

Protection of Groundwater Resources by Grey Wastewater Management and Reuse

"When Conventional Wastewater Management is not Affordable"

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Abstract

There are 297 natural springs in the West Bank which provides around 60 million cubic meters per year of drinking water (PWA). Most of these springs are polluted by septage. Given the severity of water shortage in the area, springs serve a dual purpose of domestic and irrigation use. Al- Zaitunatah with 6,500 inhabitants reported shortage of water supply especially in summer and pollution of local water resources (two springs). Water provided by tanker trucks costs up to NIS180 (42 US \$) per 5m³, a price that 90% of Al-Zaitunah residents cannot afford. With Mekerot (Israeli water supply company) reducing the water supply to the village, especially during summer season, the village council's record has shown that the average liter/capita/day for domestic water consumption (drinking, cleaning, cooking and house gardening) is 40 l/c/d, which is dramatically below the WHO recommendation of minimum 100 l/c/d for domestic use. A large number (about 90%) of Al-Zaitunah residents who cannot afford buying tanked water have to depend on two contaminated springs (Krekeh & Al-Balad, with summer discharging capacity of 5 cubic meter / hour) as their main source of free of charge drinking water, ignoring the health hazards that may result from these contaminated springs. The two springs are heavily polluted by wastewater infiltrated from neighboring household cesspits and the surrounding environment, causing an urgent public health problem that requires prompt intervention. To avoid health hazards caused by using polluted water for household purposes and to protect Palestinian Israeli shared groundwater, the two springs needed to be protected by eliminating the sources of pollution. In addition, to alleviate the impact of scarce water supply in summer and ensure minimal waste and appropriate management of this natural resource, safe storage of water through the construction of a 150m³ cistern was made. Water diseases prior to the project intervention were registered where few Hepatitis cases and so many Ameba cases were witnessed specially within poor families of the town. The village council as well as national concerned authorities can't afford costly

centralized wastewater management which will lead to local water resources and environment protection. The construction of one low cost and easy to construct and to operate grey wastewater treatment plant serving seven families (50 people) combined with two modified cesspit tanks for the treatment of black wastewater was implemented with USAID financial support as technically and financially affordable solution which aims to protect available water resources and human health as well as to provide additional non conventional and culturally accepted water resource, existing cesspits which represented for many years a source of pollution to the environment and to the springs and on which the above seven families relied for years were demolished, the two springs are now safe and connected with a 500 meter pipe line (4 inches) which is finally connected to a 150 cubic meter storage reservoir, night flow is collected and surplus drinking water is used also in irrigation where extra 200 donums are now cultivated with vegetables and trees. The decentralized wastewater management consisting in grey wastewater treatment plant combined with modified cesspit tanks represented a solution to a local chronic and shared ground water pollution problem, poor residents of Al Zaitunah are enjoying safe drinking water at almost zero cost, human health is protected and reuse of treated wastewater by the seven families is socially and religiously accepted where reuse is limited to only grey treated wastewater (80% of total produced wastewater), the religious negligence of reusing treated wastewater by Muslims is due to the concept of Najasah (impurity), this impurity is intended by Muslims to be in the black wastewater which we did not reuse. The adopted grey wastewater treatment system (shown below) is continuously monitored where influent and effluent are analyzed, operation and maintenance is continuously assessed and, social impact is monitored. The main goal of the paper is to assess and present the possibility of using a low cost, efficient and culturally accepted grey wastewater management system which represents an affordable tool to protect large part of Palestinian - Israeli shared aquifer and environment.

Key Words: Palestinian – Israeli shared ground water, protection of water resources, protection of human health, low cost technology, cultivation of extra land, reuse in irrigation,

Najasah in Islam, Analysis.

