بسم الله الرحمن الرحيم

الشبكة الاسلامية لتنمية وإدارة مصادر المياه

Inter- Islamic Network on Water Resources Development & Management.

منظمة المؤتمر الإسلامي

Final Technical Report (Approved by IDRC)

Covering INW activities for project period from February, 2004 to October, 2007

Project Name:

Greywater Treatment and Use for Poverty Reduction in Jordan (Phase II)

IDRC Centre File:

101536-001 - The Inter-Islamic Network on Water Resources Development and Management (INW), Jordan

***INW* Project Team:**

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NCARTT:

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Ouhud Dmuor

Submission Date

January 16, 2008

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الشبكة الإسلامية لتنمية و إدارة مصادر المياه
Inter-Islamic Network on Water Resources Development and Management (INWRDAM)
Network Member States: Bangladesh, Egypt, Iraq, Jordan, Lebanon, Malaysia, Mali, Niger, Oman, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia, Turkey and Yemen

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Project Synthesis

This section is intended to brief those not fully informed of the project's background and actions planned to achieve project sustainabilty and long term ownership by local community. INW conducted Phase I of this IDRC funded project from May 2001 to May 2003 in Tafila Governorate, southern Jordan. During Phase I, INW installed 25 greywater units in low-income households of a peri-urban community of Ein Al-Baida town in Tafila. Five different types of on-site greywater treatment units/modules were developed and tested over more than three years. Two out of the five modules were selected as potential units for further improvement and scale up. One module is known as the 4-barrel unit, which consists of four recycled plastic barrels lined up in an arrangement to receive greywater and achieve physical and biological treatment. A small automatic electric pump is used to deliver treated greywater to a trickle irrigation system serving a small garden of trees. The second unit is known as the Confined Trench (CT) module. It consists of a stage for removal of oil and grease as well as a dug trench of about 3.5 m3 filled with gravel that serves as the treatment medium. The treated greywater is then pumped automatically through a trickle irrigation system to the beneficiaries' home garden. In addition to units installed in Ein Al-Baida, in 2002 INW also installed over 750 greywater units of different types for the benefit of low-income families across Jordan through a project financed by the Jordanian Ministry of Planning and International Cooperation (MOPIC).

In Phase II, 110 additional greywater systems for low-income families in a cluster of six peri-urban areas of Karak Governorate are constructed, so as to further improve technical aspects, remove social and institutional obstacles and build momentum, thus accelerating the adoption of the reuse system in Jordan and elsewhere in the region. Phase II will involve cooperation between concerned agencies in wastewater reuse, social development, building codes and public health. The National Centre for Agriculture Research and Technology Transfer (NCARTT) is involved in the environmental and agricultural research components of this project.

The Phase II Goal is: "To help the peri-urban poor in Jordan preserve precious fresh water, achieve food security, and generate income, while helping to protect the environment". The Phase II Objective is: "To evaluate previous greywater use projects in Jordan, validate existing approaches, address social and institutional obstacles to scaling up greywater use, and monitor and refine systems to ensure long-term sustainability".

INW work on the project since August 31st, 2006 focused on long-term sustainability of the project through strengthening community, with special interest to women in general and to women of beneficiary households in particular, in addition to maintaining regular contacts with the local governmental organizations. Intensive maintenance to the 110 Greywater systems installed was done regularly based on outcomes and feed from the beneficiaries and from the regular visits by project team. In addition to the permanent office at project site, the regular visits by project team and researchers to the site, the weekly scheduled training of beneficiaries and local technicians continued. A new work plan (work plan) was agreed between INW and IDRC during August 29th, 2006. This work plan was also discussed and approved by both the Project Steering Committee and the Karak Project Follow up Committee. This final technical report covers all activities conducted by INW during the time from February 1st, 2004 up to October 31st, 2007.

Executive Summary

The project accomplished the set goal and objectives and resulted in scaling up of greywater use practices in Al Amer Villages in the Governorate of Karak. The accomplished work is relative to what was possible to achieve under the prevailing conditions in the project area. The project resulted in significant improvements in design of low cost greywater treatment methods that are suitable for rural low income households and resulted in governmental policy directions that encourage greywater use in rural home gardens. As a result of the project activities 110 low income households in the Al Amer villages in Karak Governorate are practicing sustainable greywater applications. Thus, the project succeeded in the introduction of comprehensive greywater use practices; greywater recovery and treatment, permaculture principles and local capacity for operation and maintenance.

This project represents a pilot attempt by IDRC and INW to establish a greywater practicing community in Al Amer villages with 110 households interested and able to operate and maintain the greywater systems and as a result of this their food security was improved and fresh water was possible to save.

The project tried different approaches to make beneficiaries pay some cash contributions in order to receive a greywater system. The priorities of the poor are to meet food, shelter, clothing medical and educating the young and not to invest in new methods such as greywater practices as means of improving their food security. Therefore, it was not possible to obtain up front cash contributions but was possible to have the commitment of the greywater system owners to pay longer term electricity cost for operation greywater units and some O&M costs and at the same time gain net income from this practice.

In future greywater projects, the poor may be more likely to contribute labor and some cash to cover cost of material components of the greywater systems while a donor organization would cover some specific material costs in addition to training, capacity building of the community. The donors should cover cost of training of the local governmental agencies besides technical responsibility for continues improvement of the greywater units and monitoring long term impacts of the practices on the health and the environment. There can be different scenarios to help the poor bear the financial responsibilities through different methods such as establishing financing mechanisms in for form of revolving funds, cooperatives and private sector contributions. The training of both male and female technicians is very important in rural areas to ensure continuous servicing the greywater as some households prefer or would not like to involve male technicians.

The number of greywater units that are considered as up scaling examples are 110 units mainly of the CT type and these units are very well looked after by their owners and represent a success story of how the community's perception about greywater drastically changed in favor of greywater units and their benefits in this project. Although 110 households represent only about 30% of planned target, but it represents nearly 50% of the population of Abu Trabah, Masa-ar, Mugayer, Ariha and Al-Alia in the five villages of the project area who fulfil set criteria for beneficiaries selection. A recent comprehensive survey showed that those how own these units are committed to sustain

the greywater units they own. This is good indication that the project gaol is achieved through this number of units installed.

Water consumption data for representative households was recorded. The results of weekly measurements of greywater produced from five typical households resulted in average of about 237 litres/day and monthly average is about 7 m3. This constant flow of greywater is enough for a small garden planted with about 20 olive trees. This means that beneficiaries depend on greywater use more than on fresh water for irrigating their home gardens and that greywater units are operational.

Five locations were sampled on monthly basis. The quality of the product water is shown in Appendix I. The quality is acceptable according to Jordanian wastewater quality requirements for restricted irrigation. It was found that greywater quality is more dependant on beneficiaries care and regular cleaning of the units than having larger size or septic stage in the system. It is noticed that greywater quality from CT without a septic stage is equivalent or better that that obtained by RSS units that include septic stage. Considering the cost and complexity involved in having a septic stage is not justified and greywater units should be kept as simple and cost effective as possible. This will lead to more uptake by the rural communities and better widespread in the country and the region.

Odor control was possible to some extent by different methods. First by improving the greywater quality and by burying drip irrigation pipes. Beneficiaries are trained on how to control odor by simple practices and continuous care for the units. Beneficiaries were trained to deal with possible reasons for odor emitted from greywater specially at the start of the pump that delivers water to the drip irrigation system.

As a result of these improvements in the design of 4-barrel and CT units over the past four years it is now possible to say that these units with the used dimensions are optimized to meet WHO and Jordanian greywater quality guidelines, but CT construction is flexible and allows room to modify size of CT trench to enable construction of lager units when a situation demands.

INW suggests that future CT development be directed to solve technical issues that allow larger sizes to handle flows of more than half cubic meter up to 5 or 10 cubic meters per day. Also important to investigate possibility of using low cost CT construction methods for wet land applications so that odor is more controlled and higher greywater treatment is possible. This will also has to address the possibility of using ordinary centrifugal pumps in place of the expensive submersible ones so that higher pump head is possible at lower cost.

The Second monitoring survey results indicated that agriculture component of the project achieved expected results and greywater users are satisfied with noticeable improvements in growth of trees and garden crops. Majority of respondents indicated that they learned new methods of cropping and irrigation methods and their awareness on greywater use has increased. Majority of respondents (98%) indicated that they would be able to sustain the greywater systems after the end of the project and that 95% said they consider their greywater systems as their personal possessions and 87% said that they would encourage their relatives and friends to use greywater. Two-third of respondents (72%) said they have access to a local technician trained by the project for O&M if needed. Available

figures from a recent socioeconomic analysis based in the second survey results and data from INW indicates that the average B/C ratio estimated for 56 beneficiaries is 2.7 to 1. This means that for each dollar spent on constructing and operating the systems over a period of ten years (the estimated life of the typical greywater unit) about 3 dollars are gained by the user.

The situation of households reclaiming and using treated greywater on private property was not legally covered by these standards. INW discussed with WAJ the need for a legal framework that covers use of greywater at households level in peri urban areas of Jordan. The proposal was well accepted by WAJ and they collected greywater quality data from the project beneficiaries. WAJ and INW and concluded that enough monitoring data was available to present a proposal to JISM to decide on the technical contents and a Jordanian greywater quality standard coded DJS 1776:2007 is now adopted. This is a major positive policy outcome that will help endorse greywater practices at national level and more donor organization will be willing to fund greywater activities.

During the third year of the project a detailed socioeconomic evaluation was conducted to evaluate the economic benefits of the greywater practices. The evaluation was based on representative financial statements from 60 beneficiaries out of 110 total greywater users. Details of the survey is reported in the Handy Volume (Appendix II). This socioeconomic evaluation is considered as the first comprehensive and detailed B/C ever carried out on greywater use practices to date.

Based on the results of the second monitoring survey and monitoring of water, soil and plants data one can say that greywater is well accepted by peri-urban poor and this project can be implemented in other communities. On the other hand, greywater standards proposed by INW is now in final stages of approval under code DJS Monitoring of the impact of greywater on soil and plants indicated slight increase in salinity of the monitored soils. However, it is not possible to make definite conclusions on trends and scale of these impacts, unless long-term results are established. It is hoped that the capacity building efforts of the project will help the beneficiaries deal with greywater impacts on soil and plants, improve home garden productivity and the local environment. Details of greywater quality, soil and plants is presented in Appendix I.

Soil samples where obtained from gardens of two beneficiaries at two depths to compare mulched and no mulching results on organic matter and nutrients increase in soil. Table No.1 and 2 shows that organic matter and major nutrients increased under mulching. This is attributed to organic matter decomposition in the soil since mulching provides more suitable conditions for bacterial growth under humid conditions. A positive indicator is that CaCO3 contents in soil irrigated with greywater compared with soil not irrigated with greywater did not increase.

Average greywater quantities produced by households were monitored for 5 houses. Result of greywater amounts generated per selected houses for the year 2007 is shown in Table No. 13. The results of weekly measurements from five typical households resulted in about 237 liters/day. This constant flow of greywater is enough for a small garden planted with about 20 olive trees. The greywater amounts generated is low which is expected since most families connect kitchen water to the greywater treatment unit. In

addition, the families have low water consumption compared with other location in Jordan.

