sustainable sanitation alliance

Case study of sustainable sanitation projects

Effluent reuse from constructed wetland system Haran Al-Awamied, Syria

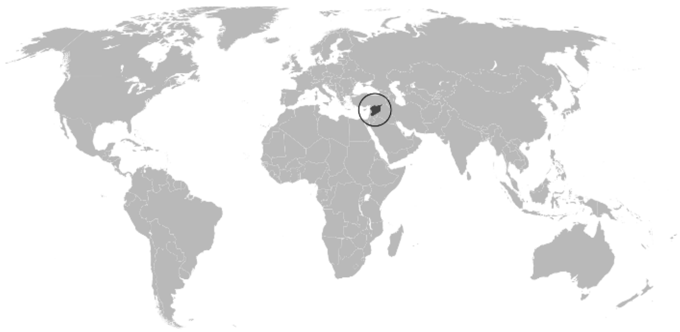

Fig. 1: Project location

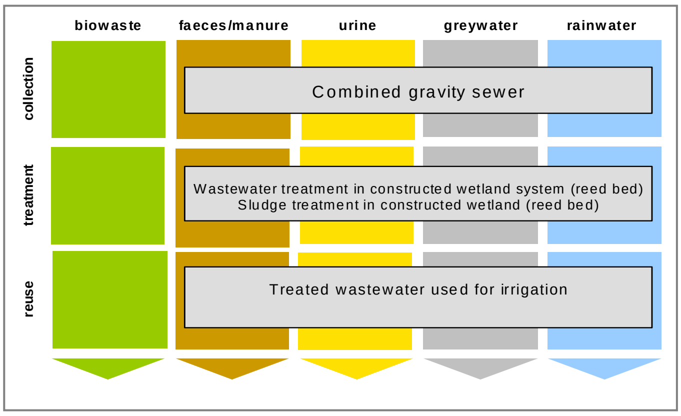

Fig. 2: Applied sanitation components in this project

1 General data

Type of project:
Pilot project of a constructed wetland (reed bed system) for domestic wastewater treatment in a rural area, with reuse in agriculture

Project period:
Start of planning: 1997
Start of construction: April 1999
Start of operation: November 2000
Monitoring ongoing

Project scale:
Design value in 1999: 300 m³/d domestic wastewater (7000 people)
Measured value in 2009: 600 m³/d domestic wastewater (possibly now 14,000 people connected)
Capital cost in 2000: € 95,900

Address of project location:
Haran Al-Awamied – about 40 km from Damascus
Governorate of Rif Damascus, Syria

Planning institution:
Ministry of Housing and Construction (MHC), Syria
University of Damascus (Environmental Engineering)

Supporting agency:
Ministry of Housing and Construction Syria: 70% of capital cost
German Ministry for Economic Cooperation and Development (BMZ) via GTZ: 24%
German Embassy in Syria: 6%

2 Objective and motivation of the project

When this project was started, it was a pilot project and had the objective to test the suitability of constructed wetlands for the treatment of wastewater in Syria considering factors such as social acceptance, relevant legal aspects, operation and maintenance issues and financial sustainability.

A further objective was to test the feasibility of reuse of the treated effluent for irrigation in Haran Al-Awamied.

Now that the system has been operational for 8 years, the current objectives are to:
- Demonstrate long-term functioning of this system; and
- Treat the wastewater of the residents of Haran Al-Awamied

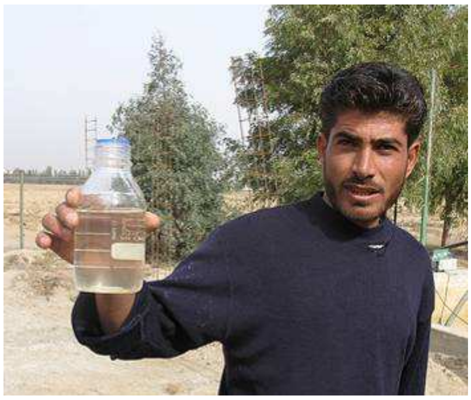

Fig. 3: Operator at treatment plant, showing effluent quality of constructed wetland when plant had been operational for 8 years (source: E. v. Münch, Jan. 2009)

3 Location and conditions

In Syria, much of the water resources are used inefficiently and uneconomically. Agriculture currently uses around 87% of the available freshwater resources for irrigation, supplemented by the use of untreated wastewater, which leads to health hazards, especially with regards to vegetables which are eaten raw.