Introduction:

Many communities living in the rural areas of the West Bank are unable to access sufficient quantities of water to adequately meet their daily needs. Rural water networks supplied by Mekorot (the Israeli water carrier) are old and are interrupted for consecutive months; particularly during the seven months summer dry period. Rain water which is collected in winter and stored in wells usually finishes within few weeks, which requires the population (especially the poor families) to completely rely on tankers, agricultural wells and on spring water. Communities who can no longer afford the price of tanked water during these periods of shortage are forced to rely on other sources of water, which are often contaminated by sewage water disposal and over use of fertilizers and pesticides. At the same time, as more and more groundwater wells are being controlled and seized by the Israeli government, and digging of new ones in the Palestinian territories is almost forbidden, the water resources available for Palestinians are becoming more and more limited as their demand on fresh water is increasing including springs, which are an important source of fresh water that is still available to Palestinians. However, the lack of wastewater disposal systems in the West Bank in general and at Ramallah and Al-Bireh directorate in particular is a major source of pollution to this water resource, mainly due to leakage from sewage networks and cesspools. This has contributed to spreading epidemic diseases during the last few years including Hepatitis A. In addition to cesspools, people in rural areas use other facilities such as septic tanks, cesspits or small-bore sewer, which dispose their wastewater into the ground, as in the case of Al-Zaituna. Al-Zaitunah city is considered as one of the most marginalized towns in the central area of the West Bank, which suffered from a continuous deterioration in economic conditions in recent years. This is evidenced in the very low quality of public services provided and the lack of infrastructure development projects especially during the last four years. Currently, Al Zaitunah municipality depends mainly on funds allocated by the Ministry of Local Government, which in turn depends on irregular external funding sources, to sustain the minimal provision of public services. Water provided by tanker trucks may cost up to NIS 180

per 5m³ or NIS 35 per cubic meter , a price that more than 90% of Al-Zaitunah residents cannot afford. With Mekerot reducing the water supply to the village, especially during the summer season, the village council's records have shown that the average liter/capita/day for domestic water consumption (drinking, cleaning, cooking and house gardening) is 40 l/c/d, which is dramatically below the WHO recommendation of 100 l/c/d for domestic use. A large number (about 90%) of Al-Zaitunah residents who cannot afford buying tanked water have to depend on two contaminated springs (Krekeh & Al-Balad) as their main source of free of charge drinking water, ignoring the health hazards that may result from these contaminated springs. The two springs are heavily polluted by wastewater infiltrated from the neighboring household cesspits and the surrounding environment, causing an urgent public health problem that requires prompt intervention. To avoid health hazards caused by using polluted water for household purposes, the two springs need to be protected by eliminating the sources of pollution. In addition, in order to alleviate the impact of scarce water supply in summer and ensure minimal waste and appropriate management of this natural resource, safe storage of water through the construction of a 150m³ cistern is envisaged. The objective of the paper is to assess and present the possibility of using a low cost, efficient and culturally accepted grey wastewater management system which represents an affordable tool to protect large part of Palestinian - Israeli shared aquifer and environment and to protect the population against health hazards.

Methodology:

"Polluted Springs causes health hazards":

The population of Al Zaitrunah (6500 inhabitant) are living the same conditions of all other rural population of the West Bank, they are unable to access sufficient quantities of water to adequately meet their daily needs. Drinking water supply is interrupted for consecutive months; particularly during the six months summer dry period. Rain water collected in winter and stored in wells usually finishes within few weeks, which requires the population to completely rely on tankers and the poor on spring water. The village council's records have

shown that the average liter/capita/day for domestic water consumption (drinking, cleaning, cooking and house gardening) is 40 l/c/d, which is dramatically below the WHO recommendation of 100 l/c/d for domestic use. A large number (about 90%) of Al-Zaitunah residents who cannot afford buying tanked water have to depend on two contaminated springs (Krekeh & Al-Balad) as their main source of free of charge drinking water, ignoring the health hazards that may result from these contaminated springs. The two springs are heavily polluted by wastewater infiltrated from the neighboring household cesspits and the surrounding environment, this was proved by analysis made by the laboratories of the Palestinian Ministry of Health (MoH) where it showed too many fecal coliform to count and 150 ppm of Nitrates causing an urgent public health problem that requires prompt intervention. Given the severity of water shortage in Al Zaitunah, the above springs serve a dual purpose of domestic and irrigation use. The poor population not affording buying tanked water in summer is obliged to drink polluted spring water. 18 cases of Hepatitis A have been registered within poor family members who are using Krekeh and Al Balad water for domestic use. More than one third of Al Zaitunah population is suffering from ameba.

