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PROJECT FINAL TECHNICAL REPORT

(8 May 2002 to 30 June 2005)

Greywater Treatment and Reuse in A Cluster of Six Towns in West Bekaa, Lebanon

IDRC Project File #: 100980-001

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Project Duration: 2002-2005

Funded by: IDRC – International Development Research Centre of Canada

Implementation: MECTAT – Middle East Centre for the Transfer of Appropriate Technology of Lebanon

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Project Manager

June 2005

ABSTRACT

The IDRC/MECTAT Project "Greywater Treatment and Reuse in A Cluster of Six Towns in West Bekaa, Lebanon", commenced on May 8th 2002 and ended on 30 June 2005. This project is built on the experience of the Greywater Project of the Inter-Islamic Network on Water Resources Development and Management (INWRDAM) of Jordan. During the duration of the project an active cooperation was established between the two greywater research projects of IDRC in Lebanon and in Jordan.

The project activities during the first year concentrated on meeting with the local officials, NGO representatives and beneficiaries. The main achievements of this period was the identification, selection and installation of 34 treatment and reuse systems, the kits, at the backyards of households who were ready to cooperate with the Project Team for carrying out a 3-year research on issues related to the treatability and safe reuse of greywater, for irrigation and food production in their gardens. The installation, upgrading and follow-ups of the systems (kits) were done by the team of the Project's local technicians.

The activities of the following two years of the Project concentrated on:

- Frequent meetings of the Project Team members with the beneficiaries, holding training sessions with them and evaluating the performance of their treatment systems. Instructing them on proper maintenance of the treatment and drip irrigation systems, reduction of organic waste entry in the greywater stream and on proper agricultural practices.
- Maintenance and upgrading of the installed 34 standard, 4-barrel type, treatment kits and solving their technical problems, such as: odor, blockage, failure of valves and other issues, for problem free use of the kits.
- Monitoring the fruit and vegetable production with the use of treated greywater.
- Laboratory testing of greywater samples, plant parts, fruits and vegetables, and soil samples. And,
- Dissemination of the research results.

Towards the end of the Project, it was found that the treatment and reuse of greywater brings in significant benefits towards food production. Most of the beneficiaries appreciated the benefits of their greywater systems in terms of providing them with 150m^3 of reusable water per year for irrigation and enabling them to safely grow new varieties of fruits and vegetables. The very few that were not so much satisfied were the ones not seriously interested in the art of food growing.

The main achievements of the project were: upgrading of the greywater treatment kits; identification of the groups that can significantly benefit from the kits; establishment of a dialogue and a cooperative atmosphere with the beneficiaries; establishment of a cooperation with similar greywater projects in the region; dissemination of the research results; and, to a certain extent advancing decision making on policy level.

1- Introduction

The MECTAT/IDRC Research Project on greywater treatment and reuse originally targeted 30 households in the six towns of West Bekaa region of Lebanon namely: Kawkaba, Rashaya, Dahr Al-Ahmar, Libbaya, Kfar Mechki, and Majdel Balhis. Towards the end of the project four treatment system were also introduced in the three neighboring towns. The project aimed at carrying out research on the treatability of the greywater and its acceptability for reuse in urban agriculture. The project beneficiaries presented the four major religious communities of Lebanon.

The **objectives** of the Greywater Project of Lebanon are to:

- Increase greywater recovery and make it more convenient and safe to handle.
- Minimize environmental impacts associated with greywater reuse.
- Improve the gardening practices.
- Identify and incorporate relevant socio-economic, including gender issues related to greywater reuse.
- Strengthen local capacity to safely and efficiently reuse greywater.
- Promote changes in policies to encourage greater greywater reuse in Lebanon.
- Self monitor the impacts of the project.
- Establish a regional cooperation with similar ongoing greywater projects.

Most of these objectives were fulfilled during the implementation of the Project.

The anticipated **benefits** of greywater reuse for the beneficiaries include:

- Increase in the availability of household water, in the form of greywater, by more than $150m^3$, without additional cost, to be used for crop production.
- Increase in crop yield leading to food security and income generation.
- Decrease in expenditures related to emptying of over-flown septic tanks.
- Decrease the workload of housewives related to gardening.

The **choice of the project area** was based on the following criteria:

- Availability of backyard gardens.
- Area classified as one of the nine low income communities of Lebanon.
- Prevailing scarcity of water.
- Absence of sewer networks in the six towns of the project area.
- Existance of health and environmental problems due to open bottom septic tanks of the households. Emptying these tanks costs up to US$100 per household per year.
- Ethnic distribution in the project area presented a microstate of Lebanon's communities. In the six towns of the area there are four different communities.
- At the policy level, wastewater treatment and reuse are considered as useful activities for water demand management.

Backyard gardening is an essential economic activity in the project area. Households grow drought resistant trees and vegetables, such as olives, grapes, figs, pomegranate, melons and others. With the availability of greywater, households now have the opportunity to plant additional trees (apples, pears, plums etc.), vegetables and herbs that improve their food security.

The Greywater Project of Lebanon became the first project in its kind ever implemented in Lebanon. It aimed at maximizing the local water resources of this

water stressed region, where surface and groundwater resources are not easily available during 7 to 8 consecutive months of the year.

The main activities of the Project concentrated on the **selection** of the beneficiaries, **installing** the standard 4-barrel type treatment kits at each household, **maintenance** and **upgrading** of the treatment kits, assessing the **acceptability** of the project and other **socio-economic issues** that are related to the proper use of the kits.

The Project Team members held many group and individual meetings with the beneficiaries. The operation of the treatment kits were monitored and the maintenance practices of the beneficiaries were evaluated and many types of advice were transferred to them by the Project Team of experts. Also laboratory tests were carried out for the influent and effluent greywater. The installation, upgrading and reparation of the kits were done by the Project's local technicians.

