ELARD

THE COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION (CDR)

# ENVIRONMENTAL AND SOCIAL SAFEGUARD STUDIES FOR LAKE QARAOUN POLLUTION PREVENTION PROJECT

## COMPREHENSIVE PERFORMANCE AND ENVIRONMENTAL AUDIT OF AITANIT WASTEWATER TREATMENT PLANT

## AUDIT REPORT

**August 7, 2015**

| ELARD LEBANON | | |
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| AWTP | Aitanit Wastewater Treatment Plant |
| BOD | Biological Oxygen Demand |
| BOD5 | Biological Oxygen Demand Over 5-day period |
| $CaCO_3$ | Calcium Carbonate |
| CDR | Council for Development and Reconstruction |
| CFU | Colony Forming Unit |
| $Cl^-$ | Chloride ions |
| COD | Chemical Oxygen Demand |
| DO | Dissolved Oxygen |
| EA | Environmental Audit |
| ELARD | Earth Link and Advanced Resources Development |
| HSE | Health, Safety and Environment |
| HSE | Health, Safety, Environment |
| ISO | International Organization for Standardization |
| LRA | Litani River Authority |
| MSDS | Material Safety Data Sheet |
| N | Organic Nitrogen |
| NH3-N | Ammonia-Nitrogen |
| $NO_3^-$ | Nitrate |
| $PO_4^{3-}$ | Ortho-phosphate |
| PPE | Personal Protective Equipment |
| $S^{2-}$ | Sulfides |
| SCADA | Sensing, alarm, response, Control, and Data Acquisition system |
| $SO_4^{2-}$ | Sulfates |
| SPCC | Spill Prevention, Control, and Countermeasure |
| SPM | Spill Management Plan |
| TKN | Total Kjeldahl Nitrogen |
| TP | Total Phosphate |
| TSS | Total Suspended Solids |
| USAID | United States Agency for International Development |
| WWTP | Wastewater Treatment Plant |

# 1. INTRODUCTION

## 1.1 BACKGROUND

Earth Link and Advanced Resources Development s.a.l. (ELARD) has been appointed by the Council for Development and Reconstruction (CDR) to prepare the environmental and social safeguard studies for the Lake Qaraoun Pollution Prevention Project. This project aims at implementing certain components of the Business Plan to Combat Pollution at the Qaraoun Lake that was prepared by the Ministry of Environment. As a result of this plan, a follow-up Committee led by the Litani River Authority (LRA) was assigned by the government to follow-up implementation of the plan. The government has requested financial assistance from the World Bank, which is supporting the implementation of the following components:

- Component 1- Improve the collection of municipal sewage
- Component 2- Increase the adoption of Integrated Pest Management (IPM) practices
- Component 3- Technical Studies in Solid Waste Management and Capacity Building and Project Management

This audit of the Aitanit Wastewater Treatment Plant (AWTP) is related to Package 3 of Component 1, which aims to increase the utilization of Aitanit WWTP, designed and implemented by the United States Agency for International Development (USAID), by maximizing its sewage network coverage.

## 1.2 OBJECTIVES

This audit report mainly focuses on assessing the performance of Aitanit WWTP and its operational environmental impacts. The objectives of the audit are:

- Verification of compliance with design criteria and national regulations;
- Evaluation of the WWTP site;
- Review process and construction documentation;
- Assessment of the WWTP operation status;
- Assessment of treatment efficiency;
- Identification and assessment of environmental management practices; and
- Provision of recommendations with opportunities to improve the WWTP operation.

## 1.3 AUDIT TIME FRAME

ELARD audit team comprised experts in the fields of mechanical, environment engineering and environmental sciences Mr. Joseph Eid (Senior Wastewater Expert), Mrs. Wiam Khashba (Environmental Engineer) and Ms. Imtithal Sheet (Environmental Specialist)). A pre-audit meeting was conducted during a normal operation day with the operator of the Aitanit WWTP

on the 27th of June, 2014. A comprehensive inspection tour of the plant was completed afterwards.

# 2. GENERAL DESCRIPTION OF AITANIT WWTP

## 2.1 BACKGROUND

Sewage generated by the villages of Baaloul, Qaraoun, Aitanit and Machghara contribute to the Aitanit Treatment Plant. The villages of Machghara and Aitanit lie to the west of the Qaraoun Lake whereas the villages of Qaraoun and Baaloul lie to its east. The Aitanit wastewater treatment plant (WWTP) is located within the cadastral area of the village of Aitanit at approximately 400 meters south of the Qaraoun Dam on the Litani River.

## 2.2 DESCRIPTION OF THE FACILITY AND SURROUNDING ENVIRONMENT

Aitanit WWTP is operated by the Union of Municipalities of the Lake who covers the operation expenses that reach about 100,000 USD per year according to Table 2-1 below.

**Table 2-1 Aitanit WWTP Yearly Expenses (source: Union of Lake Municipalities)**

| Item | Quantity | Expenses (USD) |
|---|---|---|
| Staff | 3 | 30,000 |
| Diesel | 5000 L/month | 50,000 |
| Electricity | -- | 20,000 |

Aitanit wastewater treatment plant is designed to provide secondary treatment level to the wastewater originated from Baaloul, Qaraoun, Aitanit and Machghara. The plant was designed to treat an average daily flows of 5000 $m^3$/day and allow a peak of 7440 $m^3$/d to pass through the plant. Currently the WWTP treats 800 $m^3$/d of domestic wastewater, the maximum flows that reached the plant during its operation period were 1200 m3/d. Therefore, the plant has sufficient spare capacity to treat additional flows conveyed by the new sewerage lines connected through the project. In fact, increased wastewater flows to be treated to bring it to half of the plant design flows will Increase the plant operation efficiency and will improve the treatment process stability as the diurnal flow variations will be attenuated by larger connected community.

The plant consists of the following units:

- Manual Bar Screen: one screen, bar opening is 45 mm. Maximum flow: 7440 $m^3$/ day.
- Static Screen: two screens where clear opening space is 2.5 mm. Maximum flow: 3,750 $m^3$/day (each).
- Primary Clarifiers: three rectangle clarifiers (3 ×12×3) m.
- Trickling Filters: two plastic media filters (Ø18.7 ×H 6.1) m.

- Final Clarifiers: three rectangular clarifiers (3 ×18×3) m.
- Chlorine Contact Basin: one basin (43.3×1.1×1.1) m.
- Anaerobic Digesters: four square digesters (9×9×5) m.
- Sludge Drying Ponds: 6 Units; the area per bed is 1,200 $m^2$ and each bed's dimensions are (60×20) m.
- Septic Haulers Receiving Station: One screen where clear opening space is 20 mm.

Figure 2-1 presents the process flow diagram of Aitanit WWTP.

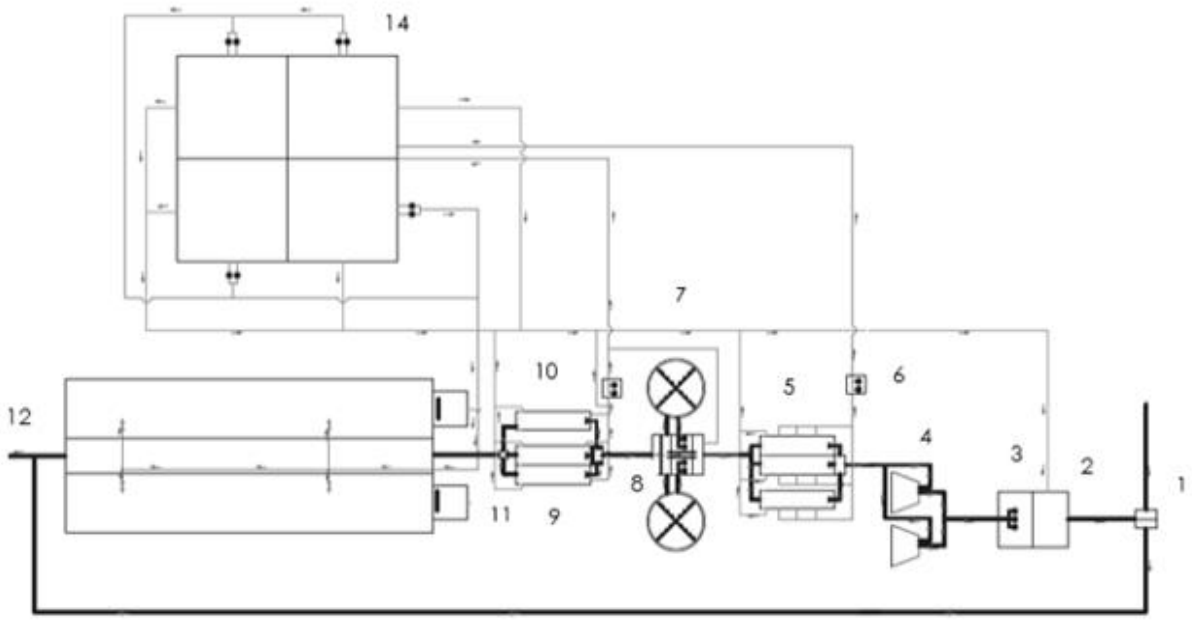


**Figure 2-1 Process Flow Diagram of Aitanit WWTP**

| LEGEND | | |
|---|---|---|
| **ID #** | **Description** | **Quantities** |
| 1 | Flow Diversion | 1 |
| 2 | Coarse Screen | 1 |
| 3 | Influent pumps | 3 |
| 4 | Fine Screen | 2 |
| 5 | Primary settling tank | 3 |
| 6 | Primary sludge pumps | 2 |
| 7 | Trickling filters | 2 |
| 8 | Trickling filter pumps | 4 |
| 9 | Final Clarifier | 3 |
| 10 | Final Clarifier Pumps | 2 |
| 11 | Chlorine Contact Channel | 1 |
| 12 | Sludge drying ponds | 10 |
| 13 | Digester sludge pumps | 8 |
| 14 | Sludge digester | 4 |

# 3. AUDIT FINDINGS

The following sections present a description of the audit findings. This audit represents a comprehensive performance evaluation to review and determine whether there are design issues, deficiencies in the operation and maintenance procedures or equipment malfunctions and to propose solutions to overcome identified deficiencies, if any. Plant performance, including its environmental performance were evaluated.

