German-Lebanese Technical Cooperation Project

Public Awareness Campaign for Schools
Planning of the Mokhada Wastewater Treatment Facilities

BGR
September 2012

Dr. Armin Margane, BGR
Groundwater Catchment of Jeita Spring

Groundwater catchment

406 km²

Nahr Ibrahim

Protection of Jeita Spring

Status: May 2012

Surface water catchment

249 km²

2628 m
The Jeita groundwater catchment consists mainly of limestone units which have been exposed since a long time so that they are highly karstified. Because of the high karstification, the planning of wastewater facilities needs geoscientific expertise.
Where does Beirut’s drinking water come from –
Groundwater discharge

Jeita Spring
The main Source for Water Supply of Beirut

75 % of Beirut’s water comes from Jeita

Awareness Movie „Beirut Waters“
Groundwater Flow

Mean travel times

- Lower Aquifer (J4): 150 m/h, 4 days
- Upper Aquifer (C4): 70-200 m/h, 4 days
- ~20 days
- 10 days
There are five measures that need to be implemented in order to protect the groundwater resources used for drinking water supply against pollution:

• assess pollution risks and implement mitigation measures (e.g. abandon industrial sites or clean-up of contaminated sites)
• establish groundwater (and surface water) protection zones (landuse restrictions must be enforced)
• collect and treat wastewater generated in the GW catchment
• adopt landuse planning policies
• monitor water quality

► In karst areas it is important to find the appropriate location for wastewater treatment and effluent discharge
Currently wastewater is discharged
- into injection wells
- into open cess pits or
- into nearby creeks/rivers/wadis

residences with no wastewater collection and treatment

Infiltration of untreated wastewater into highly karstified Jurassic limestone (Faitroun)

► microbiological contamination of Jeita spring
Fractures and dissolution channels (conduits) reach deep into the underground. Rain infiltrates along these pathways together with contaminants.
Contamination Risks from Wastewater

Wastewater is typically discharged through open cess pits or injection wells.

Permeable areas of the underground are selected so that the cess pits will not need to be emptied so often to save costs.
the karst is open, i.e. it is not covered by a protective layer. There is only a thin soil cover. Therefore contaminants can reach groundwater easily.
### Health Effects

Dbayeh raw water (treatment plant)

High and continuous microbiological contamination

<table>
<thead>
<tr>
<th>Date</th>
<th>Analysis Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/06/2008</td>
<td></td>
</tr>
<tr>
<td>18/12/2008</td>
<td></td>
</tr>
<tr>
<td>06/07/2009</td>
<td></td>
</tr>
<tr>
<td>22/01/2010</td>
<td></td>
</tr>
<tr>
<td>10/08/2010</td>
<td></td>
</tr>
<tr>
<td>26/02/2011</td>
<td></td>
</tr>
<tr>
<td>14/09/2011</td>
<td></td>
</tr>
<tr>
<td>01/04/2012</td>
<td></td>
</tr>
</tbody>
</table>

**Escherichia Coli**

**Maximum allowable limit:**

\[< 1 \text{ mpn/100 ml}\]

- Analysis frequency: 4 days
- Exceedances:
  - >1 100%
  - >50 97%
  - >100 85%

Because there are so many point-sources of contamination by wastewater, bacteriological contamination in raw water is continuously very extensive. The microbes contained in the spring water are the cause for serious illnesses. Not all bacteria, viruses and protozoa can be eliminated by chlorination. This is why even treated water may not be safe.

**Protection of Jeita Spring**
Numerous bacteria, viruses and protozoa are contained in groundwater. Many of them are related to human activities.

