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THE ROLE OF SMALL SCALE WASTEWATER TREATMENT IN THE DEVELOPMENT OF WATER RESOURCES IN WEST BANK OF PALESTINE

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SUMMARY -There has been substantial developments in wastewater management and treatment technology worldwide during the past decades. Approximately 95% of the generated wastewater in the world as well as 93% in the West Bank is released to the environment without treatment. Wastewater has been identified as the main land based point source pollutant causing contamination of the marine environment. The increase in population and therefore in sewage production imposes a great challenge to develop and introduce sustainable sewage collection and treatment .The efforts in providing these essential services especially for poor regions of the world are hindered by the shortcomings of the current concept of water management and financial limitations. In Palestine, the only substantial water resources available are ground water. Presently the application of wastewater treatment is limited because of high cost and technology complexity of conventional systems. Seepage from domestic wastewater on-site cesspits, as well as inadequately performing off-site sewage treatment plants, demands that proper treatment should be applied at the household level to conserve the environment. Small-scale treatment plants can be effective in treating wastewater.
Palestine is suffering from severe shortages of fresh water caused by Israel's exploitation of Palestinian water resources. Predicted population growth and rise in living standards could further threaten water supplies. In light of this, wastewater is an invaluable resource that may successfully be used for irrigation upon treatment. At present, rural Palestinian areas dispose of the wastewater using cesspits, most of which have no cement base or liner allowing sewage to infiltrate into the earth, potentially polluting the ground water. Owners often avoid using the expensive services of the vacuum tankers to empty them. 12 % of Palestinian communities have wastewater collection systems while 43% of the population is connected to wastewater networks. These systems do not, however, exist in rural areas. Only one wastewater treatment plant is operating well. The uncontrolled flow of sewage causes many environmental problems and health hazards.
Collection of waste water and constructing large treatment plants might be difficult in Palestine due to the great capital needed as well as the need of large areas to locate treatment plants. In addition, constructing large treatment plants requires a large area located in the same region to be irrigated by the treated wastewater. Small-scale reuse of treated wastewater for agriculture would play a major role in increasing agricultural area in Palestine as well as help to conserve the environment.

PROBLEM DESCRIPTION

The rural population in the West Bank, constituting around 35% of its total population, lives in more than 450 villages. There are 53 localities that have wastewater collection in the West Bank, while the rest depend on cesspits and open channels. Most of Palestinian rural population depends on agriculture to make their living and is therefore in a good position to use treated wastewater. The wastewater collection component of this system accounts for 80 to 90% of the capital cost which makes it economically unfeasible for the dispersed pattern of houses in rural areas. As a response to such a situation, 'Small- Scale Wastewater Technology' could be the most appropriate solution to replace current cesspit systems in rural areas of the West Bank.

SMALL SCALE WASTEWATER TREATMENT PLANTS IN RURAL AREAS

Strategic planning and appropriate policy for wastewater management in rural areas does not exist despite the high population in these areas and lack of adequate sanitation. Recently, in 2003 the Palestinian Water Authority started to collect information on the type of the plants used in order to prepare strategy for small-scale plants**.** About 73% of West Bank houses have cesspit sanitation and approximately 3%, mainly in rural areas, lack any sanitation facilities. Several small-scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied. Most of the recently installed rural sanitation facilities entail trickling filters and natural treatment systems preceded by septic tanks.

The need for small wastewater treatment and reuse

Centralized sewerage systems, the preferred choice of planners and decision makers, are inadequately provided to individual communities. In some instances wastewater is transported from several scattered communities to centralized facilities. The high cost of conventional sewers is regarded as one of the major constraints to expanding wastewater services to small communities. A world Bank review of sewerage investments in eight capital cities in developing countries found costs range between us$600-4000 per capita (1980 prices) with total household annual cost of us$15-650.The conventional sewerage systems are more costly in small communities, because of their size and layout.). As example, the capital cost of construction wastewater treatment plant for ALBeireh city, with a population of 30,000, exceeds 15million USD

Treating wastewater at the house level will be cheaper and easier than at the municipal level. Municipal wastewater is more than twice as concentrated as wastewater generated by individual house systems and, in addition, contains industrial wastewater, which has adverse affect on treatment hence its reuse for irrigation. Most wastewater from centralized treatment plants cannot be reused due to the invariability of land in that region that can accommodate that wastewater.