## 3.1 GENERAL OBSERVATIONS

General observations based on the review of available design documents and the site visits are listed below:

- Aitanit wastewater treated effluent qualities were found in compliances with applicable standards and regulations. It is the best treated effluent between the actually seven operational treatment plants in the Beqaa Valley. As noted below, these effluent qualities can be further ameliorated with minor adjustments to the plant operation (i.e. apply chlorine disinfection, etc…).

- According to the plant operator, some hydraulic overload occurred but was caused by storms and heavy rainfall during winter season.

- Corrosion is noted in some water storage tanks and overflow pipes.

- One of the four digesters was not functioning properly because the pumps were out of service.

- Unpleasant odors can be smelled next to the headwork, mainly the fine screening unit and the drying lagoons and no control measures are detected.

- Some pumps were out of service namely; the influent pumps, the RAS pumps, the trickling filter pump and the digester pumps. These submersible pumps were installed on concrete skid and exposed to sunlight and heavy rainfall without an adequate connection to the cooling media recycle causing operational damages and disturbances (Figure 3-1).

- Rising sludge is observed in the preliminary and secondary settling tanks probably due to the presence of high concentrations of ammonium nitrate in raw wastewater or nitric nitrogen or filamentous bacteria in the final effluent.

- The control panel of the seepage pump station is shaded; however, the control panels of the digester tanks, sludge pumps and primary clarifier pumps are exposed to the sun and rainfall (Figure 3-2).

- An inadequate connection between the outlet of the cooling jacket of the sludge transfer pumps and the plant service water network was observed and may lead to the contamination of the service water by mixing the pumped wastewater with the service water plant inside the pump cooling Jackets.

- Other than the broken sewer pipeline coming from Machghara, no leaking tanks or pipes were detected.

- The structural problem of the Machghara pipeline caused an excess infiltration and accumulation of stones, gravels and grits in the plant's headwork, the treatment units and the pumps. As a result, the performance of the plant was affected especially in the absence of a detritus tank. It's important to note that these particles may end-up in the primary settling tank which will require additional efforts from the plant operators to remove it.

- No evidence of spills or mishandling of chemicals was observed during the site visit between the storage area and the feeding units.

## 3.2 FLOW INDICATORS

The following points are related to inflows to the plant:

- The plant actual inflow is about 800 $m^3$/day originating from the villages of Baaloul, Qaraoun, Aitanit and Machghara. The plant is designed to handle peak hydraulic flow of about 7440 $m^3$/day.

- A hydraulic overload of the plant (flows exceeding maximum plant capacity of 5000 $m^3$/day) occurs during the rainfall season and is observed through the maximum level float switch. Nevertheless, this system is not very reliable.

- When the influent increases and exceeds the plant's capacity, the flow is manually diverted to the river. As the plant was not provided with any emergency storage ponds, this arrangement minimizes the environmental impacts and health risks that may result from high flows of strongly diluted raw wastewater.

- A flow receiving pit and an interceptor piping system are installed in the plant to balance peak flows. Grits small stones and sand originating from Machghara sewer pipeline are accumulating in the flow receiving pit and are being removed manually by the plant operators every three months according to the characteristics of the wastewater entering the plant.

- Excessive seepage dumping by septic tank pumpers occurs two times per week.

## 3.3 HEADWORKS

### *3.3.1 Flow Measurement*

Some observations include:

- Flow measurement device is not properly installed

- An in-line type magnetic flow meter is located next to the fine screening unit and installed at the influent pump discharge line (ABB Brand) to measure the plant's influent flows. This flow meter is very sensitive to air bubbles and cannot distinguish entrained air from the process fluid; therefore, air bubbles will cause the meter to read high values (Figure 3-3).

#### *3.3.1.1 Manual Bar Screen*

Some observations include:

- The screen is cleaned manually which requires frequent raking by the plant personnel to prevent clogging (increased operational efforts). Manually cleaned screens require little or no equipment maintenance and provide a good alternative for smaller plants with few screening particles.

- There is excessive buildup of large screening particles (stones and gravels) on the screen (Figure 3-4).

- The screen is not provided with a screening storage device such as a basket-type bin rack that can be manually hoisted and cleaned; this also poses operational challenges.

#### *3.3.1.2 Fine Screen*

Some observations include:

- The Screening receiving device (e.g. Garbage bin) that is included in the plant is not suitable (Figure 3-4).

- Two Static Sieve type fine screens used to remove solids from primary effluent to reduce clogging problems of the trickling filters are installed. When screened solids reach the bottom of the sieves and pass through a short cone and discharge into plastic bags that are stored next to the screen.

- Screenings are disposed of at Machghara's landfill (once per week).

- Oil and grease are accumulating on the fine screen sieves due to the absence of an oil and grease separator and end-up in the final effluent when not skimmed from the surface of the clarifiers.

### *3.3.2 Treatment Units*

#### *3.3.2.1 Primary Clarifiers (Sedimentation Tanks)*

- Flows from the fine screens are equally divided through distribution chambers and diverted to three rectangular primary settling tanks. The flow in the settling tanks is parallel to the tank's length under actual flow conditions. One tank is set offline to maintain sufficient sludge blanket in the other two tanks. The offline tank is typically set online during wet weather events or when the plant's flow reaches its ultimate capacity.

- Wastewater liquids and solids are separated by gravity in the PST. Scum is skimmed from the surface by a hand-operated slotted pipe skimmer and is collected in a scum pit located outside the tank. Part of the grease and oil that float on the surface of the Water in the PST are eliminated by the same skimmer.

- Settled solids are removed from the bottom by two submersible pumps that are installed in a dry pit between the tanks, fully exposed to sunlight and rain water.

- The cooling Jacket recycle line of the two submersible pumps is not connected.
- The two submersible pumps are connected to the tanks by UPVC pipes. Due to UV radiation, a change of color of the exposed surface of the pipes was observed.
- The three primary tanks are in a moderate condition.
- The gas bubbles and the floating materials that are observed on the surface of the sedimentation tank resulted either from an improper operation of the scum skimmer, an excessive sludge accumulation in the basin, decomposing organics, and the return of well nitrified activated sludge.
- The floating sludge, the black color of the raw wastewater and the unpleasant odors indicate that settled sludge is being retained for a long period of time in the PST (Figure 3-5).

*3.3.2.2 Trickling Filters*

- This filter is equipped with an underdrain system that collects the filtrate and solids that are then conveyed to the settling tank. Part of the filtrate is recirculated through the trickling filter by the trickling filter recirculation pumps. Adequate doors for passive ventilation and fans for forced air are provided. Vent doors are shut when the fan is running (Figure 3-6).
- A thin layer of algae is observed on top of the filter.

*3.3.2.3 Final Clarifiers*

- A secondary settling tank composed of three clarifier tanks (two are in use), each equipped with six manually activated telescopic valves installed in a GRP Channel to draw off the sludge from the bottom hopper of the tank into the GRP are observed (Figure 3-7).
- The solids that settle in the clarifier are discharged directly into a sludge digester or recycled and sent back to the trickling filter by pumping capacity.
- Clarified water flows by gravity to the chlorine contact tank for disinfection prior to disposal into the river through the outfall pipe.
- The GRP channels in Aitanit WWTP were supposed to be built in concrete. These channels showed deformations along the edges.
- Excessive gas bubbles, floating bulks and rising sludge appeared on the surface of the wastewater. This indicates improper settlement of sludge and forming clouds caused by filamentous bacteria and denitrification process inside the clarifier. Tiny floc particles that were moving to the final clarifier weirs increased the turbidity of the effluent.

*3.3.2.4 Chlorine Contact Basin*

- No evidence of a reliable and applicable method for chlorination is detected.
- No automatic control of the residual chlorine concentration is noted.

- The treated effluent is being discharged in the river without disinfection, even though chlorine dosing pumps are available.
- No disinfecting agent is found in the Chlorine contact tank (Figure 3-8).
- The chlorine feeding room is not equipped with eyewashes.
- The chemical solution tank for the preparation of the chlorine solution is missing. Instead, a 20-L drum is being used for chemical solution preparation.
- No chlorine test kit was available at the time of the visit.
- The chlorine agent was expired at the time of the visit.

### *3.3.3 Sludge Treatment*

#### *3.3.3.1 Anaerobic Digester*

- Four digester tanks with an open top used for thickening and sludge ageing as well as decanting pipes on facing surfaces are installed in the plant (Figure 3-9). Those digesters are the source of unpleasant odors in the plant and its surrounding area.
- Decanting pipes are used in the anaerobic digester to ensure the evacuation of the supernatant (excess water) into the primary settling tank.
- In order to mix the digester content and transfer the sludge to the drying ponds two submersible pumps with cooling jackets are installed in a dry pit fully exposed to sunlight and rain water. The cooling Jacket recycle line of these pumps was not connected at the time of the visit. The suction and discharge pipes of the pumps were not adequately positioned to provide a complete mixing of the tank's content.
- The area above the pumps and the control panels is not shaded.

#### *3.3.3.2 Sludge Drying Lagoons*

- The supernatant evacuation through the sluice gates is not effective because these open from bottom to top instead of top to bottom to allow supernatant, which accumulates on the top to be released (sludge deposits on the bottom of the ponds and the supernatant remains on the top)(Figure 3-10).
- Ten drying lagoons are available within the Aitanit WWTP. After the digestion process, solid sludge is conveyed to the drying lagoons for dewatering purposes (Figure 3-11). The sludge drying ponds contain sludge during winter and summer which is unsafe especially during rainfall periods.
- Due to the lack of adequate sludge disposal practices the following was detected in the drying lagoons:
    - appearance of poor sludge distribution;
    - noxious odors (next to the ponds);

- Presence of snails and vegetations.

