CHILANGA TOWNSHIP SEWERAGE TREATMENT PLANT

Contents:

Introduction

This partial report gives information on the sanitary aspects on the rehabilitation project of the Chilanga Township Sewerage Treatment plant. Together with the mechanical and electrical recommendations it forms the base for the second phase of the project. In the first section a short description of the plant is given. The second section gives the basic information on sewerage production in the Chilanga township including some assumptions Based on the information of the first two sections, in section 3 calculations have been carried out to verify the capacity, hydraulically and with respect to the organic load, of the existing plant. Section 4 gives a list of activities for the rehabilitation in the second phase of the project. This report ends with section 5 which gives the overall conclusions and recommendations.

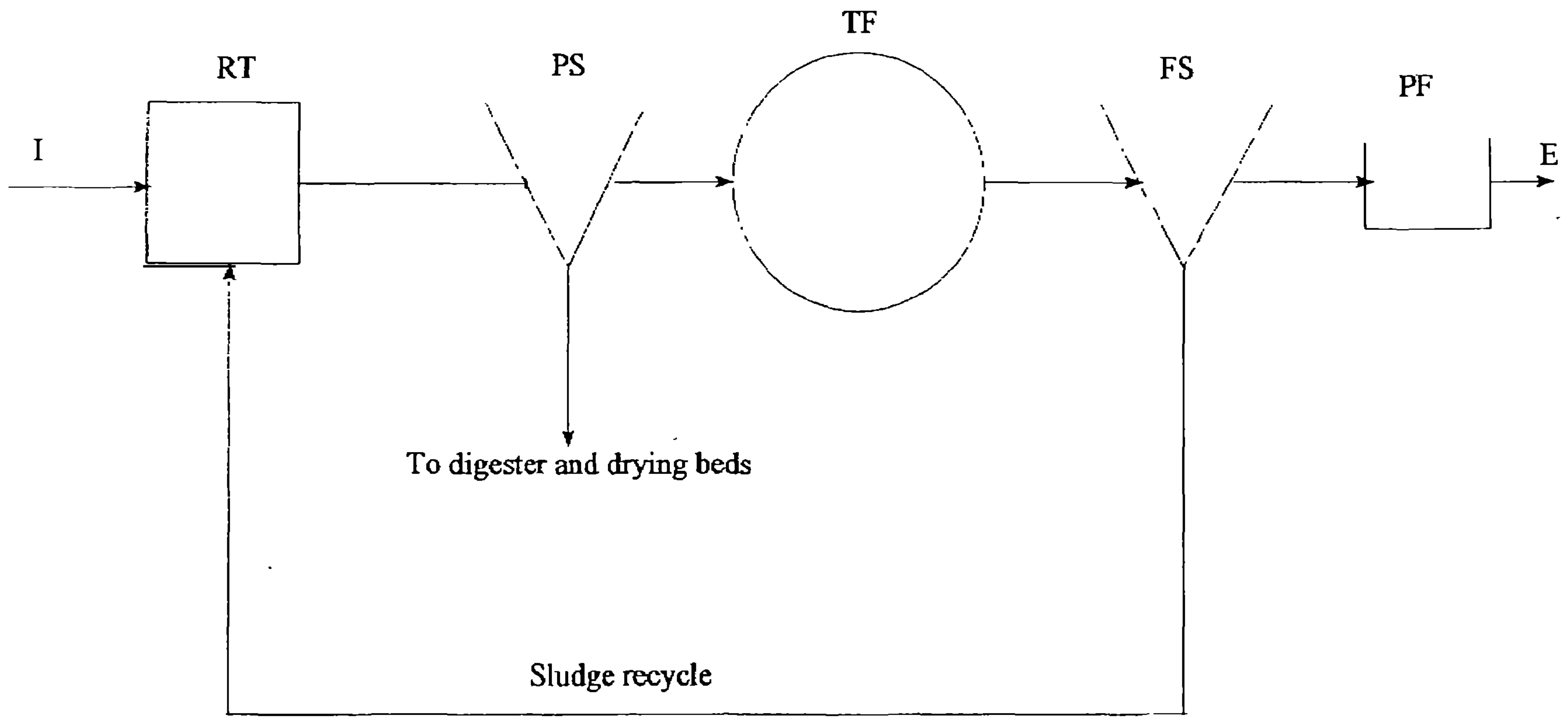
1. Short description of the Chilanga Township waste water treatment plant.