The Municipal Council of Al Zaitunah is suffering shortage of financial resources where it has not the possibilities to implement a proper centralized wastewater management scheme in order to protect it's community from health hazards and in order to protect ground water resources from pollution, this is a typical situation in all rural areas of the West Bank (WB). In addition, the Palestinian National Authority (PNA) is also suffering shortage of financial resources and can't provide an adequate central wastewater management scheme to the Palestinian rural population which constitutes 60% of the total Palestinian population.

Action and criteria:

To avoid health hazards caused by using polluted water for household purposes, and to contribute to the protection of the Israeli Palestinian shared ground water source the two springs need to be protected by eliminating the sources of pollution. Since there is no possibility to provide a centralized WW management scheme due to its high cost, then a non conventional, efficient, low cost and socially accepted scheme must be introduced. In addition, to alleviate the impact of scarce water supply in summer and ensure minimal waste and appropriate management of this natural resource, safe storage of water through the construction of a 150m³ cistern is envisaged.

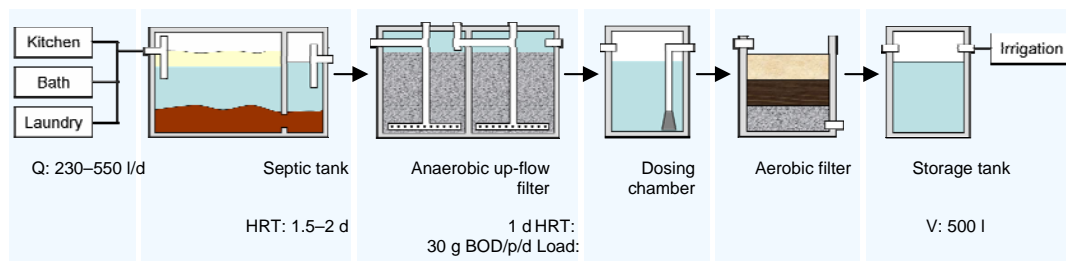
When Conventional Wastewater Management is not Affordable:

In the absence of a centralized WW management solution where it is not economically nor technically affordable, the introduction of a decentralized WW management scheme is the optimal solution where it was applied in a limited area which was causing ground water pollution and consequently threatening the health of the population especially the poor. The proposed WW management scheme was a house hold WW management scheme where grey wastewater was separated from black WW at a house hold level and separately treated. The separation of grey and black WW was intentionally made and aiming to achieve community acceptance of reusing treated WW in agriculture and to provide a low cost operation and maintenance scheme as well as to achieve high quality effluent. Contrary to many critical literatures and to the opinion of many critics who states that the motive for grey waste water management in low- and middle-income countries relates in most cases to freshwater saving and cost reduction due to less frequent desludging of septic tanks where It seems that health aspects and environmental protection play only a secondary role, the introduction of the decentralized WW management scheme in Al Zaitunah had the main goal of protecting the health of the population and the environment and in a secondary place the provision

of unconventional source of treated grey wastewater to be reused in agriculture.

Description of grey wastewater treatment :

The grey wastewater is treated in a plant consisting of a simple screen, a septic tank, two anaerobic up-flow filters in series and a vertical-flow aerobic filter. The grey wastewater flows by gravity through bar screens into a septic tank with a hydraulic retention time (HRT) of 1.5–2 days. The water passes through a T-shape pipe into a two chambered up-flow anaerobic gravel filter. The void space for the two chambers is 40% and 50%, respectively. The organic loading rate of the anaerobic filter is 30 g BOD/p/d and the minimum HRT is one day. The anaerobic filter works at maximum flow at day hours and zero flow at night hours. Water from the subsequent dosing chamber is pumped (submersible pump, 0.6 kW) onto an aerobic filter consisting of three layers (sand, coal, gravel). Treated grey wastewater is stored in a 500 litres plastic tank and used for irrigation.