In addition to the pollution of residential areas, the use of cesspits enhances pollution of groundwater. Agricultural reuse of wastewater at the household level will not require outside labor as any member of the family can work in the field any time (e.g. a student could easily manage the work after the school).

In terms of marketing agricultural products, the problem will be much easier since the landlord has to market small agricultural product and he can sell them in the same village easily.

On the other hand, treating wastewater at house level or even serving one small community will have the following advantages:

1. Easy to build, the owner of the house can build it (can be purchased as package i.e. just to install).
2. Cheaper, since the owner of the house can build it from his own resources while big treatment plant needs huge funding.
3. No need for external technical support.
4. Job creation for the family member.
5. Operation and maintenance since the family will cover all the operation cost, as well the cost is much less than the conventional plants which includes pumping cost, maintenance of the wastewater treatment plant and wastewater network.
6. It will act to increase public awareness, as all family members will be involved in the process.

Different types of small plants have been installed in the West Bank, including:

1. UASB (Up flow And Anaerobic Sludge Blanket)
2. Sequencing Batch Reactors
3. Contact Stabilization
4. Septic Tank-Anaerobic Filter

Table 1. Data Related to Existing Wastewater Treatment Plants in the West Bank

West Bank

Treatment Plant	Area served	Population currently Served	Capacity (CM/day)	Treatment type	Status (efficiency)	Disposal of effluent
Ramallah	60% of domestic wastewater/ Industrial in Ramallah city	39,950	1,276	2 Aeration lagoons Stabilisation pond	Badly managed and operated (5%)	Overflow pipeline discharged to Wadi Beituniya
Al-Bireh	Al-Bireh city, Al-Am'ari Camp, Madura CAAP/ Al-Vire Industrial Soné	41,347	3600	Extended aeration Sludge stabilization	Running well (95%)	Discharged to open Wades
Junín		17,765	1000	Three aeration lagoons	Not currently functioning (0%)	
Tulare	Tulare city, Tulare Camp, Nor Shams camp, 'Anabta, western outlet of Nablus system	115,443	5000	Three ponds - Primary Treatment (sedimentation and flocculation)	Overloaded (15%)	Effluent carried across Green Line into Israel where it flows to treatment plant
Hebron	East of Hebron City	0	6742	Two sedimentation ponds	Not currently functioning (0%)	
Deir Samit	Hebron District	500	35	Two sedimentation ponds Four reservoirs containing stones	Operating well (83%)	Effluent from reservoirs discharged to Wade Deir Samit Effluent form sedimentation ponds – collected in 50m^3 storage tank
Sarra	Nablus District	916	50	Subsurface constructed wetland	Not yet in service	Planned

Possible non-conventional water resources in Palestine:

Ground water is the only source for fresh water in Palestine. This water is extracted through wells and springs. Regarding non-conventional water there are two main possible resources:

1. Saline water: This can be either from springs and seawater

2. Treated wastewater**.**

Utilizing saline water for irrigation is unlikely due to the high cost of desalinization .In the case of wastewater it is easier and cheaper to reuse treated wastewater for irrigation: treated wastewater is potentially available in every district and major city. The total treated amount of wastewater available for reuse in Palestine (based on 2005 figures) is 109MCM compared to 137 MCM water consumed for domestic purposes (*Table 2*).

At present Palestine cannot utilize all of this potential wastewater due to the following constraints:

a- The occupation: constructing wastewater treatment plants requires approval from Israel; it is very difficult to get this approval

b- Capital needed: this is far beyond the capacity of Palestine. 93% of wastewater generated in the West Bank is untreated - there is only one functioning West Bank treatment plant (at Al Beirh). The cost of constructing a treatment plant for a city with a population of 40.000 will be in the range of 6-10million USD.

c- Technical problem. Due to the shortage of land and the absence of flat land it is very difficult to adopt waste stabilization ponds that capital and operation cost is kept to a minimum. If a sophisticated plant is to be constructed capital outlay including operation cost will be high which raises questions about the sustainability of plants.

