Constructing and operating treatment plants (case study)

17th WEDC Conference
Infrastructure, environment, water and people
Nairobi, Kenya 1991

Constructing and operating treatment plants (case study)

Mesfin Shenkut

The high cost of constructing and operating conventional water treatment facilities has been the main snag in providing safe drinking water to the majority of the urban population in developing countries. Considering this problem, treatment plants should be used only when there are no other alternatives. Nevertheless, wherever these installations are deemed to be absolutely necessary, emphasis should be given to the following points.

1. Systems which could be constructed using locally available skills and labour.

2. Systems which do not require chemicals.

3. Systems which do not require the use of mechanical equipment.

4. Systems which could be easily maintained and operated at a community level.

Considering these points, a water supply system appropriate to tackle a high burden of silts & feacal pollution,a system that incoroporates plain sedimentation, horizontal roughing filtration and slow sand filtration is presented. The system has been constructed and is under operation producing 92m^3/hr at present.

1. Plain Sedimentation

Rivers in tropical countries carry a considerable amount of suspended materials especially during the high flood seasons. Most of these materials settle if their flow is retarded. In order to retain these suspended materials which easily block the filter media of filtration units, plain sedimentation tanks are constructed.

2. Design parameters of the sedimentation tanks.

The following design parameters are considered.

.L/B ratio = 3: 1 where L-length
B-width
.DT(detention time) = 3 hrs
.Number of units = 2
.Surface loading rate=20m^3/m^2/day
.d(depth of tank) = 2m

Sludge zone = 2%

3. Construction tehniques of the sedimentation tanks.

The walls of the tank were constructed out of masonry stone. Structurally, it is erected trapezoidally by excavating the earth depending on its angle of internal friction. The thickness of the wall & floor is not more than 40cm which was made water tight by plastering the top surface after placing chicken wire. The inlet zone has two flow breaking mechanisms as shown on the sedimentation tank drawing. One is metal plates welded to the inlet pipes and the other is a baffle wall constructed out of staggered bricks. The position of the inlet zone is in the middle half portion of the wall.

The outlet is a weir type construction instead of gutter type for ease of construction in masonry.

4. Horizontal Roughing Filters (HRF)

Even though plain sedimentation tanks considerably reduce the suspended solids concentration of the raw water,the effluent is not clean enough to be treated by slow sand filters. Therefore, horizontal roughing filters are introduced to improve the water quality to suit the SSF units.

5. Design parameters of the HRF

The following design parameters are considered.
.V(face velocity) = 2m/hr
.Number of compartments(zones)=4
1st zone L=8.2m
size 19-22mm river gravel
2nd zone L=6.0m
size 13-18mm river gravel
3rd zone L=4.0m
size 9-12mm river gravel
4th zone L=3.0m
size 4-6mm river gravel

6. Construction techniques of the HRF

The wall of the tanks have the same structural consideration as the sedimentation tanks. The inlet and outlet zones are packed with crushed stones of average size 50mm. The media are separated from each other by mesh wires attached to the walls & floor of the tank.

7. Slow Sand Filters (SSF)

Slow sand filters are the final treatment units responsible to produce water of acceptable quality mainly in terms of bacteriological and turbidity contents.

8. Design parameters of the SSF

The following design parameters are considered in the design of the SSF.

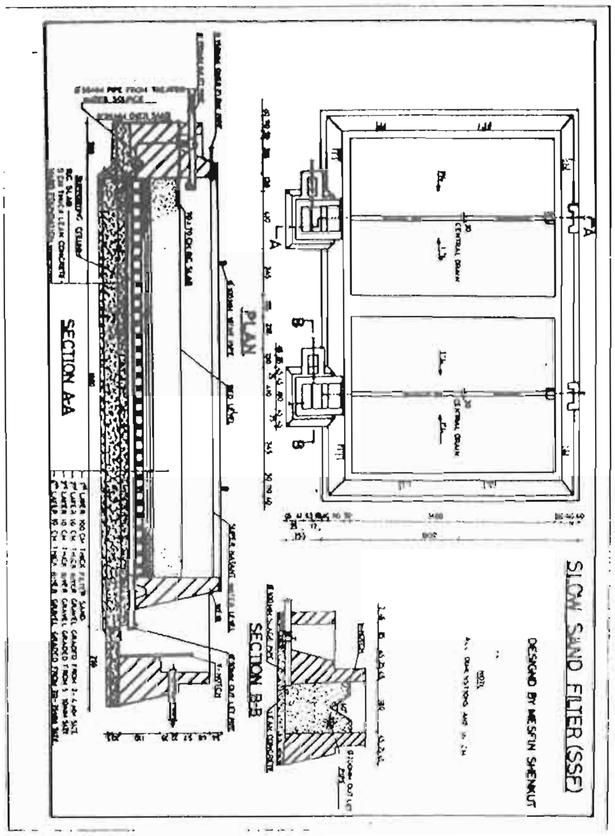
.Number of units = 4
.Filtration rates = 0.15m^3/m^2/hr
.Initial height of filter bed=1m
.Supporting gravel height=0.3m
.Under drain height=0.25m
.Free board = 0.20m
.Sand type ES= 0.15mm - 0.35mm
uniformity coefficient 2-3