2- Overall Beneficiary Perspective

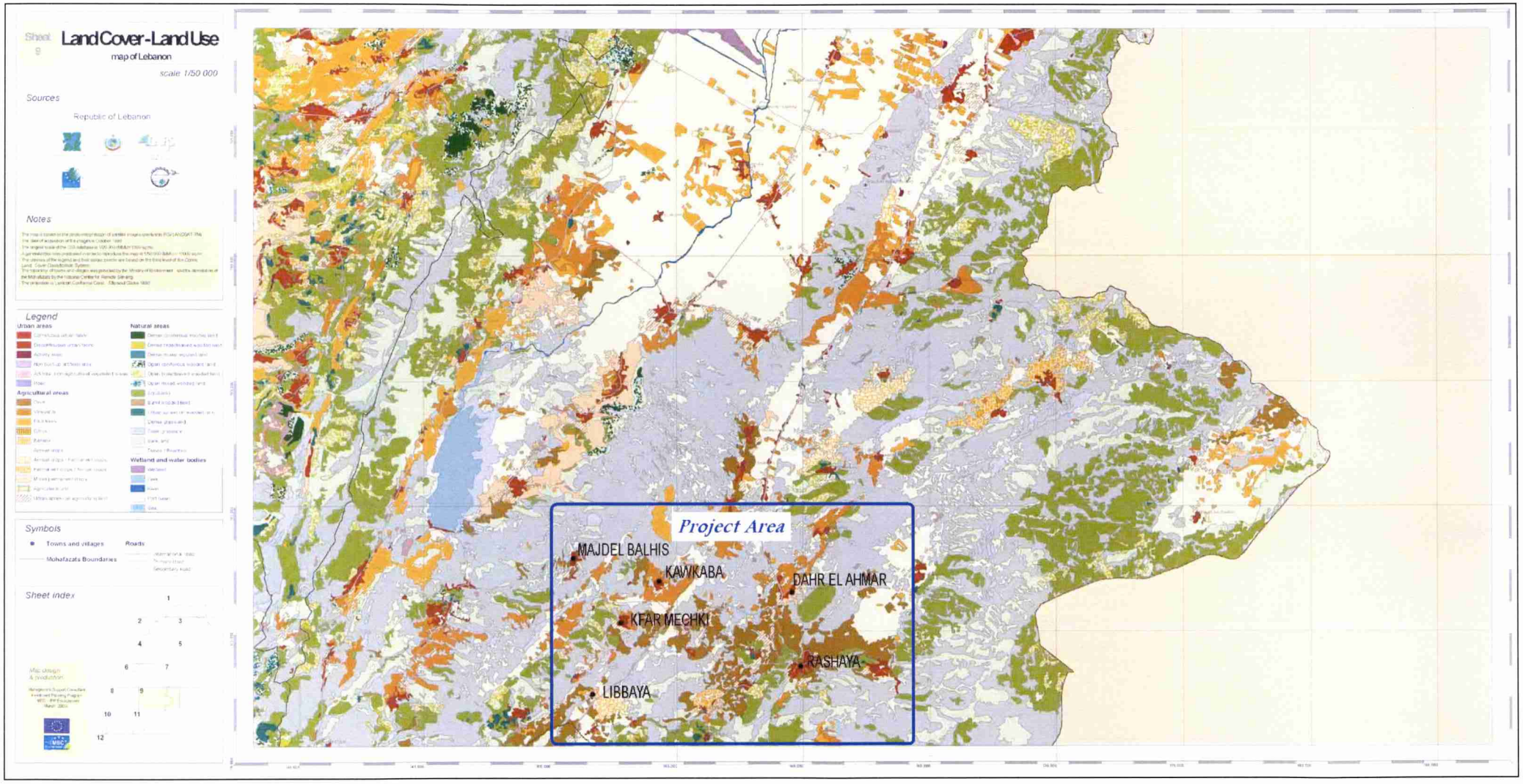
• Distribution of the Beneficiaries in the Project Area

Originally it was planned to target 30 beneficiaries in six towns of the project area. But the number grew to 34, because of the interest and demand of the beneficiaries. It was also planed to install only six standard 4-barrel type treatment kits with drip irrigation systems and the rest to have 2-barrel type systems or underground trenches, which were cheaper to install. But once the first 4-barrel type kit was installed, all of the beneficiaries wanted to have this type. In spite of its high costs, it was decided to install the 32 standard kits and only two kits of 2-barrel type.

Table-1 summarizes the distribution of the beneficiaries from the start of the Project and their evolution by the end of the Project. At the end of the project the kits were installed in nine towns instead of the original six.

During the Project life only 3 beneficiaries decided to stop their participation. The first one was due to the fact that the site presented many technical problems and the system was idling often. The owner decided to give his kit to another householder who can benefit from it in a better way, rather than wait for a while for upgrading his system. The second one, after 2 years of use found that his neighbors are complaining for the odor and decided to transfer it to a poor fellow, who can benefit from its use. The third one driven from the nonsense gossip of his friend broke the system. This was transferred to another guy, who is very much satisfied from the performance of the kit. There are also a couple of beneficiaries whose pumps have been removed (or stolen) and they have not taken action to replace these. They expected from the Project to provide them with new pumps, which was refused due to their lack of enthusiasm toward the kits.