The sewerage treatment plant is made up of six units, namely; the raw sewage receiving tank and pump house, the primary sedimentation tank incorporating a sludge chamber and digester; the biological filter; the secondary sedimentation tank (the humus tank); the polishing sand filter and the sludge drying beds. Figure 1 shows the flow diagram of the treatment process, figure 2 the plant layout and figure 3 gives the cross section of the units

Receiving Tank and Pumphouse

Raw sewage from the township enters an underground square tank made with concrete walls. There is an opening at the top covered with a steel plate through which a manually operated winch is mounted. A steel wire mesh basket acts as a screen for the removal of coarse solids and other floating debris to protect the pumps.

A ball float arrangement to facilitate recirculation of sewage from the final clarifier is provided. There are two pipes at the bottom for the intake of the two pumps. The control panel and the pumps are accommodated in the pumphouse.



I influent
RT: Receiving tank
PS : Primary sedimentation tank
Tf : Trickling filter
FS · Final sedimentation tank
PS : Polishing sand filter
E · Final effluent

Figure 1 Flow diagram of the Chilanga Wastewater Treatment Plant

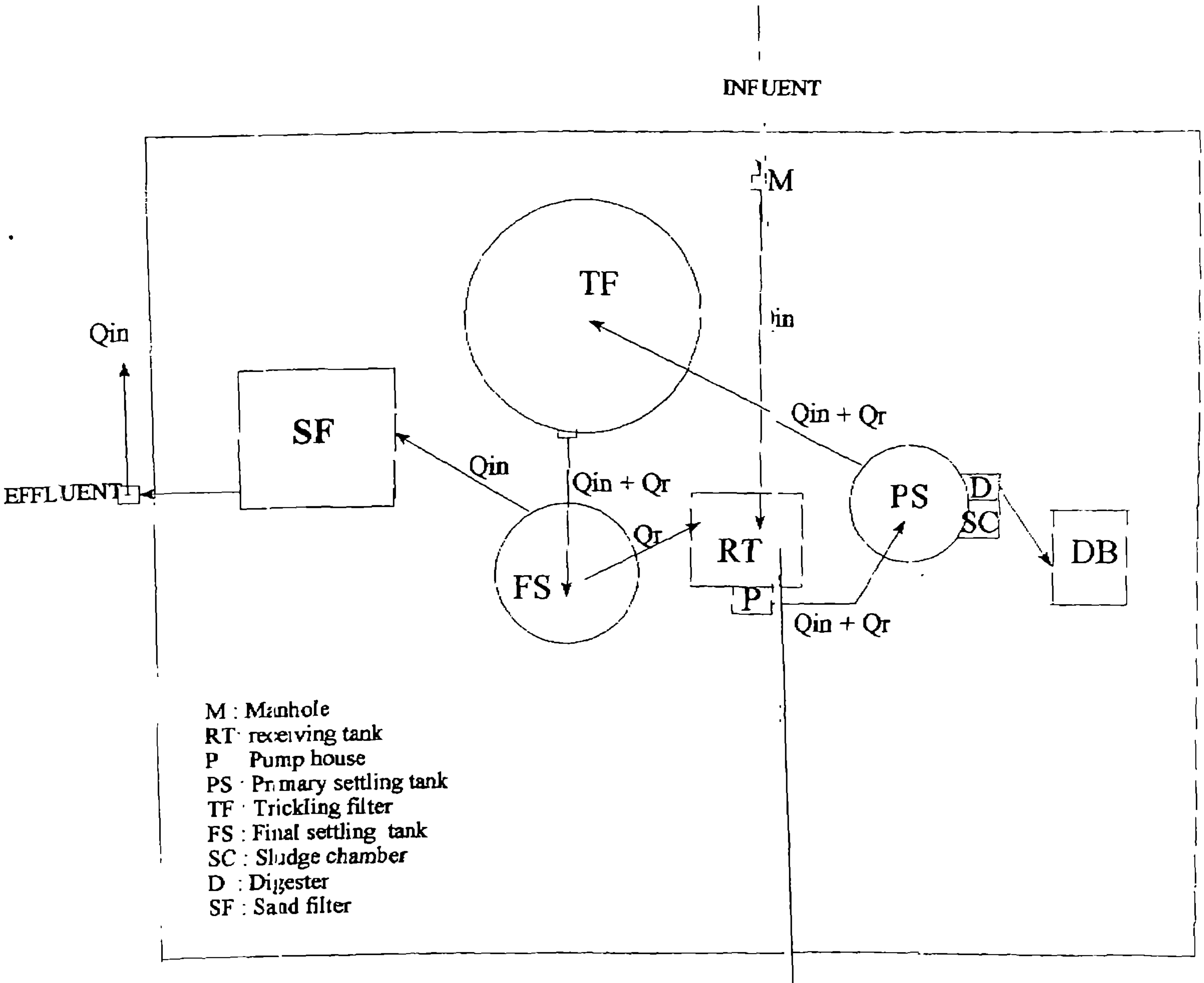


Figure 2. Layout of Chilanga Wastewater Treatment Plant

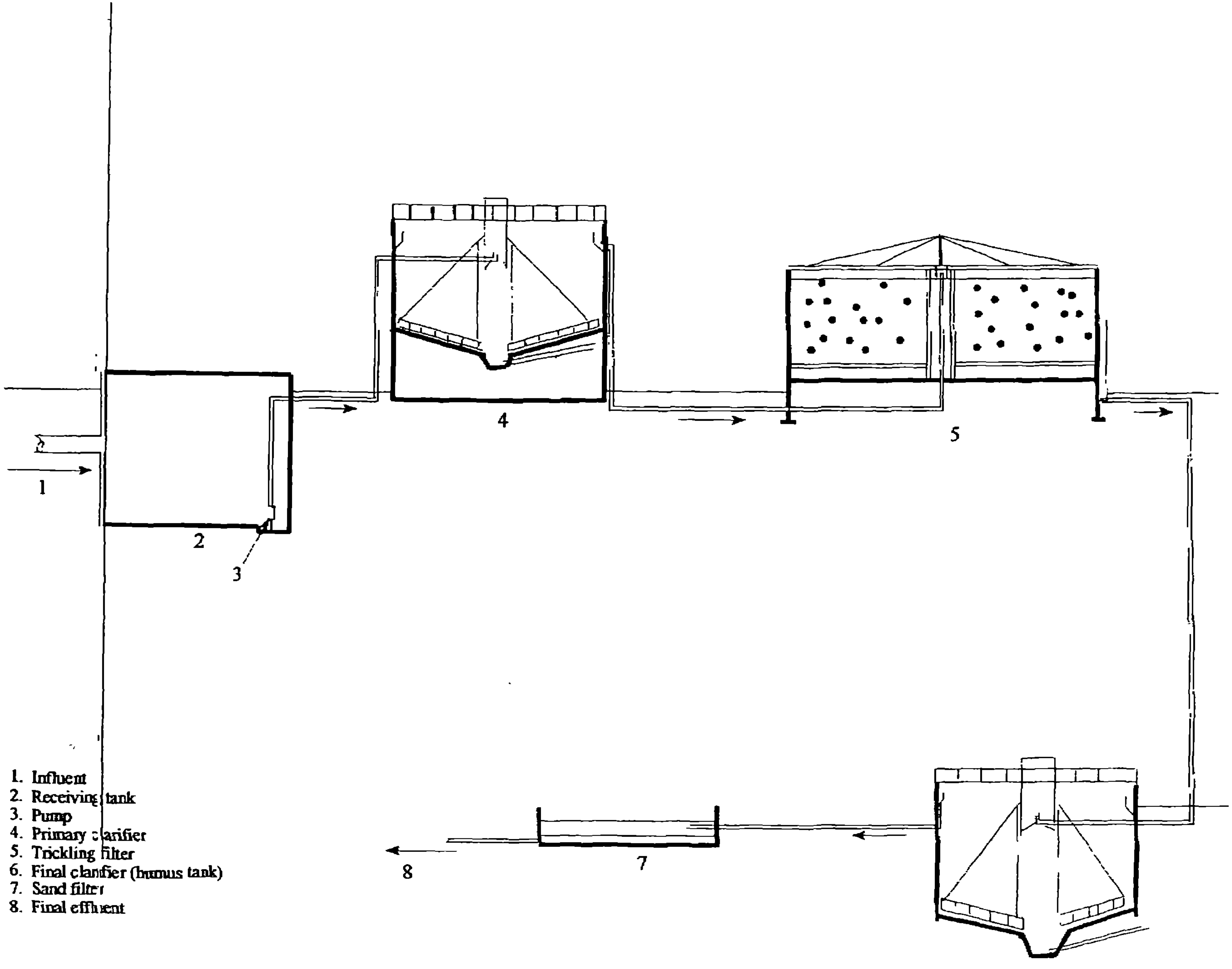


Figure 3· Cross section of the Chilanga Wastewater Treatment Plant (Not to scale)