Due to the factors mentioned above only 53 of 450 communities in the West Bank are served by wastewater collection: the majority of these communities are only partially connected. As for treatment, there is only one city that is served by an efficient treatment plant at Al Beirh. Other cities either lack such facilities or have completely non efficient treatment plant: these are in most cases only a series of unlined ponds. This implies it will be very difficult to implement wastewater collection for villages or remote dwellings: small treatment plants that can serve one house or group of houses, even a small village, will play a major role in treating wastewater and reducing environmental pollution, as well as increasing the amount of water for agriculture.

Table 2. Annual Wastewater Generation in the West Bank and Gaza Strip Districts

		Annual Wastewater Generation / Locality Type (MCM)			
District	Population (2005)	Urban Areas	Rural Areas	Refugee Camps	Total
Nablus	326,873	1.509808	2.153584	0.168608	3.832
Ram Allah	280,805	0.20904	0.340704	0.074256	0.624
Jericho	43,620	2.46636	2.195856	0.641784	5.304
Jerusalem	149,150	3.61088	4.15772	0.9114	8.68
Bethlehem	174,654	2.1852	1.4148	0	3.6
Jenin	254,218	0.424128	1.079872	0	1.504
Tubas	46,664	1.007136	0.73168	0.413184	2.152
Tulkarm	167,873	3.189032	5.56444	0.598528	9.352
Qalqiliya	94,210	2.2368	3.025272	0.329928	5.592
Sal fit	62,125	2.498816	4.184064	0.58112	7.264
Hebron	524,510	8.11504	3.657824	0.339136	12.112
West Bank	**2,124,702**	**28.02747**	**28.1475**	**3.841024**	**60.016**
Dear Al-Balah	201,112	1.439	0.142	3.017	4.6
Gaza	487,904	22.76	0.5	4.81	28.01
Khan Yunis	269,601	4.78	0.75	1.18	6.72
North Gaza	265,932	4.58	0.26	2.45	7.3
Rafah	165,240	1.366	0.30	1.62	3.3
Gaza Strip	**1,389,789**	**34.925**	**1.952**	**13.077**	**49.9**

(Source: Arij 2006)

Role of the Palestinian Water Authority:

The PWA needs to announce policies as regards its regulation of work and should seek understand how it can benefit from each cubic meter of treated wastewater. The PWA is in the progress of preparing policies in this field, where cooperation between parties such as Ministry of Agriculture and Environment Authority is necessary.

Technical management for safe reuse of treated waster

Wastewater is considered as an important potential water resource in Palestine. Hence, all efforts should be put into projects associated with the reuse of wastewater for agriculture.

According to the 2002 law No.3 the PWA is responsible for wastewater treatment and reuse. The main aim of the PWA is to set policies for solving the problems caused by wastewater and to make use of the resultant potential sources through proper planning, design, implementation, and management of the sector, stressing the interdependence of water supply and sanitation services.

PWA has developed policies and Strategies for wastewater treatment and reuse

Waste water treatment policy:

1. Treatment plants must be signed to solve identified and potential environmental and health problems from existing and future wastewater production.
2. Industrial connections must not create environmental problems or cause problems with water treatment at plants.
3. All wastewater treatment plants must operate in accordance with permits from secured.
4. Wastewater treatment plants must be designed according to PWA regulations or document that demands will be fulfilled.
5. Treatment plants designed for less than 50 persons must be of a kind accepted by PWA and operated according to regulations
6. The potential energy in wastewater and sludge must be utilized whenever appropriate
7. Farmers should be involved in small wastewater energy recovering projects