So, we can definitely say that at least 25 beneficiaries are satisfied with the use of the treatment kits. In fact in April/May 2005, when we did the final adjustments to all of the kits, we asked the beneficiaries if they wish to terminate their participation so that we can transfer the kits to other householders, who are waiting to install one. No body wanted to give out their kits. This was an assurance for us that they wish to keep their kits and use them effectively.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Project Area
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KAWKABA
DAHR EL AHMAR
KFAR MECHKI
RASHAYA
LIBBAYA

Table-1. Distribution of the Standard 4-barrel Type Treatment kits in the Project Area

Town	Status of the No. of kits in 1st Year	Status of the No. of kits in 2nd year	Status of No. of kits by end of project
Kawkaba	15	15	15
Kfar Mechki	2	2	2
Majdel Balhis	2	3	3
Libbaya	3	2	2
Rashaya	6	5	5
Dahr Al-Ahmar	3	3	3
Akabe (a nearby town)	2	2	1
Mhaidseh (a nearby town)	1	2	2
Bakifa (a nearby town)	-	-	1
TOTAL	**34**	**34**	**34**

In the case of the two large treatment plants, each one of them designed for 4 to 6 families, the main beneficiary of Rashaya plant is highly satisfied with the results of his garden, which is now being irrigated with greywater. He is also satisfied with the solution that resulted to his septic tank problem, which needed weekly emptying, with significant cost. The second large greywater treatment plant is not so well maintained by its user, in spite of our frequent meeting with the beneficiary and adequate discussions with him.

• Good Relations Between the Project Team Members and Beneficiaries

The Project developed friendly and cooperative relations with the beneficiaries. A sound dialogue was established between them and the Project Team members. Particularly the two main researchers experienced good cooperation with beneficiary women, who are the main care takers of the treatment kits. It is worthwhile to mention that most of the meetings took place in their kitchens, which is not a common behavior towards visitors in rural areas of Lebanon. This is a sign of friendship and trust that was developed. We have gained the housewives' trust and there after they started responding positively, in terms of adopting our messages and advice. It is worth mentioning that, women who practice gardening are more interested in the treatment system and maintain them well. Their proper maintenance has significantly lowered the smell problem and eliminated the blockage problem of the kits.

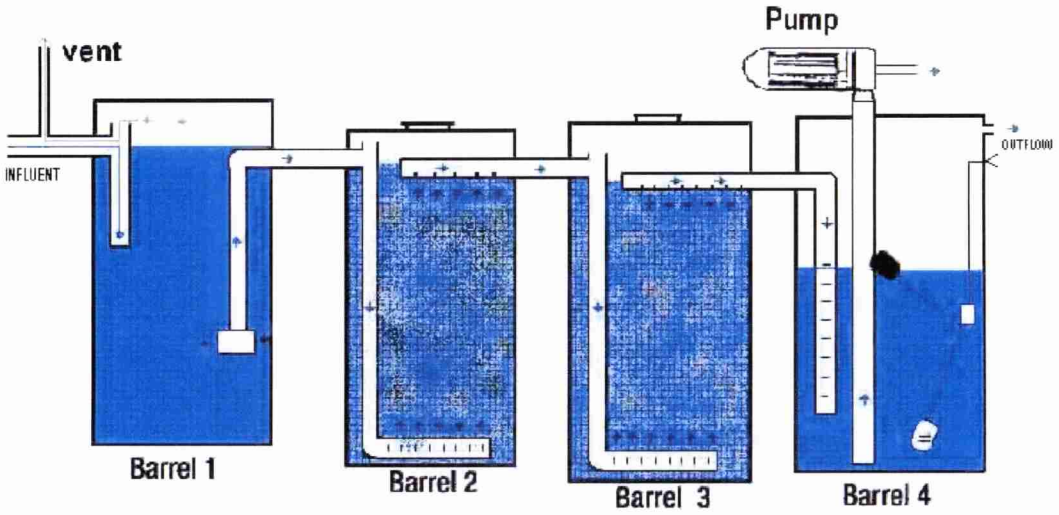
During the final meeting with the beneficiaries, the farewell gathering, which took place on the 29th of June 2005, women beneficiaries expressed their satisfaction from the project activities and from the team members. They wished that the good relations are preserved and that the visits of the Project Team members to continue. We promised to visit them whenever this would be possible. During that final gathering we provided them with certificates of participation in the Lebanon Greywater Project and indicated to them that in the future an association of users of greywater might be established. We thanked them on behalf of IDRC for their participation in the project activities.

3- Lessons Learned During Project Life

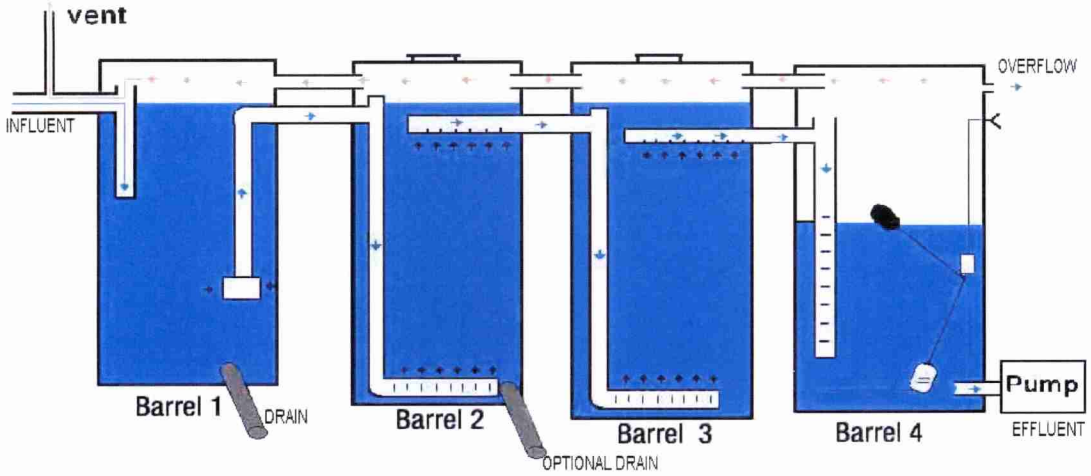
- **Solving the Technical Problems and Upgrading the Treatment Kits**

The major technical problems of the original treatment kits, INWRDAM design, were solved during the project life. These problems included the **idling** of electric pumps due to air entrapment, **smell** problems due to venting problems and intrusion of organic material in the system, **blockage** of the system due to deposits of organic material in the gravel media of the second and third barrels. The solutions of these problems were not difficult, but it took long time. The two illustrations here below indicate the details of the design of the original kit and the final design of the upgraded one.