Work Accomplished

This is the Final Technical Report (Report) of the project on "Greywater Treatment and Use for Poverty Reduction in Jordan" (Phase II) and submitted to the International Development Research Centre (IDRC), Ottawa, Canada in fulfillment of the Grant Conditions. This report covers activities conducted by INW from February 1st, 2004 up to October 31st, 2007 as well as the work conducted according to workplan agreed between IDRC and INW on August 2006. The Report discusses results achieved from implementing each one of the six objectives (objective one to objective six), lessons learned and recommendations for future actions and research for further scale up of greywater use in peri urban communities.

This Report should be read with the previous three interim project reports submitted by INW up to January 31st, 2007.

Objective 1: Conduct a post-project evaluation of Phase I and other INW implemented projects to guide the proposed up-scaling project.

The PPE report was submitted to IDRC in August 2004 and included specific recommendations for Phase II of greywater research and prepared a monitoring framework plan . INW took the recommendations of the PPE and followed the monitoring framework plan and the following is a summary of what Phase II achieved in this regard:

- ✓ **PPE outline section** mentioned that previous IDRC funded research had "limited governmental involvement; lack of community participation and attention to gender issues". These comments were all taken into consideration, specially since Phase II is more related to community and policy issues than Phase I which was more related to technical development of the greywater applications. A project steering committee (SC) and the Karak project Follow up Committee (KPFC) and was composed of main governmental stakeholders. The SC conducted regular meeting (total of xx meetings) to monitor project progress and gave recommendations to INW and PN how to ensure local community participation and training. INWRAM helped local leader women to establish the "Al Amer Women Cooperative Society" (ALCOOP), the only CBO in the area with main objective to promote greywater use in rural areas of their community. Other governmental involvement was achieved by having NCARTT as partner in the Phase II implementation and by having WAJ involved in greywater monitoring and the development of Jordanian Greywater Standard for Rural Communities No. 2007-1776 by JISM.
- ✓ **Targeted objectives section** mentioned "need to lessen the beneficiaries heavy dependence on INW and the technicians for maintenance of their systems". The project conducted extensive training of families with particular attention to women. The situation now is that all beneficiaries are taking care of the systems by themselves and local technicians are available for support when needed. THE

ALCOOP is also helping the beneficiaries deal with O&M needs of the greywater units. The relevant ministries in Jordan were all presented in the SC and aware of the project contribution to promote greywater use in the country.

- ✓ **Socio-economic analysis section** recommended "... more training, sound agricultural practices and incorporation of gender in all stages of Phase II". The agriculture component was set out as an objective and was conducted by NCARTT and achieved good results. Training and gender issues are mentioned above.
- ✓ **Community participation and local capacity section** recommended "...there should be inkind or cash contribution from beneficiaries ....and to set up community selection criteria.." The proposed ideas were tested and PN lead the community components in the project from the beginning up to January 2006 when partnership was split. It was noticed that PN focused more on fulfilling its part of the community component of the project without due considerations to delays resulting from the fact that they did not adequately mobilized the community to understand their role. **It is recommended that in future projects of this kind** the community mobilization components and installing demonstrations greywater units must take place prior to starting the installation of greywater to committed households because batch implementation increases the costs of the units, and requires contribution form the poor beneficiaries who are not yet sure what to get in return.
- ✓ **Technical dimensions section**....." consider the long term impacts of greywater on soil... more monitoring soil salinity and ....salinity preventive measures. Phase II included a main activity for monitoring greywater impacts on soil and plants and investigated and tested ways to mitigate salinity problems. These measures included training on farm water and plant management, permaculture practices that indicated possibility of reducing salinity impacts through mulching and other methods in addition to introducing many new crop varieties.
- ✓ **Financial dimensions section**...." All issues related to the financial considerations were addressed in Phase II in the benefit- cost study. The results from monitoring surveys showed that the beneficiaries are carrying/ committing financial responsibility that included separation of greywater inside the house, preparation/ improvement of the installation site in addition to the running cost and costs of operation and maintenance for up to nearly ten years. There is good evidence that the beneficiaries developed a strong sense of ownership of the greywater units and consider these as their valuable household assets.

The project has resulted in significant improvements in design of low cost greywater treatment methods that are suitable for rural low income households and resulted in governmental policy directions that encourage greywater use in rural home gardens. As a result of the project activities 110 low income households in the Al Amer villages in Karak Governorate are practicing sustainable greywater applications. Thus, the project succeeded in the introduction of comprehensive greywater use practices; greywater recovery and treatment, permaculture principles and local capacity for operation and maintenance.

This project represents a pilot attempt by IDRC and INW to establish a greywater practicing community in Al Amer villages with 110 members interested and able to operate and maintain the greywater systems and as a result of this improve their food security and save some fresh water.

The project tried different approaches to make beneficiaries pay some cash contributions in order to receive a greywater system. The priorities of the poor are to meet food, shelter, clothing medical and educating the young and not to invest in new methods such as greywater practices as means of improving their food security. Therefore, it was not possible to obtain up front cash contributions but was possible to have the commitment of the greywater system owners to pay longer term electricity cost for operation of the units and some O&M costs and at the same time gain net income from this practice.

In future greywater projects, the poor may be more likely to contribute labor and some cash to cover cost of material components of the greywater systems while a donor organization to cover some specific material costs in addition to training, capacity building of the community. The donors should cover cost of training of the local governmental agencies besides technical responsibility of continues improvement of the greywater units and monitoring long term impacts of the practices on the health and the environment. There can be different scenarios to help the poor bear the financial responsibilities through different methods such as establishing financing mechanisms in for form of revolving funds, cooperatives and private sector contributions.

Objective 2: To expand and upscale the number of greywater treatment systems

During the start up phase, a campaign to inform the community about the project was implemented by project team through meetings at the project location and through installation of 10 demonstration greywater units distributed over the 6 villages. This turned out to be very essential component of the process of informing the local community and introduce an improved version of greywater treatment units such as the confined trench (CT). This was also combined with field visits to local government offices to inform them about the project. The local officials were interested to know more about what the project could contribute in poverty alleviation in their area. Later sections of this report will describe more about how the attitudes of the local officials changed with project producing promised results. Formal meetings were conducted with local officials including the Governor of Karak, the Local Governor and community members and other government officials.

It is recommended that future greywater projects should start the community informing phase by constructing samples of greywater units to enable new communities see results. Also new communities can be allowed to visit locations were other greywater projects succeeded and to have discussion with these communities.

The project team conducted an average of three field visits each week to the project site. Collection of baseline was data done mainly through visits to local government offices and field surveys to households to evaluate the potential for greywater use.

Tentative list of potential beneficiaries was prepared jointly by INW and PN with support from the LSC. This list was based on WAJ water meter records of the area. The list was refined according to water consumption criteria and was matched with beneficiaries selection criteria proposed by the PPE. INW checked the conditions on the ground by conducting site surveys of households and prepared lists of locations for construction of greywater units and possibility for greywater separation and other technical details.

It was noticed that the LSC was somehow biased to help relatives and friends whom households did not fulfill set criteria. This is expected and convincing those members of the LSC to understand the importance of their role as community leaders was helpful. PN was also helpful in doing this education exercise to some members of the LSC. Lists for constructing barrel or CT units were prepared. However, implementing 4-barrel units was constrained by the desire of beneficiaries to have CT type units because they were interested in immediate gains in the form of materials they would receive from the project (submersible pump, PE sheets, gravel media and so on) more than what these units will benefit them in the future. Managing the community and informing them about these issues of future benefits was primarily responsibility of PN. This did not happen as desired and certain difficulties were experienced by INW in this regard.

Three groups of trainers from previous INW greywater projects were involved in installation of demo greywater units and training was conducted as on the job training of some local technicians. INW was able to identify few local technicians but not many. This is due to the nature of the project community living in remote place and little construction compared to other parts of the country. By the end of project three local technicians were trained and available to construct/ install and maintain greywater units for interested households in this and nearby communities. The training of both male and female technicians is very important in rural areas to ensure continuous servicing the greywater as some households prefer or would not like to involve male technicians. The local technicians, some of whom were project field staff, were involved in training of the beneficiaries on cleaning, O&M of the greywater and drip irrigations systems.

The project target of constructing 150 barrel and 150 CT units was not possible to achieve due to many reasons. Main difficulties were that INW and PN had some conflicting approaches on household contributions in order to be accepted as a beneficiary and the condition that he/she must preparing greywater installation site. INW thought that it was difficult in such a poor community to ask for either cash or inkind contribution when some existing greywater units from a previous project (MOP project that did not include a suitable training component) were not fully working and no feeling of satisfaction by their owners. This is an important step that future projects should consider to inform the community of how other communities are benefiting from similar greywater use practices. More on this in the recommendation sections to follow.

INW submitted regular interim reports and these reports were satisfactory and represented clear idea to IDRC on progress made on the ground. In August 2006 a new project work plan was approved that limited number of sustainable greywater units to less

than 150. The number of greywater units that are considered as up scaling examples are 110 units mainly of the CT type and these units are very well looked after by their owners and represent a success story of how the community's perception about greywater drastically changed in favor of greywater units and their benefits in this project.

The following reporting material is related to accomplishments according work plan agreed between IDRC and INW in August 2006.

The work plan agreed between IDRC and INW on August 29th, 2006 was fully implemented by INW. This included concerted efforts for capacity building of the greywater users community in the project areas were conducted during the last two years of the project duration. The project team conducted the agreed on number of regular weekly visits to the site. Attendance to training sessions on O&M showed that women constituted majority of attendees and that they are becoming responsible for care of the greywater and irrigation systems.

The initial anticipated project plan was to serve up to 300 households with greywater units and irrigation systems, however, it was found out through by working with the local steering committee (LSC) and the Karak Project Follow up Committee (KPFC) that the uptake capacity was 110 units with owners willing to look after and maintain their units in a sustainable manner. Although 110 households represent only about 30% of planned target, but it represents nearly 50% of the population of Abu Trabah, Masa-ar, Mugayer, Ariha and Al-Alia in the five villages of the project area who fulfil set criteria for beneficiaries selection. A recent comprehensive survey showed that those how own these units are committed to sustain the greywater units they own. This is good indication that the project gaol is achieved through this number of units installed.

The capacity building and training of local community on O&M of greywater was fully implemented by the end of the project. Family members of households that benefited from the project were trained on different modalities of O&M and talking problems with the pump, drip irrigation and odour. It appears that the community is able now to sustain the greywater units for the anticipated life of these units. Project records show that xx number of visits to project sites conducted by INW staff and technicians over the past were xx. The number of training sessions on O&M provided to beneficiaries were xx during the last 14 months.

Water consumption data for representative households was recorded. The results of weekly measurements of greywater produced from five typical households resulted in average of about 237 liters/day and monthly average is about 7 m3. This constant flow of greywater is enough for a small garden planted with about 20 olive trees. This means that beneficiaries depend on greywater use more than on fresh water for irrigating their home gardens and that greywater units are operational.

INW maintained two full time local staff members at project office who kept daily contacts with the beneficiaries and the KPFC. Observations from these visits are recorded on the project data base for future reference and for use by external evaluation of project work. Useful input was obtained from the beneficiaries on matters related to O&M and maintaining productive gardens.

