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WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

Design improvement for pond sand filter

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POND SAND FILTER (PSF), a special small scale filtering device has been used mainly in the coastal parts of Bangladesh to treat the water from rain-fed ponds. It is a manually operated treatment unit, based on the principle of slow sand filtration. Water is pumped up from the pond by a handpump and is poured into a small concrete tank, having more compartments, of which one is the filter chamber filled with the sand. Water passes through the sand filter chamber from where it flows into adjacent storage chamber. A small chamber filled with brick chips acts as a pre-treatment unit. The treated water quality depends on the efficiency of the filtration system and also on the raw water quality of the pond. Again, the water quality of the pond depends on design of the pond, the use being made of the pond by people and or livestock, and the runoff into the pond of drainage and wastewater.

Situation analysis

The one of the major problems to study the PSF is the lack of information on its operational conditions, the quality of the treated water, level of user acceptability etc. There is no independent assessment report on performance of PSF. WHO (1998), Dhaka in collaboration with DPHE and UNICEF has carried out a survey on operational status 130 PSFs. Only 63 (48.5%) PSFs were in operation and 67 (51.5%) PSFs were not in working conditions. Out of 130 PSFs surveyed, 70 handpumps were in operation and 60 (46.1%) handpumps were not in operation. However, the study did not conclude any relationship between the handpumps condition and the PSF condition.

The study also describes the physical condition of the different components of PSF like filter condition, pre-treatment unit, platform condition, drainage condition etc. The result shows that the connection pipe is in satisfactory condition only in 43 cases of 130. So, it is obvious that negative pressure may develop in many instances and the filter bed may become dry at the night. The conclusions drawn form the studies are as follows.

- Users are not sufficiently aware the health benefits of drinking PSF water.
- Location of PSFs is not correctly selected in some instances.
- Supervision of construction works was not adequate.
- The C.I. sheet cover is not strong enough and delivery spout is not appropriate.
- The thickness of sand filter is reduced affecting effectiveness of PSF.
- Training and maintenance tools are not adequate.
- The ponds are not protected against the unwanted flows.

Study area

The field study has been carried out at Shyamnagar, a Thana (sub-district) of Satkhira district. Satkhira is located on is 22°42’ N (latitude) and 89°04’ E (longitudinal). It is one of the coastal districts of Bangladesh where suitable groundwater (salinity free) is not readily available. PSFs has been introduced by DPHE-UNICEF in this area from the 1985. The other available drinking water sources are VSST (very shallow shrouded tubewell) and manually operated deep tubewell.

Comparison of design criteria of SSF and PSF

As earlier mentioned, PSF follows the same working principles of SSF. An effort has been made to compare the design standard of SSF and PSF and also to identify the possible effect in PSF (Table –A).

Field findings

Reason of not operation

The field study was carried out on 13 Nos. of PSFs. 4 Nos. of PSFs was found not in operation. 2 PSFs were abandoned due to saline water intrusion in the pond from a shrimp culture field. Other 2 PSFs have been temporarily out of operation due to problem in handpump and shortage of pond water.

Sand bed

The depth of the sand bed was found between 11 inch (27.94 cm) to 12 inch (30.48 cm) measured in the 5 PSFs. The uniformity coefficient was found 2.18, which higher than DPHE standard, but in the range of slow sand filter. The effective size was found 0.39, which is just above the standard given for slow sand filtration and pond sand filter.

Pre-treatment chamber

The size of brick chips is not defined in the design. However, DPHE suggests to use 1 inch (2.54 cm) brick

Table A: Comparison of design criteria of SSF and PSF.

Criteria	*Standard of SSF*	*Standard of PSF*	*Remarks for PSF*
Depth of supernatant water	1.0 m – 1.5 m	0.3048 m	The depth of supernatant is inadequate to provide a sufficient head of water and to create a sufficient detention time.
Sand bed Depth UC Effective size	 Minimum 0.6 m 2.0 – 3.0 0.15 – 0.35	 0.27m – 0.31 m 1.5 –1.7 0.2 – 0.35	The depth of the sand bed is very limited. It is revealed from the filtration theory that full bacterial activity extends over a depth of about 0.6 m of filter bed so that the effective bed thickness should be not less than 0.7m.
Thickness of Underdrain	0.3 m – 0.5 m (including gravel layers)	0.381 m	Within the limit.
Inlet structure	Well control structure.	Water falls directly over the sand filter.	PSF has no inlet structure. This direct flow of water can damage the filter skin on the top of the sand bed. It may also create a route for passes of bacteria in the filter bed to the treated water.
Weir in outlet structure	Weir on top of a brick wall in the outlet chamber.	Raised pipe in storage chamber.	Not well designed. The PVC connection is vulnerable to manual cleaning of storage tank.
Filtration rate	0.1 – 0.3 m/h	Not mentioned	Variable filtration.
Filter regulation and control device	Well defined controlling valves	No major controlling valves. Valves for only drainage of water.	Absence of filter regulation and control creates uncertainty in the operating system and probably effect the water quality.
Run times	20 – 100 days	10 – 20 days	Discontinuous operation.
Number of filter bed	Minimum 2	1	Makes PSF less effective.
Mode of raw water pumping	Motorized pump	Handpump	The type of supply in PSF is intermittent and there will be no supply after certain time in the night.