Wastewater reuse policy

1. Treated wastewater is a valuable resource that must be utilized in an optimal way
2. Agriculture is given priority in wastewater reuse
3. Reuse of treated wastewater is to be performed in an environmentally and healthy way
4. Use of treated wastewater should be co-ordinated on a national level and carried out at the appropriate local level
5. Public participation in wastewater reuse should be encouraged
6. Use of raw wastewater is considered as pollution
7. Cost/beneficial options should be considered for the optimal use of the treated effluent

Waste water reuses strategy:

1. Establish planning tools for reuse and recharge
2. For every reuse project beneficiaries (farmers) must be involved in all project phases
3. Reuse projects must undergo an environmental impact assessment
4. Use of treated wastewater should be coordinated on national level and carried out on the appropriate local level
5. Public

Wastewater reuse action plan:

1. make technical guidelines for reuse for different purposes
2. make standards for monitoring and documentation of reuse
3. make overall plans for reuse in different sectors
4. Planning Guidelines for reuse (public involvement, cost/benefit calculations, post treatment, etc)
5. Make a checklist for the content of the EIA-reuse element
6. Make an overall plan for education and training of staff and management for reuse
7. Arrange training programmed and campaigns
8. Create incentives to avoid pollution

9. Implementation of the control and fine systems
10. The reuse plans must include how to utilize treated wastewater in wintry seasons and if the effluent quantity drops below demand
11. Co-ordiate the reuse policy with the agriculture policy

MEASURES TO BE TAKEN IN ORDER TO MINIMIZE HEALTH RISK

Wastewater should be used for irrigation safely and economically. National regulations for the use of treated wastewater stipulate that it is forbidden to grow crops that are to be eaten raw on treated wastewater. In the case of small plants it is very difficult to monitor these individual projects, in this case strict laws should be issued in order to insure safe reuse and minimize the risk of contamination. Monitoring these projects should be coordinated between the ministry of local government and the local council.

Public awareness programmers should be adopted in order to reduce the associated health risks. Stakeholder participation should be insured in the planning and implementation of the projects.

For these projects to be sustainable and safe, the following guidelines should b adopted:

1. It is forbidden to irrigate any crop that can be eaten raw.
2. Drip irrigation or subsurface irrigation should be used to prevent spray contamination
3. All crops to be eaten should be those which grow away from the ground (eg cabbage) Crops with extensive ground cover should be avoided.
4. Priorities should be given to trees especially olive, citrus, jojoba, nut tress, flowers, producing of seedlings etc.
5. Sprinkler and surface irrigation shouldn't be used
6. Vaccination: all whom will work in the project should be vaccinated
7. Fodder crops should be encouraged.
8. The treatment plant should be efficient if monitored regularly.
9. Public awareness and training of farmers as well as educational leaflet distribution to promote safety measures e.g. wearing boots and gloves, no smoking or eating during working with wastewater, washing hands and face with soap and water after work, cover all exposed wounds with a sterile dressing…..etc
10. Monitoring from local authorities (village council as example) should be implemented. Inspectors from local council can inspect farms easily by just looking at fields. Monitoring the irrigated crops should be at the field level since it is very difficult to monitor the products beyond the farm.
11. Fine systems to be applied and the village council have the right to destroy the entire field that didn't follow these regulations on the account of the farmers.
12. Industrial crops, table grape as well as fodder crops to be grown
13. Incentives should be given to the active farmers in order to encourage the others using treated wastewater safely for irrigation and reserve fresh water for domestic use.

Farmers should contact their doctor in case of:

A-persistent stomach aches, diarrhea and bad digestion
B-symptoms of worm infection such as itching skin around the bottom or worm traces in excreta.
C-chest problem, especially if they come with asthma or lung inflammation
D- Regular checkup at least once yearly

Table 3. Recommended guidelines by the Palestinian standards Institute (www.psi.gov.ps)

Effluent parameter (mg/l)	Fodder irrigation		Gardens playgrounds	Industrial crops	Groundwater rechargeable	Landscapes
	Dry	wet				
BOD_5	60	45	40	60	40	60
COD	200	150	150	200	150	200
DO	> 0.5	> 0.5	> 0.5	> 0.5	> 1.0	>0.5
TDS	1500	1500	1200	1500	1500	50
TSS	50	40	30	50	50	50
PH	6-9	6-9	6-9	6-9	6-9	6-9
NO_3-N	50	50	50	50	15	50

Contamination of Water Resources

Contamination of groundwater aquifers and springs as a result of wastewater percolation is a serious problem in several areas of the West Bank. Pollution of springs has been identified in all district (*Table4*).

