25th WEDC Conference Addis Ababa, Ethiopia, 1999

INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION

Multistage filtration in water treatment

Mesfin Shenkut, Ethiopia

SIXTY PER CENT of the world population do not have access to safe water and only 25 per cent enjoy adequate sanitation facilities.

In Ethiopia, it is only 25 per cent of the population with access to poorly maintained water supply systems and the sanitation coverage is less than 7 per cent.

The combined effect of poor water supply provision and virtually non-existent sanitation facilities account for over 75 per cent of the diseases in the country.

Surface water treatment

Groundwater is generally much better than surface water in quality, however, due to unavailability, difficulty in abstraction and some time salinity and fluoride problems, more and more people depend on surface water. As the surface water is in most cases highly polluted with pathogenic substances and suspended solids and consumed without treatment of any kind, these sources are the major causes of health hazard in developing countries. Treating the surface water sources using conventional treatment systems requires imported chemicals, sophisticated electrical and mechanical gadgets as well as the necessity for highly trained personnel. As these requirements are beyond the capacity of the people, they are forced to consume the water without treatment of any kind.

In order to alleviate this situation, a strategy of using locally available resources has been considered. This strategy gives due attention to the following points in the choice of treatment plants:

- Using locally available materials, skills and work force.
- The use of chemicals avoided or limited to post chlorinating.
- The use of mechanical and electrical equipment be avoided or minimized.
- Systems should be operated and maintained at community level.

The technology of Multistage Filtration (MSF) which is combination of course gravel pre-filtration and slow sand filtration (SSF) has been found to be a successful means of treating surface water meeting the above stated points. In areas where the suspended solid concentration is very high, particularly in hilly and low vegetation places, MSF is aided with plain sedimentation to lower the pressure on MSF.

Plain sedimentation

Plain sedimentation tanks are most useful during periods of peak floods where by they significantly reduce the suspended solids by simple detention. The tanks are constructed out of masonry stone. The walls are erected trapezoidal by excavating the earth depending on its angle of internal friction. The thickness of the wall is not more than 400mm wide and made watertight by plastering the inside surface with cement mortar reinforced with chicken wire (ferro-cementing). This structural arrangement is for ease of construction and economic advantage.

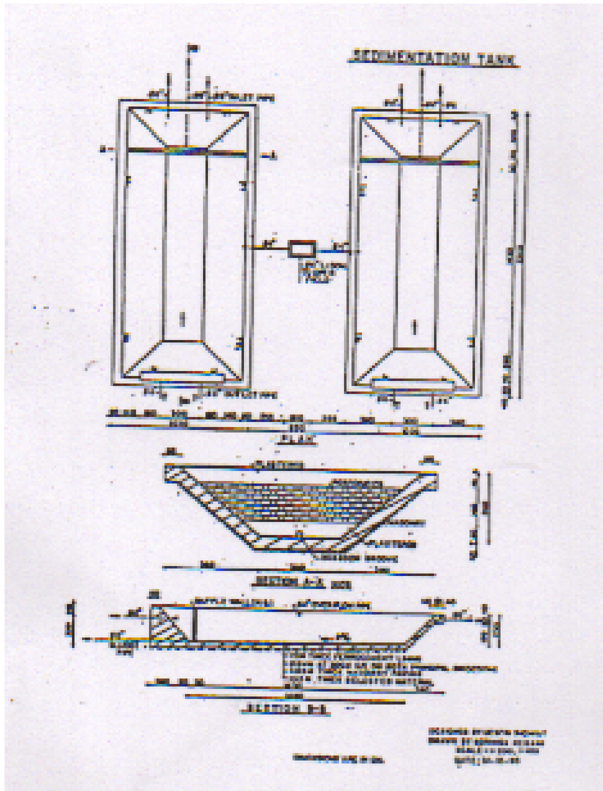

Figure 1. Plain Sedimentation Tank

The surface-loading rate of the sedimentation tanks is $20m^3/m^2/day$.

