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Experiences with slow sand filters in Tanzania

1. INTRODUCTION

The use of groundwater to meet domestic demands in most developing countries is generally limited to areas with potential aquifers only if that type of water requires minimum or no treatment at all. Where suitable water bearing aquifers are absent, consumers will have to rely on surface waters whose quality is usually not good enough for consumption without treatment. Slow Sand Filtration (SSF), if properly applied, is one of the most appropriate processes for treatment of surface waters in developing countries. However, the quality of most tropical surface waters limits the applicability of SSF alone and often they have to be preceded by some form of pretreatment.

Although it has been a common practise to characterize the suitability of water for SSF with turbidity, one should not forget the fact that clogging of filter beds is brought about by solid and organic matters which are responsible for physical blocking of the interstices. Turbidity is measured by photo-metric principles which allow determination of the intensity of light scattered and absorbed by suspended matter in water. One has to bear in mind that, scattering of light is on the one hand a function of number, shape, size and refractive index of particles in water and on the other of its wavelength spectrum.

It has been experimentally established (ref. 4) that, total suspended solids concentration and filtrability can characterize more accurately the suitability of water for SSF. In practise, a correlation of the former to turbidity can be developed over the linear range for the sake of estimating the levels of suspended solids in water indirectly from records of turbidity kept.

2. BACKGROUND HISTORY

The initial application of Slow Sand Filtration (SSF) as a water treatment process in Tanzania during the early seventies has had an unpleasant history. Most of the schemes which were designed to apply SSF faced operational difficulties due to the extremely short filter runs experienced with them. For example, (ref. 1) reported that SSF constructed in about five villages in Tabora region were already inoperational hardly two years after commissioning. In (ref. 2), similar operational problems with SSF were reported in a number of provinces in Kenya.

Besides hindering the development of biological activities, the short filter runs led to abandonment of some of the treatment plants with SSF due to the heavy burden of cleaning the filter beds frequently. There were two likely causes of these problems, one of which might have been improper operation of the pretreatment units say by application of very high overflow rates. The other main cause was feeding of raw waters with high contents of impurities directly into the SSF.

3. RESEARCH IN PRETREATMENT OF SSF

In a bid to alleviate some of the problems mentioned in the foregoing chapter, research work aimed at ultimate development of an appropriate bio-physical pretreatment process for SSF was initiated at the University of Dar es Salaam (UDSM) early in 1979. To this effect, the following activities were done:

3.1 Water quality survey

The survey and statistical analysis of water quality data for surface

waters in Tanzania showed the prevalence of relatively high suspended solids concentration characterized by remarkable seasonal fluctuations as shown on table 1. below. The results proved the necessity of pretreatment of most raw surface waters prior to SSF.

3.2 Laboratory tests at UDSM

Investigations on performance of a number of bio-physical pretreatment methods showed that Vertical Flow Roughing Filters and Horizontal Flow Roughing Filters (HRF) had equal treatment efficiency but the latter were preferred to the former on basis of economic, operational and technical merits.

3.3 Field tests

In order to check the validity of laboratory findings in the field, a number of similar tests were carried out at Handeni, Wanging'ombe and Iringa urban water treatment plant sites during the period of 1980/81. In between 1981 and 1983, extensive field tests were carried out with the bigger pilot plant constructed at Iringa in order to have more data for production of design guidelines for HRF in Tanzania.

3.4 Companion research work

Since February 1982, a companion research programme in HRF was undertaken by the International Reference Centre for Wastes Disposal (IRCWD) in Switzerland. The objective of this work was to provide detailed

explanations about the prime factors responsible for purification in HRF and as a result, towards the end of the year 1984 a filtration model for HRF was developed.

3.5 Results

- The field tests results were in very close conformity with the laboratory investigations in terms of treatment efficiency of HRF.
- Pretreatment of raw water with HRF prolongs the filter runs of SSF to acceptable durations (i.e. more than four weeks).
- Average turbidity removals of 50% and maximum removals of 80% were observed during the research period. Higher removals were attained at relatively low filtration rates.
- After a ripening period of about three weeks, HRF could remove 50 - 75% of E.Coli and Total Coliform bacteria from a raw water with less than 1000 Total Coliform counts per 100ml after 24 hours of incubation.
- The following design guidelines should be observed for HRF:
 - In general, filtration rates should be kept less than or equal to 2.0 m/hr. The best way of getting the optimum rate is by carrying out pilot tests with the raw water to be treated.
 - HRF should be designed with filter runs of at least six months.