Krauss & Griebler (2011)
Their survival in groundwater depends on temperature, pH, microflora, organic carbon content, presence of cations (adsorption). Low temperatures support a long persistence. At typical groundwater temperatures of $\leq 15^\circ$C viruses may survive and stay infectious for several hundred days.
Specific Problems concerning Wastewater Planning

Jeita Catchment

- **Topography** (WW must be pumped up at several locations; extremely high gradients)
- **Electricity** not available 24/7 (max 40%)
- Large spacing between residential areas (often only up to 70% of a village can be serviced by a wastewater scheme)
- Households cannot be forced to connect to WW collector lines
- Municipalities have begun to construct WW collector lines without coordinating with the responsible agencies (aim: divert WW out of the village)
- Their concept, material, etc. does not fit with KfW’s/EIBs concept, material, etc.
  - i.e. all new foreign donor funded investment in the wastewater sector will not use any of the preexisting collectors!
- **Geology**: geohazards and impacts on water must be considered:
  - karst, tectonics, landslides, rock falls, earthquakes
In order to establish a wastewater scheme (collection & treatment),
• a **Wastewater Master Plan** (WMP) has to be developed. This WMP defines the target for a specific planning horizon (e.g. 25 years), i.e. what must principally be done to cover a certain area with adequate collection and treatment facilities. The WMP proposes several individual wastewater schemes and includes a rough estimation of costs.

• An **initial site investigation** for the proposed wastewater treatment plants (WWTP) has to be conducted to determine their suitability (draft environmental impact assessment (EIA), especially on water resources). Based on this draft EIA, an update of the WMP is done.

• The agencies responsible for planning in the wastewater sector (here: CDR, MoEW), according to the available funds, **define which wastewater schemes** will be implemented, what are the exact boundaries of these schemes and what is the timeline for implementation.

• The **municipalities** involved in the proposed wastewater schemes have to **agree** to the planned wastewater facilities.

• Tender documents are prepared and a **consultant is contracted** to build the wastewater scheme.

• The **EIA for the scheme** is prepared by the consultant and discussed with all stakeholders (public participation).

• The wastewater facilities are built and transferred to the agency operating it (WEBML).
Centralized sanitation systems

- Collection of all wastewater from an area (groundwater catchment) and transfer to a central location mostly downstream of this area for treatment
- Treatment at a central wastewater treatment plant (WWTP) and discharge of treated effluent downstream of WWTP

Wastewater treatment Plant (WWTP)
Kiel/Germany
380,000 PE
(PE-person equivalent)
Decentralized sanitation systems
- Collection of wastewater from individual households, small areas or parts of the catchment and treatment at different locations (small, less sophisticated treatment plants)

Decentralized treatment system for a single house
Wastewater Projects North of Beirut

Fragmented wastewater schemes because of lack of systematic planning
▶ wastewater master plan needed at the beginning of the planning process!
Investigation of Proposed WWTP

Vertical flow through unsaturated zone
~ 360 m

land surface
560 m

initially proposed WWTP

Protection of Jeita Spring

monitoring sites

injection sites

~ 200 m asl

flow in saturated zone
6.75 km

land surface
540 m

Jeita-Grotto

Daraya tunnel

Abu_Mizane (amidochromamine G)

land surface
70 m asl

5 kg
Investigation of Proposed WWTP

Results Tracer Test 1A

Consequence: KfW requests BGR to prepare proposal of alternative locations

Protection of Jeita Spring

(mean travel time:
WWTP - Daraya tunnel: 56 h
Daraya tunnel Jeita: 6h

injection 5 kg uranine

first arrival @ Daraya (2.8 km) after 44 h

first arrival @ Jeita (6.75 km) after 51 h

second flushing 20 hours after first flushing)
Result
Tracer arrival in Jeita after only 62 h leaves not enough time for attenuation of pollution (die-off of bacteria/viruses/protozoa min. 10 days)
In case of by-passing of untreated wastewater (WW) at wastewater treatment plant (WWTP) a direct and concentrated pollution would occur at Jeita

Consequence
WWTPs should not be located in Nahr el Kalb Valley upstream of spring
► centralized treatment at/near coast, downstream of Jeita spring
Planning of Wastewater Facilities

- General criteria
- Geological/hydrogeological criteria ← BGR
- Financial criteria