Greywater quality was monitoring by NCARTT and later since December 2006 continued by WAJ. Five locations were sampled on monthly basis. The quality of the product water is shown in Appendix I. The quality is acceptable according to Jordanian wastewater quality requirements for restricted irrigation.

Objective 3: enhance the design and performance of greywater systems to get the best effluent quality possible

The aim of this objective was to enhance the design and construction of the systems to attain the best possible greywater effluent quality and quantity, to make regular cleaning operation and maintenance more easy to handle by beneficiaries, and to develop simple techniques and practices to reduce odor and long-term environmental impacts.

The methods developed by INW as a result of Phase I for greywater treatment produce effluents suitable for restricted irrigation according to the World Health Organization (WHO) Guidelines for Wastewater Use in Agriculture. This project enhanced the designs and improved O&M in order to obtain the best possible greywater effluent quality using low cost on site treatment. Plans for larger greywater unit serving many houses was investigated but found unfeasible in this community.

The outcomes of the Phase I project were five different designs were tested and evaluated, the CT was considered an optimum combinations for low cost, effluent quality, O&M and construction ease. Therefore, the PPE recommended this type as a priority for Phase II. The approaches taken/ followed by INW to improve the performance and greywater quality form the CT depended on observation over three years that lead to technical evaluation of the treatment process, technicians feed back and notes on construction and beneficiaries feedback on cleaning of the units. This led to many significant improvements in the design of the present CT. These points will be discussed in more detail in relevant subsections of this objective. Lessons learned during previous greywater research proved that for a greywater treatment unit to last for 10 years, materials and components must be reliable and available in local market. Therefore, quality of materials used/ recommended were of good quality.

Design modification of greywater units is a continuous process and one of the most important lesson-learned by INW was that 'never assume things simple for you, as a researcher to be 'must be simple' for the beneficiaries'. For example, the use of a pump that needs priming proved to be not sustainable at many households, although pump priming is a simple practice and training of the beneficiary may overcome pump priming, yet the use of submersible pumps proved to very much contribute to the ease of maintenance and therefore, make the greywater unit more reliable and sustainable. On major outcome in the modification of the design came as a feedback from the community, which was the replacement of the first barrel in both the 4-Barrels and CT units.

The issue of greywater research at collective households level could not be implemented by INW during phase II. This was due to many factors including social and technical.

The households in these villages are spread and are relatively far away from each other and there is no spread of extended families.

The installation of greywater at community level proved to be extremely beneficial for improvement of the design of the different greywater modules. In fact, the community feedback in Phase II included specific small, although crucial, design alternatives that greatly enhanced the greywater unit design and performance in many ways, including mainly ease of installation and O&M, thus, leading to increase beneficiaries confidence in their greywater systems, increase of efficiency and reliability. This fact was applied to both the 4-B and CT designs. These lessons can best be learned by investigating the from the feedback of the community or a wide group of beneficiaries of common standards of living and living in the same village or area.

Regular water quality monitoring program was implemented during the implementation of Phase II by NCARTT and continued from December 2006 to October 2007 by WAJ. It can be concluded that the intensive training campaign and the capacity building programs implemented by INW during Phase II from June 2006 to October 2007 contributed in enhancing the treated greywater quality. This is mainly due to enhanced practices related to use of water inside the household, of the beneficiaries

The following reporting material is related to accomplishments according work plan agreed between IDRC and INW in August 2006.

Improvements of the design of the 4-barrel and CT units was possible within the constrains of construction complexity and low installation and running coats and the intended end use of effluents for restricted irrigation of home garden crops.

Prevention and reduction in frequency of clogging of greywater pipes was possible by increasing diameter of pipe work from50 mm to 75 mm. INW produced new rubber seals to fit the lager pipe diameters. IDRC researchers Mr. Naser Faruqui and Mr. Mark Redwood proposed this modification during one of their monitoring visits to the project site. This modification resulted in small increase in cost of the unit, but helped over come a possibility of common O&M problem due to blockage of greywater feed lines. After test trials in a number of houses for about one year, it was decided that use of larger diameter pipes and smooth bends as additional precaution to reduce pipe blockages. During 2007 all pipe work of units were converted from 50 mm to 75 mm sizes. Also it was noticed that pipe work must include minimum of sharp bends, in the form of T-joints or elbow joints and to avoid using buried T- joints. After about two years of assessing problems related to pipe work clogging and difficulties in cleaning buried pipes, it was decided to use only larger diameter pipes. The result of this modification is standardized and all new users will use drawings that include these pipe dimensions.

Another modifications was implemented to facilitate cleaning and more reduction control of suspended solids reaching the first stage of treatment in the first barrel. The purpose was to trap more solids that escape the kitchen sink screens and from other sources such as washing cloths, lint and hair. Generally, conventional wastewater treatment incorporate a primary settling tank/grit screen stage where about 40-60% reduction of incoming BOD_5 in the form of grit and floating material is removed. The first barrel in a

greywater kit also accomplishes similar purpose. In a greywater treatment kit such as the 4-barrel or the CT, a barrel is used to act as a primary stage where most oil and grease and solids are trapped. the first barrel must be cleaned regularly based on households activities that result in more dirty or less dirty greywater. Cleaning is done by scooping fatty materials by small implement with handle and wire mesh or using a plastic carrier bag as gloves. Households complained that a deep 160 liter barrel was difficult to clean and suggested to INW to solve this problem. This feed back from beneficiaries was useful to guide INW technicians to look for alternatives to large barrel that could do the job and facilitate cleaning. After some trials it was found that 50 liter capacity PE barrels are available in the market as scrape recycled containers and tests also showed that opening of 39 cm instead of 50 cm was not a problem but it reduced the depth from 90 cm to 50 cm. Therefore, the size and dimensions of the first barrel is reduced from 160 liter capacity barrel to one of 50 liters. This modifications was tested in the field in a number of cases where households complained about difficulty in cleaning the 160 liter size barrels.

Another modification in CT construction was implemented that helped prevent buckling of the pump container that receives treated water from the CT gravel media and also helped reduce possibility of insects getting into and out of the pump container. Before this modification, the pump container was perforated at a certain depth to allow water to drain into it from the CT gravel media. Perforations were made by use of a hand held grinding wheel to cut straight cuts at fixed level around the diameter of the pump container. The result was that some cuts extent to the top of the gravel and allows insects to pass into the pump tank. The modification is to replace the cuts with a 75 mm opining at fixed depth under water level in the gravel media and to insert a 75 mm diameter and 2 meters long pipe to drain water from fixed depth in the gravel media. This modification meant that draining water from CT trench to pump tank is fixed at predetermined depth. Technicians are now more confident that they can control depth of water in the CT media as indicated by a simple drawing they use in the construction of a CT unit. In case of construction a larger than standard size CT unit more than one drain pipe can be installed around the diameter of this tank in the same way.

A survey was conducted to evaluate demand from beneficiaries for capturing more volumes of greywater. It seems that most beneficiaries do not like this proposal. Only four out of about 90 wanted to connect more greywater source points. Main reasons for low requests could be that they do not want alternations in the existing building drainage pipe work. This signifies that building codes for separated greywater is important component of maximum greywater recovery in urban and peri urban context.

It was found that greywater quality is more dependant on beneficiaries care and regular cleaning of the units than having larger size or septic stage in the system. It is noticed that greywater quality from CT without a septic stage is equivalent or better that that obtained by RSS units that include septic stage. Considering the cost and complexity involved in having a septic stage is not justified and greywater units should be kept as simple and cost effective as possible. This will lead to more uptake by the rural communities and better widespread in the country and the region.

Better odor control was possible by different methods. First by improving the greywater quality and by burying drip irrigation pipes. Beneficiaries are trained on how to control

odor by simple practices and continuous care for the units. Beneficiaries were trained to deal with possible reasons for odor emitted from greywater, specially at the start of the pump that delivers water to the drip irrigation system. One approach was to train beneficiaries how to burry drip irrigation pipes to a depth of 20-30 cm to prevent reduce sun warming effect and subsequent decomposition of organic mater that contain sulfurous and nitrogenous matter in the greywater. But burying pipes leads to little extra cost as drippers had to be installed in 4mm diameter and 50 cm long flexible extension PE tubes that connect each dripper to a buried irrigation pipe. Installing a flexible extension tube is also useful to move the dripper around the truck of the tree and prevent excessive damp areas. Also it is extra work for the households as they have to pull the these pipes up every time they plough the garden. This solution works and helps extend practical life of the PE pipes as this keeps PE away from direct sun light. A solution was improvised by some owners that worked nicely in nearly completely preventing a surge of odor every time the pump turns on. Their solution was to cut in half an empty mineral water container of 1or 1.5 liter size and place the bottom part of the container over each dripper of the irrigation system. This meant that when a pumping cycle starts and foul air flushed by flowing water the odor do not spread as some air is trapped in the space of the inverted and released slowly later on. The volume of foul air trapped in drained typical drip installation on a tree planted area of 1000m2 is about 50 liters. These caps are able to trap that much air for some time and part of it would re-dissolve in the greywater and seeps to the root zone on plants. More observations and measurements would reveal the way this process works. This method is now widely practiced by most families that feel the need to for it. This is also a result of training that enable community devise solutions that suit local solutions.

As a result of these improvements in the design of 4-barrel and CT units over the past four years it is now possible to say that these units with the used dimensions are optimized to meet WHO and Jordanian greywater quality guidelines, but CT construction is flexible and allows room to modify size of CT trench to enable construction of lager units when a situation demands.

INW suggests that future CT development be directed to solve technical issues that allow larger sizes to handle flows of more than half cubic meter up to 5 or 10 cubic meters per day. Also important to investigate possibility of using low cost CT construction methods for wet land applications so that odor is more controlled and higher greywater treatment is possible. This will also has to address the possibility of using ordinary centrifugal pumps in place of the expensive submersible ones so that higher pump head is possible at lower cost.

Objective 4: To monitor social, environmental and economic impacts of such systems

All monitoring planned for this reporting period was done. Results of water, plant and soil are attached in Appendices, and the socioeconomic, policy options, health and second comprehensive monitoring survey are shown as separate attachments to this report. INW requested WAJ to conduct greywater monitoring (4 rounds of sampling was completed by last week) as part of an attempt to issue Jordanian standards for greywater quality for use in restricted irrigation.

The Aqaba Stock-taking meeting that was organized by IDRC and CBSE in Aqaba during February 12-15th, 2007 was informed about the socioeconomic and policy frame work. It was agreed with IDRC that the Aqaba meeting would replace a regional workshop on greywater to be conducted by INW.

The partner PN prepared the base line studies about the project location and targeted community. This information was submitted to IDRC by PN and INW did not have copies of the data base or related investigations. However, the targeted community which is composed of six nearby villages constituted a homogenous demographic and socioeconomic mix. INW and its partner NCARTT and in cooperation with the LSC and KPFC collected fresh data that focused on training needed and on strengthening the role of women in sustaining the greywater units and permaculture pilot sites. Most of this data was reported in previous interim reports. Most important was the second comprehensive survey that was conducted as a requirement for a monitoring framework plan developed by PN. The out put of the second survey provided many clues as to the sustainability of the project and the scope of change in the attitudes of the community towards the project and provided crucial data for conducting a detailed socioeconomic and benefit cost analysis of the project on the community.