In Syria only few of the big cities have wastewater treatment plants (activated sludge treatment plant in Damascus and Homs, Hama, aerated lagoons in Aleppo and stabilization ponds in Salamieh).

Diseases such as typhoid, fever and parasitic infections not only cause suffering but also have enormous economic disadvantages for those infected and the national economy. In the Governorate of Rif Damascus, where the constructed wetland treatment plant is installed, around 75% of the inhabitants were infected with hepatitis (Health Ministry, 1997)[1].

The pilot plant is constructed in the village of Haran Al-Awamied, in the Governorate of Rif Damascus. The village is located 40 km south east of Damascus and has a population estimated to be 17,500 (during the design phase, the estimate was 8,750)[2]. It has a semi-arid climate, with 185 mm of rainfall per year, falling within a period of four months. The residents get their water (for domestic use and for irrigation) from wells, most of which are not licensed but are "illegal".

The inhabitants in the village are poor with farming being the main source of income. Farming consists of cattle-breeding and production of wheat, corn and cultivated fodder. The population growth in the village is high (2.3% p.a.)

Before the installation of the constructed wetland, the village's wastewater was already collected by a gravity sewer system and used for irrigation without treatment. In Syria more than 87% of the inhabitants are connected to sewers, but few of these sewer systems are connected to treatment plants.

This village fulfilled all the selection criteria of the supporting agencies such as a good size village, existence of sewers and enough space for building and future expansion of the treatment plant.

Fig. 4: View of village Haran Al-Awamid (viewed from wastewater treatment plant). Source: E. v. Münch, Jan. 2009.

[1] No exact reference available fort his statement.
[2] In design phase: 80% of population (or 7,000 people) were assumed to be connected to the sewer. In 2009, the observed sewage flowrate was twice as high as the design value, therefore, the population has possibly doubled (this is a rough estimate).

Fig. 5: Typical toilet in Syria: Squatting type with flushing. Hose on the left is for anal washing with water. Source: E. v. Münch, Jan. 2009.

4 Project history

The project was initiated by GTZ and MHC (Syrian Ministry of Housing and Construction, formerly Ministry of Housing and Utilities). All the preparatory work was carried out by MHC in 1998.

Construction began in April 1999, and the operation of the plant began 1.5 years later in November 2000. The treatment plant has been operating satisfactorily ever since – which is already a good sign for sustainability.

During the PhD thesis of Abir Mohamed (now working at ministry MHC), the treatment plant was closely monitored, documented and practical research carried out with it (during 1999 to 2004) – see Section 13 for how to obtain the PhD thesis.

An expansion is planned for 2009 as there is significant population growth in this village. It is still regarded as a pilot project as it is only one of two constructed wetlands in the country so far (the other one is at Yabous, and is being constructed in March 2009 under a PPP project between GTZ-Syria and the German company IPP Consult).

5 Technologies applied

A combined gravity sewer system had been installed in Haran Al-Awamied for the collection of rain and wastewater in 1992 by the municipality. The municipality collected the wastewater with sewer systems but they generally did not have any treatment plants (as is common in Syria). The municipality pays for the O&M costs of the sewer system.

This wastewater is transported to a wastewater treatment plant, which has the capacity to treat the wastewater of 7,000 inhabitants. The wastewater treatment plant has a settling tank for pre-treatment and a constructed wetland (sub-surface, vertical flow) for secondary treatment. Further design details are provided in Section 6.

This type of constructed wetland is also called a reed bed: Reed beds are in fact examples for a constructed wetland treatment process (vertical or horizontal sub-surface flow, soil filter planted with *Phragmites communis* or other marsh plants).

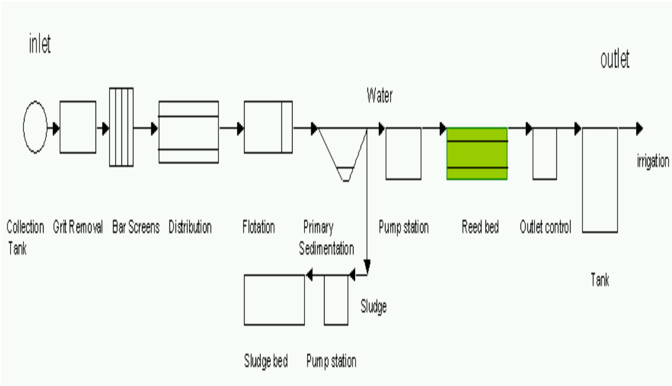

Fig. 6: Flow diagram of the wastewater treatment plant (reed bed system, vertical-flow, sub-surface constructed wetland) at Haran Al-Awamied (source: A. Mohamed).