### *3.3.4 Sludge Disposal*

- The secondary sludge is being stored for a long period of time in the settling tank and is then being pumped back into the PST.

- The quantity of sludge generated during the first year of the plant's establishment was 50 kg/day; however, after the opening of the Qaraoun valve, the sludge quantity doubled and was kept for three years in the drying beds without being eliminated to a landfill.

- The Seepage delivery is directly diverted to the drying beds without passing through the sewage treatment units.

### *3.3.5 Treated effluent*

- Treated wastewater is discharged into the river through a 1 km outfall. The structural problem in the design of the outfall can be translated into the absence of a Rip rap structure or a diffused outlet into the river to avoid point pollution and disturbance of the aquatic life in the river.

- No regular analysis is conducted for treated effluent or receiving waters by the operator (except for the pH, DO and temperature).

### *3.3.6 Standby Power and Alarms*

- The total power capacity of the generator is 150-250 kV

- The plant (treatment units and headwork) is equipped with local alarms to notify units' failure or loss of power.

- No gas detector equipment is connected to the generator to detect the flammable and toxic gases.

- A noise reduction system is installed to reduce disturbance from the generator.

- Continuous monitoring of unusual excessive heat, noises, vibrations, and burnings is ensured.

- Operators regularly (daily/ weekly/ monthly) conduct maintenance programmes for the generator by controlling and inspecting the generator's voltage, the cycles and engines, the battery, the fuel tank level and the battery chargers.

- The average monthly fuel consumption is 10,000 L/day which corresponds to 4 to 12 hours/ day of average daily operation time. The daily operation time is highly dependent on the electricity supplied by the Government.

- The storage tank is located underground.

- There is no intention to replace high energy consuming equipment with energy efficient equipment.
- Diesel-powered plants and equipment are turned-off while not in use to reduce excessive energy consumption.

### *3.3.7 General Housekeeping*

- Repair tools are available at the workshop area.
- Maintenance and operation manual is available in the plant.
- The plant is generally clean, free from open trash areas.
- No pest control program is initiated in the plant due to the absence of a landscaping area.
- Regular and daily cleaning procedures are carried out for the plant treatment units, the digester, the blowers and the pore systems.
- The treated effluent that reaches the chlorine contact tank is used for cleaning.
- No SPCC Plan (Spill Prevention, Control, and Countermeasure) is set at the plant; however, the employees are well trained to control spills (oil and fuels).
- Spills and leaks that occur in dry areas are directly controlled.
- Storage and labelling requirements of the chemicals are not respected in the plant.
- Some spare parts are maintained in the plant (recommended spare parts are presented in Appendix A).

### *3.3.8 Safety*

- The access to the plant is secured through two gates, one in front of the administrative building and the other by the side of the drying lagoons. The first gate is normally used. Gates are not provided with security alarms.
- All ladders and catwalks were provided with adequate handrails for the safety of the operator (Figure 3-12).
- A list of emergency phone numbers is available at the plant (Figure 3-13).
- Personal Protective Equipment including hard hats, rubber boots and gloves are available at the plant.
- Emergency response plans are accessible at the facility.
- Warning signs (no smoking, non-potable water, danger-fire risk, danger-chlorine and electric shock risk) are available on site in critical area (Figure 3-14).
- Material Safety Data Sheets (MSDS) are available for chemicals.

- First aid kit is available in the plant but most of the medicines are found to be expired (Figure 3-15).

- Fire extinguishers are available at the plant but the expiry dates are passed and the extinguishers have not been renewed (Figure 3-16).

### *3.3.9 Environmental Monitoring plan*

- At earlier stage when the feasibility study was conducted, a general environmental and social impact assessment was conducted for all of the three plants funded by USAID (Fourzol, Ablah, Aitanit). This assessment covered Aitanit environmental impact and was used also to elaborate an environmental monitoring plan to assist the operator in managing and monitoring this plant impacts on the environment. This monitoring plan is included in Appendix D.

### *3.3.10 Sampling*

- The laboratory is equipped with a kitchen sink, cabinet and drawers to store laboratory equipment and instruments.

- The only available laboratory instruments and reagents on site are pH meter, DO meter, distilled water bottle and some pH buffer solution. Instruments are not properly calibrated as the reagents and the buffer solutions are expired.

- The sampling and analysis plan and the daily process control sampling are available.

- The available instruments were not sufficient to operate a wastewater treatment plant adequately.
- The DO meter (YSI Brand) was indicating false measurement results due to the non-accuracy of DO sensor.

### *3.3.11 Records*

- A full record of the operational performance of the plant, the equipment maintenance and the reparation procedures is available.

- As-built drawings, shop drawings, site layout, design plans and criteria and construction specifications are available on site.

- Maintenance and reparation records for the wastewater treatment plant units are available.

- A process flow diagram, instructions for the operation of the equipment, warranty information and different record forms (sludge settle ability test forms, sludge handling daily process control data sheet, flow meter testing data collection form and the standby power generator record form) are available.

- Records of previous environmental problems are available.

- There are no records for the daily plant influent or effluent characteristics; however, there is logbook for the daily flow meter reading, DO measurement and pH value.

### *3.3.12 Treatment efficiency*

The treatment efficiency was evaluated by comparing the quality of the inlet wastewater and the outlet treated wastewater as well as comparison with the prevalent standards. Two (2) Twelve hours composite samples were collected from the effluent chamber and the certificates are included in Appendix B.

According to the results, the wastewater treatment efficiency for BOD removal is 97.8% and the efficiency of COD removal is 88.6%;

The wastewater analysis results of the effluent were compared against the proposed Lebanese Wastewater Reuse guidelines (Table 3-1), Water Quality for Irrigation[1] and the Lebanese Maximum Allowable Limits for discharging wastewater into surface water (Table 3-2). Exceedances to the standards are highlighted in bold.

Coliform Bacteria concentrations exceeded the standards for category 1 and 2.

Coliform Bacteria concentrations exceeded the Lebanese standards for maximum allowable limits for receiving surface water bodies as the plant operator was not disinfecting the effluent to reduce his operational cost. The treated water is being used for irrigation purposes and hardly any water is being discharged to the river due to the lack of water in the area. The effluent pipes are currently closed and the farmers are pumping out treated water from chlorine contact tank for irrigation. Therefore, the audit did not find it as incompliance issue. However, the recommendation will be made to properly operate choline addition as designed and level of Coliform Bacteria will be monitored closely.

TDS level in the effluent require slight to moderate restriction on use for irrigation, whereas after disinfection with chlorine it can be discharged to surface water without any restriction.

Total Nitrogen concentrations exceed slightly the reclaimed wastewater reuse guidelines in Lebanon as the plant was designed before the approval and implementation of the Ministry of Environment decision 8/1of the year 2001. De-nitrification was not part of this plant treatment process design while actually partial denitrification is occurring in the secondary settlement tank due to the long retention of sludge inside these tanks. The excess in the total nitrogen above the reuse guidelines will not restrict the possibility of reuse of reclaimed water for irrigation purposes as nitrate will enhance the fertilizing quality of the treated water and don't cause any harm for trees when in Nitrate status.

In addition to wastewater analysis, a sludge sample was collected from the drying ponds on July 16, 2014. The analysis results were compared against the sewage sludge ordinance for Lebanon that respects the local conditions and follows the orientation of the European directive 86/278/EEC. Limit values are based on current recommendations of the European Commission (Table 3-3). If sludge does not meet the above described standard or if the demand of sludge is insufficient then it must either be disposed by incineration or on a sanitary landfill. It is recommended that the operator prepares a sludge management plan in accordance with this ordinance.

[1] Proposition for Lebanese Wastewater Reuse Guidelines- United Nations-Food and Agricultural Organization (FAO) Rome, 2010

According to the results, the sludge concentration of heavy metals and organic compounds are within the limit values for use on land with the exception of the Zinc. The concentration of the AOX exceeded the standards; the AOX is probably formed inside the treatment plant under the anaerobic conditions or resulted from the discharge of the industrial wastewater into the plant.

**Table 3-1 Comparison of the Results of Aitanit WWTP Effluent against the proposed Wastewater irrigation Reuse Guidelines**

| Parameter | Category (Appendix C) | | | Results of Aitanit WWTP Effluent |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| pH* | 6-9 | 6-9 | 6-9 | 8.05 |
| Total Suspended Solids (mg/L) | 60 | 200 | 200 | 20.3 |
| $BOD_5$ (mg/L) | 25 | 100 | 100 | 16 |
| COD (mg/L) | 125 | 250 | 250 | 90 |
| Faecal Coliforms (in 100mL) | <200 | <1,000 | None required | **100,000** |