The project conducted two monitoring surveys, the first one was carried out by PN in January 2006 and the survey team was composed of the LSC members and a local NGO. At that stage the project were facing some difficulties with some important components such as training and pilot gardens still in progress and the community was still not aware of the benefits they could accrue. The main findings reported by PN on the first monitoring survey were that beneficiaries preferred the CT over the barrel greywater units, and not much saving was appreciated so far and that beneficiaries were concerned with odor and cleaning problems of the greywater units and that most neighbors asked about the systems and the majority of beneficiaries recommend the systems to their neighbors. The first monitoring survey revealed important research questions that the project should address with beneficiaries and in cooperation with local authorities in a participatory manner. INW intensified training of beneficiaries on how to clean and maintain the greywater systems that resulted in and noticed improvements in odor and treated greywater quality.

A second project monitoring survey was carried out in December 2006 by members of KPFC. The survey questionnaire was based on the questionnaire used by PN in the January 2006 mentioned above and covered 60 beneficiaries out of 110 from all the six villages. The Second monitoring survey results indicated that agriculture component of the project achieved expected results and greywater users are satisfied with noticeable improvements in growth of trees and garden crops. Majority of respondents indicated that they learned new methods of cropping and irrigation methods and their awareness on greywater use has increased. Majority of respondents (98%) indicated that they would be able to sustain the greywater systems after the end of the project and that 95% said they consider their greywater systems as their personal possessions and 87% said that they would encourage their relatives and friends to use greywater. Two-third of respondents (72%) said they have access to a local technician trained by the project for O&M if needed. Available figures from a recent socioeconomic analysis based in the second survey results and data from INW indicates that the average B/C ratio estimated for 56

beneficiaries is 2.7 to 1. This means that for each dollar spent on constructing and operating the systems over a period of ten years (the estimated life of the typical greywater unit) about 3 dollars are gained by the user.

The project regularly monitored greywater quality. WAJ was interested to take part in the evaluation of the greywater quality that results from these low cost units. All greywater sampling and analysis during December 2006 up to August 2007 was conducted mainly by WAJ. The quality of greywater effluents monitored by WAJ were comparable to the Jordanian restricted irrigation standards.

In the previous stages of greywater research, treated greywater quality was compared with WHO guidelines or Jordanian reclaimed water standards. These guidelines and standards regulate discharge of treated wastewater to public sewers or the environment. The situation of households reclaiming and using treated greywater on private property was not legally covered by these standards. INW discussed with WAJ the need for a legal framework that covers use of greywater at households level in peri urban areas of Jordan. The proposal was well accepted by WAJ and they collected greywater quality data from the project beneficiaries. WAJ and INW and concluded that enough monitoring data was available to present a proposal to JISM to decide on the technical contents and a Jordanian greywater quality standard coded DJS 1776:2007 is now adopted. This is a major positive policy outcome that will help endorse greywater practices at national level and more donor organization will be willing to fund greywater activities.

Project activities included many processes for documenting the results and impacts of practicing greywater at households level. The benefit/cost ratio (B/C) is a major issue with respect to scale of uptake of the greywater use by peri urban communities, besides other technical and environmental issues. Therefore, the project monitored and recorded the observations and responses of beneficiaries with regards to what they consider as benefits and what they consider as costs and burdens. It was observed that a number of beneficiaries with some background about technical matters, as a result of being in the army or similar professions started early on to appreciate more than others the benefits of greywater use and a number of pilot gardens were started at their homes. Olive trees were the dominant trees in most home gardens and good results were obvious due to irrigation with greywater in the form of better growth rates and increased olive oil production. NCARTT documented results of yield of olives and other crops.

Training focused on O&M of the greywater units and agriculture components besides many other subjects of relevance to the project community. Some misconceptions by some households that the greywater pump draws much electric power was possible to rectify by training and by asking trainees to calculate for themselves what is the actual amount of electricity needed to run the small pump. Responses of beneficiaries on what they considered as project benefits included direct and indirect benefits. They considered saving some fresh water and more productivity of the home garden and more forage to feed the animals and chicken as direct benefits and they also considered having a nice garden an added advantage.

As it is mentioned in more detail in Objective five that follows, this project introduced many new agriculture and irrigation techniques to the local community. Leader women were identified for more specific training that will improve their skills as local leader

women. This resulted in good improvement in their ability to discuss matters related to the project such as what training subjects they preferred and started to indicate the most convenient times for them to attend training and visits by project staff. One lady was markedly active and used to accompany the technicians to learn how to deal with O&M problems of the greywater units. INW latter decided to recruit this girl (Miss Eman Alamer) as a local technician to work as attendant at the project site office and to respond to calls for O&M of greywater units. Before project close down this lady joined other leader women form the beneficiaries decided to join their efforts and little financial resources and establish and register the first cooperative in the area; the ALCOOP and she was elected as the first president for the that coop. Miss Eman Alamer even decided to run for the Jordanian Parliament elections of November 2007, but did not win.

Based on the results of the second monitoring survey and monitoring of water, soil and plants data one can say that greywater is well accepted by peri-urban poor and this project can be implemented in other communities.

Continuous interaction with the project community during more than threes years resulted in a better understanding of their community and how project staff would best approach members of the local community.

The following reporting material is related to accomplishments according work plan agreed between IDRC and INW in August 2006.

All monitoring planned for this reporting period was done. Results of water, plant and soil are attached in the Appendices, and the socioeconomic, health and second comprehensive monitoring survey are documented in an attached publication entitled: "Studies of IDRC Supported Research on Greywater in Jordan Conducted by INW", Handy Volume. INW requested WAJ to conduct greywater monitoring in an attempt to propose a Jordanian standards for greywater quality in Jordan. This proposed standard is now in final stages of approval under code DJS 1776:2007. All work planned under this objective is documented in the Handy Volume.

Objective 5: To establish and maintain productive UA gardens and conduct research on permaculture – soils and crops

The main aim of objective five was to establish, maintain and monitor household productive gardens to increase income of households and continue monitoring the impact of greywater use on soils and plants.

The project concept is based on the idea that the use of treated greywater in home gardens could enable the urban poor to produce food supplements and other forms of family income and thus become producers rather than solely consumers. The majority of peri-urban families in Jordan own a small garden. The olive tree is a traditional tree planted in almost every home garden in Jordan and in the Middle East. One mature olive tree when irrigated well could yield 30 to 50 liters of olive oil per season. Rainfall is scarce in most parts of Jordan, therefore, greywater could provide significant amount of water requirements of olive trees during summer season. Greywater reuse can provide the balance of irrigation requirements so that olive trees can give optimum yield. Treated greywater can safely be used to irrigate olive tress, forage and other plants such as cactus

so that goats or sheep and hens can be raised to provide milk and offspring to support family diet and income.

Comprehensive baseline data was collected and documented in the interim reports. The data collection involved local sources and specialized governmental departments. The baseline data will be useful for INW partners and specially to Al Amer Ladies Cooperative Society (ALCOOP). A copy of the baseline data was provided by INW to ALCOOP for their future plans ands activities related to greywater in the area.

The project team kept continuous contacts with the beneficiaries, local community and local governmental officials. Beneficiaries' gardens were visited regularly and the required improvements were identified to meet household productive garden needs based on permaculture practices methods. Examples are tillage and mulching. Assessments were done for 12 gardens. Plants which are tolerant to greywater quality such as salinity and biological parameters were selected. Different types and varieties of plants were tested at beneficiaries home garden. These included: 1) industrial; mainly olive in addition to fiber crops, 2) fruit trees such as almonds and Carob, 3) forages, e.g. Sudan grass, corn, millet, soybean, fenugreek, mustard, 4) medical plants such as maleesa, and 5) legumes such as vetch, in addition to other plants such as corn, sunflower and okra (Indian type).

Seven monitoring sites were regularly monitored to evaluate the impacts of greywater on plants including monitoring greywater quality from five sites to assess the impacts of greywater on soil.

Irrigation with greywater was scheduled based on available quantity of and number of trees in home garden. Valves were installed to control the amount of water and water meters were used to measure the quantity of greywater produced from selected houses. Beneficiaries were trained on these practices and kept informed of achieved results.

A criteria where and how to construct pilot permaculture sites were developed in cooperation with the beneficiaries. This was done in a participatory approach so that the beneficiaries were informed on the responsibilities and they agreed on the methodology used for selecting these sites. This criteria was based on garden size, cropping pattern, land suitability and potential for rain harvesting.

Permaculture training was developed and delivered to all beneficiaries. The training included topics and practical applications on composting, rainfall harvesting, soil management and conservation, plant disease control, drip irrigation system and use of safe household chemicals. Beneficiaries were open to learn and benefit from the these project practices.

Monitoring of the impact of greywater on soil and plants indicated slight increase in salinity of the monitored soils. However, it is not possible to make definite conclusions on trends and scale of these impacts, unless long-term results are established. It is hoped that the capacity building efforts of the project will help the beneficiaries deal with greywater impacts on soil and plants, improve home garden productivity and the local environment. Details of greywater quality, soil and plants is presented in Appendix I.

Project pilot sites were visited on weekly basis to follow up and document the permaculture practices at these sites and to continue training beneficiaries on these

activities. Records of field visits are available in the project database and in the log books. It was observed that beneficiaries started to realize the benefits of permaculture practices demonstrated at the pilot sites and requested to have similar permaculture sites at there households. Since this was not possible, INW intensified the training of the beneficiaries to enable them duplicate what they considered useful to them. Seedlings and seeds were seasonally distributed to all beneficiaries. This was done in cooperation with NCARTT local office and the office on the Ministry of Agriculture in the project area.

Beneficiaries were trained on rain harvesting practices in an attempt to increase irrigation water and to counter act salinity nature of greywater. Two demonstration sites for rain harvesting and soil mulching were implemented and beneficiaries were trained on these techniques.

Visits to households were conducted periodically and after each training activity to assess the impacts of training activities on beneficiary response and interaction with the training content. It is possible to say that at least 50% of the trainees adopted permaculture practices and follow the proposed guideline for greywater use.

Baseline data on soil properties was done during year 2004. Yearly soil sampling and analysis were done also on five selected sites. In addition, soil analysis was done also for the demonstration sites to assess the impact of permaculture practices on soil properties. Water meters are installed to monitor greywater amounts for 12 sites.

The following reporting material is related to accomplishments according work plan agreed between IDRC and INW in August 2006.

Permaculture techniques used in the project were amid to increase crop yield and quality and reduce greywater impacts on soil and plants. Pilot permaculture site selection criteria was first identified and approved by project partners and the local community. Surveys were then conducted to identify potential pilot site based on garden area, the amount of greywater generated and beneficiary's interest. Total of 12 pilot sites are selected and implemented. The permaculture practices included soil mulching, rain harvesting, introduction of new crops and pest control using environmental friendly methods.

Local community was not aware of the new techniques that help increase garden productivity and quality. Most beneficiaries had valuable local knowledge on use of animal manure, agricultural practices, irrigation practices and pest control.