Primary Sedimentation Tank, Sludge chamber and Digester

The primary sedimentation tank consists of a circular tank 4.8 m in diameter and 2.4 m sidewall depth, a sludge chamber with a volume 2.9 m^3 and a digester with a volume of approximately 2.5 m^3. Sewage from the receiving tank is pumped through a 100 mm pipe to the inlet well at the centre of the tank.

Primary settling aims to remove settleable suspended solids (organic and inorganic) from wastewater so as to reduce the load to the subsequent biological treatment units. The removal depends on the hydraulic surface loading rate and retention time. Removal rates are in the order of 40 - 75% and 25 - 45% for the total suspended solids (TSS) and the biochemical oxygen demand (BOD), respectively. Sludge and scum are collected by rotating radial collectors. Scum is swept outward to a hopper, while sludge is directed to a central pit by scrapers. By the hydrostatic pressure inside the sedimentation tank and by opening and closing valves the sludge will be pressed into the sludge chamber. The sludge is transferred to the digester by a manually operated pump, while supernatant water will flow back into the sedimentation tank.

Digested sludge is discharged to sand and stone drying beds for dewatering by evaporation and seepage The wastewater that seeps through the bed is collected in underdrains and returned to the receiving tank.

Biological Filter

The biological filter consists of a circular concrete tank 11 metres in diameter and 2.5 metres deep constructed above groundlevel. It is filled with rock media 1.5 m deep averaging 40 mm in size. Settled sewage from the primary sedimentation tank is fed to the filter through a concrete pipe and is sprinkled uniformly over the media by a rotating distributor and trickles down through the bed. The distributor is rotated by hydraulic pressure between the sprinkler outlets and the fluid level in the primary sedimentation tank. As the waste water flows through the filter the organic components get in contact with microbiological slime layer growing on the media surface. The organic substances are then absorbed on the slime layer and degraded by bacteria.
The biological filter is an important part of the treatment process where mainly dissolved organic matter in the fluid is broken down into harmless substances by the bacteria attached to the media. The filter is also fitted with vertical pipes around the peripheral of the tank to allow ventilation necessary for the microbiological oxidation. Air flow through the pipes should be unimpeded by ensuring that the pipes are clear of objects such as stones and other materials.

The efficiency of the filter depends upon the hydraulic load (the amount of water treated by the volume of the filter), the organic load (the amount of organic material in relation with the volume of and the biomass in the filter) and its construction (good distribution of water over its surface, good air ventilation). Most probably the filter was designed as a low-rate filter, able to treat relatively low organic loads.

Humus tank

The humus tank is a circular tank, 4.8 metres in diameter and 2.4 metres deep, constructed at ground level and serves to separate the humus sludge from the clarified effluent of the biological filter. As the biological filter is a low rate filter, the quantity of produced humus is limited.

The humus tank also provides plant recirculation water, especially during the night when the flow of raw sewerage from the township is low. The water from the humus tank is fed back to the receiving tank through an automatic valve arrangement operated by a float in the receiving tank. It should be noted that the flow of fluids in the plant must be continuous to prevent clogging of stones in the biological filter and pipes in the sedimentation tank.

Polishing sand filters

The overflow from the humus tank is discharged to sand bed filters where the remaining suspended solids particles are removed. The fluid is fed through the central channel and flows downwards through the filters. The resulting effluent collected in the underdrain which should be clear water is then discharged into a pond located near the plant.

2. Basic data on waste water production of Chilanga Township

In order to be able to check the capacity of the sewerage treatment plant the following data have been used in section 3. Where no information was available, assumptions have been made as indicated below.