* Field measurement

**Table 3-2 Comparison of the Results of Wastewater Analysis against the Maximum Allowable Limits for Surface Water and Irrigation Water Quality**

| Parameter | Aitanit WWTP Inlet and Outlet | | Maximum Allowable Limits For Surface Water (MoE Decision 8/1) | Degree of Restriction on Use | | |
|---|---|---|---|---|---|---|
| | Raw wastewater | Treated water | | None | Slight to Moderate | Severe |
| pH | 7.88* | 8.05* | 6-9 | 6.5 - 8 | 6.5 - 8 | 6.5 - 8 |
| Salinity (mg/L) | 895* | 683* | - | <700 | 700-3,000 | >3,000 |
| Specific Conductivity (µS/cm) | 1549* | 1202* | - | | | |
| TDS (mg/L) | 1.1 * $10^3$* | 855* | - | <450 | 450 - 2,000 | >2,000 |
| Temperature (°C) | 26.2* | 22.2* | 30 °C | | | |
| BOD (5 day, 20°C) (mg/L) | 712 | 16 | 25 mg/l | | | |
| COD (dichromate) (mg/L) | 790 | 90 | 125 mg/l | | | |
| Total Suspended solids (mg/L) | 310 | 20.3 | 60 mg/l | <50 | 50-100 | >100 |
| Total solids (mg/L) | 1136 | 872 | | | | |
| Hydroxide Alkalinity (mg/L) | 0 | 0 | | | | |
| Carbonate Alkalinity (mg/L) | 0 | 0 | | | | |
| Bicarbonate Alkalinity (mg/L) | 610 | 259 | | | | |
| Chlorides (mg/L) | 839 | 481 | - | <105 (Sprinkler irrigation) | >105 (Sprinkler irrigation) | |

| | | | | <140 (surface irrigation) | 140 - 350(surface irrigation) | >450(surface irrigation) |
|---|---|---|---|---|---|---|
| Ammonia (NH4+) (mg/L) | 68 | 1.5 | 10 mg/l | | | |
| Organic Nitrogen (mg/L) | 0.96 | 3.82 | | | | |
| Total Nitrogen[2] (mg/L) | 68.96 | 5.32 | 30 mg/l | <5 | 5 - 30 | >30 |
| Nitrate (NO3-) (mg/L) | 48 | 130 | 90 mg/l | | | |
| Total Phosphorus (mg/L) | 7.0 | 3.9 | 10 mg/l | | | |
| Phosphate ($PO_4^{3-}$) (mg/L) | 1.80 | 0.87 | 5 mg/l | | | |
| Sulphate ($SO_4^{2-}$) (mg/L) | 80 | 140 | 1,000 mg/l | | | |
| Sulphide ($S^{2-}$) (mg/L) | 3.85 | 0.003 | 1 mg/l | | | |
| Coliform Bacteria 370 C in 100 ml[3] | $6.6*10^6$ | **100,000** | 2,000 | | | |

[2] Sum of Kjeldahl-N(organic N + NH3),NO3-N, NO2-N
[3] For discharges in close distance to bathing water, a stricter environmental limit value could be necessary

**Table 3-3 Sludge analysis results**

| Substance | Unit | Aitanit Sludge | Limit Values in sludge for use on land |
|---|---|---|---|
| Dry matter | % (w/w) | 95.7 | |
| Organic matter | % (w/w) dm | 68.2 | |
| Residue on ignition | % (w/w) dm | 31.7 | |
| Fraction < 16 µm | % (w/w) dm | 30.8 | |
| Fraction < 2 µm | % (w/w) dm | 1.6 | |
| **Metals** | | | |
| Arsenic (As) | mg/kg dm | <5.0 | |
| Cadmium (Cd) | mg/kg dm | 1.3 | 10 |
| Chromium (Cr) | mg/kg dm | 39 | 1000 |
| Copper (Cu) | mg/kg dm | 150 | 1000 |
| Mercury (Hg) | mg/kg dm | 2.7 | 10 |
| Nickel (Ni) | mg/kg dm | 25 | 300 |
| Lead (Pb) | mg/kg dm | 220 | 750 |
| Zinc (Zn) | mg/kg dm | **2900** | 2500 |
| **Sum Extractable Organic Halogenes** | | | |
| EOX | mg/kg dm | 41 | |
| **Polycyclic Aromatic Hydrocarbons, PAH** | | | |
| Naphtalene | mg/kg dm | 0.19 | |
| Acenaphtylene | mg/kg dm | 0.042 | |
| Acenaphtene | mg/kg dm | 0.043 | |
| Fluorene | mg/kg dm | 0.032 | |
| Phenanthrene | mg/kg dm | 0.32 | |
| Anthracene | mg/kg dm | 0.13 | |
| Fluoranthene | mg/kg dm | 0.22 | |
| Pyrene | mg/kg dm | 0.22 | |
| Benzo(a)anthracene | mg/kg dm | 0.059 | |
| Chrysene | mg/kg dm | 0.15 | |
| Benzo(b)fluoranthene | mg/kg dm | 0.12 | |
| Benzo(k)fluoranthene | mg/kg dm | 0.068 | |
| Benzo(a)pyrene | mg/kg dm | 0.37 | |
| Dibenzo(ah)anthracene | mg/kg dm | <0.010 | |
| Benzo(ghi)perylene | mg/kg dm | <0.010 | |
| Indeno(123cd)pyrene | mg/kg dm | 0.93 | |

| Substance | Unit | Aitanit Sludge | Limit Values in sludge for use on land |
|---|---|---|---|
| PAH 10 VROM (sum) | mg/kg dm | 2.4 | 6 |
| PAH 16 EPA (sum) | mg/kg dm | 2.9 | |
| **miscellaneous research** | | | |
| AOX | mg/kg dm | **840** | 500 |

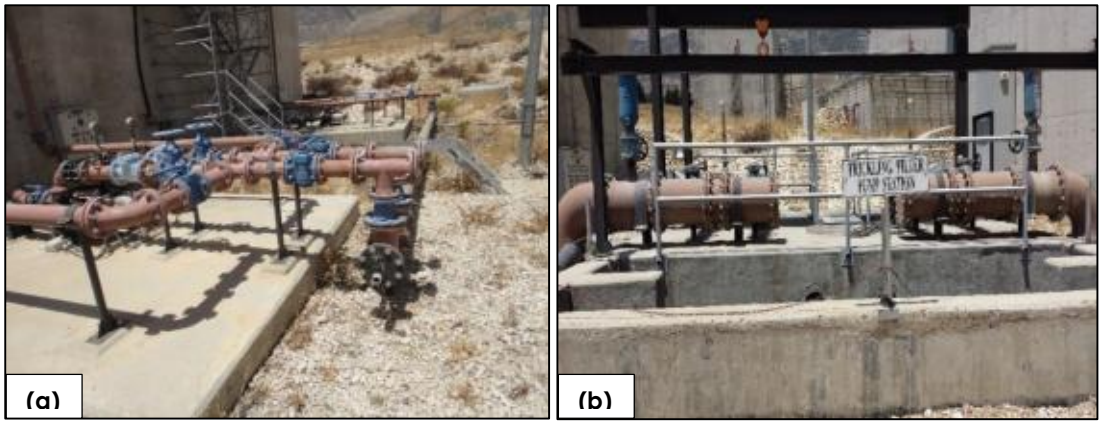


**Figure 3-1 Pump stations for digester tanks (a) and Trickling Filter Unit (b)**

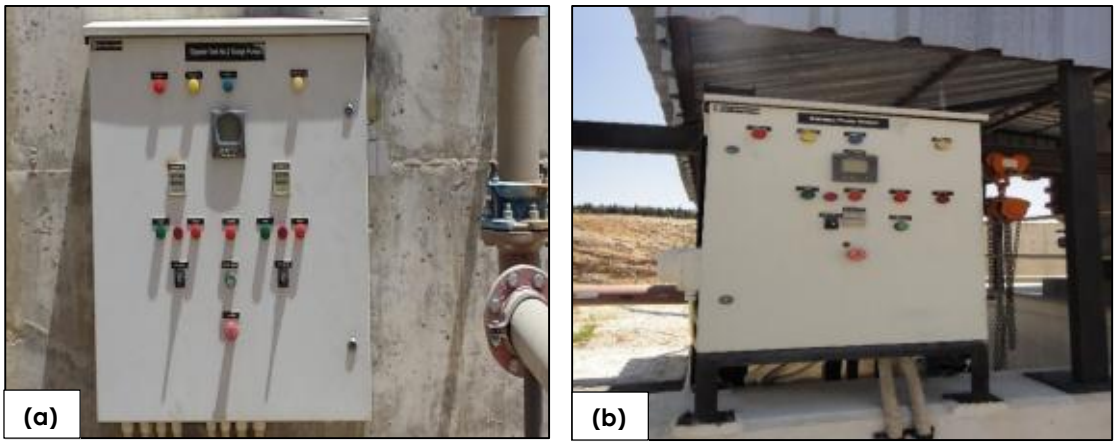


**Figure 3-2 Control Panels for seepage pump station (a) and digester tank sludge pump (b)**

**Figure 3-3 Influent Flow Meter**


**Figure 3-4 Screening Unit at Aitanit WWTP includes: (a) Bar Screen; (b) Two Static Sieve Type Fine Screen and (c) Fine screen with hand filling plastic bag.**