Soil mulching as a permaculture practice was selected because most materials needed for mulching is available locally and beneficiaries lacked knowledge on permaculture and certain modern techniques. Soil mulching using plant residues increases soil organic matter and nutrients content. This was evaluated on selected beneficiaries gardens irrigated with greywater. Mulching was demonstrated using plant residues resulting from weeds harvesting, post harvest straw and wood chips. Mulching was spread over tree basin with at least 3 cm depth. Beneficiaries were interested in the permaculture methods and observed improvement in olive growth and yield because they found out that moister content lasted for longer periods than those areas not mulched.

Soil samples where obtained from gardens of two beneficiaries at two depths to compare mulched and no mulching results on organic matter and nutrients increase in soil. Table No.1 and 2 shows that organic matter and major nutrients increased under mulching. This

is attributed to organic matter decomposition in the soil since mulching provides more suitable conditions for bacterial growth under humid conditions. A positive indicator is that CaCO3 contents in soil irrigated with greywater compared with soil not irrigated with greywater did not increase.

Table 1. Results of mulching on nutrients and $CaCO_3$

Musa Amer garden	Soil depth (cm)	OM %	P	K	N	$CaCO_3$%
Mulched soil-1	0-30	0.46	44.60	475.18	0.095	23.7
	30-60	0.53	37.00	231.36	0.104	22.6
Mulched soil-2	0-30	0.53	49.40	572.3	0.098	25.6
	30-60	0.46	60.0	432.18	0.112	25.6
No mulching + greywater	0-30	0.53	31.2	219.54	0.098	24.5
	30-60	0.40	71.4	432.18	0.11	22.6
No mulching + no greywater	0-30	0.46	34.8	89.60	0.084	30.2
	30-60	0.20	31.8	396.74	0.095	20.7

Table 2. Results of mulching on nutrients and $CaCO_3$

Abu Faisal garden	Soil depth (cm)	OM %	P	K	N	$CaCO_3$%
Mulched soil-1	0-30	0.86	89.4	396.7	0.106	26.4
	30-60	0.86	17.6	231.4	0.09	27.1
Mulched soil-2	0-30	0.86	49.8	184.1	0.106	24.5
	30-60	0.60	14.6	42.3	0.084	22.6
No mulching, no greywater	0-30	0.60	4.6	172.3	0.126	23.7
	30-60	0.26	1.2	65.54	0.084	24.5

This is a preliminary assessment of impacts of mulching under the existing permaculture practices developed in the project. These results confirm suitability of mulching for local conditions where beneficiaries seem to be content with improved growths of their olive trees.

Two demonstrations on rain harvesting were conducted in home gardens planted with olive trees. Rain harvesting methods were based on net and pan system which is suitable for land topography of the two sites (steep land). As expected, rain harvesting reduced soil salinity build up for both soils irrigated with greywater. Beneficiaries were trained on how to harvest rain by this method.

Table No. 3 shows that rain harvesting reduce salinity increased due to greywater use. Rain during winter helped leach salts accumulated during summer seasons when greywater was used. Table No. 3 showed that on average soil salinity under greywater irrigation is less than other sites under greywater irrigation without rainfall harvesting.

Table 3. Results of mulching with rain harvesting

Abu Faisal garden	Soil depth (cm)	EC(dS/m)	SAR
Rain harvesting + mulching + greywater, location No 1	0-30	1.04	2.14
	30-60	1.00	2.29
Rain harvesting + mulching+ greywater, location No 2	0-30	0.85	1.52
	30-60	0.72	1.35
Reference location with no rain harvesting and no greywater	0-30	0.74	1.39
	30-60	0.45	1.79

Legumes are crops able to fix nitrogen in soil naturally. Base line data indicated that local beneficiaries are not aware of Vetch as a legume crop therefore, seeds of this were distributed to all beneficiaries during winter season. All beneficiaries were trained on vetch cultivation in the areas under trees (Olive) so that the route system can benefit from nitrogen fixed by legume. Beneficiaries were also trained on how to keep part of plants in their home garden to produce seeds for next season. Local beneficiaries benefits from extra vetch as forage for animals.

Soil samples of the project area are poor in organic matter and plant nutrient. The local community traditionally uses goat manure as fertilizer to improve plant growth. However, they were not aware of best practices that could increase value of manure as plant nutrient and results in less environmental problems such as smell and insects. Composting was included as a subject in all training during early 2005 to the end of the project. This training focus on how to prepared compost by simple means such as the hall method (making a small trench in the garden) or by barrel method (using recycled PE barrel with holes that allow air circulation and fast composting). Goat manure (solid compost) mixed with plant residue was used to prepare the compost. Chemical analysis of samples of compost are shown in Table No. 4. These results show that compost contains good percentage of organic matter, high C/N ratio and low pH value, which is good for the local calcareous soils. House owner were very pleased with composting results they obtain using these methods. Beneficiary preferred the trench method because it is cheap and resulted in less bad smell or insects during composting process.

Liquid compost (tea compost) was prepared from solid compost by shacking it in fresh water for about 10-15 days. Results of tea compost analysis show that it contains good amounts of major plant nutrients (N, P and K) and also low pH value. The tea compost extract has low Cl and Na content (see Table 5). It is noticed that tea compost of chicken or pigeon has higher N content compared with that of goats. EC value is high compared with fresh water or greywater EC due to concentration of minerals. Beneficiaries were trained on the best practices to use tea compost. Use of tea compost during 2006 results in good olive trees growth. One major side effect of tea compost was emission of odors

and spread of insects in case of improper practices during preparation. This side effect was possible to control by covering containers of the compost.

Table 4. Results of analysis of solid compost from goat manure with plant residues

Parameter analyzed	Units	Results
N	%wt/wt	0.81
Moisture	%	22.4
Ash	%	53.7
Organic matter	%	23.9
C/N	NA	17:1
pH	NA	6.1
EC	dS/m	1.28
P_2O_5	%wt/wt	0.79
K_2O	%wt/wt	0.7
Na	%wt/wt	0.19
Cl	%wt/wt	0.17
Pb	ppm	Less 0.01
Cd	ppm	Less 0.002

Table 5. Results of analysis of tea compost extract

Type of compost	pH units	EC dS/m	N	P	K	Na	Cl
			ppm				
Goats	5.21	6.4	1400	102	216.10	183.33	355.00
Chicken	4.03	6.3	4900	115	140.25	105.56	266.25
Pigeon	4.15	7.7	4848	8.1	530.35	294.44	621.25

Seedlings of forestry trees of environmental and economical value were distributed to all local beneficiaries during winter season of 2006-2007 to be planted in their home gardens. Trees seedlings shown in Table 6 below:

Table 6. Types of forestry trees

Types	Importance
Pine for seeds	Economical, Wind breaks
Wild almond	Economical
Ceanuous mollee	Repel dangerous insects
Carob	Attract dangerous insects
Eucalyptus	Environmental, reduce septic tank disposal

Willow	Environmental, reduce septic tank disposal
Albezia	Environmental, a legume crop
Bercensonia	Environmental, a legume crop and wind breaker

On other hand, bad smell is a problem associated with greywater irrigation. Odor is generated during irrigation when trapped air in drip lines is released to air by flowing water. Two trials implemented to reduce greywater bad smell. First attempt was to burry drip irrigation lines under soil while drippers were covered with pieces of cloth then soil. Second attempt was to cover drippers with plastic bottle to prevent sudden release of trapped air in irrigation pipes. Both activities reduce greywater bad smell and many beneficiaries were satisfied with the results. The draw back of burying irrigation lines is that beneficiaries have to uncover drip system before tillage activities beginning of winter while for the second method the plastic bottle need repair during summer. Beneficiaries were encouraged to use these two methods to reduce greywater odor.

Safe and natural materials are introduced for local community as alternatives for chemical pesticides. These materials include extracts of tobacco, wild weeds and sulfur (solid spray). These materials have been used in the demonstration sites as alternatives for chemical pesticides which are used by beneficiaries normally. Pest traps were used also during summer season in case of olive trees. Pest traps are simple and cheap since it is made of local plastic bottle. Traps are filled with a mixture of some fertilizer (contains N and P) and yeast and some water. They work effectively in trapping inspects that attack olive trees.

Drip irrigation system was improved based on field observations and feed back from beneficiaries. Important improvements were to select drippers that suit crops water needs and less prone to clogging. Clogging problems due to greywater quality were also investigated. It was found that use of low cost locally made sand and screen filters could be an effective way to reduce line and drippers clogging.

Three types of filters were evaluated on seven of the pilot sites. These types were:

A. Molded case PE screen filters (of fine mesh)

B. Metal case with screen filter inside

C. Metal case with variable size silica particles

Greywater samples are collected before and after filtration and analyzed for TSS contents. Results showed that plastic filter is not efficient to reduce greywater TSS over long time and need frequent maintenance. Metal screen filter and sand filter were very efficient to improve greywater quality and reduce TSS content. Its notice also that sand filter is very efficient to reduce greywater TSS for greywater results from 4 barrel treatment system (Table 7). Improving greywater quality would reduce drippers clogging under greywater irrigation, reduce drip system maintenance and increase drip system age.

Table 7. Filtration efficiency

Filtration methods	**TSS (ppm) content**	

	In	Out	Efficiency
Molded case PE screen filters	185	174	(6%) In-efficient
Metal case with screen filter	198	163	17.7 %
Metal case with variable size silica -4 barrel system	932	85	90.9%
Metal case with variable size silica - CT	64	57	10.9%

Drip system valves were introduced to beneficiaries as incentive during training activities to schedule greywater irrigation. Since a typical greywater unit pumps about 100 liter each time which has to be distributed to different trees in the garden. Valves were introduced to control the amount of greywater distributed to different trees in the garden.

Mobile drippers were installed to allow location of the dippers in the tree basin. Mobile drippers proved to be of good efficiency in preventing salt accumulation in the tree basin. SAR values when mobile drippers were used were lower than the standard practice of fixed drippers. This is shown in Table No 8 below.

Table 8. Soil monitoring for mobile drippers

Methods	Soil depth (cm)	EC(dS/m)	SAR	OM %
Mulched soil with mobile drippers	0-30	1.0	2.27	0.53
	30-60	1.4	3.41	0.46
Mulched soil with mobile drippers	0-30	1.51	3.19	0.46
	30-60	0.93	2.17	0.53
Soil without mulching	0-30	1.16	1.52	1.06
	30-60	0.50	1.02	1.19
Not irrigated	0-30	0.66	2.09	0.66
	30-60	0.62	1.7	0.86

New crops of higher cash value and productivity were introduced to beneficiaries. These included pumpkin, malesa, okra, sunflower, corn. Beneficiaries were encouraged to change their old habits of sticking to traditional crops and move into use of new crops of high cash value. Seeds of the new crops and seedlings of medical plants are distributed to Beneficiaries who attended the training sessions as incentives. It is notice that beneficiaries who have large greywater quantities obtained better yields form these new crops.

Permaculture experiment was conducted at a beneficiary garden on intercropping of okra (Indian type) with sunflower and corn. Okra plants were planted between corn and sunflower plant to maximize use of available land and to reduce plant infection with insects. Plants were cultivated under black plastic mulching. Goats manure was added at planting and mixed with top soil layer. Drip irrigation system used with compensating

pressure type drippers (4 liters per hour) are used in the experiment. Routine plant practices are done by the family under team supervision. For okra, the branches within the first 30 cm were removed. It is noticed that okra, corn ad sunflower are suitable for local area conditions. Crop yield data shown in Table No 9 was recorded on weekly basis.