Fig. 7: Circular primary settling tank at Haran Al-Awamied treatment plant. Source: E. v. Münch, Jan. 2009.

6 Design information

The design value for the wastewater treatment system was 7,000 people and 43 L per person per day, which is a rather low figure compared to more affluent populations. The treatment plant thus has a design capacity to treat 300 m³/d.

However, the actual measured influent flowrate in 2009 was about **600 m^3/d**, due to population growth in the area. Thus, the plant is now overloaded, but appears to be functioning quite well (albeit at its limits, with some water-logging being evident). This water logging may reduce treatment plant performance[3].

The exact number of people now connected to the sewer system is not known but is estimated to be approx. 14,000 people. It was observed that in summer the wastewater flowrate is lower due to lower water availability for the residents (wastewater is thus more concentrated in summer than in winter).

The treatment plant consists of the following treatment units:

- Pre-treatment with manually-raked bar screens
- Primary treatment with a circular sedimentation tank (primary settling tanks)
- 2 vertical-flow, sub-surface constructed wetlands or reed beds (each: 68 m length, 22 m width, 1.5 m depth) for secondary wastewater treatment (total area of both reed beds: 2992 m^2).
- A reed bed (20 m x 10 m x 1.8 m) for sludge treatment.
- A 150 m³ collection tank for treated wastewater for irrigation purposes (with a pump to pump effluent to adjacent fields).

The specific reed bed surface area per inhabitant used in the design was **0.5 m²/person**, which means 2800 m^2 of surface area was required. This design figure is significantly lower than the value typically used in colder climates (3-5 m^2/person in Germany), although the hydraulic load (flowrate) per person is also lower in Syria (on the other hand, the organic load per person would be similar for both countries).

The reed beds are lined with PVC plastic foil (1 mm), and are filled with layers of gravel and sand, with gravel forming the upper and lower layers. The pre-treated wastewater is distributed onto the upper gravel layer and collected through drainage pipes in the lower layer.

The treated wastewater is collected in a tank and pumped to irrigate agricultural fields near the plant (see Section 7). The treatment plant reached a good effluent quality after reeds had grown (2 years), see Table 1.

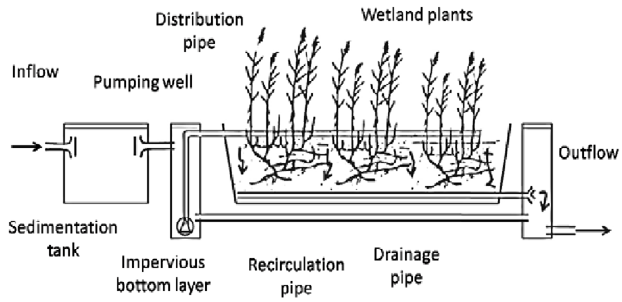

Fig. 8: Schematic structure of vertical flow reed bed (source: Brix and Arias, 2005)[4].

Table 1: Typical results for influent and effluent quality (source: Mohamed (2004))[5].

Parameter	Influent	Effluent	Removal efficiency
COD (mg/l)	446	70	84%
BOD (mg/l)	220	32	85%
PO_4-P (mg/l)	19.3	6.1	68%
NO_3-N (mg/l)	1	45	-
Worm eggs (eggs/100 mL)[6]	Typical: 100 – 1000	1	-

[3] No recent monitoring data for effluent quality was available at the time this document was written.

[4] Brix, H and Arias, C. A. (2005). The use of vertical flow constructed wetlands for on-site treatment of domestic wastewater: New Danish guidelines. Ecological Engineering 25:491—500.

[5] In the PhD thesis of Mohamed (2004), results for 9 influent samples and 9 effluent samples are shown (taken during 2-year period Dec. 2000 to Apr. 2003). The data shown in Table 1 represents typical values during that time period.