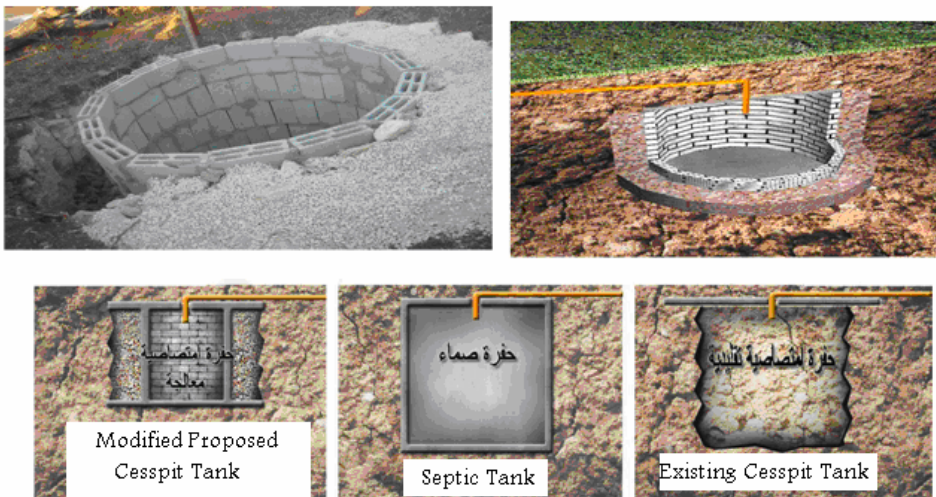
In Al Zaitunah three neighboring improperly constructed cesspits causing the pollution of the spring have been demolished, one grey WWTP plant was built instead which consists of two treatment systems; one for the black WW, and another for the grey WW. The first is used to treat the black WW through connecting the WC flow of each of the three neighboring buildings through a 4 inches galvanized steel pipe to a treatment pit; a 12m³ circular masonry block tank, surrounded by gravel, where the black waste water is treated and safely discharged to the sub soil. The second treatment system is for the grey wastewater collected from the kitchen, shower, washing machine and sinks' discharges of each of the three neighboring buildings. This

grey WW is biologically treated in a treatment plant consisting of a simple screen, anaerobic pond, first gravel filter, second gravel filter, balancing tank, aerobic filter. WW flows by gravity into the treatment plant through bar screens which is manually cleaned, flow passing through the manual screen enter the anaerobic pond, where the solids settle down, the grease and foam settle up on the surface, in addition to the separation of grease and solids, anaerobic treatment takes place where decomposition of biological and chemical pollutants takes place. In the first gravel filter (containing stones with size from 2-3 cm) decomposition of more pollutants takes place, the bio-film created on the media is containing huge numbers of bacteria which is treating the pollutants in the grey wastewater, connection of these tanks is made through pipes. The second gravel filter contains stones of dimensions (0.5-1 cm) where further anaerobic treatment takes place. The last compartment is used for the sake of treated water storing which is pumped via a small submersible pump (3/4 horse power) to the aerobic filter composed of gravel, carbon and sand strips. Finally the treated grey water is stored in 0.5 m³ plastic tank ready to be used in irrigation of no edible crops.

Description of black wastewater treatment:

The modified cesspit tank for the treatment of black wastewater has proven efficiency in the treatment of black wastewater in many parts of the Palestinian Territories; it is more than 10 years that the first modified cesspit tank is constructed, till this moment not any inconvenience had been indicated. The modified cesspit tank works as follows: Black waste water (50% organics), falls down from a pipe collecting black wastewater from the toilet; this black wastewater is one fifth of the daily per capita water consumption and only 10 liters of black WW per capita per day is produced in the rural areas, the average number of Palestinian family is 7 persons. Each house hold produces around 70 liters per day of black wastewater. 2.5-3 liters of the above black wastewater

are feces with certain concentration of solids, it settle down at the bottom of the modified cesspit tank which is concrete and completely water proof, mean while solids settle down water flows over and after around one month and a half black wastewater starts infiltrating among the voids (between the bricks) and flows out side the cesspit tank toward the stone filter, for the first 50 cm of the filter it is subject to aerobic treatment, then for other 50 cm it is subject of an oxic area, at the same time and after a start up period of about one month depending on few parameters such as temperature etc a biological film is build around the bricks where bacteria (likes biological films) starts also to work prior of the first 50 cm of the filter. In addition to certain biological treatment of the black WW in the first one meter of the modified cesspit tank there are other three stages of biological treatment. In addition black WW flowing through the gravel filter is infiltrated where suspended organics and solids are infiltrated by the filter, at this stage black WW is only one meter below ground and it is treated and in small quantities.