Table 4. some major cases of spring pollution by wastewater in the West Bank

District	Villages where contamination of springs occurred
Ram Allah	Beittin, Al-Janiya, Silwad, Yabroud, Deir Jarir and Abu Shkheidem.Sinjel
Bethlehem	Aortas, Wade Foqin, Nahhalin and Battir.
Hebron	Beit Ummar, Halhul, Nuba, Kharas, Sa'ir, Kharsa
Jenin	Nothing specific was mentioned.
Tulkarm	Jaiyus, A'zoun, and all villages who receives water from A'zoun well
Nablus	Burin, Ijnesiniya, Yatma, Jit, Abalone, Es Sawyer and Odla.Jourish
Jericho	Aluja,AlQilt

Source: ARIJ survey, 2006.

The groundwater in the West Bank is vulnerable to pollution from sewage streams and from wastewater disposed of through cesspits. Indicators of pollution appear as nitrate concentration increases in groundwater. Testing of groundwater samples conducted by ARIJ has shown levels of nitrates in some areas of the West Bank to exceed the permissible level (45 mg/l). This increase in nitrate concentration could be as a result of wastewater percolation into the ground or due to the extensive usage of fertilizers.

Another problem associated with the percolation of wastewater into the ground is the pollution of rainwater collection cisterns. This source of water is the main source of drinking water in many Palestinian villages. Pollution may occur especially when cisterns are located a few meters from cesspits and in a location below cesspit level.

One of the main concerns of the Palestinian municipalities is to limit the pollution of the underground aquifer, the only source of drinking water. Groundwater pollution has been found in Ish Al-Ghorab well in Beit Sahour. Accordingly, the WSSA, in order to protect the groundwater, has ratified a law to connect homes with the new sewage network instead of using cesspits. They have also suggested the introduction of septic tanks to replace cesspits in areas where there is no plan to extend the sewage network.

The locally ***small scale wastewater treatment technology*** can be successfully used at the household level for wastewater disposal and treatment**.** The implementation of such units have many positive impacts on the natural environment by 1) improving the management of wastewater

treatment and reuse at the household level, 2) protection of surface and groundwater from potential contamination, 3) increase the agricultural area by utilizing the reused water in irrigation of gardens, 4) limit health hazards as a result of illegal discharges of raw sewage.

Table 5. Water Consumed and wastewater generation in the West Bank Districts Only from the localities that have water network (2003)

Governorate	Water Consumed	Wastewater Generated	No. of Communities Served By Sewage network
Nablus	8683827.4	4385597	10
Ram Allah	8949008	4213317	8
Jericho	2305506.8	1131864	1
Jerusalem	6209705	2863506	7
Bethlehem	5213582	2504936	8
Jenin	3557146	1764525	3
Tubas	657914	325759	1
Tulkarem	5051148	2507316	5
Qalqilia	288252	1386579	3
Salfit	1480331.6	715790	1
Hebron	8384567	4108955	6
West Bank Total	50280988	25908144	53

Source: (PWA 2003, Arij 2006)

Only 7% of the wastewater in the West Bank is treated, despite the fact that approximately 36.39% of the West Bank population is served by sewage networks (PCBS 2002, Arij 2006). This implies that 93% of the generated wastewater in the West Bank is disposed to the natural environment without treatment. When this wastewater is disposed of without treatment, the ground water and aquifers are polluted. Clear examples of that are: Irtas spring in The Bethlehem district, Sinjel spring in Ramallah district, as well as Alzbeidat ground water well in Jericho district. In addition, flowing raw wastewater is considered a potential source of water born disease. At Al-Aroub refugee camp wastewater is flowing in open channels crossing through Shuyokh Alaroub dawn to the wadi.