The total population of Chilanga township is estimated at 520 inhabitants. Normal drinking water consumption would be in the range of 100 to 200 liters/capita.day. As an average 150 liters/capita.day will be assumed. Depending on the amount of water which is used for watering the gardens, some 50 to 100 % of the consumed drinking water will be discharged as sewerage. The waste water production is assumed to be 80 % of the consumption or 120 liters/capita.day. For the production of biochemical oxygen demand a normal average of 50 grams/capita day is assumed. For the maximum water flow it is assumed that the sewerage flow is produced during 16 hours a day (instead of 24 hours) or a peakfactor of 1 3 is applied

In summary the data used in section, are:

Total drinking water consumption :	78 m^3/d
Total wastewater production·	62.4 $m^3/d = 2.6\ m^3/h$ ($= Q_{ave}$)
Sewerage flow (Q_{max}):	$(62.4\ m^3/d)/(16\ h/d) = 3.9\ m^3/h$

BOD production:	50 grams/capita.day, with an assumed 30% removal in primary sedimentation tank.
BOD load:	50 grams/capita.day * 520 inhabitants = 26 kg BOD/day

3. Capacity of the rehabilitated treatment plant

In this section calculations are made on the treatment capacity of the existing plant and its six different treatment units. In section 3.1. is determined if the treatment plant has sufficient capacity taking into account the number of people who will be connected to the plant and based on the assumptions of section 2. In section 3.2. calculations on the capacity are made based on the dimensions of the existing plant and taking into account the normal ranges in design parameters.

3.1. Capacity of treatment plant for the present population

In this section for the six treatment units the most important process parameters have been calculated and compared with the design criteria

1. Receiving Tank

Retention time= V/Q

= (3.7 *3.4*3) m^3/3.9 m^3/h

= 9.7 hours

Comment: A retention time of 9.7 hours is too long and will lead to anaerobic conditions, sedimentation of sludge in the tank and odour problems

2. Primary sedimentation tank

Diameter: 4.8 m; Surface: A =18.1m^2 ; Depth =2.4 m; Volume: V = 18.1 * 2.4 = 43.4 m^3;

a Surface loading rate= Q/A

= 3.9 m^3/h/18.1 m^2

= 0.22 m/h

Recommended: 10 - 2.5 m/h

b Retention time = V/Q

= 43.44 m^3 / 3 9 m^3/h

= 11.1 h !!

Recommended: 1- 2 hours

Comment: The surface loading rate is too low and the retention time too long, leading to anaerobic conditions.

3. Trickling Filter

Diameter: 11 m; Surface area: A_{filter} = 95 m^2 ; Filter media depth: 1.5 m; Media volume: V_{media} = 142.5 m^3

Presettled BOD:	= 35 g/capita.day	(assuming 30 % reduction in the primary sedimentation tank)
BOD load:	= 18.2 kg/d	
Maximum flow:	= 3.9 m^3/h	

a. Volumetric organic loading rate, L_v

Install Equation Editor and double-click here to view equation kg BOD/m^3.d

(b) Hydraulic surface loading rate (HSLR)

Install Equation Editor and click here to view equation m/h < 0.05 m/h

Comment: For a low rate trickling filter the loading rate is within the recommended range, while the HSLR is slightly lower than required.

5. Secondary Sedimentation tank (Humus tank)

Diameter: 4 8 m; Surface: A = 18.1 m^2; Sidewall depth: 2.4 m; Volume: $V_{humustank}$ = 43 4 m^3
Flow: Q = 3.9 m^3/h

Surface loading rate , V_s = 3.9 m^3/h / 18.1 m^2 = 0.22 m/h

Recommended. 0.8 - 1.2 m/h

Detention time; 43.4 m^3 / 3.9 m^3/h = 11.1 hours!
Recommended: 1 - 2 hours

Comment: Both the surface loading rate and the retention time are too low.

6. Sludge Drying Beds

Area requirement: 0.09 - 0.14 m^2/capita, thus for 520 inhabitants: 47 - 73 m^2

Comment: The exiting area of 40 m^2 sludge drying beds falls below the minimum requirement.

Conclusion: Hydraulically the plant is over dimensioned. There is need for recirculation
The low rate trickling filter has sufficient capacity for the given organic load

3.2. Capacity of the treatment plant based on maximum and minimum design parameters

The following calculations are based on the dimensions of the various treatment units and the maximum and minimum values for the design parameters.