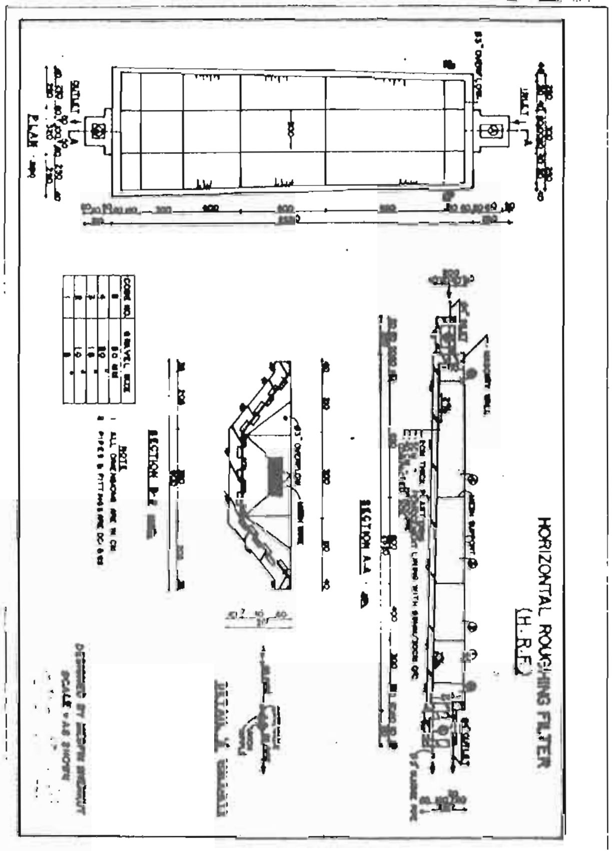
9. Construction techniques of the SSF

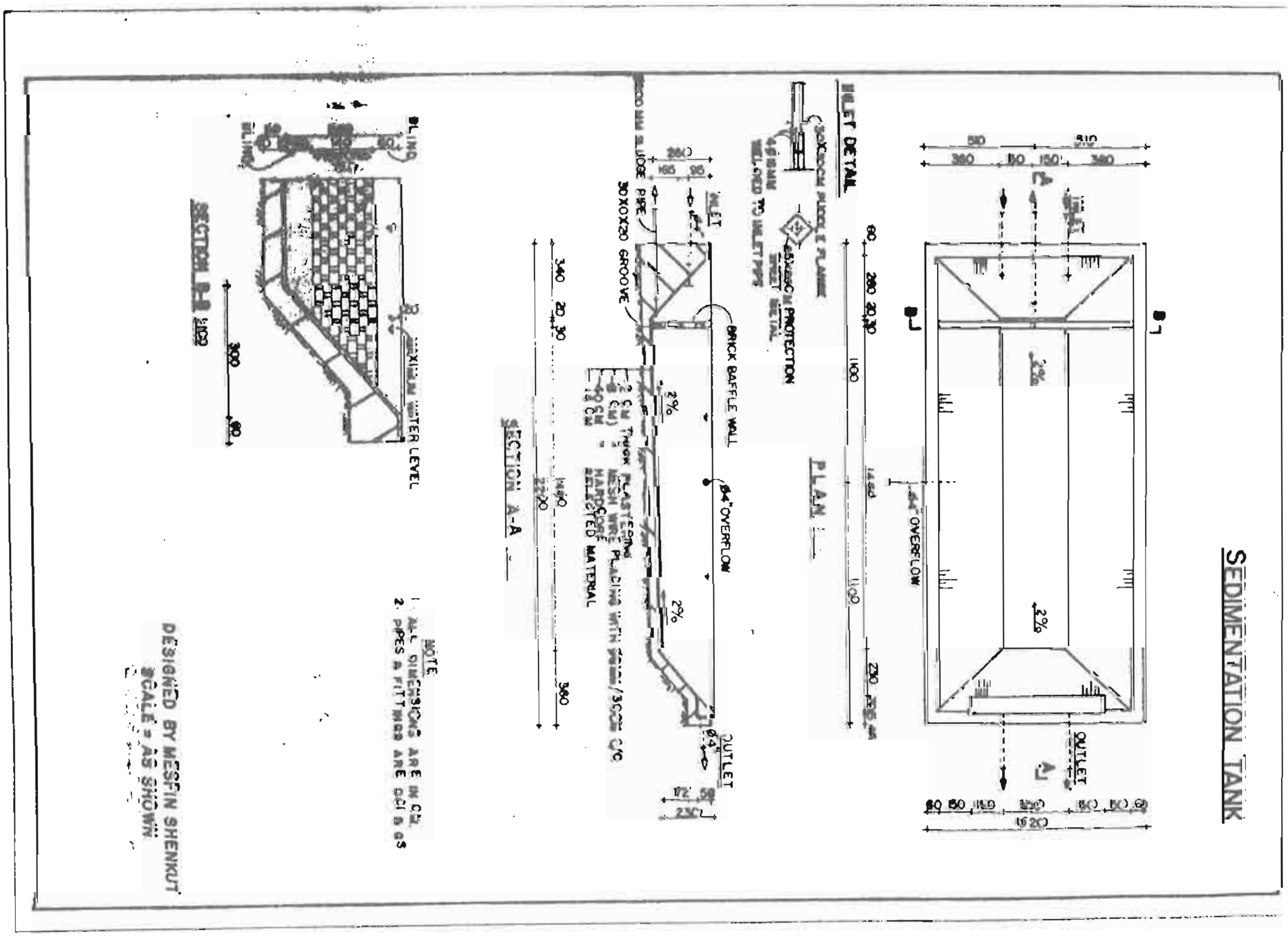
Structurally, the walls are constructed to resist hydrostatic & submerged sand pressures causing overturning, sliding, shear and tension. The floor is constructed as a mat foundation and was checked for shear, diagonal tension, bond, moment, and floatation. The bearing capacity of the soil was also checked. A V-notch has been constructed to measure the discharge.