Horizontal roughing filtration

Horizontal roughing filtration consists of course gravel filters arranged in series from course to fine in horizontal direction. It allows the treatment of water with considerable contamination higher than the levels with which SSF can operate efficiently. Though there are different layouts of roughing filters (horizontal flow, down flow and up low)

Figure 2. Performance of infiltration gallery

Figure 3. Infiltration gallery under operation

Figure 4. Performance of infiltration gallery

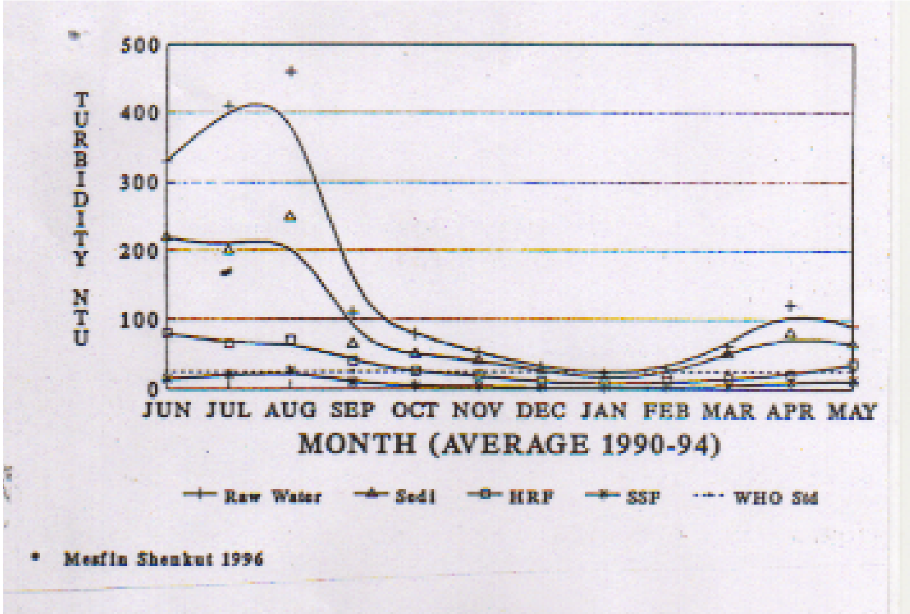

Figure 5. Performance of Sedi - HRF - SSF

horizontal roughing filters have been tried here and showed good performance. The length of this tank is 19m with the first compartment 8m long and packed with gravel sizes of 19-22mm, the second compartment 6m long packed with 13 – 18mm diameter gravel the third compartment 4m long packed with 9 – 12mm and the fourth compartment contains gravel sizes of 4 – 6mm and is 3m long. The bulk of the solid matters are separated by course filter material (first compartment), while the subsequent medium and fine filters have a polishing function. The face velocity of flow