**Figure 3-5 Primary Clarifier Unit of Aitanit WWTP**

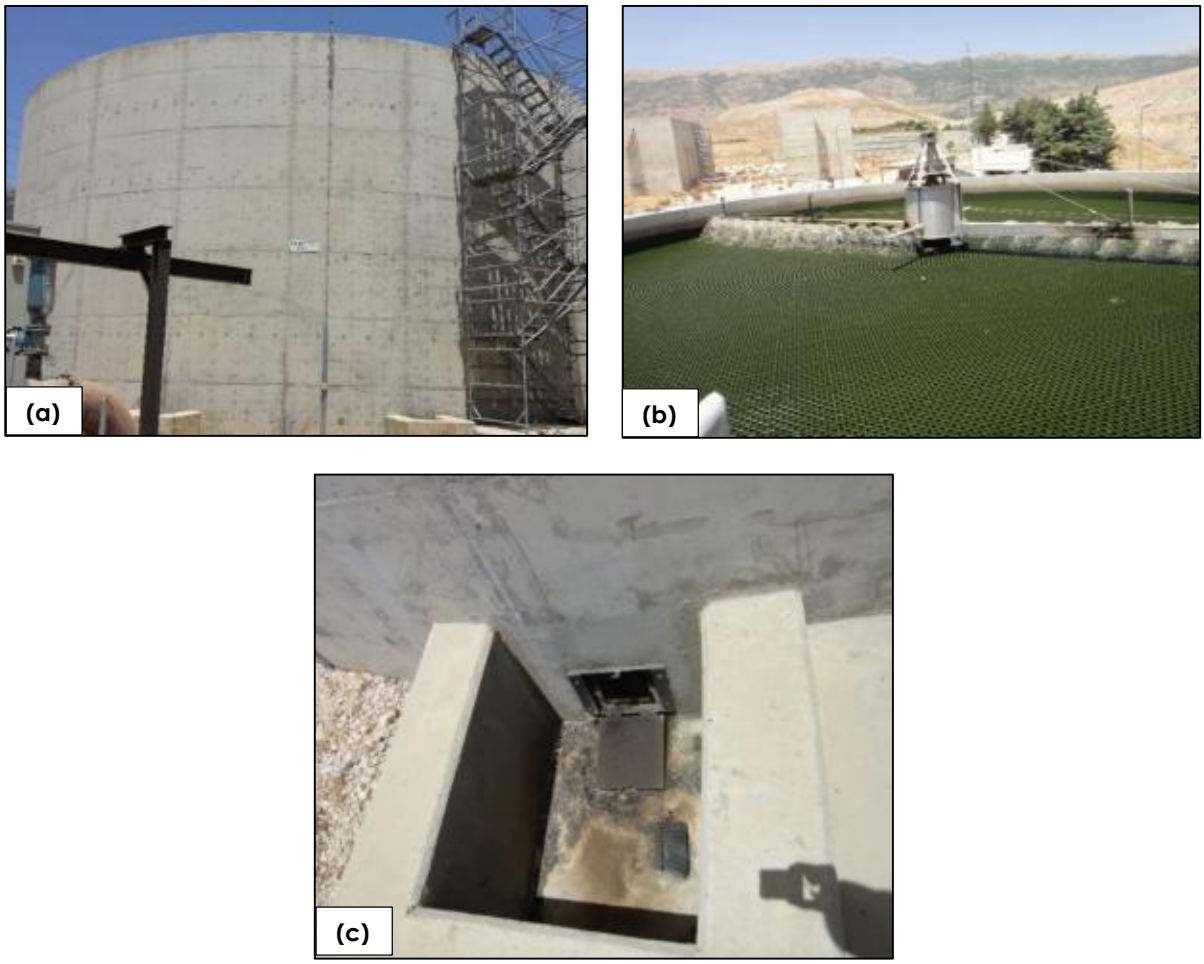


**Figure 3-6 Trickling Filter Unit showing the main TF building (a) and the rotation of distribution arms (b) and Ventilation door (c)**

**Figure 3-7 Secondary or Final Clarifier showing sudsy, billowing and bulking sludge**

**Figure 3-8 Chlorine Contact Tank**

**Figure 3-9 Digester tank and its pump station**


**Figure 3-10 Supernatant evacuation system of the sludge: sluice gates**

**Figure 3-11 Sludge drying lagoons showing sludge cakes and vegetation**

**Figure 3-12 Safe Catwalk and Ladders**


**Figure 3-13 List of emergency phone numbers**


**Figure 3-14 Warning Sign**


**Figure 3-15 First Aid Kit**

**Figure 3-16 Fire Extinguishers**

# 4. CONCLUSIONS AND RECOMMENDATIONS

Aitanit WWTP treated effluent is compliant with the MoE applicable standards and regulations and has an additional capacity to treat the additional sewage flows collected through the proposed project.

Although design of the WWTP is in compliance, an issue was found at an operational level that the operator is not properly adding chlorine, which resulted in high level of bacterial coliform. The audit concluded that this is not an incompliance issue as hardly any water is being discharged to the River due to the lack of water in the area. However, considering the possibilities of treated water to be discharged to surface water in the future, the audit recommends the Government to allocate adequate budget for chlorine addition and monitor the level of coliform closely. Implementation of the monitoring plan in Appendix D should be ensured by MoE and BWE.

Also, the operator should prepare a sludge management plan in accordance with the ordinance on the use and disposal of sewage sludge to improve the sludge disposal practices and ensure safe reuse and disposal with regular analysis. The analysis frequency must meet the minimum number of analysis per year stated in the ordinance.

Furthermore, some recommendations were made to enhance the plant's treatment performance whereby a detailed action plan was developed (Table 4-1 ). The plan included costs (where possible) to assist in budgeting the implementation of these recommendations. It has to be noted that additional processes shall be added to enhance de-nitrification when required (when plant merely reaches its ultimate capacity) as per the plant's feasibility study.

**Table 4-1 Recommendations to further enhance plant performance**

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| Structural problem occurred in the sewer trunk coming from Machghara (broken) which lead to excess infiltration and accumulation of stones, gravels and grits in to this pipe line. | Influent sewer pipe lines | Technical and structural | B, C | Implement aggressive programs to reduce inflow and infiltration from Machghara broken sewer pipe line or from any unknown sources in order to lower the number of weather-related wastewater treatment plant bypasses and the infiltration of gravels and grits from this pipeline. Replace broken Trunk Sewer lines (PVC pipe Ø 300) installed by the riverside. | 110 USD/m |
| Both bar screen and static screens are cleaned manually which require frequent raking by the plant personnel to prevent clogging. | Manual bar Screen and static screen | Structural/technical | C | • It is recommended to provide the coarse screens with an adequate trash removal that can be manually hoisted and cleaned.<br>• It is recommended to install a belt conveyor and a screening bin for the evacuation of screenings from the fine screen area. | 4,800 USD |
| Improper placement of flow measurement device. | Manual bar screen | Structural | B | Install a Parshal flume and level detecting device for flow measurement and high influent flows detection upstream of coarse screen channel. | 10,500 USD |
| Grease pass through the plant to show up in the final effluent due to the absence of oil and grease removal tank. | Static screen | Structural/technical | D | Add an oil and grease trap upstream of the fine screen and use more frequently the primary clarifier Skimmer to remove free | 8,000 USD |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| | | | | floating oil and grease from the water surface and dispose the scums instead of recycling it. | |
| Sand and grits are settled in the influent chamber and some of pass through to the primary clarifier. | Static screen | Structural/technical | D | Add sands and grits channels with adequate removal mechanism and repair sewer lines in the river. | 18,000 – 20,000 USD |
| The primary clarifiers contain black and odorous wastewater with a scum which indicates improper sludge withdrawal rate or frequency, return of well-Nitrified waste -activated sludge. | Primary clarifier | Operational | C | • The operator must use the water analysis to identify the problems and rectify it.<br>• It's recommended to transfer more of the primary settled sludge to the sludge digesters and decrease the recycling of secondary settled sludge to the Primary clarifier. | NA[4] |
| Poor scum/ sludge removal, improper operation of scum skimmer and excessive sludge accumulation in the basin. | Primary clarifier | Operational | C | Improve scum/ sludge removal and eliminate co-settling of waste activated sludge. | NA |
| A rising sludge are noticed in the secondary clarifiers and the fouling is | Secondary clarifier | Technical/logistics | B,C | De-nitrification is happening in secondary clarifier due to excess storage of sludge. The | NA |

4 N/A stands for not applicable which means the following:

- The proposed mitigation measure cost is marginal and can't be estimated at this stage as it needs further elaboration situated beyond the scope of this study;
- The cost of the mitigation measure was included within another measure cost; and
- An operational modification to improve the plant work efficiency that is not associated with additional cost.