Standard 4 barrel kit developed by INWARDAM



Adopted 4-barrel (without stones) kit



The smell was the main complain of the beneficiaries and their neighbors. Actually, the duration of the smell is for a short period of a couple of minutes, i.e. when the pump starts operating, 3 to 4 or a maximum of 5 times per day. During the first minutes of pumping bad smell is released, due to the accumulation of hydrogen sulfide (H_2S) gas in the irrigation pipe network. This is because of continuation of anaerobic bacterial activity in the pipes. However, we noticed that some beneficiaries were exaggerating the issue.

With the MECTAT Project team, we have tackled the odor, blockage and idling problems by the following technical and training measures:

Technical Measures included:
1/- **lowering the pumps** of the treatment kits, from their previous upper level of barrels to the lower (base) level of the barrels. Now there is no chance for the treatment system to get idled, due to air intake problem of the pump, and create smelly situations and other inconveniences near the kits. This measure eliminated the need of the non-return valve and some pipe fittings, which lowered the material cost and labor time when installing new kits.

2/- **better venting** of the treatment system was another measure done for all of the kits. Now the venting system of the 4-barrels is inter-connected and better venting results. There are no smell problems at the sites of the 4-barrels, even when the pumps work.

3/- **by-passing the 2nd and 3rd barrels.** During the second half of 2004 we converted the blocked 4-barrel kits of 15 households into 2-barrel kit type by **by-passing** the **2nd and 3rd barrels**. This was done as an intermediate measure, since in most cases the **2nd and 3rd barrels** were completely blocked. The beneficiaries for a while claimed that their odor problem is solved. But on the other hand, the particulate matter in their filtering bag of the 4th barrel increased, which needed more frequent changing. So, by-passing did not bring in long term solutions.

4/- **emptying the gravel of the 2nd and 3rd barrels.** In the meantime, in the 2nd half of 2004, some blocked kits were cleaned from their inside gravel (2nd and 3rd barrels) and were let to continue operating as 4-barrel kits. The laboratory analysis results of this version of treatment kits was found compatible with the standard 4-barrel kits with gravel in the 2nd and 3rd barrels. This conversion was based on our laboratory analysis results of greywater, which indicated that the 4-barrel kits without gravel, give better effluent results in terms of lower BOD, oil and grease, TSS and other parameters, compared to the standard 4-barrel kits that contain gravel. Therefore, before the end of the project, during April/May 2005 we converted all of the kits into 4-barrel type but without gravel in the 2nd and 3rd barrels. We also converted the 2 kits of 2-barrel type into 4-barrel systems. Therefore, now all of our treatment kits have the characteristics of 4-barrel type without gravel, as illustration #2 indicates. We are confident that this version will function free of problems. In fact, one of our beneficiaries was using this version for more than one year and since its installation no idling has occurred and no complaints for the odor was raised by him and his wife.

5/- adding a drain valve at the bottom of the first barrel for periodic discharging of accumulated sludge and floatables, for cleaning the 1st barrel.

It is worth mentioning that the high BOD effluents from the 2-barrel kits have so far not killed or inhibited the growth rate of the trees being grown by the beneficiaries. This is due to the fact that the flow is intermittent and there is the chance of further aeration of greywater in the soil.

Our technicians reported that during the last year pumping failures were reduced to one case, from more than 20 cases of the previous year. This was achieved by upgrading the kits. We feel that problem free operation of the greywater treatment kits are the main guarantees for the proliferation of this technology to other regions of Lebanon and elsewhere in the world.

All of these adaptations and upgrading measures took time and drained a tangible sum from the budget of the Project. On the other hand, delays in the perfection of the treatment kits also delayed the frequency of the laboratory tests and visits of officials to the Project area. But we are now confident that the major technical problems of the standard 4-barrel type greywater treatment kits are solved, which will enable quicker rate of replications in the near future.

Training measures for housewives:
Changing the habits of housewives in proper maintenance of the treatment systems was a quite difficult task. It took long time, through the efforts of various experts of the Project Team, in order to bring changes in their habits. Many group and individual training sessions were fielded by the Project Team, particularly during the third year of the Project life. In spite of this, some housewives are still not practicing proper use of the screens in their kitchen sinks, which will limit the introduction of particulate organic wastes into their greywater collection and treatment system and solve (or limit) the smell problem, as well as eliminate the blockage of the kits and other problems.

During the meetings with women, it became apparent that the instruction pamphlets that the project has distributed to them was not enough for motivating them to reduce the introduction of oils and other organic material into the sinks of their kitchens and also take care of the maintenance, particularly by removing the accumulated oils and other sorts of floating organic material from the surface of the first barrel.

Meetings with small groups of women

General meeting with beneficiaries

In every meeting women were instructed how to avoid and reduce the introduction of organic material, particularly oils. On the other hand they were instructed how to reduce the use of chemical detergents and cleaning liquids, such as Clorox. They were encouraged to start using local and natural products such as vinegar, which can be used instead of Clorox. Vinegar is a local product that all houses in the area produce from their low grade grapes. Vinegar sterilizes and gives good smell to the dishes.

More than 45 meetings or training sessions were held with women in groups of 2 to 4 people. Gathering more than three women in a single meeting has proven to be a

very successful strategy. Women that have done good maintenance work have talked on their experience during the meetings, which became a motivation for others to do similar work. When visiting the sites of the treatment kits and inspecting the operations, it was clear that the women who were caring their systems did not face blockage and smell problems.

During the meetings, satisfied women talked about their positive experiences with the greywater treatment system, and told about how much they have benefited from these. They even came up with some useful tips, from their own experience, on better use of the system. This created a sort of a challenge for the other women beneficiaries. It motivated them to make additional effort when it comes to the proper maintenance of the system.