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 Scheme and Photo Prepared for Al Zaitunah Project, RAFEED, USAID

Treated WW flowing slowly out of the filter is adsorbed by the soil where it is treated further. Plantation having shallow roots and requiring water is recommended to be planted around. The modified cesspit tank is circular and two meters deep, has a

diameter of two meters, the first meter (counting from the bottom) is completely water proof, the second meter deep is build out of bricks having small voids, the tank is finally ceiled wit a normal concrete ceiling. Around this chamber there is one meter wide filter (crushed stone filter) and for the total depth of the chamber.

Performance of the grey WW treatment plant:

Analysis of the grey wastewater from the plant showed very high COD and BOD5 In the influent of 1,270 mg/l and 590 mg/l, respectively.

Parameter	Unit	Result
pH	–	7.2
COD	mg/l	125
BOD ₅	mg/l	45
TSS	mg/l	70
NO ₃ -N	mg/l	23
PO ₄ -P	mg/l	47
Fecal coliform	number	0.0

Effluent characteristics

Project Description and Implementation:

The project included building one grey WWTP, two modified cesspit tanks, 2000 m² of access roads to guarantee easy and safe access to the springs, a 150 m³ water storage reservoir, and the polluted springs are protected and rehabilitated. In addition, 500 m closed water pipeline connecting the two springs to the reservoir was installed. Training of farmers, plant owners and Municipal officials on construction, operation and maintenance and on reusing of treated grey WW in agriculture was also made.

A. Wastewater treatment Plants Construction. The three neighboring improperly constructed cesspits were demolished, and one WW treatment plant was constructed

instead. The plant consists of two treatment systems; one for the black WW, and another for the grey WW.

B. Access Roads Rehabilitation. A 50 m long road which leads to the upper (Krekeh Spring) and a second 360 m long road , which is an access road to al Balad spring were rehabilitated. The first road was rehabilitated to allow access for the rehabilitation and maintenance of the upper Krekeh spring, whereas the second to allow access to the reservoir and to Al Balad spring, these roads are used as an access road for water transportation and filling from the reservoir.

C. Krekeh & Al Balad Springs' Rehabilitation and Water Pipeline laying. To provide a better quality and quantity of water; Debris and solid waste covering the outlet of the springs and around the springs and in the surrounding area were removed, old springs outlet's protections were demolished and new ones have been constructed, springs' outlets are now paved, and a small hood was constructed to protect the spring. 500 m of 4 inches black steel pipelines, with cement in lining and polyethylene outer coating were laid and connected the springs to the reservoir.

D. Storage Reservoir Construction. Water flows down from the higher Krekeh spring toward Al-Balad spring by gravity. The flowing water of the two springs was transferred through 4 inches pipes to a 150m³ water storage reservoir, which is constructed in the joining point of the down streams of the two springs, and taps have been installed for public withdrawal.

E. Awareness and training campaign. Eight training sessions were made by PWEG Staff, and were divided into two parts; a theoretical part at each phase of the project, and a practical part at the closing of the project, owners of the plant as well as municipal council members and employees and other people from Al zaitunah have participated at the training which in addition to the training on operation and

maintenance of the plant included also an elaboration on the importance of ground water protection and saving as well as the importance of health and environment protection. A workshop including a presentation on the planned project components was made at the start of the project. Training sessions on the importance of grey wastewater treatment and reuse and how it contributes to health protection and food generation was also made. A training session on construction of grey water plants and description of plant's components was made on site and training sessions on operation and maintenance of the treatment plant and treated grey water reuse were made to the council members and to the plant owners.

Achieved project objectives:

The project aimed at reducing health risks caused by consumption of polluted water , protecting the free of charge drinking water source from septage infiltration and addressing the water consumption needs of Al Zaituneh through the following activities which were successfully implemented:

- Construction of one low cost household wastewater treatment systems.
- Rehabilitation of the two access roads leading to the springs and the reservoir.
- Cleaning and rehabilitation of the surrounding environment of the springs.
- Connecting the springs to the reservoir through a 500 m of pipelines
- Construction of a 150m³ reinforced concrete reservoir,
- Provision of eight awareness and training sessions to the targeted beneficiaries, and the Municipal Council.