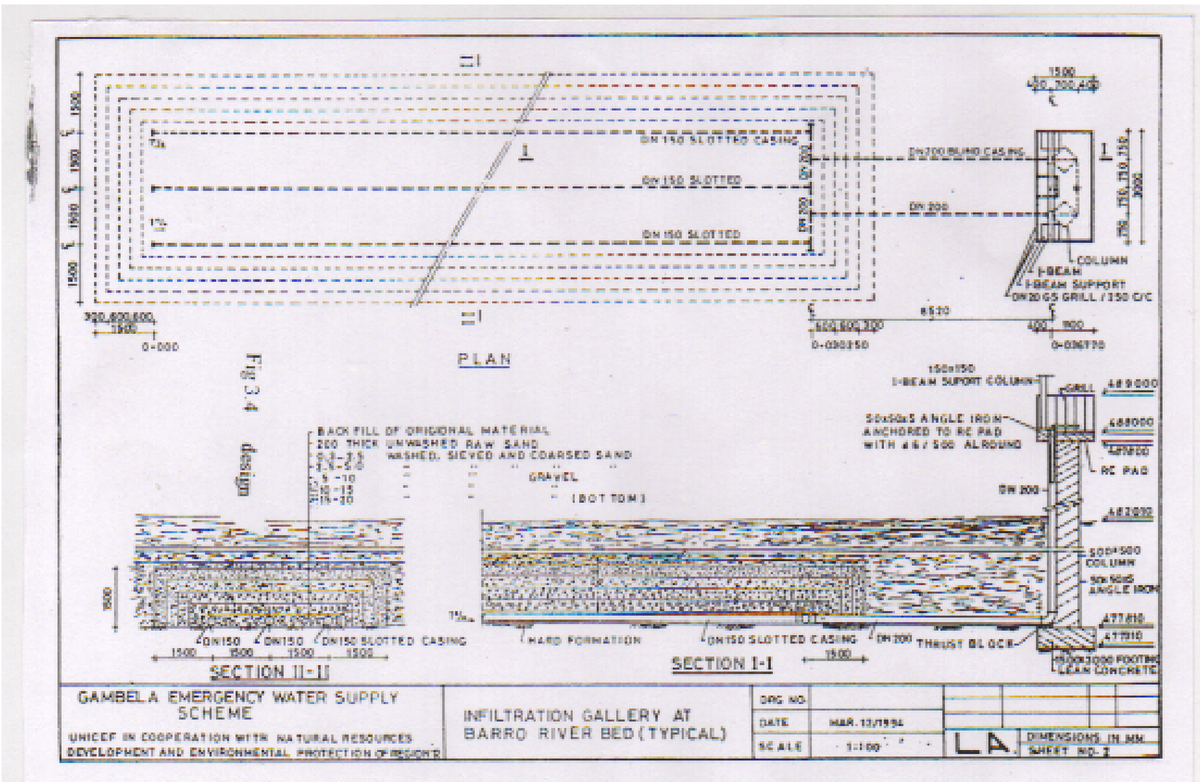

Figure 6. Design of Infiltration Gallery System

in the horizontal roughing filters is taken to be a maximum of 2m/hr.

The walls of the tank have the same structural consideration with that of the sedimentation tank. The different media are separated by mesh wire and the inlet and outlet zones are packed with gravel size of 50mm.

Slow sand filtration

Slow sand filtration is considered as the main treatment step in the entire process. It destroys the microorganisms in the water, retains fine organic and inorganic substances as well as oxidizes organic compound, which are dissolved in the water.

An average filtration rate of $0.15m^3/m^2/hr$ has been used. The main sand media is 1m deep with effective size of 0.15 – 0.35mm and uniformity of coefficient 2 – 3.

Infiltration galleries

Infiltration galleries are the best way of abstracting clean surface water where there is sufficient surface and subsurface flow with medium to course sand strata in river basins. Horizontal slotted casings surrounded with gravel and course sand filter envelope is laid 3m deep in the basin . The horizontal casing are then connected to vertical pipes which act as sumps. Submersible pumps were installed to pump the water from the sumps (see Fig 6). The effluent is free from pathogenic organisms and the turbidity load is within WHO drinking water standard.

System performance

The performance of the systems, which depend on multistage filtration, is satisfactory. A system consisting of sedimentation-HRF-SSF with turbidity load ranging between 20 – 1000 NTU and producing $1500m^3/day$ has been working successfully for the last nine years. The reduction in turbidity over four consecutive years is indicated in Figure 5. The fecal coliform count from the SSF units is nil in most of the seasons.

The initial quality improvement of the infiltration gallery was remarkable where by the 600 NTU turbidity was reduced to 17 NTU within two weeks of operation.

The infiltration gallery sump was fitted with submersible pumps. Due to leakage in the first 10m head, the pumps were run out of their duty zones. This creates rattling of the pumps hence reducing the amount of flow and also shaking the whole system and deteriorating the quality of the effluent. In order to improve this situation, it has been recommended to maintain leaking rising mains especially in the first 40m height. The sustainable solution would be to change the type of the pump from submersible to vertical centrifugal type.

Reference

IRC small communities water supply, 1981, Technical Paper Series No. 18, The Hague Netherlands.

SCHLULZ and OKUN, 1984, Surface Water Treatment for Communities in Developing Countries, John Wiley and Sons, USA.

SHENKUT MESFIN, 1996, Eceperience in Slow Sand Filtration in Ethiopia, Advances in Slow Sand and Alternative Biological Filtration, edited by Niglel Graham and Robin Collins, John Wiley and Sons, USA.

WEGELIN MARTIN, 1996, Surface Water Treatment by Roughing Filters, SKAT, St. Gallen, Switzerland.

MESFIN SHENKUT, PO Box 30504, Addis Ababa, Ethiopia. Tel: 611434, Fax: +251 1 51 95 48.