Throughout the visits, a friendly ambiance grew between the Project Team members and the beneficiaries and therefore they trusted more to the advice of the Team.

Some findings from the meetings and roundtables with beneficiaries:

- In general, the beneficiaries are satisfied with the concept of greywater reuse and the benefit they obtain. The major complaint of some of them is the "smelly conditions", which can be solved when the treatment kits are well maintained.

- Poor families and women who practice gardening are more interested in the greywater systems and maintain them well.

- Women who do not care for the treatment kits, even after a third meeting with them have not improved their behavior. They keep on pouring particulate organic material and spent oils through their kitchen sinks and do not clean the floating matter that accumulates in the first barrel.

- Men always tend to encourage their wives to use less cleaning chemicals. They also value the economic aspect of greywater reuse in backyard agriculture.

• How the Maintenance Work Should Be Carried Out

In the case of Greywater Project of Lebanon, a team of two local technicians were trained in the installation and maintenance of the treatment kits. They were paid according to the number of days they have worked with the project, which was done on ad hoc basis. They pursued their own private work during the rest of the time. This created some problems between the technicians and the beneficiaries. For instance, when failures of the treatment kits happened, sometimes the beneficiaries could not obtain the services of the technicians immediately, because they were engaged with their private work, sometimes in a location more than 100km from the project area. In such cases beneficiaries have thought that the technicians were not willing to help them. The reality was that they were not in a position to drop their private work on the spot and run for fixing the treatment systems of the beneficiaries. This they could not afford.

Sagih Mghames

Adel Abou Ghosh

Therefore, when implementing greywater projects for other areas, we feel that it is necessary to provide a somehow regular maintenance services to the beneficiaries, particularly during the first six months after the installation of the treatment kits. This can be done by allocating a small salary to one of the technicians and assigning some specific days of the week for his services, which he should do properly.

This measure will strengthen the confidence of the beneficiaries on the project and on the other hand, it will strengthen the belongingness of the technicians to the greywater project by securing a small but a secure salary for him. In our case, we are sure that those who quitted from the project were the ones that did not get the prompt services of the technicians when their help was needed in a specific time.

- **Reuse of Greywater for Irrigation and Food Production**

It is estimated that each of the Project beneficiaries are generating about 150m^3 of greywater per year, which is used for irrigating the trees of their backyards. This additional water is enabling them to grow various new varieties of fruit trees, such as apples, pears, walnuts, chestnuts and others. Traditionally they used to practice dry farming and grow trees that depend on the rainwater, such as olives, vines, almonds, apricots and others. Now they are valuing the irrigation water that they generate by treatment and reuse of their greywater. In case the households would have purchased 150m^{3}of water per year, the cost of this would have been a sum equivalent to $500/year.

All of the treatment kits and drip irrigation systems operate in an environmentally friendly manner. That is, the generated greywater is properly collected, treated and reused for irrigation. There is no chance that mosquito breeding takes place in the system. In addition, the effluent greywater directly reaches to the ground, without having the chance of being sprayed, which eliminates the probability for creating health problems. So far the beneficiaries have not reported any health problem, accidents, and other sorts of inconveniences related to the treatment systems. But of course there is the complaint of some of them on the intermittent smell of very short duration.

Laboratory test results of the fruits and vegetables indicated that there are some differences in the major nutrient (N-P-K) contents of the crops grown with greywater and those that are cultivated in conventional ways, where chemical fertilizers are applied. Crops irrigated with greywater contain lower levels of N-P-K nutrients. Also fruit trees that have been irrigated with greywater, their leaves have a bit higher levels of N-P-K, which in turn returns to the soil and brings fertility to it. Details of this issue is discussed here after, under the section on Laboratory Test Results.

Greywater treatment and its reuse does not pause a danger. So far we have not heard any complain on the health impact of the treatment systems. This is a good sign. Actually, the residents do not have the chance to get in contact with the greywater, which automatically flows from the houses, through the treatment kits, and then reaching the trees.

- **Who Should Be the Target Beneficiaries**

In the beginning of the Lebanon Greywater Project it was quite difficult to identify the real beneficiaries. This work was carried out in cooperation with the local municipalities. Sometimes driven by political interests they have advised to consider wrong candidates, who at the end proved that they are not interested in the concept of greywater. Such people usually turned out to be the well to do class of the communities. On the other hand, the municipalities did not know what are the real benefits and limitations of the greywater systems. So far they have not seen a working model of the treatment kits. This "ignorance" also contributed in the wrong choice of some beneficiaries.

But during our 3 year experience with the Project, we found out that the ideal beneficiaries of greywater projects, particularly in the case of newly introduced projects, could be the following:

- those who have water shortages and need irrigation water for food production,
- those who value the water and wish to reuse it,
- those who have overflow problems with their septic tanks,
- those who are environmental activists and would like to conserve the resources of the world,
- teachers who are involved in gardening and also have environmental concerns,
- Others.

3- Laboratory Test Results

During the period October 2004 to June 2005 several rounds of Laboratory analytical tests were done. A total of 30 greywater samples were tested, which were taken from the same six typical household. 12 fruits and vegetable samples and 4 samples of soil were tested to determine the health and environmental impact of irrigation with greywater.