Health Pressure

Since most wastewater is either collected in cesspits problems arise in the wet season when these as well as open channels overflow into the streets. Due to these problems it is worried that conditions at, for example, Al-'Aroub refugee camp and Shyokh Al-'Aroub village, are a source of spreading diseases and insects.

With respect to public health, there are frequent outbreaks of diarrhoea in the West Bank. Data indicates that 600 of 2,721 water samples failed to meet WHO bacteriological guidelines for drinking water (Ministry of Health, 2001). Only three of all the samples tested showed no signs of coliform bacteria, and 50 % should not be used for household purposes without treatment.

In January 2003, in North Gaza alone, 182 new cases of airborne diseases and 231 of diarrhoea in children under 3 years age were reported–little additional data on diseases exists for Gaza.

Nitrate concentrations have been shown to exceed WHO guidelines in 50 % of samples collected from domestic municipal wells (Rishmawi,2004) – causing “blue baby syndrome”. Parasites and helminthes transmitted by mosquitoes as well as skin infections and allergies are also common.

The 2002 study by Arabtech Jardanah (consulting firm located in Ramallah) indicated that UNRWA clinic in the Al-'Alaroub refugee camp treats about 10 cases per day related to untreated sewage, with diarrhoea representing 5% of the daily cases treated by the clinic. One of the other major diseases in the study area was Leishmanias; this as a result of insects able to multiply rapidly in

stagnant sewage. At Shyoukh Al-'Arroub and Irqantrad those seeking medical assistance often used different private or public sector health centers increasing the difficulty of effective data collection, hence a complete record of the types of diseases is not available.

Another example is Alzbeidat village in the Jordan valley (Jericho District), where the people used to depend on a polluted well for their domestic needs. The well was polluted as a result of wastewater seepage from cesspits, the water of which has been the cause of skin rashes among the residents until they stopped using it for drinking purposes. Water is now imported from a nearby settlement which implies additional cost for the villagers.

It is also important to mention that the Betir Village, (Bethlehem District) also faces the danger of diseases associated with untreated sewage. The rocky nature of the village's land rendered the population living at the bottom of the village exposed to sewage contaminated rock surfaces as a direct consequence of sewage seeping from cesspits located at a higher level.

Flooding of Wastewater into the Ground Surface

Frequent flooding of wastewater from cesspits and open channels, especially during the winter season, is a major environmental and health threat. The accumulation of wastewater in open areas potentially leads to the transmission of infectious disease and the release of foul odor. This scenario is repeated in most Palestinian villages and refugee camps in the West Bank. Flooding of cesspits and open channels is common too, and in some cases one locality may affect another locality as is the case of Al-Jalazone refugee camp and Jifna village in the Ramallah district where Jifna village has been suffering from wastewater overflow from Al-Calzone refugee camp, creating wastewater ponds, and damaging crops and agricultural lands. Due to lack of proper infrastructure, incomplete regulations, standards, and enforcement all types of wastes are released untreated into the environment.

As is important to mention, flooding of wastewater from cesspits and open channels is not the only source of pollution to the ground surface. The irresponsible behavior of some citizens, disposing of their sewage by installing a submersible pump in their septic tanks and disposing its effluent freely to the surroundings is another source of pollution to the ground surface.

Fig. 1. Betir infected rocky surfaces due to sewage that seeps from cesspits located at higher levels (Source: Arij, 2005)

Ground Water Pressure

Ground water in wells, springs and volumes of retained water in aquifers, has represented the main source if not the only source of drinking water in the West Bank. The followings are some examples of the ground water pollution due to disposing of wastewater untreated to the natural environment:

- Sinjel spring in Ramallah district where the spring is completely polluted with wastewater seeping from the cesspits of the village.
- Irtas Spring in Bethlehem district. Where the spring has been polluted by sewage seeping from nearby cesspits.
- Alba than (Nablus district) springs and wells; these springs and wells are polluted from Nablus sewage that flows to the east of the town toward Alba than and wadi Alfaro.
- Ein Al-Qalt and Aluja spring in the Jordan Valley (Jericho District); these springs have been polluted from sewage that seeps from the neighboring mountainous areas.
- Ein Areek Eltahta spring in Ramallah district is another example.