1. Primary sedimentation tank

Diameter: 4.8 m; Surface area: $A = 18.1\ m^2$; Depth: 2.4 m; Volume: $V = 43.4\ m^3$
Recommended overflow rate: $V_s = 1.0 - 2.5$ m/h

$Q = V_s * A$: $Q_{min} = 1.0 * 18.1\ m = 18.1\ m^3/h$

$Q_{max} = 2.5 * 18.1 = 45.2\ m^3/h$

Retention time :
$t = A / Q$: $t_{min} = 43.4/45.2 = 0.96$ h

$t_{max} = 43.4/18.1 = 2.4$ h

Comment: The minimum and maximum retention times are within the required limits.

2. Trickling filter

Diameter: 11 m; Surface area: $A_{filter} = 95\ m^2$; Filter depth: 1.5 m; Volume; $V_{filter} = 142.5\ m^3$

Recommended HSLR: 0.05 - 0.3 m/h

$Q = HSLR * A_{filter}$ $Q_{min} = 0.05 * 95 = 4.75\ m^3/h$

$Q_{max} = 0.3 * 95\ m^3/h = 28.5\ m^3/h$

Recommended organic load: 0.1 - 0.2 kg BOD/m^3.d

BOD load = filter volume * Lv: $BOD_{min} = 142.5 * 0.1 = 14.2$ kg BOD/d
$BOD_{max} = 142.5 * 0.2 = 28.3$ kg BOD/d

Comment: The calculated minimum and maximum BOD-loads correspond with a served population of 405 and 810 inhabitants, respectively. These values are for the temperate climate ; higher values and therefore a larger population can be served for our tropical climate.

3. Secondary Sedimentation tank

Recommended overflow rate: $V_s = 0.8 - 1.2$ m/h

$Q = V_s * A$: $Q_{min} = 0.8 * 18.1 \text{ m} = 14.5 \text{ m}^3/\text{h}$

$Q_{max} = 1.2 * 18.1 = 21.7 \text{ m}^3/\text{h}$

Retention time :
$t = A / Q$: $t_{min} = 43.4/21.7 = 2$ h

$t_{max} = 43.4/14.5 = 3$ h

Comment: The retention times are slightly higher than recommended.

4. Polishing Filter

The recommended filtration rate: 3.6 - 30 m/h
Area of one filter: 22.4 m^2
Capacity: 80.6 - 672 m^3/h
Number of filters provided: 2

The polishing sand filters are more than adequate for the loads expected in the plant

From the foregoing calculations, the following observation is made:

highest minimum: 18.1 m^3/h
lowest maximum: 21.7 m^3/h

The design flow for the whole plant ideally should be between 18.1 and 21.7 m^3/h. Taking into account that the calculated maximum assumed flow is 3.9 m^3/h, recirculation of the treated waste water after passing the secondary sedimentation is necessary. Considering the maximum organic loading of the trickling filter, a population of over 800 inhabitants can be served.

4. Proposed activities for the second phase of the rehabilitation project

The first phase of the rehabilitation of the Chilanga waste water treatment plant for the Chilanga Cement Compound consisted of the calculation of the capacity of the existing plant, after rehabilitation, and the relation with actual and future population which will be providing waste water to the plant. The results of the assumptions and calculations have been given in the sections 1 to 3.

The second phase of the rehabilitation consists of the final determination and calculation on the necessary equipment, piping and valves, the needed volumes of filter sand and gravel, the necessary repairs in masonry or concrete and so on. In this section a short description is given on the necessary activities for the second phase split up into different units

4.1. Receiving tank:

- the inlet pipe

The pipe between the cut-off manhole and the receiving tank has to be repaired and cleaned and a control valve installed.

- the pumps

Most probably new pumps have to be installed. The capacity of these pumps should be in the range of 20 to 25 m^3/hr (head 8 metres), according to the hydraulic capacity of the plant and its piping. A selection has to be made between the installation of one or two pumps, of the same or different capacity and how they electrically should be installed (high and low level control, emergency stop etc.)

- the piping

In order to maintain a recirculation flow between the humus tank and the receiving tank the installation of a floating device, connected to the valve regulating the recirculation flow has to be rehabilitated.This includes repairing and cleaning of the (sludge) return pipe between the (sludge) outlet at the bottom of the humus tank and the inlet into the receiving tank. In case very high recirculation flows are required, the installation of an additional pump should be considered.