- **Greywater tests:**

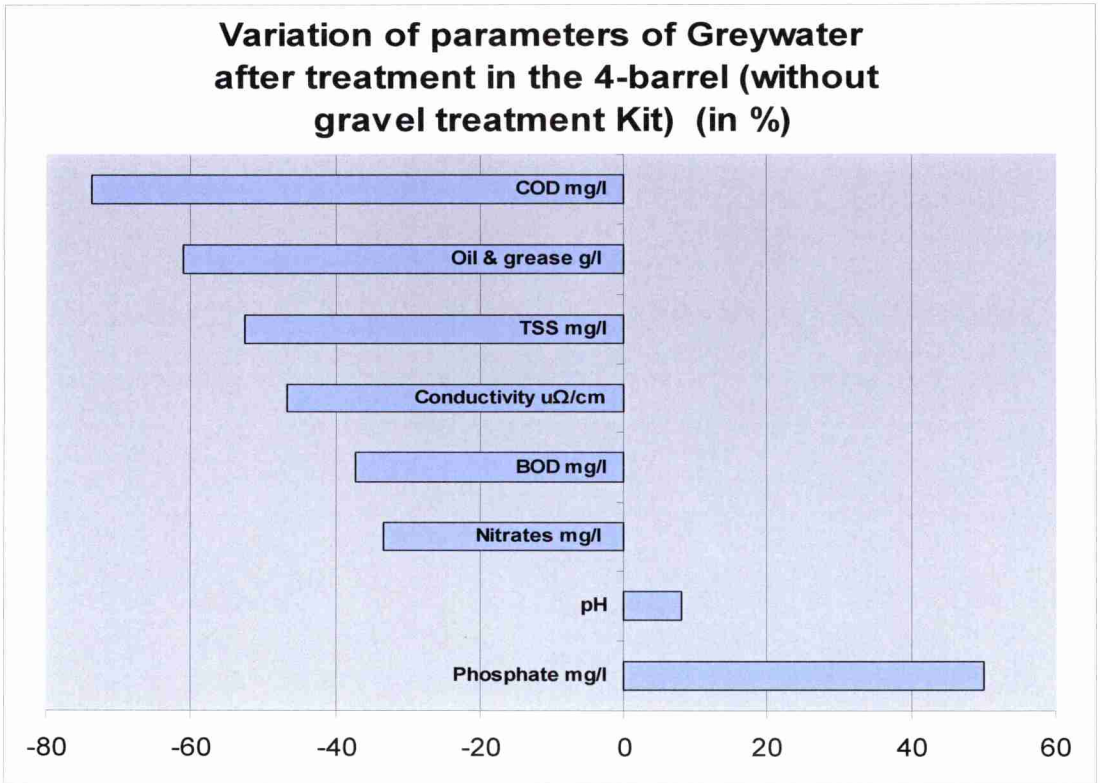
The table and diagram here below summarize the average results of laboratory tests that were done so far on the quality of greywater, while using the standard 4-barrel type treatment kit, without stones in the 2nd & 3rd barrels. Details of test results for 4-barrel type kits with gravel in the 2nd & 3rd barrels have already been discussed in the 5th Technical Report of the Lebanon Greywater Project.

Because we have too many parameters with different scales of measurement, we have chosen the « Base of 100» Index as a measurement tool that will help us indicate the variation of each of the parameters of the tested greywater effluent, crops and soil.

This index is a measurement tool that helps compare a value (e.g. conductivity) in two different situations (e.g. before treatment and after treatment). The initial value (e.g. influent) chosen as a reference, is by convention given the value of 100. The formula used in calculation is the following: **Variation= (T_1/T_0 x100)-100.**

Table-2. *Average results of lab. tests for 4-barrel type treatment kits (without gravel in the 2nd & 3rd barrels).*

Parameters & Characteristics	(T_0) Influent *(base of 100)*	(T_1) Effluent	Variation
BOD mg/l	811	509	-37%
TSS mg/l	80	38	-53%
Conductivity uΩ/cm	682	363	-47%
Nitrates mg/l	30	20	-33%
COD mg/l	3197	842	-74%
Oil & grease g/l	2.024	0.788	-61%
Phosphate mg/l	26	39	50%
pH	6.2	6.7	8%
Coliform Bacteria colony/100ml	>10,000	>10,000	0%



The average **BOD_5** of influent greywater is 811 mg/l (4-barrel kits with on gravel in the 2nd and 3rd barrels) while the average BOD_5 of effluents is 509, which mean that there is a reduction of 37% after treatment, which still remains far higher than the WHO

levels. This is due to the low water consumption rates in the project area, which leads into high concentration of BOD in influent greywater. The water consumption rates in the project area are about 85 l/c/d, while the minimum demand is about 100 l/c/d. The high rates of organic matter insertion through the kitchen sinks is also a factor to be considered, eventhough sink screens were distributed for reducing the input of biowastes from the kitchens.

The explanation to the fact that there is high concentration of **coliform bacteria** in the effluent greywater, the Core Lab director of American University of Beirut indicated that all over Lebanon fresh water municipal supply networks contain some coliform bacteria, due to irrational human practices, which is the cause of having e-coli in drinking water and also in the final greywater effluent. Actually, the coliform bacteria proliferate in the greywater treatment kits where they reside for 1 to 2 days. This increase is high when the ambient temperature is high, particularly during the Summer, This is why the effluent count for coliform bacteria indicates values greater than 10,000 per 100ml. But this does not pause any health problem since the treated greywater reaches directly to the plants, through the drip irrigation network. There is no chance for humans to get contact with the greywater.

It should be noted that, the first barrel of the 4-barrel type treatment kits acts as a trap for **oil, grease and settleable solids**. More than 60% of the oil & grease is trapped in here. It is also a filter for the total Suspended Solids (TSS); there is an average reduction of 53% of the TSS after the treatment in the 1st barrel. In here the 1st barrel provides a primary level treatment to influent greywater.

Conductivity, which is an indicator of salinity in water, is also reduced by 47%. Thanks to the Greywater treatment systems.

As for the **pH Level**, The Greywater treatment system has increased it by 8% bringing it closer to the neutral level. **Phosphorus**, which is a good nutrient for the soil and is the essential component in most fertilizer formulations, has also increased by 50% after treatment in 4-barrel kits.