**ANNEX 1: Criteria for Site Selection and Design of Wastewater Facilities in Lebanon**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Collector Lines</th>
<th>WWTP Location</th>
<th>WWTP Design</th>
<th>discharge Location</th>
<th>Remarks</th>
<th>Tasks / source</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of inhabitants to be serviced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Geological and Hydrogeological Criteria**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Collector Lines</th>
<th>WWTP Location</th>
<th>WWTP Design</th>
<th>discharge Location</th>
<th>Remarks</th>
<th>Tasks / source</th>
</tr>
</thead>
<tbody>
<tr>
<td>geology (rock type, underground as a barrier, dip direction/angle)</td>
<td>xx</td>
<td>xx</td>
<td></td>
<td>if natural geological barrier is existing, it should be used</td>
<td></td>
<td>geological mapping</td>
</tr>
</tbody>
</table>

**Cost related Criteria**

- method of treatment (primary / secondary / tertiary)
- reliability of treatment
- storage capacity (bypass in case of overload?)
- possibility / need for treated WW reuse
- sludge management / reuse of (treated) sludge for agriculture
- costs for primary collector lines
- costs for secondary collector lines
- costs for household connections
- costs for WWTP construction
- costs for effluent discharge pipeline / canal
- overall costs for construction (available funds)
- annual costs for maintenance and operation (available budget)

Remarks:
- can existing regulations / guidelines for effluent (reuse) quality be maintained at all times?
- must be large enough to guarantee that bypassing untreated WW will not be necessary
- discharge location must be high enough to use as little energy as possible for reuse
- can existing regulations / guidelines for quality of (organic) fertilizer be maintained at all times?

Tasks / source:
- analysis of sludge content; determine sites for sludge application; determine treatment of sludge and related feasibility
- xxxx - killing arguments, xxx - very important arguments, xx - important arguments, x - less important arguments
Proposed Wastewater Schemes

Centralized sanitation systems only

Main Criteria:
- Topography, size of area
- Minimum pumping
- Minimum impact on water resources
- Local acceptance
KfW Jeita Project

Serviced area
- (Zouk Mosbeh)
- Jeita
- (Sheile)
- Ballouneh
- Aajaltoun
- Daraya
- Kleyyat
- Kfar Debbiane

Phase I: 42,000 PE
Phase II: 85,000 PE

BGR prepares EIA for all components of KfW wastewater scheme related to impact on water resources and impact from geohazards.
Guideline for Environmental Impact Assessment for Wastewater Facilities in Lebanon

1. Introduction
2. Legislative and Institutional Frameworks
3. Description of the Project
4. Description of the Environment
5. Impact Identification and Analysis
   5.1 Impacts on all Components of the Proposed Wastewater Facilities resulting from Geohazards
       (including risks of tectonic movements, earthquakes, landslides, rockfalls, rock collapse structures (e.g. dolines), land subsidence, soil liquefaction (instable soil), flooding, etc.)
   5.2 Impacts on Water Resources
       (including impacts of all components of the proposed wastewater facilities on groundwater and surface water resources, impacts resulting from the modification of surface drainage, etc.)

6. Mitigating Adverse Project Impacts
7. Environmental Management Plan
8. Public Involvement and Participation
9. References

Annex 1: Topographic Map of the Study Area including hydrography, spring locations, water supply facilities
Annex 2: Geological Map of the Study Area
Annex 3: Hydrogeological Map of the Study Area
Annex 4: Map showing all Components of the Proposed Wastewater Facility (overview and detailed views)
Possible forms of public participation

1. **Public meetings**
   - open with no restriction as to who may attend

2. **Advisory panels**
   - group of individuals chosen to represent stakeholders
   - meet periodically to assess work done/results obtained
   - advise on future works

3. **Public information centres**
   - facility in an accessible location
   - contains information on the project
   - members of the public can visit, obtain information and express concerns

4. **Interviews**
   - open-ended interviews with selected community representatives

5. **Questionnaires**
   - a written, structured series of questions issued to local people assemble concerns/views/ideas

6. **Participatory Appraisal techniques**
   - a systematic approach to appraisal based on group inquiry and analysis with multiple and varied inputs
Construction

Protection of Jeita Spring
Thank you for your kind attention

www.bgr.bund.de/jeita

Dr. Armin Margane – Project Team Leader
Raifoun, Saint Roche Street
armin.margane@bgr.de +961 70 398027

Protection of Jeita Spring