4.2. Primary sedimentation tank:

- piping and valves

The inlet and outlet piping of this tank has to be checked and if necessary be repaired Especially the sludge return pipes and the supernatant water return between the sludge chamber and the tank have to be cleaned. All valves have to be checked, cleaned and repaired if necessary The opening and closing directions have to indicated for operating purposes.

- sludge chamber and digester

The piping between sludge chamber and digester has to be checked and cleaned. The manual sludge pump has to be removed and an electrical intermittent sludge pump has to be installed. The digester needs checking and cleaning. Special attention has to be given to the outlet for the digested sludge.

4.3. Biological filter:

- cleaning of gravel

Preferably the gravel should be cleaned of humus and dust which have accumulated during the period the plant was out of use. The risk of clogging exists.

- checking of false bottom and ventilation inlet

The false bottom which sustains the weight of the gravel bed but leaves exit facility for the drainage of treated waste water has to be checked for damages and if necessary should be repaired. The installed metal air pipes have to be emptied and protected against new blockage.

- *the piping and distribution rotor*

The inlet and outlet piping should be checked and if necessary repaired. The distribution rotor has to be rehabilitated and thoroughly checked for reliability.

4.4. Humus tank.

- *the piping*

The inlet and outlet piping has to be checked and repaired. Special attention has to be given to the return (sludge) pipe to the receiving tank in relation with the design recirculation flow.

- collecting channel

The damaged circular collecting channel has to be repaired (part of the concrete face is missing) to guarantee an even distribution of effluent into the drainage channel.

4.5. Polishing filters.

- *cleaning of filters*

Preferably the filter material (sand, fine and coarse gravel) has to be cleaned to get rid of dust, clay and humus which has accumulated. These materials can be reused and missing material has to be replenished. This cleansing includes the inlet and outlet channels and piping.

- *valves and weir*

All valves have to be inspected and repaired, if necessary. The weir has to be checked Possibly a measuring scale can be calibrated and fixed inside the outlet channel for the measurement of the effluent flow.

- *volumes and grain diameter of filter material*

The volumes and grain diameter of the necessary additional filter material has to be calculated.

4.6 Sludge beds:

- *channels and valves*

All channels, piping and valves of the sludge beds have to be inspected, cleaned and if necessary repaired.

- *return water*

The water which filters through the drying sludge could be returned to the receiving tank. The piping has to be checked and cleaned.

4.7 Overall activities:

- Guidelines have to be written for the operator, including a check list on possible problems, instructions on maintenance and a plant logbook.

- A technical drawing has to be prepared for the whole rehabilitated plant, including details as electrical schemes, technical information on pumps, etc.
- A concrete parking lot could be constructed to be used, besides for parking vehicles, as additional space for cleaning gravel and filter material.
- After the rehabilitation has been completed, the first start up should be done with clean (drinking) water (estimation: 100 to 150 m^3) which will be recirculated. Once the plant is hydraulically under control, raw waste water can be allowed The first three months samples should be taken on a regular basis (possibly once a week) to evaluate the performance of the plant. After this period and depending on the laboratory results the frequency will be reduced and during a period of 3 to 6 months the performance will be monitored.

5. Conclusions and recommendations

Based on the calculations and assumptions of the hydraulic and organic loads the following conclusions and recommendations have been made.

1. The existing plant has a capacity for the treatment of waste water of a population of more or less 810 persons, based on the organic load of the low rate biological filters. Hydraulically the capacity is much higher, but this will be regulated by recirculating treated waste water. This over dimension of the plant guarantees that no overflow problems will occur during the rainy season, with an expected higher inflow of waste water.

2. The design and construction of the plant are of very good workmanship. A lot of attention has been given to details. This means that rehabilitation of the plant is relatively easy and against economically reasonable costs. It is therefore recommended to carry out some labour intensive jobs such as cleaning the biological and polishing filters.

3 It is recommended to postpone physical/chemical and microbiological tests until the plant has been started. During a period of 6 to 9 months after the startup, the performance of the plant will be monitored and on the results will be reported.

4 It is recommended that a set of manuals, drawings and a maintenance programme be prepared for the operator and the operation of the plant.

5. The possibility should be considered to connect nearby dwellings to increase the hydraulic load and therefore reduce recirculation.

6. Attention should be given to an awareness programme to educate the community on the consequences and effects of this rehabilitated treatment plant and how to avoid failure by discharge of harmful materials into the sewer.