Treated Waste Water to be used as Supplementary Irrigation to Enhance Sustainability of Agriculture

Treated wastewater can be used for irrigation in west –bank by the followings methods:

1. Reusing of the treated wastewater for irrigation as the only source of irrigation water. This can be in small-scale village scale or region (waster water is collected from several communities) and reused for irrigation
2. Supplementary Irrigation: here in this case treated wastewater can be applied as supplementary irrigation where plants are already planted in the area.
3. Treated wastewater can be reused in small scale systems at the household level (home garden) especially in villages, towns and remote houses. Treated wastewater can be used alone as the only water source, or rainwater can be collected and used either separately or mixed with treated wastewater.
4. Gray wastewater can be treated and recycled for use in toilet flush in order to conserve using fresh water for this purpose

Table 6. Al Bireh Pilot Plant (Using Treated Waste Water for Irrigation)

Kind of Treatment		Crop Type	Production kg / dunum Seeds	Straw
Irrigation Fertilizer	with	Wheat 870	687	1375
Irrigation without fertilizer			656	1332
Rain fed Fertilizer	with	Wheat 870	537	1187
Rain fed Fertilizer	without	Wheat 870	500	1031
Irrigation Fertilizer	with	Wheat Amber	864	1656
Irrigation Fertilizer	without	Wheat Amber	824	1212
Rain fed Fertilizer	with	Wheat Amber	600	1000
Rain fed Fertilizer	without	Wheat Amber	236	336

Source: ANERA files

Home gardens and reusing treated wastewater for irrigation as a mean of enhancing sustainable agriculture.

Nowadays there is a move toward small-scale wastewater treatment systems, where small treatment plants conserve one or a group of houses. This plant can treat either black wastewater or gray wastewater. In the case of gray wastewater, the treatment needed is much less than black wastewater and **different** crops can be irrigated easily and safe. Treating the gray water will be cheaper and securing effluents that meet safe standards will be easier.

In Palestine, especially the rural areas, the wastewater from each house or group of houses can be treated, and can be stored and reused in the garden in order to provide food for the people as well as create jobs.

Another additional benefit of treating wastewater and its reuse is the reduction in cost with loss of the need to empty them. A reduction in cesspit/septic tank seepage pollution is another benefit. In addition more fresh water will be available for domestic purposes.

In this case, the combination of rainwater harvesting from the roof of the house with the treated wastewater and use it for irrigation will play a major role in providing the following:

1. Provide rainwater for irrigation i.e., water free from salts and organic matter.
2. Reduction of wastewater impact on the crop, soil and human being i.e., leaching the salts.
3. Expand the potential for crop selection where in this case most of the crops can be irrigated.

Another advantage of home garden (small scale treatment plant) that planting can be practiced in the entire West Bank region (Jordan valley, mountains), as well during the entire year (summer and winter).

Table 7. Average production of agricultural crops from the year 1988-1994 according to the statistics of ministry of irrigation

Crop	Planted area 1000 dunam	Production ton/year	Consumption ton/year	Production %
Wheat	170	23,800	300 000	7,9
Barley	140	21000	108 000	19,9
Pease	29	2320	11885	19,5
Alfalfa_animal feed	26	15600	1110 000	14

Strategic Options According to the Palestinian Environmental Strategy

Wastewater management has been identified as the most urgent element in the Palestinian Environmental Strategy (PES). The strategy calls for establishing an effective wastewater management system that considers the following measures: (Ministry of Environmental Affairs, 2000)

- Rehabilitation of existing wastewater treatment plants and/or construction of new plants based on maximization of capacities in order to minimize the number of plants required
- Maximizing coverage of households' connections to the sewer system;
- Considering alternative collection and disposal measures for areas where the construction of sewage networks is unfeasible
- Developing regulations for treatment or disposal of sludge that is generated by wastewater treatment plants
- Enabling an acceptable quality range of influent wastewater, so that treatment plants will be able to treat wastewater effectively
- Industries have to undertake on-site pre-treatment measures to comply with the treatment plants specifications
- Developing guidelines and specifications for the wastewater treatment technologies and locations
- Establishing a cost recovery system.