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| overflowing the weirs; the effluent from the settling tank contains a high concentration of suspended solids. | | | | bubbles of nitrogen act as a sludge carrier. Remove sludge more frequently from Secondary clarifiers to avoid excessive de-nitrification. | |
| Treated effluent is discharged without disinfection. As a result, the level of Coliform exceeds the maximum allowance to be discharged to surface water. | Chlorine contact basin | Technical/logistics | D | Most of water is being reused for irrigation purposes due to the lack of water in the area, However, it is recommended to apply chlorination to the treated water before discharge it to the river or use it in irrigation. The Actual Operator (Union of Municipalities of the Lake) is required to allocate enough budget for the operator to operate the choline addition system.<br><br>MoWE/BWE will implement the Environmental Monitoring Plan included in the Amended Environmental Impact Statement Small Village Wastewater Treatment Systems "EIQC – TO818" dated November 2005. Especially more rigorous monitoring is required for Coliform. The operator must ensure that treated effluent meets applicable requirements prior to land application for agricultural uses. | 24,000 USD |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| The anaerobic digesters contain dead areas without any mixing. | Anaerobic digester | Structural/operational | C | Add an adequate mixing technique such as agitator to insure proper mixing in the anaerobic digester and enhance sludge digesting. | 15,000 USD |
| The anaerobic digesters are not operating properly. | Anaerobic digester | Operational | C | Improving the load distribution between multiple tanks is required and can be achieved by using two digesters for the primary scum and two for the final scum with the focus on increasing of sludge concentration. | NA |
| Sludge is stored all the year in liquid form to be dried in summer. No draining is allowed from sludge drying ponds. | Sludge drying ponds | Operational | C | • The operator should develop a sludge management plan in accordance with the Ordinance on the use and disposal of sewage sludge to improve the sludge disposal practices and provide landfills for disposing the sludge with regular analysis. The only existing sanitary landfill is Zahle. There is a planned landfill in Jeb Jannine to be used when fully constructed.<br>• Insure proper operation of the drying ponds sluice gate to allow supernatant evacuation and reduce the time required for drying. | 3,000 USD |
| Dried Sludge is being stored in the sludge drying ponds for the past three years. | Sludge drying ponds | Operational / Logistic | C, D | • The dried sludge should be relayed off the plant to a landfill or to be used in agriculture. In both cases, sludge quality must be tested to ensure safe | NA |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| | | | | reuse/disposal in accordance with the ordinance on the use and disposal of sewage sludge (CDR 2003).<br>• It is preferred to apply sludge in agriculture as a fertilizer with suitable management measures related to application rates, crop selection and not to use it in areas that are irrigated with the treated effluent to avoid accumulation of contaminants. | |
| Sludge constituents are not analysed to evaluate the performance of treatment and the ability of use as a fertilizer. | Sludge drying ponds | Operational | C | As the sludge was never moved from drying ponds it was never monitored or tested by the operator. The sludge analysis conducted on collected samples from drying ponds showed results and quality suitable for fertilizing usage. It is recommended to conduct routine analysis for sludge prior to permission of use it in agriculture. | 600 USD/test |
| Future increase of wastewater inflow to the plant will put more pressure on sludge treatment units. | Influent | Operational | C | • The plant has four sludge digesters where only two are used for the time being, increasing inflows may require running all the four digesters and that may increase sludge retention time which will lead to a reduction in sludge production and reduce further its VSS content and will enhance its quality for reuse or disposal. | 300 USD/Month |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| The service pumps are out of service | Pumps | Technical | B | It is recommended to repair the plant water pumps. | 800 USD/pump |
| Frequent damage to the functionality of primary clarifier and trickling filter pumps' upon exposure to heavy rainfall and sunlight | Primary Clarifier and Trickling Filter unit | Technical | B | The area of related pump skids and its control panels shall be shaded in order to avoid any unexpected damage upon exposing to sunlight and heavy rainfall. | 12000 USD |
| The effluent is not clear; suspended solids, turbidity, grease and scum present in the treated water. | Effluent discharge point | Operational | C | It is recommended to conduct routine analysis for treated water prior to permission of use it in agriculture. | 500 USD/test |
| Treated effluent is discharged through the chlorine basin without disinfection. The discharged water are used by the farmers to irrigate the cultivated land of the surrounded area. Small volumes of the treated effluent are used in the plant for miscellaneous purposes. | Effluent discharge point | Technical | D | It is recommended to restrict the reuse of the treated effluent in agriculture for category 1 and 2 considering crops selection, in case disinfection limits were not achieved it can be used for irrigation of category 3 crops without further treatment. | Cost of conveyance of treated water to irrigation areas to be bared by farmers |
| Treated water discharge structure into the Litani river must be modified to reduce the discharged water impacts on the environment. It encounter some beaks different places and need to be repaired. | Treated water outfall | Operational/ Technical | C | • It is recommended to modify the outfall design and propose a structure to prevent excessive degradation in the discharging point.<br>• Implementation of the Environmental Monitoring Plan included in the Amended Environmental Impact Statement Small Village Wastewater Treatment Systems "EIQC – TO818" dated November 2005. | 110 USD/meter + 3,000 USD |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| No adequate measures for odor control are considered or applied in the plant design and construction. | - | Operational | D | • Add a mechanism of Hydrogen Peroxide injection for headwork's odor control. Hydrogen Peroxide typically controls odors and corrosion at the WWTP by direct oxidation of hydrogen sulphide (H2S) within the wastewater.<br>• Implement a green belt to reduce the odor emissions and their spread.<br>• Insure routine relay of the sludge and the screenings out of the plant. | 800 USD for setup and 1,750 USD/year |
| The plant is equipped with a fire alarm system but it is not operational due to its power battery failure. | - | Operational | C | Fix the fire alarm system and put it in service. | 250 USD |
| Fire extinguishers are available in the plant but they are expired. | - | Operational | C | Insure that the fire extinguishers are always filled and not expired. | 500 USD |
| First aid kit is available but most of the medicines are expired. | - | Operational | C | Insure that the first aid kit is always available and medicines are not expired. | 150 USD |
| Power failure influence on treatment efficiency and sludge removal. | - | Operational | B | Aitanit is provided with electricity from Qaraoun Dam, it suffers from power outage only in drought season. The union of municipality is requested to supply enough diesels for the main generator of the plant to cover the power shortage. | 2000 USD/ month |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| No gas detector equipment is connected to the generator to detect the flammable and toxic gases. | - | Technical | C | Provide the plant with a gas detection system. | 2,000 USD |
| Only three staffs are working in the plant (operator, operator assistant and guard), which is not adequate for plant operation and securing. | - | Operational | C | • It is required to employee additional personnel for plant operation and maintenance after following training on the O&M manual and analysis procedure.<br>• Subcontract a specialized O&M company to operate, maintain and secure the plant (consumable not included) | 148,000 USD<br><br>210,000 USD |
| The available instruments are not sufficient to operate a wastewater treatment plant adequately. | - | Operational | D | • Update the pH meter and supply new sensors for DO meters and provide lab equipment suitable for plant running including the main analysis such as pH, BOD, COD, TSS, bacteriological, TKN, orthophosphate, TP.<br>• Train the operator to use the lab equipment including samples preparing, analysis performing and instrument calibration. | 24,000 USD |
| Poor emergency and management programs | - | Operational / Logistics | | • Conduct regular wastewater treatment plant infrastructure and performance reviews with the end goal of achieving good and economical effluent. | |

| Problems/Deficiency | Location | Type | Rating | Recommended Action | Cost |
|---|---|---|---|---|---|
| | | | | • Emergency backup power systems should be maintained and be available at all times to avoid any spill or discharges of untreated effluent from the site. Fuel for Genset must be provided.<br>• On-line instrumentations (Dissolved Oxygen, pH, H2S Monitoring, Free residual chlorine, etc…) or at least portable instrumentations to enable monitoring of wastewater treatment operations must be provided. | 3,800 USD/month<br><br>12,000 USD |

***** Rating is marked as following:

A – Excellent: No mitigation measure needed;

B – Minor improvement possible: Identify a level of deficiencies that needs minor action to be rectified; these actions are possible to be done by the actual operator;

C – Minor problems need attention: Identify a level of deficiencies that need attention at plant management level, its associated costs are beyond the operation budget;

D – Structural problems need attention in long run: Identify a level of deficiencies that need major modification in the plant structure and are beyond the capacity of the actual plant management; and

E – No data available: Identify deficiencies of which we could not collect any data.

The priority of mitigation measure shall be given to identify deficiencies ranked form E to A.

# 5. REFERENCES

National Environmental Auditing Manual (2000). First Edition.

Standard Methods for the examination of water and wastewater, 22nd Edition, 2012.

Ministry of Environment. Decision 8/1/2001. Standards for air pollution & wastewater discharges from industries & drainage water process stations.

# APPENDIX A: RECOMMENDED SPARE PARTS

| |
|---|
| **Generator** |
| Filter, coolant |
| Fuelfilter |
| Filter |
| Filter, oil |
| Sealing ring |
| Gasket, valve cover |
| V-belt set |
| Sealant |
| Thermostat |
| V-belt set |
| Fuse, 1.5A, 250V |
| Fuse, 3A, 250V fast acting |
| Fuse, 3A, 250V fast acting |
| Industrial air cleaner |
| Lamp, 28V, 4.8W |
| **Sbmersible pumps** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| Wear ring |
| **Sludge pumps (Primary clarifier pump station)** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| **Submersible pumps (Trickling filter pump station)** |
| Mechnical seal kit |
| Thrust bearing kit |
| O-ring kit |
| Radial bearing kit |

| |
|---|
| **Generator** |
| Wear ring |
| **Submersible pumps (Final clarifier return sludge pumps)** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| Wear ring |
| **Submersible pumps (Final clarifier waste sludge pumps)** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| **Chemical feed pumps** |
| Pepair and preventive maintenance kit |
| Pump head |
| Auto-prime valve |
| **Plant water booster** |
| Seal kit + OR sleeve |
| Gasket (Novus) |
| **Sludge pumps (Anaerobic digester pump station** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| Wear ring |
| **Sludge pumps (Septage receiving station)** |
| Mechnical seal kit |
| Radial bearing kit |
| Thrust bearing kit |
| O-ring kit |
| Wear ring |

| **Generator** |
| --- |
| **Portable diaphragm pump** |
| Polyethylene flapper valve |
| Thermoplastic diaphragm |

# APPENDIX B: ANALYSIS CERTIFICATES

AUB American University of Beirut
Faculty of Engineering and Architecture
Department of Civil and Enviromental Engineering
كلية الهندسة والعمارة
قسم الهندسة المدنية والبيئية
www.aub.edu.lb

**Civil Engineering Service Laboratories | مختبرات الهندسة المدنية**

**CERTIFICATE OF TEST**

Requested by:

**ELARD**
**Lebanon**

Date: **22/07/2014**

Your Ref.:

Our Ref.: **R -25632-W**

Nature of Test:

**Sample type: Wastewater raw and treated**
**Date samples received: 16/07/2014**

| Parameters | Sample IDs | | | |
|---|---|---|---|---|
| | Ablah (R) | Ablah (T) | Aitanit (R) | Aitanit (T) |
| Biological Oxygen Demand (mg/L $BOD_5$) | 985 | 61 | 712 | 16 |
| Total Suspended solids (mg/L) | 480 | 71 | 310 | 20.3 |
| Total Solids (mg/L) | 1576 | 984 | 1136 | 872 |
| Hydroxide Alkalinity (mg/L as $CaCO_3$) | 0 | 0 | 0 | 0 |
| Carbonate Alkalinity (mg/L as $CaCO_3$) | 0 | 0 | 0 | 0 |
| Bicarbonate Alkalinity (mg/L as $CaCO_3$) | 863 | 378 | 610 | 259 |
| Chlorides (mg/L $Cl^-$) | 844 | 518 | 839 | 481 |
| Ammonia-Nitrogen (mg/L $NH_3$-N) | 79.8 | 8.1 | 68 | 1.5 |
| Organic Nitrogen (mg/L as N) | 6.66 | 1.31 | 0.96 | 3.82 |
| Total Kjeldhal Nitrogen (mg/L as N) | 86.46 | 9.41 | 68.96 | 5.32 |
| Nitrate (mg/L as $NO_3^-$) | 54.5 | 64.5 | 48 | 130 |
| Total Phosphorous (mg/L as P) | 11.0 | 7.1 | 7.0 | 3.9 |
| Ortho-Phosphate (mg/L as $PO_4^{3-}$) | 1.02 | 1.39 | 1.80 | 0.87 |
| Sulfates (mg/L $SO_4^{2-}$) | 68 | 124 | 82 | 140 |
| Sulfides (mg/L $S^{2-}$) | 5.65 | 0.004 | 3.85 | 0.003 |
| Chemical Oxygen Demand (mg/L $O_2$) | 985 | 112 | 790 | 90 |
| Fecal Coliforms (in 100 ml) | TNTC* | ~428,000 | ~6.6 x $10^6$ | ~100,000 |

*TNTC = Too numerous to count in 0.01 ml of the sample.