Obtained Direct Results:

- One low cost household grey WW treatment system and two modified cesspit tanks are constructed,
- The surrounding environment of the springs is cleaned, rehabilitated and

protected,

- Ground water and human health are protected,
- 500 m of pipes laid connecting the springs to the reservoir,
- 400 m long access roads rehabilitated,
- 150 m³ reinforced concrete reservoir constructed,
- Eight Awareness and training sessions on the treatment system construction, operation and maintenance, reuse of treated grey WW to targeted beneficiaries, and the municipality provided.

Social benefits:

- No new cases of Hepatitis A infections since demolition of the cesspits and construction of the grey wastewater plant has been registered.
- Increase in water availability:
350 liter/day of treated grey water are available and used in irrigation of previously cultivated trees and summer cultivation of vegetables.
150 cubic meter/day of safe water which is stored in the water reservoir are available for drinking, domestic use and irrigation of near by cultivations and newly cultivated area.
Cash saving on cesspits emptying and on drinking water cost.

Lessons learned:

- Grey wastewater management plays an important role in health and water resources protection when conventional wastewater solutions are not affordable.
- The community accepts sharing construction and operation of grey wastewater plants.
- The community has no problem in reusing treated grey wastewater in gardens due to its purity (taher)

- No bad odors claims by the beneficiaries or their neighbors are made.
- In two years only one time the beneficiaries called PWEG staff for assistance due to operation difficulties.
- Necessity of planning quality control, research and monitoring after project Construction.

Reuse of treated grey WW and the concept of Najasah:

Reclaimed water can provide a constant and reliable supply of water and beneficial nutrients for agricultural reuse throughout the year. In the Palestinian Territories, the use of reclaimed water to meet increasing agricultural water demands was identified as one of the main objectives of the Palestinian water sector (CH2M HILL 2002). Local Palestinian experience in reuse of treated wastewater in agriculture is young and fairly poor (GTZ, CEC, 1998). However, many attempts to introduce the concept of reusing treated WW in agriculture had largely failed where Al Bireh WW reuse project is the most indicative example, the local community did not accept the reuse of treated WW in agriculture due to its belief in the Najasah (impurity) of the treated WW, the farmers were not enthusiastic to reuse or to come in contact with the treated WW, due to the above reasons and due to the exclusion of the targeted farmers from the reuse scheme planning at the project early phase of planning and due to selecting an agricultural area owned by wealthy owners from Dr Dibwan area the Al Bireh reuse project had failed. In addition to the concept of Najasah, in the Palestinian Territories it is not socially accepted to consume products irrigated with treated WW. Najasah for Muslims is believed to be in the black WW and the grey WW is believed to be Taher (opposite of Najasah, meaning pure), therefore the reuse of grey WW is culturally and socially accepted. It is clear that the refusal of reusing total treated WW is due to a religious belief which hinders also the acceptance to have a total WW treatment plant at a household level, and the acceptance of having a grey WW treatment plant in the

garden is the most culturally and socially accepted method of WW management in the Palestinian Territories and this explains the large success which the grey WW treatment and reuse is having in the rural areas and the failure of the reuse of total treated WW at both central and house hold levels.

Conclusion and Recommendations:

Grey wastewater treatment and reuse is of high importance in the Palestinian Territories since it tackles the pollution of ground water at a low cost. It is obvious that where central WW management systems can not be applied and therefore, protection of ground water resources can not be achieved, grey wastewater treatment at house hold and local level is the solution for ground water protection and for health protection. It's low cost implementation, easy and cheap operation and maintenance and the possibility of it's implementation in certain special, isolated and particular cases make it the most appropriate for protection of water resources and health in rural poor Palestinian areas. In addition, the social and cultural acceptance of grey WW management system is one of the most important assets for the sustainability of WW management schemes in the area. It is strongly recommended to work on the introduction of this kind of WW management system and to support researches on grey WW management systems to extend it at village level and to work on reducing the cost of implementation of grey WW treatment schemes.

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