ARIJ EXPERIENCE IN SMALL SCALE PLANTS

ARIJ has engaged in implementing 3 units of small scale plants to test their efficiency and performance. It was found that their performance was acceptable as seen below. Furthermore the operation cost is also acceptable

Quality of the treated effluent

Selected parameters were analyzed to study the efficiency of the small scale wastewater treatment system, and whether if this effluent is suitable for irrigation purposes. These parameters are the Biological Oxygen Demand (BOD_5), the Chemical Oxygen Demand (COD), the Total Suspended Solids (TSS), the Ammonium Nitrogen ($N\text{-}NH_4$), and the Total Phosphorus (TP). These analyses were carried out in the Biological and Chemical Analysis Center of Al-Quds University. The quality parameters of the effluent are given in *Table 8*.

Table 8. Effluent quality of locally small scale wastewater treatment system

Effluent parameters	Concentration (mg/l)	
	Sample1	Sample2
BOD_5	15	15
COD	27	17
TS	653	651
TSS	173	171
PH	7.1	7.1
$N\text{-}NH_4$	4.6	4.1
TP	5.08	5.23

According to the Palestinian Standards Institution for treated wastewater characteristics (shown in Table 3), the results of effluent parameters show the quality of treated wastewater from a small-scale wastewater treatment unit to be acceptable for garden irrigation purposes with no hazardous impact. However, the TSS concentrations are generally high according by Palestinian standards. Furthermore, by WHO standards, the effluent quality is acceptable for irrigation purposes, except for the TSS which is high, particularly when drip irrigation is used.

RESULTS of ARIJ SMALL SCALE PLANTS

The results of the small-scale plant installed by ARIJ are encouraging where effluent BOD5 didn't exceed 23mg/l during the first year of operation. At $0.3usdollar/cubic meter operation costs are reasonable and should be accepted by house owners.

CONCLUSION AND RECOMANDATION

1. Current available water is not enough to meet the demand for both domestic and agricultural purposes.
2. Wastewater collection by networks from individual houses and treatment is highly needed in covered by wastewater collection. So small treatment plants can play a major role in covering this gap and preserve the environment
3. Proper planning of wastewater collection and treatment should be done to achieve sustainable wastewater treatment plants.
4. Planning for centralized treatment plants should take into consideration the topography of the area in order to avoid unnecessary pumping. All of the West Bank should be treated as one unit without separation between the districts.

5. It seems that implementing waste water collection and treatment for all of the communities is very difficult, furthermore covering the rural areas seems to be impossible due to the huge capital needed as well as due to the permits needed from Israel.
6. Collecting wastewater and treating it at the household level or even at that of the small community will be efficient for its reuse in irrigation
7. Reusing the treated wastewater in the home garden will be economical and highly feasible as a source of water for irrigation. Even on the village scale, waste water can be collected, treated and reused for irrigation
8. Reusing of treated wastewater on a large scale can also be used for irrigation if treatment can be secured.
9. The Palestinian Water Authority as well as ministry of agriculture should plan for using treated wastewater for agricultural purposes at all levels. All of the parties should cooperate in order to make wastewater treatment a success, since any deviation is likely to result in further environmental and heath problems.
10. Palestinian authorities should implant public awareness programs for residents as well as for the local authorities
11. The Palestinian Water Authority should prepare plans to utilize all of the treated waste water for irrigation either on a small or large scale according to the prevailing conditions, e.g. taking into consideration the economic issue, and the suitabliity of the land to be irrigated with treated water.
12. Reusing treated wastewater at the household level will be cheaper since there will be no need for collection and pumping. As well as this treated wastewater will be reused for irrigation at house level

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