[6] Type of worm egg not recorded (probably *Ascaris*).

Fig. 9: Overloaded, water-logged reed bed towards outlet section of reed bed (source: E. v. Münch, Jan. 2009)

Fig. 10: Foreground: primary sludge drying bed (was: reed bed for primary sludge conversion to soil). Background: reed beds (source: E. v. Münch, Jan. 2009)

7 Type and level of reuse

The treated wastewater fulfills the irrigation water quality set by the Syrian Arab Organization for Standardization and Metrology (SASMO) which are based on the WHO standards, and were recently updated (in 2008).

The treated wastewater in Haran Al-Awamied is used for irrigation with a fertilising effect due to its nitrogen and phosphorus content (see Table 1). The inhabitants in the village use the treated wastewater to irrigate their fields; the distribution is organized by the villagers themselves in cooperation with the treatment plant workers.

The treatment of the “primary sludge”, which is pumped daily from the base of the primary settling tank (Fig. 7), takes place in a reed bed. Here, the sludge is converted into humus-like material during a process taking several months.

It is planned that the humus will be further composted with the reeds cut from the reed beds and then reused in agriculture.

In January 2009, the mineralised sludge from the sludge reed bed was harvested for the first time (after 8 years of operation), and piled up next to the reed bed, see photo below. Its appearance is now earth like, dry and without any odours (observation in January 2009). The exact properties of this material have yet to be analysed, but this material can be used as a soil conditioner at or around the treatment plant.

When the converted (mineralised) sludge was removed from the reed bed, the plastic lining of this reed bed was unfortunately partly damaged.

The harvested reed plants (from reed beds for wastewater treatment) could be reused to make waste baskets and roof materials. So far, this has not happened yet.

Fig. 11: Mineralised, earth-like sludge taken out of the reed bed used for sludge treatment (after 8 years of operation) – this reed bed used to be where there is now liquid sludge in previous picture (source: E. v. Münch, Jan. 2009).

Fig. 12: Foreground: effluent tank with two effluent pipes discharging from the two reed beds. Background: reed beds and group of trainees (source: E v. Münch, Jan. 2009).

8 Further project components

The project site is used during workshops and training events on constructed wetlands in Syria. Based on the success of the pilot plant, the Syrian government has decided to allocate more resources to build constructed wetlands in other regions of the country.

The Ministry of Housing and Construction (MHC) is presently preparing the planning documents for a program that would combine capacity development at governorate level with investment in about 23 additional plants of the same type (during 2009-2010). Germany plans to return the credit taken by the former East German state (GDR) in the form of a development fund. This fund will be utilised via KfW (German development bank) for the construction of the 23 additional constructed wetlands treatment plants.

Fig. 13: Training session during a workshop on constructed wetlands in Damascus, organised by MHC: Abir Mohamed in front of reed bed (source: E. v. Münch, Jan. 2009).

9 Costs and economics

The costs for this project are shown below (for the year 1999/2000 for construction):

- Construction costs: € 95,900 (cost break-down shown in Mohamed (2004)[7])
- Construction costs per person (based on 7,000 people): € 13.7
- Operating costs: € 7,000 per year (design figure in 1999) – in 2008: € 9,000 per year
- Operating costs per person and year: € 1 (for design figure) or € 0.6 if population is now in fact 14,000 people.

The operation cost includes the salaries of operators and security guard, electricity for pumps (primary sludge pump), laboratory reagents and the cost to cut the reed.

The construction costs of the reed bed system were clearly less than other comparable treatment systems such as aerated lagoons (construction costs per person € 19 and the operating costs per person and year € 5.7) or conventional activated sludge (construction costs per person € 25 and the operating costs per person and year € 3.8). These costs were estimated in the report "Theoretical Statement from General Establishment for Technical Studying and Consultancies in cooperation with Ministry for housing and utilities 2002"[8].

The site of the constructed wetland was provided by the administration of Haran Al-Awamied free of charge. German technical co-operation (GTZ) then agreed to support part of the material costs. The national Syrian government agreed to take over the construction costs and later the personnel and operating costs. Additionally, the German Embassy in Damascus supported the sludge treatment part of this demonstration plant (they have a budget for environmental projects).