The Greywater treatment and reuse through the 4-barrel-without gravel-kit has proven to be a successful treatment system as it provides a treatment level equivalent to something in between the **primary and secondary level**s treatment in conventional WWT plants. The diagram shows reductions in the harmful parameters in greywater after treatment This does not often comply with the World Health Organization's (WHO) guidelines for restricted agriculture.

Now all of the project beneficiaries have this final upgraded version of 4-barrel type kits, i.e., without gravel in the 2nd and 3rd barrels.

- **Vegetables and leaves tests:**

Crop tests were done in order to monitor their quality. This was essential for the beneficiaries, who were concerned about the health aspects of irrigation with greywater.

The N-P-K tests were done for vegetables, fruits and the leaves. The lab test results indicate that there is a negative difference in the content of major nutrients in the vegetables and fruits watered with greywater and that of the control samples that are irrigated with plain water with the use of chemical fertilizers. But in the case of leaves, those irrigated with greywater have higher percentages of K (29%). According to the Project agricultural engineer, these results indicate that, fruits and vegetables

irrigated with greywater are free from high levels of nutrients and their consumption does not create health impacts. As for the high level of some nutrients in the leaves, the trees and vegetable plants will eventually shed their leaves, which will be turned into organic nutrient for the soil. This is good for fertilizing the soil and eliminating the need for applying chemical fertilizers. It should be added that the treated greywater contains some nutrients, which enriches the soils and enable the beneficiaries to save money, by avoiding the application of chemical fertilizers.

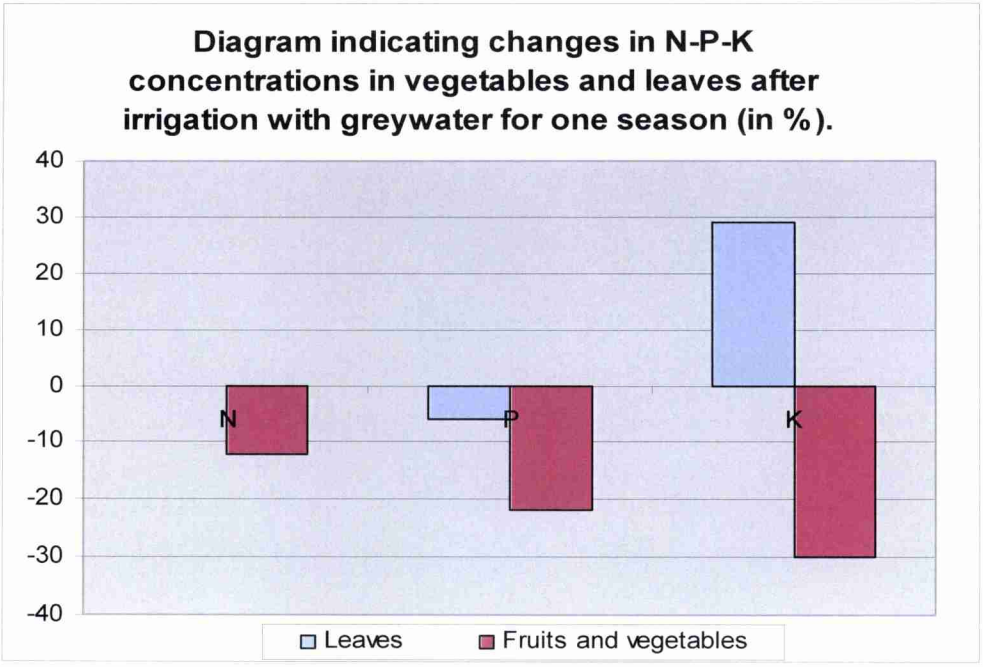
The following tables and the diagrams summarize the lab test results done for vegetables and leaves.

Table-3. *Average results of lab tests for vegetables irrigated with greywater for one season.*

	Irrigation with natural water *(base of 100)*	**Irrigation with GW**	**Variation in %**
N	2.21	2.21	0%
P	0.18	0.17	-6%
K	1.33	1.72	+29%

Table-4. *Average results of lab tests for fruit tree leaves irrigated with greywater for one season.*

	Irrigation with natural water *(base of 100)*	**Irrigation with GW**	**Variation in %**
N	3.76	3.32	-12%
P	0.58	0.45	-22%
K	2.79	1.95	-30%



- **Tests performed on Soil:**

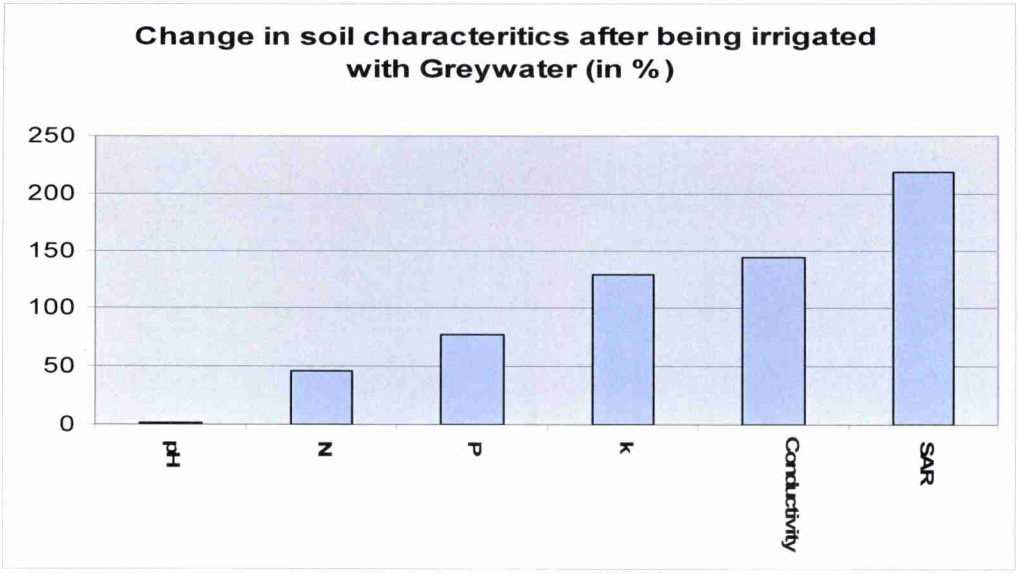
The soil tests results were done during April/May 2005 on soils irrigated with greywater for 2 consecutive years to be later compared with soil samples of non irrigated soil taken 10 meters far from the irrigated spots. The results were all positive as there is an increase in **Potassium** contents by 129%, an increase in **Phosphorus** level by 78% and an increase of **Nitrogen** by 46%. This means that the nutrient components of the soil have increased due to irrigation with greywater, which also explains the increase of some of these minerals in the tested fruits and leaves. This has also been proved by the fast growth of the crops at the beneficiaries gardens. Vegetables like squash, beans, tomato and fruit trees like vines, pears and apples have grown twice faster than the control plants of the same varieties. Beneficiaries are happy for this fact.