Table 9. Okra, corn and sunflower yield from demonstration example

Plant	Number of plants	Yield/plant (Kg)	Total Yield
Okra	35	0.94	32.9 Kg
Corn	20	4.75 (cob)	95 (cob)
Sunflower	35	1.86 (flower)	65 (flowers)

The beneficiaries were impressed by the production from the garden. The garden served as a model for local community to generate income for greywater reuse. Other families in the village plan to grow okra and sunflower during the next season.

Some promising forage crops were introduced also during this period. Fenugreek, which is also a medical plant consumed by local people, was introduced as a forage crops for chicken. Fenugreek is rich with protein and could increase chickens growth. Fenugreek fresh yield reached 11 Kg/m^2. Mustered was introduced also for beneficiaries as winter forage crops for animal. Mustered plant yield at one beneficiary garden was 1.5 Kg/m^2. Soybean was also introduced at two home gardens as a forage crop for chicken and goats. Local people are interested in these new crops as a supplement forage crops. It is noticed that the limited area in home garden for some families limits the benefits from these crops.

Table (10) showed results of soil salinity, SAR and organic matter content over the project period. It notice that some EC values increased for five samples out of ten in year 2007 compared with year 2006 while the other are similar or less to those of 2006. Its notice also that SAR values have increased greatly for all samples compared with values taken in year 2006 which is expected due to use of detergents in cleaning practices in house. The use of drip irrigation with low flow drippers (8 L/h) would increase salinity build up in especially in soil layer. High SAR values of 3-6 with EC of 1.2 and more will not affects soil infiltration rate (according to FAO guideline for irrigation water quality) but would affects crops like deciduous trees and grapes which are sensitive to sodicity hazard. The fact that irrigation results in increase of soil salinity and more so when salinity of irrigation water is high. This is a natural phenomena and can be dealt with by soil leaching with excess water from rainfall or supplement irrigation is recommended. This would prevent salts accumulation within the root zone and reduce sodicity hazard to soil and plant. It is notice that organic matter content decreased compared with year 2006 which could be attributed to organic matter decomposition and consumption by plant.

Table (10): EC, SAR and organic matter values for soil samples collected from selected sites.

		Before greywater irrigation	2006	2007

Household	Soil depth (cm)	EC(dS/m)	SAR	OM %	EC(dS/m)	SAR	OM %	EC(dS/m)	SAR	OM%
Asad Falah	0-30	0.64	1.85	1.51	1.3	0.26	4.49	2.85	5.71	0.64
	30-60	0.96	2.6	1.38	1.26	0.22	3.49	5.48	7.44	0.56
Mo'd Shawaheen	0-30	0.42	1.2	2.06	2.2	0.22	3.07	1.03	1.69	1.06
	30-60	0.62	2.01	1.38	1.69	0.21	3.17	1.21	2.53	1.19
Atallah Naser	0-30	0.51	2	2.89	1.22	0.22	4.26	1.07	1.78	0.89
	30-60	0.57	2.44	1.24	1.61	0.34	5.45	1.37	2.647	0.86
Ali Oqbi	0-30	0.7	1.6	4.54	1.22	0.19	3.59	1.56	2.8	0.65
	30-60	0.67	1.85	1.51	1.1	0.16	2.8	1.07	2.84	1.01
Ahmad Qderi	0-30	0.36	0.44	3.16	1.82	0.3	4.53	2.65	3.21	0.82
	30-60	0.34	0.49	1.93	1.32	0.26	4.53	2.23	4.54	0.79

Okra (Indian type), corn, sunflower and bean samples were collected and analyzed for major chemical and microbiological characteristics. The results (Table 11) showed plant nutrient are similar to plants irrigated with fresh water irrigation in other area in the country. No heavy metals presents in the samples.

Table (11): Plant chemical analysis (Abu Ibrahim garden)

Plant	N	P	K	Na	Cl	Cd	Pb
	%					ppm	
Okra-fruits	2.62	0.362	2.55	0.07	0.84	IDL	0.41
Okra-leaves	2.67	0.231	2.23	0.051	0.86	IDL	0.90
Bean-fruits	2.52	0.43	2.97	0.036	0.97	IDL	-
Bean-leaves	3.06	0.50	2.63	0.057	1.97	IDL	0.48
Corn-fruits	2.03	0.314	1.0	0.033	0.21	IDL	0.95
Corn-leaves	1.93	0.371	1.91	0.06	0.83	IDL	0.49
Sunflower-fruits	2.01	0.23	1.92	0.029	0.2	IDL	0.49
Sunflower-leaves	3.17	0.38	3.03	0.055	1.11	IDL	0.46

Biological analysis for plant samples (samples collected from the top soil to all plant parts) showed that corn and sunflower fruits are safe for use (Table 12). Results of okra and bean analysis showed that one fruit sample is infected with pathogen while the leaves are not infected which reflects a direct contact of greywater with the fruits. Both okra and bean fruits are cooked vegetables which mean it is safe for human production. The family was trained on safe harvesting and handling of fruits. The family benefits from the garden to met part of the home need. It is recommended to use good plastic mulching cover for

vegetables crops under greywater irrigation to prevent direct contacts of plants with greywater.

Table (12): Microbiological analysis for plant samples (Abu Ibrahim garden).

	Total coliform/g	Fecal coliform/g
Okra fruits	1.100	240x10^2
Okra leaves	Less 3	Less 3
Bean fruits	4x10^2	Less 3
Bean leaves	4x10^2	Less 3
Corn fruits	4x10^2	Less 3
Corn leaves	Over 1.100	Over 1.100
Sunflower-fruits	93x10^2	Less 3
Sunflower-leaves	Less 3	Less 3
Soil 1	Over 16x10^2	3.5x10^2
Soil 2	Over 16x10^2	3.5x10^2

Local community was generally unaware of the permaculture practices that could achieve best greywater management, increase garden yield and reduce insects and flies. Training program was design based on local community needs and knowledge of agriculture and irrigation practices. Training program conducted on weekly basis for groups of 15-20 beneficiaries each time and included the following subjects:

- Permaculture concept, methods and practices.
- Composting.
- Rainfall harvesting practices.
- Soil management and conservation under greywater irrigation.
- Safe plant protection and disease control.
- Irrigation system management and maintenance.
- Management of household hazardous chemicals and environmental friendly alternatives.

Training activities targeted local community beneficiaries. It was observed that women attended these training sessions more than men and interacted actively with relevant project activities. Incentives were provided in the form of plant seeds, seedling and safe detergents. Training activities covered all greywater beneficiaries with other participants from local community.

Project team visits to beneficiaries showed growing positive change in their attitudes towards greywater unit operation, greywater use and better garden management. This is a result of the accumulated benefits from all training activities conducted and the team visits to local beneficiaries.

Average greywater quantities produced by households were monitored for 5 houses. Result of greywater amounts generated per selected houses for the year 2007 is shown in Table No. 13. The results of weekly measurements from five typical households resulted

in about 237 liters/day. This constant flow of greywater is enough for a small garden planted with about 20 olive trees. The greywater amounts generated is low which is expected since most families connect kitchen water to the greywater treatment unit. In addition, the families have low water consumption compared with other location in Jordan.

Table 13. Average greywater quantities generated per house hold

Households No	Family size	Liters per day
1	12	161
2	7	324
3	7	303
4	6	261
5	7	140
Average	**7.8**	**237.8**

Table 14 shows results of olive yield irrigated with greywater for two season (2006/2007). The results shows, on average, an increase in olive yield for the season 2007 compared with season 2007 which is expected due to greywater irrigation. Olive yield for most villages in Jordan in year 2007 is low compared with year 2006 since olive yield increase in one year and decrease in the next year. These results showed a good potential to increase olive yield with greywater irrigation compared with olive yield under rain fed irrigation.

Table 14. Average olive tree yield (Kg/tree) for year 2006/2007

	Average olive yield (Kg/tree)	
HH	**2006**	**2007**
Sami Faryyah	3.5	13.67
Abu Nedal	41.33	39.3
Abu Faisal	17.67	25
Yousef Asyidah	57	32.67
Musa Amro	55	63.33
Ali Asyidah	26	24
Abu Sael	24.67	36.67
Um Fahad	10.67	16

The value of yield obtained from okra, corn and sunflower from the permaculture improved garden was calculated for season of 2007. The total yield value obtain was equal to 105.28 JD and represents the total income from harvesting these new crops. This amount is equivalent to about 30% of a typical poor family income in project area.

Table 15. Typical new crop yield values

Plant	Total yield (Kg)	Sale price	Value (JD)
Okra	32.9 Kg	1.8 JD/Kg	59.22
Corn	95 cobs	1 JD/7 cobs	13.56
Sunflower	65 flowers	0.5 JD/flower	32.5
		Total	**105.28**

Conclusion and recommendations

- Greywater impact on soil was noticed through SAR increase and to less extent EC increase compared with original soil status. Olive is classified as moderately tolerant to soil so it will be slightly affected but for other crops like almond and lemon it will be greatly affected. Impact is expected also on soil properties, mainly infiltration rate on long term use.
- On-farm rain harvesting was very effectives to leach excess salts and reduce salinity build up due to greywater irrigation. It is recommended to adopt this method for all greywater users to leach excess soil salts.
- Most beneficiaries connect kitchen greywater only to the treatment unit which rich with organic pollutants especially oils and grease in addition to soluble salts results from kitchen practices. It is recommended to connect all house water activities to the treatment unit to improve the quantity and quality of greywater (especially salinity and SAR) and reduce the impacts on soil.
- The use of permaculture practices (organic mulching and composting) under greywater irrigation increase soil contents of nutrients and organic matter content which could alleviate the impacts of greywater on soil and plant.
- Safe pest control as a permaculture practice help to improve agriculture quality and recommended to adopt permaculture practices in future agricultural activities in Al-Amer villages.
- It is recommended to promote the use of environmental friendly detergents by greywater users and make it available in local market with a similar price to regular detergents which will help greatly to reduce detergents impacts on soil and plant.
- New crops like forages, okra, corn, sunflower, carob and malesa as a medical crop showed a good potential under greywater irrigation which could generate high income for local community.
- Drip system coverage with appropriate material like soil (including drip with cloth material first) showed good efficiency to reduce bad smell results from greywater irrigation. In addition, drippers covered with plastic bottle showed to reduce also the bad smell results from greywater use.