Table 1. Surface water quality

PARAMETER	Average X			67% limit:(X+σ)	
	Wet season	Dry season	Annual	Wet season	Dry season
Turbidity (NTU)	41	28	35	105	61
Colour (mg Pt./l)	79	55	67	162	116
Suspended solids (mg/l)	96	42	69	271	92

(σ : Standard deviation)

- . The diameter of filter media to be used (usually gravel) should range from 4 to 50mm and only three or four fractions should be provided.
- . The net total length of filter media should lie in the range of 10 to 20 metres.

4. WORKING CONDITIONS OF W/S SCHEMES WITH SSF IN TANZANIA

The following observations were made during the site visits to w/s schemes having SSF in different areas of Tanzania during the year 1983, see (ref. 5).

4.1 Pretreatment units operation

In many cases, improper operation of pretreatment units result in very short filter runs of SSF. For example, the poor settling efficiencies of sedimentation tanks are usually a result of application of high overflow rates. However, this can be alleviated by either installation of weirs or simply by construction of additional units. For some chemically assisted pretreatment units, shortage of chemicals, non-existence of rapid mixing facilities at the dosing points, and unreliable analyses of optimal doses of Aluminium Sulphate (Alum) contribute to poor settling efficiencies experienced.

4.2 Cleaning of filter beds of SSF

In extreme cases, the filter bed is washed within the SSF box by filling it with water and after thoroughly mixing up the contents, dirt is flushed off through the overflow pipe. However, such a practise is not recommended at all because it disturbs the purification mechanism of the SSF to a great extent and allows penetration of impurities deep in the sand bed.

The most common practise is to scrape off the top one to three centimetres of sand from SSF bed after clogging and to refill it after washing. In any case, the application of this technique should have some technical and economic justification. Thus it has to be clearly

established that the cost of refilling fresh sand stored at the site or brought in from nearby sand quarries is much higher than the cost of washing it after scraping if unsieved sand is used.

4.3 Background knowledge of the plant operators

The background knowledge of the plant attendants about operation and maintenance of SSF is completely insufficient. In order to ensure that they at least have the minimum understanding, some theoretical and practical instructions should be conducted for them, preferably in Swahili language. The pilot plant at Iringa is available for such a training to start with and the Department of Civil Engineering of UDSM could organize such workshops upon request from the responsible ministry on specific terms of reference.

4.4 Control of filtration rates

For reasons already mentioned in item 4.3 above, most of the attendants are not even able to check the filtration rates of SSF at any time during normal operation of the plants. In order to have a more reliable control of filtration rates, devices which can indicate them visually should be made use of. Such a device can be installed in the outlet box of the SSF as a floating structure just before the weir itself, see (ref. 3).

4.5 Design of SSF

The design of inlet and outlet structures of some of the SSF are completely unacceptable and in many cases, the latter is not properly provided for, thus allowing the occurrence of negative pressures in the filter beds and hence resulting in premature filter runs due to the subsequent air binding.

5. SSF RESEARCH WORK IN PROGRESS AT UDSM

The following research activities in the field of SSF are in progress at the University of Dar es Salaam.

5.1 To check whether or not refilling of washed or unused sand on top of the SSF bed after scraping has any effect on the duration of full rejuvenation of biological activities on the filter bed.

5.2 Comparison of treatment efficiency of SSF beds with sieved and unsieved sand complying with SSF bed specifications recommended in literature.

5.3 Continuation of research with HRF - SSF systems in Tanzania.

6. CONCLUSIONS

6.1 Slow Sand Filtration is an appropriate and reliable treatment process for surface waters in rural areas of tropical developing countries if carefully implemented.

6.2 The component of training to be plant operators should not be overlooked during the stage of planning execution of new w/s schemes with SSF.

6.3 HRF can be very conveniently applied as pretreatment prior to SSF in schemes which have high bacterial pollution loads and considerable amounts of settleable suspended matter.

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ABBREVIATIONS USED

SSF	Slow Sand Filtration or Filter
HRF	Horizontal Flow Roughing Filter
UDSM	.....	The University of Dar es Salaam
IRCWD	.....	International Refe- rence Centre for Waste Disposal
ref.	.....	reference number
w/s	.....	water supply
σ	.....	Standard deviation