All tests are performed in accordance to the "Standard Methods for the Examination of Water and Wastewater", 22nd Edition, 2012 as approved by the American Public Health Association, the American Water Works Association, and the Water Environment Federation unless otherwise noted.

George M. Ayoub, Ph.D.
Professor of Civil & Environmental Engineering

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## Certificate of analysis

| | | | |
|---|---|---|---|
| Your project number | J0086 | Certificate number/Version | 2014097481/1 |
| Your project name | Qarauon | Start date | 08-28-2014 |
| Your order number | Ferzol | Report date | 09-15-2014/16:26 |
| | | Annex | A,B,C |
| Sampled by | | Page | 1/2 |
| Sample matrix | Soil; Sludge, sediment | | |

| | Analysis | Unit | 1 |
|---|---|---|---|
| | **Sample Pre-treatment** | | |
| Q | Cryogenic grinding | | Executed |
| | **Characteristics** | | |
| Q | Dry matter | % (w/w) | 87.9 |
| | Organic matter | % (w/w) dm | 45.8 |
| Q | Residue on ignition | % (w/w) dm | 53.3 |
| Q | Fraction < 16 µm | % (w/w) dm | 35.2 |
| Q | Fraction < 2 µm | % (w/w) dm | 13.4 |
| | **Metals** | | |
| Q | Arsenic (As) | mg/kg dm | <5.0 |
| Q | Cadmium (Cd) | mg/kg dm | 1.2 |
| Q | Chromium (Cr) | mg/kg dm | 55 |
| Q | Copper (Cu) | mg/kg dm | 280 |
| Q | Mercury (Hg) | mg/kg dm | 3.9 |
| Q | Nickel (Ni) | mg/kg dm | 37 |
| Q | Lead (Pb) | mg/kg dm | 83 |
| Q | Zinc (Zn) | mg/kg dm | 1400 |
| | **Sum Extractable Organic Halogenes** | | |
| | EOX | mg/kg dm | 0.39 |
| | **Polycyclic Aromatic Hydrocarbons, PAH** | | |
| | Naphtalene | mg/kg dm | <0.010 |
| | Acenaphtylene | mg/kg dm | 0.013 |
| | Acenaphtene | mg/kg dm | <0.010 |
| | Fluorene | mg/kg dm | 0.015 |
| | Phenanthrene | mg/kg dm | 0.11 |
| | Anthracene | mg/kg dm | 0.024 |
| | Fluoranthene | mg/kg dm | 0.21 |
| | Pyrene | mg/kg dm | 0.23 |
| | Benzo(a)anthracene | mg/kg dm | 0.071 |
| | Chrysene | mg/kg dm | 0.12 |

| No. | Sample description | Date sampling | ›fins Analytico-# |
|---|---|---|---|
| 1 | F-Sludge -1+2 | 28-Aug-2014 | 8237986 |

Q: Dutch Accreditation Council (RvA) accredited test
A: AP04 accredited test
S: AS3000 recognized test



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BIC: BNPANL2A

Eurofins Analytico B.V. is ISO 14001: 2004 certified by TÜV and qualified by the Flemish Region (OVAM and Dep. LNE), the Brussels Region (IBGE/BIM), the Walloon Region (DGRNE-OWD) and by the Governments of France and Luxembourg (MEV).

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RvA L010

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**Certificate of analysis**

| | | | |
|---|---|---|---|
| Your project number | J0086 | Certificate number/Version | 2014097481/1 |
| Your project name | Qarauon | Start date | 08-28-2014 |
| Your order number | Ferzol | Report date | 09-15-2014/16:26 |
| | | Annex | A,B,C |
| Sampled by | | Page | 2/2 |
| Sample matrix | Soil; Sludge, sediment | | |

| Analysis | Unit | 1 |
|---|---|---|
| Benzo(b)fluoranthene | mg/kg dm | 0.13 |
| Benzo(k)fluoranthene | mg/kg dm | 0.045 |
| Benzo(a)pyrene | mg/kg dm | 0.079 |
| Dibenzo(ah)anthracene | mg/kg dm | <0.010 |
| Benzo(ghi)perylene | mg/kg dm | <0.010 |
| Indeno(123cd)pyrene | mg/kg dm | <0.010 |
| PAH 10 VROM (sum) | mg/kg dm | 0.66 |
| PAH 16 EPA (sum) | mg/kg dm | 1.0 |
| **miscellaneous research** | | |
| AOX | mg/kg dm | 280 1) |

| No. | Sample description | Date sampling | ›fins Analytico-# |
|---|---|---|---|
| 1 | F-Sludge -1+2 | 28-Aug-2014 | 8237986 |

Q: Dutch Accreditation Council (RvA) accredited test
A: AP04 accredited test
S: AS3000 recognized test

Verified
ASM
KK

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TESTING
RvA L010

# APPENDIX C: CATEGORIES EXPLANATIONS

**Category 1:**

a) Fruit trees and crops that are eaten cooked
b) Parks, public gardens, lawns, golf courses and other areas with direct public exposure
c) In case of stabilisation pounds, the TSS limit value is 100 mg/L

Water treatment expected to meet the criteria: Secondary treatment + filtration + disinfection.

**Category 2:**

d) Fruit trees
e) Lawns, wooded areas, and other areas with limited public access, road sides outside urban areas
f) Landscape impoundments: ponds, water bodies and ornamental streams, where public contact with water is not allowed

Water treatment expected to meet the criteria: Secondary treatment + filtration + disinfection or Secondary treatment + either storage or well-designed series of maturation ponds or infiltration percolation.

**Category 3:**

g) Irrigation of cereals and oleaginous seeds, fiber and seed crops
h) Crops for canning industry, industrial crops
i) Fruit trees (except sprinkler-irrigated)
j) Plant nurseries, ornamental nurseries, wooden areas, green areas with no access to the public

Water treatment expected to meet the criteria: Secondary treatment + a few days' storage or Oxidation pond systems.

# APPENDIX D: AMENDED ENVIRONMENTAL IMPACT STATEMENT OF SMALL VILLAGE WASTEWATER TREATMENT SYSTEMS "EIQC – TO818": ENVIRONMENTAL MONITORING PLAN

USAID | Lebanon

FROM THE AMERICAN PEOPLE

# Small Village Wastewater Treatment Systems
# EIQC – TO818

## Amended Environmental Impact Statement

## FINAL Report

**November 2005**

CDM International Inc.

In Association with

dar group

TO818/L0491

# Section 6
# Environmental Monitoring Plan

## 6.1 Program Development and Summary

The project team met with the Ministry of Environment (MoE) to get clarification on their monitoring program requirements and Environmental Limit Values (ELVs) for discharges into surface waters provided in Table 6-1. The MoE indicated that they are in the process of developing and finalizing the environmental monitoring program which is not published yet. The project team has opted to suggest a monitoring program that is in compliance with international requirements for the protection of surface water from wastewater discharges and based on the MoE ELVs, for approval by the MoE, as part of this EIA report.

The project team reviewed Environmental Monitoring Programs submitted with EIAs for other WWTPs in Lebanon and considered what would be sustainable by the municipalities. In summary, the environmental monitoring program will include:

1. Sampling Locations
2. Sampling Frequency
3. Parameters to be analyzed
4. Compliance Requirements

## 6.2 Compliance Monitoring and Reporting Program

### 6.2.1 Sampling Locations

Samples taken will be representative of wastewater influent and effluent, and river water indicating influence of effluent on the environment. Sampling locations will include:

- Receiving water downstream of the plant /effluent. A sampling location should be carefully selected and agreed upon/approved by the plant operators and the MoE. The sampling location should be representative of the river as effected by the plant.
- Receiving water upstream of the plant/effluent. This sampling location should not be effected by the effluent, but should be representative of the river before receiving the effluent from the plant.
- Samples of the influent wastewater shall be collected from the influent pumping station, once every month for record keeping of influent quality, or when an unusual event (i.e. severe color or odor change) is noticed.
- Effluent samples shall be collected downstream of the Chlorine contact tank or at the outfall, from the last manhole within the plant site or from the treated effluent pumping station, as applicable to the specific site. Recommended frequency of sampling at this location is shown in Table 6-1.

A minimum of two liters of the sample shall be collected in sterile, amber glass bottles whenever Bacteriological or BOD tests are to be carried out. Samples shall

be preserved as per the requirements of the Standard Methods for the Examination of Water and Wastewater, latest Edition, prior to storage and analysis.

## 6.2.2 Parameters to be analyzed

The water quality parameters recommended for analysis are directly related to the ELV and compliance requirements. Table 6-1 summarizes an effluent monitoring program recommended as a typical program for all the proposed wastewater treatment plants under consideration, and Table 6-2 summarizes the influent monitoring program. The critical water quality parameters for monitoring are listed in the table, along with the ELV and the proposed sampling frequency. The MoE considers the ELV as "per sample maximum values" and typically only recommends monitoring Total Nitrogen and Total Phosphorus for nutrients from the treatment plant effluent.