The **pH level** of soils has increase by 2%, making them less acidic, and therefore safer for irrigation.

On the other hand, **conductivity** has increased by 144% making the soil more saline, and the Sodium Absorption Rate **(SAR)** has dramatically increased by 218%. This is a bad indicator for soil degradation, because accumulated Salt and Sodium influence the soil structure and texture, limiting aeration and root penetration. However, the project area receives annual rainfall of more than 700 mm, which enables to wash out the accumulated salts and this eliminates the chance of accumulation.

Table-5. *Average results of lab tests for soils irrigated with greywater for two years.*

Parameters	Not Irrigated *(Control)*	Irrigated	Variation
SAR	743.72	2366.18	+218%
K	0.7	1.6	+129%
Conductivity	155	378	+144%
P	1344	2386	+78%
N	0.1085	0.1582	+46%
pH	6.99	7.13	+2%



None of the beneficiaries have reported cases of tree or plant dying because of irrigation with treated greywater. On the contrary, they have observed better growth of plants.

4- Policy and Institutional Landscape Related to Greywater In Lebanon

During the project duration we have established friendly relations with the mayors of more than 12 towns of the project area. We often promoted the concept of greywater treatment and reuse to them. They have been cooperative and found the greywater treatment and reuse systems beneficial for their communities. They are willing to cooperate in case new greywater projects are planned for the area. During the two general meetings of the beneficiaries in 2005, at least 3 to 4 mayors have attended our presentations and have given their positive comments on the greywater project.

At the ministerial level, we have concentrated our relations specifically with Ministry of Environment (MoE) and with Ministry of Energy and Hydraulic Resources (MEHR). Earlier in 2005, contacts were made and meetings were held with high ranking officials in order to plan for their representatives' field visits to our project area, for showing to them the working models of greywater kits and present to them the concept of greywater treatment and reuse. It was also planned to hold a national workshop in 2005 for presenting the achievements and research results of the Greywater Project. But unfortunately, on the 14th of February the former Prime Minister of Lebanon, Mr. Rafic Al-Hariri, was assassinated and the country entered into a period of political turmoil, which is still continuing until now. During April-June the country was involved in the parliamentary elections. And now there is the issue of forming the new Cabinet of Ministers.

During this last 5 months virtually most of the activities of the ministries were paralyzed and decisions were not taken easily. So we could not implement these two activities related to field visits and holding a workshop. These two activities would have lead into drafting a code for greywater reuse. But for sure we, as MECTAT and *Environment & Development* magazine, will continue pushing the concept of Greywater reuse all over the Arab countries.

5- The Research Results Dissemination Plan and Future Plans for Advancing the Greywater Technology All Over Lebanon and in the Region.

Research Results Dissemination Plan:

It is planned by MECTAT to carry out the following activities for the dissemination of greywater treatment and reuse technology in Lebanon and in the Arab World. In the near future we shall do the following activities:

- Write an article in the *Environment & Development* magazine (EDM) on the experience of the Lebanon Greywater Project. EDM is the prominent environmental magazine in the Arab world, where more than 40,000 copies are circulated.

- Make a presentation on Greywater during the Regional Workshop for Municipalities, to be held in Beirut in November 2005, organized by MECTAT and EDM, co-sponsored by UNEP/ROWA.

- Presentations to Associations of Municipalities of Lebanon, when organizing for them half day workshops. Four such presentations are planned for 2005. Already one was held in June 2005.

- Include the subject of Greywater Treatment and Reuse in the educational manuals for school teachers, that we are planning to produce during 2006.

Plans for Advancing the Greywater Technology All Over Lebanon:

- **Proposal to IDRC/WaDimena**:

We have already applied to *WaDImena* program of IDRC for a new greywater project and our application is already accepted for presenting a detailed version of our proposal, which will be submitted by 15th of September 2005. We are going to implement a greywater project for 60 beneficiaries by concentrating in just a couple of new towns in our project area. In here the mistakes of the first project will be eliminated, particularly in the realm of selecting the beneficiaries and the choice of the best model of treatment kits.

- **Proposal to the World Bank**:

In May 2005 we have applied to World Bank's Small Grants Project for installing 50 greywater treatment kits in a town of arid zone of Lebanon. We shall hear their answer in Late September.

- **Proposal to Czech Embassy:**

In early 2005 we have presented a proposal to the Czech Embassy of Lebanon for installing 100 greywater units in a couple of towns in South Lebanon. Lately we were informed that they have considered it as a priority project and there is high probability that a funding will be secured from their budget of 2006.

- **Proposal to EU:**

In the near future we are going to present a proposal to EU for funding a project on scarce water resources development for the rural areas of Lebanon, where one of the activities would be promotion of greywater treatment and reuse kits in the poor and dry areas of Lebanon.

We shall size every single opportunity for implementing greywater projects in various areas of Lebanon and elsewhere.

19/07/2005