10. Operation Technique of the System

The operation technique has been designed in such a way that operators have little to do. The discharge from the SSF is marked on the outlet of the V-notch of the SSF. The operator keeps this elevation constant by slowly opening & closing the inlet and outlet valves so that there is no back up effect on the HRF & sedimentation tank units. The operator always keeps the incoming water at the overflow level. If more water is drawn by the SSF units, the level in the HRF units begins to fall; then the operator automatically opens the inlet pipe of the HRF units. Again, the back effect is felt on the sedimentation tanks. The operator uses the same principle of keeping the water at the given level by gradually opening & closing the inlet valves of the sedimentation tanks.


SLOW SAND FILTER (SSF)
DESIGNED BY MESFIN SHENKUT
PLAN
SECTION A-A
SECTION B-B


HORIZONTAL ROUGHING FILTER
(H.R.F)
PLAN
SECTION A-A
SECTION B-B


SEDIMENTATION TANK
PLAN
INLET DETAIL
INLET
BRICK BAFFLE WALL
OVERFLOW
OUTLET
SECTION A-A
SECTION B-B
NOTE
1. ALL DIMENSIONS ARE IN CM
2. PIPES & FITTINGS ARE GCI & GS
DESIGNED BY MESFIN SHENKUT
SCALE = AS SHOWN

The sand of the SSF tanks is scraped if the outlet pipe is fully open and the effluent level fails to reach the marked level on the V-notch. The HRF unit gravels are cleaned by opening the sludge outlet pipe and flushing by pressurized water or washing manually by digging out the gravel. This is done once in about five years. The sedimentation tanks sludge outlet pipes are opened to drain the settled dirts if the quality of the effluent deteriorates significantly.

11. Performance of the System.

The effluent of the SSF units satisfy all the chemical quality requirements of WHO. The turbidity removal of the various units is indicated in the following table.

Date	Turbidity (NTU)			
	Raw Water	From "Sedi"	From HRF	From SSF
6/6/90	317	234	83	17
2/8/90	420	200	65	18
8/8/90	460	249	70	20
4/9/90	41	34	13	18
10/11/90	52	41	20	5
6/12/90	32	27	11	3
18/12/90	14	12	7	3
4/1/91	22	14	8	3
10/2/91	30	22	10	4
4/3/91	62	50	15	5

Regarding the bacteriological quality of the SSF, the treated water showed a microbiological count of acceptable number, but in order to discourage the growth of pathogenic organisms, chlorine is dosed seasonally in the water storage tank.

12. Cost of the System

The cost of the "sedi" tanks (2 units) is = 138,097.birr
The cost of the HRF tanks (6 units) is = 461,568. birr
The cost of the SSF tanks (4 units) is = 869,568.birr

Note: 1 US dollar = 2.07 birr (bank exchange rate).

Pipes & fittings which account for less than 10% of the project cost are not locally available and had to be imported.

REFERENCES

1. IRC Small Communities Water Supply, Technical Paper Series No. 18, the Hague, Netherlands 1981.

2. SCHULZ & OKUN, Surface water treatment for communities in developing countries, John Wiley & Sons, U.S.A., 1984 (a book)

3. SHENKUT Mesfin; Recent Development in Water Resources in Ethiopia, Village Level Water Technology, Addis Ababa Ethiopia, 1988 (article from a proceeding).

4. WEGELIN Martin, Horizontal Roughing Filtration, IRCWD report No. 06/86 Duebendorf, Switzerland, 1986 (a design, construction & operation manual.)