- Training which focus on relevant practices to greywater use proved a good efficiency to increase beneficiaries' skills for greywater use management, permaculture and agricultural activities.
- Beneficiary interest proved to be the major factor for the success greywater reuse activities.
- Local community are not aware about other crops which are of good potential for greywater reuse and could results in high income. Good extension services are needed to improve these results.
- It is notice that religious background for some beneficiaries affects the total amounts of greywater separated for irrigation like not to mix kitchen water with toilet water (increase grey water amounts) or not to mix kitchen water with water contains children wastes (reduce grey water amounts).
- The project area needs continuous extension to local beneficiaries to ensure optimum use of garden area.
- Greywater reuse for home garden proved to be an important supplement source for irrigation.
- Greywater reuse in irrigation to increased soil organic matter content and major plant nutrients (N, P, K).
- Greywater reuse for olive irrigation increased olive yield compared with olive not irrigated with greywater.
- Permaculture practices such as mulching showed a good potential to reduce greywater impacts on soil, conserve water and improve soil contents of plant major nutrients.
- Further activities are recommended in the area to work with the beneficiaries on cropping pattern that suit greywater quality parameters and meets local needs.
- There is good potential to do other agricultural activities in the area which increase local community benefits from greywater reuse like introduce new crops like vegetables, forages and fruit trees under permaculture practices.

6. Objective Six: Build local and national capacity and increased public participation

The overall impacts of Phase II are that the local community in Karak are now well trained on the subjects related to sustainability of the project and ability to look after the greywater systems. Training of beneficiaries and trainers on cleaning and maintaining the greywater an agriculture components is accomplished by concerted efforts from INW and its partners; PN, NCARTT, SC, KPFC, WAJ and experts on community and gender issues. detergents, public awareness and writing proposals to obtain and identify funding opportunities.

Many organizations in Jordan are now more involved in greywater projects. Examples of the these organizations are the RSS, NCARTT, JOHUD, CARE and others. Universities are also aware of the Phase II research components and many post graduate students select greywater as their post graduate research subject.

Most research partners were able to attend local and international events and present their work on the project. The following are lists of main activities in this regard:

1- Presentations at the Aqaba Stock-taking experts meeting on February 2007
2-project Open Day in May 2007
3-Three events by INW and the International Foundation of Sciences (IFS) training workshops on developing greywater research proposals for young researchers; May 2005, February 2007 and October 2007 where more than 50 young researchers from Jordan, Egypt, Iraq and Palestine benefited from these workshops. Some researchers were able to obtain IFS funding for greywater research. The number of students that benefited from IFS grants are more than 20 candidates who applied for IFS grants from Jordan, Palestine, Egypt and Iraq.
4- INW researchers where able to attend many regional and international events an present the project research findings in Iran, Oman, Kuwait, Yemen, Lebanon, Syria, Germany and UAE.

The project resulted in important studies on greywater policy options, health impacts on users, socio-economic, benefit- cost and issuing a Jordanian greywater standard. Some countries like Yemen and MECTAT in Lebanon requested technical assistance from INW to start greywater applications based on CT and barrel greywater units.

INW promoted this project at many meetings and receptions (diplomatic receptions, local conferences, intra project meetings etc).

The following reporting material is related to accomplishments according work plan agreed between IDRC and INW in August 2006.

Results achieved under this objective are:

Building local awareness on greywater: It is quite important to build the local awareness of both the local community, in general and households beneficiaries, in particular. The awareness must cover all aspects related to greywater use. Therefore, INW implemented a complete awareness program on greywater which covered the following components:

a) Background on water situation in Jordan and the region and the need for water demand management initiatives in which greywater use is one potential component;
b) Importance of community participation, including women, in the actual implementation of WDM initiatives;
c) Greywater unit operation and maintenance;
d) Greywater practices inside the household;
e) Permaculture concept and practices in home gardens;

The awareness program implemented by INW covered all beneficiaries households including men, women and family members. One important outcome from the community awareness campaign was the establishment of women cooperative in the project area.

Open day activity: INW implemented on 10th May 2007 a one day activity on greywater use. This activity was patronized by the Governor of Karak and was attended by the project beneficiaries, local stakeholders ministries, SC, KPFC in addition to INW and NCARTT research team and other researchers participated in the preparation of field studies on greywater, i.e. socio-economic feasibility, public health, policy, agriculture and gender.

Greywater poster and Handy Volume: INW produced a poster that summarizes the benefits of greywater use in irrigation. The poster mentioned greywater use benefits, which include; conservation the consumption of scarce fresh water at household level which will result in reducing the household water bill, increase home garden agriculture production and therefore, contributes directly to family income. Other benefits include reducing frequency of emptying cesspits and positive impact on the local environment. INW published the major outcomes of Phase II in the form of a Handy Volume. The Handy Volume is expected to be a valuable reference for other organizations and researches working on greywater in Jordan and MENA Region. The Handy Volume includes compilation of recent greywater research outcomes in subjects related to policy, socio-economic, health, environment, social perception, guidelines, in addition to technical details of greywater treatment and use methods.

JISM has included issuing an environmental friendly detergent proposed by INW in the near future.

Objective 7: To conduct a post-project evaluation so Jordan can be used as a model to disseminate the results of the project to other countries in the region

This objective will be implemented by IDRC.

Project monitoring frame work

According to project monitoring frame work a second project monitoring survey was carried out in December 2006 by members of KPFC. The survey questionnaire was based on the questionnaire used by PN in February 2006. The survey questionnaire was discussed with the KPFC, who recommended the survey process to include more than 50% of all beneficiaries. Therefore, 60 beneficiaries out of 110 names were selected randomly from all the six villages. A survey evaluation process that covered 15 beneficiaries was conducted to assess the suitability of the questionnaire and this resulted in a minor modification to improve clarity of some questions. The KPFC then split into four survey teams, but did not include INW researchers so as to give respondents free choice in assessing the project themselves and the survey was simultaneously conducted in the six villages and completed in five consecutive days during the second week of December 2006.

- The Second monitoring survey results indicated that agriculture component of the project achieved expected results and greywater users are satisfied with noticeable improvements in growth of trees and garden crops. Majority of respondents indicated that they learned new methods of cropping and irrigation methods and their awareness on greywater use has increased.
- Majority of respondents (98%) indicated that they would be able to sustain the greywater systems after the end of the project and that 95% said they consider their greywater systems as their personal possessions and 87% said that they would encourage their relatives and friends to use greywater. Two-third of respondents (72%) said they have access to a local technician trained by the project for O&M if needed.

Appendix I: Water, Soil and Plants Monitoring Results.

Appendix II: Handy Volume a publication entitled: "Studies of IDRC Supported Research on Greywater Conducted by INWRDAM", ISBN 978-9957-8624-0-4

Appendix 1

Water, soil and Plants Monitoring Results.

Ariha- Abu Sayel

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
21/06/2005	7.0	1.33	1030	182	286	6.3	4.6	16.89
29/05/2005	6.60	2.61	1989	NA	NA	224	58	291

Abu Ali- Ariha

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
21/06/2005	7.9	1.37	1197	100	286	4.8	2.4	23.83
29/05/2005	6.50	2.57	2315			238	46	329

Ariha- Um Fahad

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
21/06/2005	7.7	1.06	747	46	53	3.9	3.5	16.89
29/05/2005	6.50	2.29	1969			270	69	210
23/05/2005								

Abu Amer- Al Alia

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
21/06/2005	6.9	1.83	850	828	830	7.9	5.3	21.5
29/05/2005	7.10	1.99	1564			190	36	234

Abu Said- Gada

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
21/06/2005	7.5	1.26	850	80	170	4.6	4	18
29/05/2005	7.50	1.44	969			74	53	186
23/05/2005			> 2419	1128	790			

Ariha- Abu Sayel			Unit installed in March 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
29/05/2005	6.60	2.61	1989	790	1128
21/06/2005	7.0	1.33	1030	182	286
16/08/2005	7.2	1.27	988	258	348

Abu Ali- Ariha			Unit installed in March 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
29/05/2005	6.50	2.57	2315	958	1110
21/06/2005	7.9	1.78	1197	100	286
16/08/2005	7.5	1.38	965	124	273

Ariha- Um Fahad			Unit installed in March 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
29/05/2005	6.50	2.29	1969	851	860
21/06/2005	7.7	1.06	747	46	53

Abu Amer- Al Alia			Unit installed in March 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
29/05/2005	7.10	1.99	1564	548	728
21/06/2005	6.9	1.83	1654	828	830
16/08/2005	6.70	1.81	1659	798	873

Abu Saed- Gada			Unit installed in March 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
29/05/2005	7.50	1.44	969	216	225
21/06/2005	7.5	1.26	850	80	170

Abu-Nedal -Mas'er			Unit installed in July 2005		
Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/	COD mg/l
16/08/2005	7.1	1.92	1466	400	474

These results indicate that grey water quality is mainly according to Jordan restricted irrigation standards.
Value of main parameters are high when grey water unit is installed recently and biological processes are not set in well.
General observation is that grey water quality from units is dependant on frequency of O&M.
INWRDAM is conducting O&M and future results will be more representative of typical units performance.

Ariha- Abu Sayel Unit instaled in March 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
29/05/2005	6.60	2.61	1989	790	1128	224	58	291
21/06/2005	7.0	1.33	1030	182	286	126	55.9	388.5
16/08/2005	7.2	1.27	988	258	348	97	67.4	107.9

Abu Ali- Ariha Unit instaled in March 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
29/05/2005	6.50	2.57	2315	958	1110	238	46	329
21/06/2005	7.9	1.78	1197	100	286	96	29.2	548.1
16/08/2005	7.5	1.38	965	124	273	66	68.7	156.4

Ariha- Um Fahad Unit instaled in March 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
29/05/2005	6.50	2.29	1969	851	860	270	69	210
21/06/2005	7.7	1.06	747	46	53	78	42.5	388.5

Abu Amer- Al Alia Unit instaled in March 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
29/05/2005	7.10	1.99	1564	548	728	190	36	234
21/06/2005	6.9	1.83	1654	828	830	158	64.4	494.5
16/08/2005	6.70	1.81	1659	798	873	125	99.04	167.2

Abu Saed- Gada Unit instaled in March 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
29/05/2005	7.50	1.44	969	216	225	74	53	186
21/06/2005	7.5	1.26	850	80	170	92	48.6	414.9

Abu-Nedal -Mas'er Unit instaled in July 2005

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
16/08/2005	7.1	1.92	1466	400	474	111	83.2	188.8

Esmail Al-amer -Mas'er

Parameters	pH units	EC-dS/m	TDS mg/l	BOD5 mg/l	COD mg/l	Ca mg/l	Mg mg/l	Na mg/l
16/08/2005	6.6	2.39	2439	978	1410	290	97.2	178

Annex A: Grey water analysis data

Water analysis form

Sampling data	19/12/2005
Reporting date	21/12/2005

Lab No.	341/2005	342/2005	343/2005	344/2005	345/2005
HH - name	Abu Ali-Ariha	Abu Sayel-Ariha	Abu Ayman-Mugayer	Abu Nidal-Massar	Ismail Khaleel-Massar
Parameters					
TSS- mg/l	29.0	6.0	37.0	28.0	118.0
COD- mg/l	140.0	180.0	370.0	650.0	1800.0
BOD5 mg/l	140.0	1.2	386.0	290.0	1146.0
pH units	6.90	6.60	6.20	6.70	6.10
EC- dS/m	1.79	1.10	1.19	1.57	3.06
Ca meq/l	72.00	70.00	70.00	96.00	312.00
Mg meq/l	61.97	76.55	66.83	69.26	125.15
Na meq/l	212.70	79.70	98.70	117.70	244.30
NO3 mg/l	24.58	5.57	22.20	23.50	45.96
SAR	4.43	1.57	2.02	2.23	2.95
E-Coli	>2419	80.00	310.00	>2419	>2419
Water class	C3-S1	C3-S1	C3-S1	C3-S1	C3-S1