***Table 6-1***
***Proposed WWTP Effluent Monitoring Program***

| WQ Parameter | ELV (MoE) | ELV based on | Sampling Frequency |
|---|---|---|---|
| Temperature, °C | 30 | Max per sample | Daily during afternoon low flow |
| pH | 6 – 9 | Acceptable range per sample | Every other day during afternoon low flow |
| Dissolved Oxygen (DO) | None | None | Every other day during pm low flow. Suggested min. DO of 4 mg/l |
| Biochemical Oxygen Demand 5-day ($BOD_5$), mg/l | 25 | Maximum per sample | Once every 2 weeks during afternoon low flow |
| Chemical Oxygen Demand (COD), mg/l | 125 | Maximum per sample | Twice per week (workday and weekend day) afternoon low flow |
| Total Suspended Solids, mg/l | 60 | Maximum per sample | Every other day during afternoon low flow |
| Total Nitrogen, mg-N/l | 30 | Maximum per sample | Once every month during afternoon low flow |
| Total Phosphorus, mg-P/l | 10 | Maximum per sample | Once every month during afternoon low flow |
| Fecal Coliform Bacteria at 37C, no./100ml | 2,000 | Maximum per sample | Once every 2 weeks during afternoon low flow |
| Residual Chlorine [1] mg/l | 1.0 | Maximum per sample at outfall | Every other day during afternoon low flow |
| Flow | - - | - -[2] | Twice daily Morning maximum flow and afternoon low flow |

[1] Chlorine disinfection is planned at the plant to met the coliform ELV.
[2] Flow is monitored as part of the O&M Process, but will be included in the EMP reporting.

| *Table 6-2 - Proposed WWTP Influent Monitoring Program*[3] | |
|---|---|
| **WQ Parameter** | **Sampling Frequency** |
| pH | Daily |
| Temperature, °C | Daily |
| Chemical Oxygen Demand (COD), mg/l | Twice per week (workday and weekend day) afternoon low flow |
| Total Suspended Solids, mg/l | Every other day during afternoon low flow |
| Total Nitrogen, mg-N/l | Once every month during afternoon low flow |
| Total Phosphorus, mg-P/l | Once every month during afternoon low flow |
| Fecal Coliform Bacteria at 37C, no./100ml | Once every 2 weeks during afternoon low flow |

Table 6-3 shows the proposed monitoring program for the other sampling locations. Results from the upstream and downstream river locations should be compared to see the effects of the plant on the environment. The results from the influent and effluent samples should be compared to see the effects of the plant on the sewage discharge to the river.

***Table 6-3***
***Proposed Monitoring Program for River Samples and Influent***

| WQ Parameter | ELV (MoE) | ELV based on | Sampling Frequency |
|---|---|---|---|
| Temperature, °C | 30 | Max per sample | Monthly at all three sites. |
| pH | 6 – 9 | Acceptable range per sample | Monthly at all three sites. |
| Dissolved Oxygen (DO) | None | None | Monthly at all three sites. |
| Biochemical Oxygen Demand 5-day ($BOD_5$), mg/l | 25 | Maximum per sample | Monthly at all three sites. |
| Chemical Oxygen Demand (COD), mg/l | 125 | Maximum per sample | Monthly at all three sites. |
| Total Suspended Solids, mg/l | 60 | Maximum per sample | Monthly at all three sites. |
| Total Nitrogen, mg-N/l | 30 | Maximum per sample | Monthly for river samples only. |
| Total Phosphorus, mg-P/l | 10 | Maximum per sample | Monthly for river samples only. |
| Fecal Coliform Bacteria at 37°C, no./100ml | 2,000 | Maximum per sample | Monthly at all three sites. |

## 6.3 Sludge Monitoring Plan

Sludge will be handled on site wherever the land area available for the construction of the WWTP allows for including the sludge handling facilities. In all cases sludge shall be digested on site. Sludge drying shall be implemented if the available area permits. Sludge quality monitoring will not be part of the proposed WWTP monitoring plan, since financing will not be available. However, the proposed designs will yield stabilized sludge, in a wet or dry form, that

[3] Influent quality is generally an operational parameter, the frequency given in the Table should be the minimum requirement.

minimizes health risks associated with the presence of pathogens and harmful bacteria. Wet Sludge handling will be in accordance with the ordinance on the use and disposal of sewage sludge (CDR 2003). Any proposed reuse program must include some monitoring of sludge quality.

## 6.4 Sampling Costs

The estimated cost of the proposed sampling program is summarized in Table 6-3.

***Table 6-3: Cost of the Proposed Sampling***

| WQ Parameter | Unit Rate (US $/test)[4] | No. Effluent Tests per Month | No. Other Samples per Month | Total Tests per month | Cost per Month ($) |
|---|---|---|---|---|---|
| Temperature, °C | 0.00 [5] | 30 | 3 | 33 | 0 |
| pH | 1.00 | 15 | 3 | 18 | 18 |
| Dissolved Oxygen (DO) | 1.67 | 15 | 3 | 18 | 30 |
| Biochemical Oxygen Demand 5day ($BOD_5$), mg/l | 16.67 | 2 | 3 | 5 | 84 |
| Chemical Oxygen Demand (COD), mg/l | 16.67 | 9 | 3 | 12 | 200 |
| Total Suspended Solids, mg/l | 10.00 | 15 | 3 | 18 | 180 |
| Total Nitrogen, mg-N/l | 13.33 | 1 | 2 | 3 | 40 |
| Total Phosphorus, mg-P/l | 13.33 | 1 | 2 | 3 | 40 |
| Fecal Coliform Bacteria at 37°C, no./100ml | 10.00 | 2 | 3 | 5 | 50 |
| Residual Chlorine, mg/l [5] | 10.00 | 15 | 0 | 15 | 150 |
| Flow | 0.00[6] | 60 | 0 | 60 | 0 |
| | | | **Total Cost $/Month** | | **792** |

These costs assume no meters owned by the municipality. The initial investment to purchase a meter, as well as regular maintenance on the meter, could save the monthly cost of some parameters such as Dissolved Oxygen, BOD, and Suspended Solids, depending on the meter model purchased.

[4] Unit rates are based on Environmental Engineering Research Center – AUB 2004 price list. Costs may vary depending upon equipment and/or laboratory to be used.
[5] Cost is assumed to be included in the O&M Cost of the Plant.
[5] Chlorine disinfection is planned at the plant to meet the coliform ELV
[6] Flow will be monitored as part of the regular maintenance and operations of the plant, and should be recorded and reported with the sampling plan.

Financing of the operation, maintenance as well as the monitoring program of the WWTP should be secured by the Municipalities as no funding for these activities is available from USAID.

# 6.5 Implementation and Responsibilities

## 6.5.1 Municipality

***Monitoring*** **–** The municipality is responsible for implementing the monitoring program as described in this report, or as approved by the Ministry of the Environment. This is part of the municipality's commitment for ensuring the proper operation of the plant, hence protecting the receiving river water quality. The WWTP operator/municipality may wish to have its own analytical measurement instrument, such as a photometric measurement unit, to ease measurements that can be done in-situ, and minimize samples to be sent to the laboratory.

***Reporting –*** The municipality is responsible for preparing clear and concise reports detailing the results of the monitoring program. The reports should be submitted monthly to the MoE, to the attention of a staff member identified by the MoE, as described in Section 6.5.2. Table 6-4 contains a sample reporting form that might be modified for use by the various plants. A standardized form will ease review.

***Training and Capacity Building*** - The municipality may need assistance with the monitoring task. The assistance required may include staffing and training for proper sample collection, analysis of the parameters by either support of a regional laboratory or a local laboratory for the treatment facility, and organizing, writing, reporting of the sampling program results. If meters are purchased by the municipality, training on these meters will be necessary. Training will also likely be necessary in the results interpretation and reporting process. The results of the monitoring program and tests will be reported monthly to the MoE by the municipality. A training program of municipal staff on the operation and maintenance of the WWTP is planned and will be provided during the construction period. The training program will cover related issues to sampling and analysis.

***Staffing Requirements*** - Estimated staffing requirements for the Municipalities are as flows:

- Daily: The plants shall be watched over on 24 hour basis, an unskilled laborer shall be present during working hours, a guard knowledgeable of the works shall be present at all non-working hours at the plant. A minimum of one-skilled operator shall be present during working hours, for larger plants additional skilled personnel may be required. A Laboratory Technician/ skilled operator shall be available on part-time basis for sample analysis.

- Weekly/Monthly: Treatment plant administrator is required to oversee all administrative issues of the plant operation and to issue the technical documentation /reports on plant monitoring to the MoE.

- Yearly: A maintenance contract may be required with a skilled contractor for carrying out the maintenance of the plant annually and during the year, whenever necessary.

## 6.5.2 Ministry of Environment

***Oversight Committee -*** It is recommended that an Oversight Committee be formed at the MoE to ensure that these tasks are completed. One staff member, the so called "plant advocate", would be responsible for receiving the submitted reports from the plants, scheduling meetings of the committee to review the reports, promptly writing a review of the reports in response to the plant operators, and arranging regular (yearly and in the case of problems more regularly) visits.

***Report Review and Response*** - The Ministry of the Environment will be responsible for reviewing the submitted reports in a timely fashion, flagging problems for further investigation, and recommending a course of action based on any problems. The "plant advocate" may wish to screen the reports when they come in monthly, and if there is anything out of the ordinary, scheduling a review of the reports within a week. If there is nothing out of the ordinary, quarterly reviews (three monthly reports reviewed together) could be scheduled, and a quarterly reply could be sent to the plants indicating that the reports are acceptable to the MoE.

***Inspection*** - The MoE will be responsible for inspecting the plants yearly. The "plant advocate" will be responsible for scheduling the plant inspections by suitable specialists, and for writing a report stating that the plant is acceptable to the MoE or recommending any constructive, reasonable and implementable operational changes at the plants. If a problem with the plants is noticed in the submitted reports, the MoE may wish to schedule more regular visits to ensure proper operation of the plants and suitable protection of the environment.