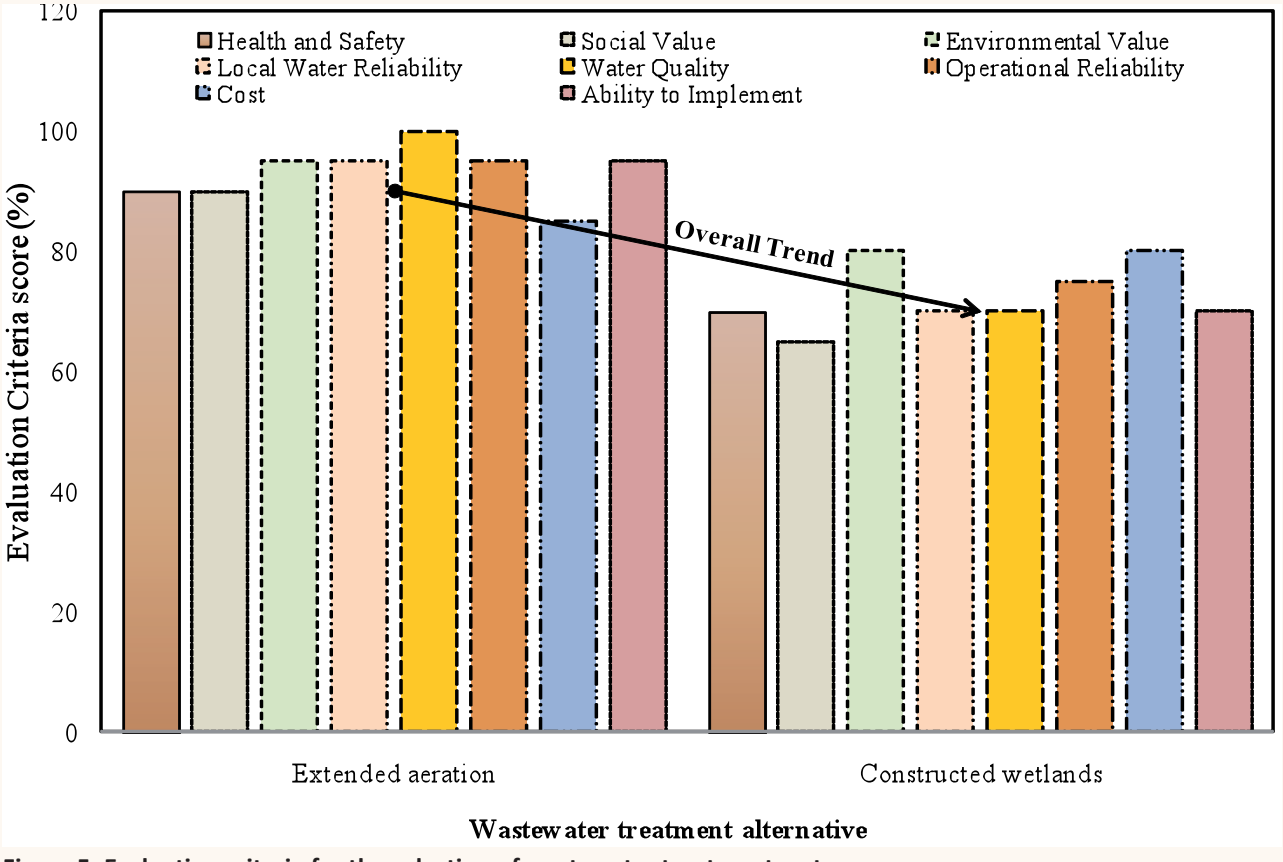

Figure 5: Evaluation criteria for the selection of wastewater treatment systems

high strength nitrogen wastewater containing other dissolved substances (TDS, heavy metals and boron ...etc) which have deleterious effects on both growth and development of plants (Lado and Ben-Hur, 2009). Recently, the Palestinian Standards Institution (PSI, 2012) issued new technical regulations (TR34-2012) implementing the precautionary principle [if, then] under the code of water resources protection. The PSI regulations require that wastewater treatment technologies should comply with an effluent quality for total nitrogen of 30 mg N/l, if the communities are planning to use recycled water in agricultural irrigation.

Considering technical, environmental, socio-cultural and economical aspects of both SBR compared and constructed wetlands revealed an overall positive decision for installing an SBR system (Figure 5). This decision is supported by the reply of respondents towards health and environmental issues, which the households and farmers reflected. The limited access to water and land as well as urgent needs to protect the environment and natural resources were the main factors behind the decision for mechanised treatment systems rather than natural based technologies. This decision enhances the safe use of recycled water as a supplement to irrigation water in Anza village; a core element of achieving an integrated water management plan.

Sustainability of sanitation and agriculture should be considered within an integral natural water-agro-ecosystem. In this ecosystem soil-water-plant-environment-living beings coincide very well, where equilibrium of food chains and their related water-energy balances are balanced (UNEP, 2011). Ecological sanitation efforts should adopt innovative and environmentally sound wastewater treatment technologies, not only to ensure sustainable agriculture but also improve agricultural productivity, improve soil quality and conserve the environment. Sanitation facilities utilizing a zero-liquid discharge as water (resource) conservation technology is the future of water and food independent communities.

Conclusions and recommendations

Based on the results presented and discussed above, the following major conclusions and recommendations can be made:

- The public acceptance is crucial to the sustainability of recycled water use in agricultural purposes in Palestinian communities. The essential role that public consultation may play should be fully recognised at all levels (decision makers, planners and funding agencies). Given the positive response of farmers in Anza to utilize recycled water in agricultural irrigation in Anza village, increasing public sensitisation of adjacent communities on recycled water use and the associated benefits will scale up Anza irrigation schemes.
- Innovative treatment and recycling systems should be employed to maximize an effective use of the recycled water in a zero-liquid discharge approach. It is important to underline the role of recycled water use to the Palestinian water sector since reuse will lower the increasing demand pressure on the available water resources. Finally, an efficient use of recycled water for different purposes will enable Palestinian communities to achieve water self sufficiency, independence and overcome the limited access to available water sources.
- Use of recycled water for arid land irrigation will reduce food insecurity and improve livelihood of farmers through cultivation of high price crops irrigate by treated effluent. Reuse of treated effluent will increase food productivity and efficacy by changing crop patterns into fruit trees, fodder and industrial crops.
- The limited access to water and land as well as urgent needs to protect the environment and natural resources were the main factors behind the decision for mechanised treatment systems rather than natural based technologies. This decision enhances the safe use of recycled water as a supplement to irrigation water in Anza village; a core element of an integrated water management plan.

Aside from the political constrains caused by the Israeli occupation, the problems of limited access to water sources and land scarcity will continue because of increased population growth, high living standards, and rapid urbanization. All this threaten the water supply in general and agriculture in particular and lead to both an increase in water consumption and pollution of land and water resources. Establishing sustainable sanitation facilities integrated with agro-ecological systems in Palestinian rural areas is the road map. Since public awareness campaigns and education are the foundations of sustainable wastewater treatment facilities, technical support, training and engagement of main stakeholders in a fair decision-making process ensure an enabling environment for food insecurity abatement and rural development in Palestine.

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