Water analysis form

Sampling data	16/1/2006
Reporting date	22/1/2006

Lab No.	341/2005	342/2005	343/2005	344/2005	345/2005
HH - name	Abu Ali-Ariha	Abu Sayel-Ariha	Abu Ayman-Mugayer	Abu Nidal-Massar	Ismail Khaleel-Massar
Parameters					
TSS- mg/l	30.0	24.0	80.0	60.0	57.0
COD- mg/l	160.0	90.0	2000.0	590.0	920.0
BOD5 mg/l	158.0	11.6	708.0	564.0	478.0
pH units	7.3	7.50	6.70	6.70	6.50
EC- dS/m	1.75	1.00	2.65	1.81	1.55
Ca meq/l	3.30	3.20	18.20	6.50	8.60
Mg meq/l	4.30	4.30	8.10	4.70	3.80
Na meq/l	9.13	3.31	6.37	6.98	4.84
NO3 mg/l	22.89	18.97	28.60	29.75	28.10
SAR	4.68	1.71	1.76	2.95	1.94
E-Coli	>2419.2	300.00	$48.8*10^2$	$79.15*10^3$	>2419.2
Water class	C4-S1	C3-S1	C3-S1	C3-S1	C3-S1

Water analysis form

Sampling data	21/3/2006
Reporting date	28/3/2006

Lab No.	341/2005	342/2005	343/2005	344/2005	345/2005
HH - name	Abu Ali-Ariha	Abu Sayel-Ariha	Abu Ayman-Mugayer	Abu Nidal-Massar	Ismail Khaleel-Massar
Parameters					
TSS- mg/l					
COD- mg/l					
BOD5 mg/l					
pH units					
EC- dS/m					
Ca meq/l					
Mg meq/l					
Na meq/l					
NO3 mg/l					
SAR					
E-Coli					
Water class					

Date of sampling September 6, 2006

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance							
Samey Algharaybeh House	Exit	7.7	7	271	348	7.2		
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit							
Mousa Salameh Alamro House	Entrance							
Mousa Salameh Alamro House	Exit							
Mohammad Hmood Alamaweh House	Entrance							
Mohammad Hmood Alamaweh House	Exit							
Othman Alawedat House	Entrance							
Othman Alawedat House	Exit	7.5	16	272	443	8.7		

Date of sampling October 17, 2006

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance	6.1	133	533	1900	38.66		
Samey Algharaybeh House	Exit	7.6	13	133	155	24.29		
Abdalla Naseer Alamro House	Entrance	5.5	336	830	1500	50.55		
Abdalla Naseer Alamro House	Exit	6.9	94	380	460	23.9		
Mousa Salameh Alamro House	Entrance	5.8	69	700	1110	36.3		
Mousa Salameh Alamro House	Exit	6.9	161	371	470	30.98		
Ahmad Khoshman	Entrance	6	1104	1320	2890	83.62		
Ahmad Khoshman	Exit	6.9	41	740	920	22.13		
Othman Alawedat House	Entrance	7.3	182	437	530	64.9		
Othman Alawedat House	Exit	8		120	190	23.57		

Date of sampling November 27, 2006

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance	7		86	480	22.39		
Samey Algharaybeh House	Exit	7.3		12	180	17.56		
Abdalla Naseer Alamro House	Entrance	4.4		1043	5570	146		
Abdalla Naseer Alamro House	Exit	6.8		486	590	38.49		
Mousa Salameh Alamro House	Entrance	5.1		1156	1930	109.45		
Mousa Salameh Alamro House	Exit	6.5		330	1080	40.33		
Mohammad Hmood Alamaweh House	Entrance							
Mohammad Hmood Alamaweh House	Exit							
Othman Alawedat House	Entrance							
Othman Alawedat House	Exit							

Date of sampling December 18, 2006

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance		116	133	715			
Samey Algharaybeh House	Exit	7.52	30	19	137	0.2 mg/1 as N	1.95 mg/1 as N	
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit	6.96	116	141	1196	0.2 mg/1 as N	6.33 mg/1 as N	
Mousa Salameh Alamro House	Entrance	5.93	358	528	1497			
Mousa Salameh Alamro House	Exit	7.19	94	131	739	0.51 mg/a as N	19.38	
Mohammad Hmood Alamaweh House	Entrance	6.14		528	3330			
Mohammad Hmood Alamaweh House	Exit	7.22	312	86	616	0.2 mg/1 as N	3.45 ng/1 as N	
Othman Alawedat House	Entrance	7.02		123	914			
Othman Alawedat House	Exit	7.47	42	28	86	7.79 mg/1 as N	18.99 mg/1as N	

Date of sampling January 29, 2007

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance	7.1	125		1019			
Samey Algharaybeh House	Exit	7.37	54		394	0.2 mg/1 as N	2.66 mg/1 as N	
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit	6.92	139		1828			
Mousa Salameh Alamro House	Entrance	6.76	122		546			
Mousa Salameh Alamro House	Exit	7.4	73		204	0.2 mg/1 as N	5.7 mg/1 as N	
Mohammad Hmood Alamaweh House	Entrance	6.38	276		830			
Mohammad Hmood Alamaweh House	Exit	7.23	101		471	0.2 mg/1 as N	8.55 mg/1 as N	
Othman Alawedat House	Entrance	7.24	23		92			
Othman Alawedat House	Exit	7.6	25		36	2.3 mg/1 ass N	5.81 mg/1 as N	

Date of sampling March 5, 2007

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance	7.52	84	138	357			
Samey Algharaybeh House	Exit	7.52	32	104	240	<0.2	3.27	
Abdalla Naseer Alamro House	Entrance	6.12	214	1240	2263			
Abdalla Naseer Alamro House	Exit	7.47	214	914	2020	0.43	18.24	
Mousa Salameh Alamro House	Entrance	7.36	111	180	344			
Mousa Salameh Alamro House	Exit	7.62	98	92	215	0.21	23.54	
Mohammad Hmood Alamaweh House	Entrance	7.82	89	170	539			
Mohammad Hmood Alamaweh House	Exit	7.96	42	126	278	0.2	7.96	
Othman Alawedat House	Entrance	7.56	54	110	148			
Othman Alawedat House	Exit	7.70	29	49	97	2.8	4.49	

Date of sampling May 29, 2007

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance							
Samey Algharaybeh House	Exit	7.64	41	124	463	0.2 mg/1 as N	5.58 mg /1 as N	
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit	7.33	226	783	2763	1.28 mg/1 as N	20.38 mg/1 as N	
Mousa Salameh Alamro House	Entrance							
Mousa Salameh Alamro House	Exit	7.52	75	86	393	0.2 mg/1 as N	14.53 mg/1 as N	
Mohammad Hmood Alamaweh House	Entrance							
Mohammad Hmood Alamaweh House	Exit	7.48	33	106	175	0.28 mg/1 as N	3 mg/1 as N	
Othman Alawedat House	Entrance							
Othman Alawedat House	Exit	7.81	12	10	68	0.42 mg/1 as N	4.56 mg/1 as N	

Date of sampling June 20, 2007

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance							
Samey Algharaybeh House	Exit	7.74	26	33	47	0.2 mg/1 as N	5.53 mg/1 as N	
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit	7.5	232	Interferances	619	0.35 ma/1 as N	34.9 mg/1 as N	
Mousa Salameh Alamro House	Entrance							
Mousa Salameh Alamro House	Exit	7.78	169	335	577	0.2 mg/1 as N	22..24 mg/1 as N	
Mohammad Hmood Alamaweh House	Entrance							
Mohammad Hmood Alamaweh House	Exit	7.63	18	28	42	0.2 mg/1 as N	0.96 mg/1 as N	
Othman Alawedat House	Entrance							
Othman Alawedat House	Exit	6.77	24	95	120	0.2 mg/1 as N	8.89 mg/1 as N	

Date of sampling September 4, 2007

Parameter	Note	PH(unit)	**TSS(mg/1)	BOD(mg/1)	COD(mg/1)	Nitrate(mg/1)	Total Nitrogen(mg/1)	Intestinal Helminthes(Egg/1)
Allowable limit***		6 to 9	150	300	500	40	70	< or = 1
Samey Algharaybeh House	Entrance							
Samey Algharaybeh House	Exit	7.57	20	160	197	<0.2 mg/1 as N	7.94 mg/1 as N	
Abdalla Naseer Alamro House	Entrance							
Abdalla Naseer Alamro House	Exit	7.66	128	144	699			
Mousa Salameh Alamro House	Entrance							
Mousa Salameh Alamro House	Exit	7.36	217	281	728	0.3 mg/1 as N	11.05 mg/1 as N	
Mohammad Mahmoud House	Entrance							
Mohammad Mahmoud House	Exit	7.48	46	37	187	<0.2 mg/1 as N	5.47 mg/1 as N	
Othman Alawedat House	Entrance							
Othman Alawedat House	Exit	7.81	14	23	45	<0.2 mg/1 as N	11.05 mg/1 as N	

Plant analysis form Ariha village
Date of sampling 28/08/2005
Date of analysis 08/09/2005

HH No.	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
Lab No.	548/2005	549/2005	550/2005	551/2005	552/2005	554/2005	553/2005	555/2005	556/2005
Beneficiaries No									
Crop type	Sudan grass	Sudan grass	Okra	Okra	Okra	Okra	Okra	Okra	Okra
Crop part	leaf	leaf	Fruit	Fruit	leaf	leaf	Fruit	leaf	leaf
Treatment			mulshing	mulshing	mulshing	mulshing	without mulsh	without mulsh	without mulsh
Parameters tested									
N (%)	2.64	2.7	2.51	2.43	2.53	2.61	2.39	3.14	3.03
P (%)	3.28	2.92	3.34	3.07	2.25	2.57	4.01	3.38	2.59
K (%)	1.93	1.98	1.86	1.84	1.37	1.4	2.13	1.62	1.94
Na -meq/l	33.91	26.52	29.57	32.17	41.30	34.35	42.61	33.48	35.22
Cl -meq/l	183.36	200.28	152.33	115.66	222.85	186.18	135.40	270.80	310.30

Plant samples where collected from the first pilot site in Ariha village. Okra plants where planted under plastic mulching as well as without mulching. Solid composted manure where added for both treatments at planting and liquid composting where added on weekly basis. Treatment without mulching receives some plant residue as soil cover. Plant samples where analyzed for N, P, K, Na and Cl. The content of N and K are closed to the nutrients contents of okra plants and other plants in other references (NCARTT researches). Its notice that the content of P is high compared with other plants. Usually P ranges from 0.1-0.3%, this increase might be due to effects of manure but these values are for the first season. Another season is needed to identify the real values.

Its notice also that the N, P and K content for okra fruits and leaves is higher for plants without mulching compared with plants with mulching. This might be due to effects of mulching (plastic mulching) which reduce the concentration of elements in the root zone as well as in plant tissues. Na and Cl contents trend are not clear for fruits and leaves under both treatments. The same trend for Sudan grass, N and K are similar to other NCARTT results while P content is high which might be due to the effects of manure.