10 Operation and maintenance

The Sewerage Company in Damascus Rif operates the treatment plant and has hired four villagers, working in a two-shift roster, to operate and maintain the plant with the following tasks:

- Pump the wastewater to the two reed beds alternately
- Pump the sludge from the primary settling tank once or twice a day to the sludge bed
- Clean the screens
- Remove weed
- Harvest the reed once a year or less frequently (could be given to farmers but is currently thrown away). Note: cutting the reed is not necessary for the performance of the treatment plant.

The required behaviour of the households for the correct functioning of the wetland (most importantly minimizing the use of domestic chemicals and not to discharge any oil with the wastewater) was explained especially to women in meetings in the village and in the mosque. Most of the inhabitants are farmers and they need to use the treated wastewater for irrigation, therefore they co-operate with the ministry (MHC).

11 Practical experience and lessons learnt

The quality of the treated wastewater in the pilot project is monitored by the responsible Syrian ministries (agriculture, health and irrigation) and used directly for irrigation in agriculture with restricted use (current monitoring data was not available). The treated wastewater contains nitrogen and phosphate, so the soils do not need any additional fertilizers.

Thus, the residents have a great interest in a well-functioning plant. This is different from other cases in Syria, where the wastewater is transported long distances to the central treatment plant, tempting farmers to break the sewer pipes to draw off untreated wastewater for irrigation.

Another important success fact was the co-operation between diverse participants in financing the construction and operation and maintenance of the plant, which worked well notwithstanding the enormous initial difficulties and resistances, in order to overcome the water problems such as high water demand and water pollution.

[7] Of this total amount, the Syrian government paid € 67,600; GTZ-Syria paid € 23,000 (being for PVC foil for sludge reed bed, and laboratory equipment); German embassy in Damascus paid € 5,300 for sludge reed bed construction.

[8] This report is available in the MHC (the costs were estimated in 2002)

This pilot project has provided valuable experience for the future of innovative closed loop wastewater management techniques in Syria:

- The planning, construction and operation of the plant was accompanied by research and observation and was the subject of a doctoral thesis (by Abir Mohamed in 2004).
- The ministries for housing, health and agriculture closely monitored the plant's performance.
- Reports in the local media served to raise awareness among many people of the possibilities and potential of such approaches.
- The treatment plant can be used for training purposes and field trips during workshops (see Fig. 13).

At present, the reed bed treatment plants in Syria are topic of substantial public discussions about their possible use in rural areas, informal housing estates and in isolated smaller localities. The most convincing reasons for the reed bed system are the low costs, easy construction and simple operation and maintenance.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 2) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 2: Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (+ means: strong point of project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene	X			X				X	
• environmental and natural resources	X			X			X		
• technology and operation	X				X			X	
• finance and economics		X			X		X		
• socio-cultural and institutional	X			X				X	

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, e.g. from fertilizer and the external impact on the economy.

Sustainability criteria for sanitation (cont.):

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

With regards to the long-term impact of the project, the main positive impact of the project is that it has demonstrated the appropriateness of constructed wetland or reed bed systems for wastewater treatment and reuse in Syria.

At the same time, the inhabitants of the village Al-Awamied have benefited from having access to a sustainable sanitation system and being able to safely reuse treated effluent (for irrigation) and treated sludge (as soil conditioner, for the first time in 2009).

With regards to the health status of the villagers in 2009 compared to the time before the project (i.e. when wastewater was reused without treatment), it is not possible to observe a difference in health status, because the villagers buy their vegetables also from other villages, and sell their own vegetables at other markets. No health studies have been carried out yet.

13 Available documents and references

PhD thesis about this constructed wetland:

Mohamed, A. (2004) Design, construction and operation of a constructed wetland treatment plant in Syria – A pilot investigation on the efficiency of constructed wetlands in semi-arid, hot summer regions. PhD thesis. University of Flensburg, Germany (in German: Planung, Bau und Betrieb einer Pflanzenkläranlage in Syrien. Eine Modelluntersuchung zur Effektivität von Pflanzenkläranlagen in semiariden, sommerheißen Gebieten. Available: www2.gtz.de/dokumente/oe44/ecosan/de-pflanzenklaeranlage-syrien-2004.pdf

14 Institutions, organisations and contact persons

Project owner:
Haran-Al-Awamied municipality
Damascus Rif, Syria (no website available)

Technical design (and operation through the sewerage company now):
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sustainable sanitation alliance

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SuSanA 2009

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