Ferdausi (1999), DPHE/UNICEF (1987a &b), Thanh *et. al.* (1982), Visscher *et al.* (1987)

chips in the pre-treatment chamber. In 3 PSFs, larger size brick chips were used. The size was more than 2½ inch (6.35 cm). It may be noted that the effective surface area of filtering media decreases with the increase of the size of filtering materials.

Turbidity and Fecal Coliform reduction in PSF

The water samples were collected from handpump, output point of pre-treatment chamber and outlet taps of 3 different plants. The turbidity of the samples was analyzed by turbidimeters and fecal coliform test was carried out by fecal coliform membrane procedure (standard method 9222 D). The results of the analysis are shown in Table B.

Table B: Turbidity and Fecal Colifrom Reduction

	Plant 1		Plant 2		Plant 3	
	T	*FC*	*T*	*FC*	*T*	*FC*
At handpump	65	90	28	69	27	75
After Pre-treatment	30	81	20	63	25	70
After sand filter	4	10	1	8	3	7

T- Turbidity in NTU   FC- Fecal Coliform in Nos./100 ml

The final turbidity of the plants were acceptable. The fecal coliform in treated water was found between 7 to 10 per 100 ml. These values are higher than the guideline value (0 per 100 ml) for drinking water. Moreover, the water quality samples were taken in the summer period i.e., in the dry season. The raw water quality generally decreases during the rainy seasons as runoff from the different unpro-

Fig A: Pumping of water from pond in a PSF

tected latrines, cattle field etc are mixed with the pond water. This may also increase fecal coliform numbers in the treated water.

Re-sanding

The runtime of PSF is very short which makes the O&M system very complicated. Generally, it was observed the re-sanding is carried out in twice in a month. In that case, users get satisfactory waters only 22 days in a month (one day for re-sanding and another 3 days for growth of biological layer after each re-sanding.)

Proposed design improvements for PSF

It has been revealed from comparison of design criteria and field findings that there is still scope for design improvement to achieve potable water from a PSF system. The design improvements are limited in 5 components, keeping in mind the extra cost involvement. The improved components with their expected effect are described below (Fig- A).

Pre-treatment Chamber

Present design - One box with larger brick chips.

Proposed design - Three compartments with smaller size of gravel (or brick chips) separated by wire mesh. Two other compartments are also used before and after the three compartments for temporary water storage. The new pre-treatment unit will act as a horizontal flow-roughing filter.

Expected improvement – It will decrease the turbidity load to the sand filter. So, the runtime of the sand filter will be increased. It will also reduce the FC due to longer detention time in the pre-treatment chamber and also due to some biological activity.

Inlet structure

Present design – No inlet structure.

Proposed design – A very small inlet structure before the sand filter.

Expected improvement – It will stop the direct falling of water to the filter sand skin and will reduce the possibilities of passing of bacteria to the treated water without treatment. It will also provide support in draining water for re-sanding.

Filter bed unit

Present design – One unit.

Proposed design – Two units.

Expected improvement – It will ensure safe and continuos operation and will allow one of the beds to be cleaned.

Filter bed

Present design – The depth of filter bed sand – 1 ft (30.48 cm).

Proposed design – The depth of filter bed sand – 2 ft 3 inch (68.58 cm).

Expected improvement – This increased filter bed will allow the full biological activity in the filter bed and will produce the acceptable quality of water. The re-sanding in the top layer (7.62 cm to 10.16 cm) will not disturbance the developed biological layer already developed in the lower filter bed. Presently, about 50 percent of the sand filter bed are scrapped off and again washed and dried sand is placed on it.

Supernatant water

Present design – The depth of supernatant water – 1 ft (30.48 cm).

Proposed design – The depth of supernatant water – 3 ft (91.44 cm).

Expected improvement – The increased water depth above the filter will provide sufficient head of water to pass through water the filter bed and sufficient detention time for various physical and biological processes.

Outlet Chamber (prevention of negative pressure in filter bed)

Present design – A raised connection pipe.

Proposed design – A brick wall.

Expected improvement – The brick wall will ensure the prevention of development of negative pressure in the filter bed. It will also ensure that filter will operate independently regardless of fluctuations in the water level in the storage tank.

O&M system of PSF

The design improvement is not enough to ensure safe water from pond sand filter. Other factors like responsibility of community, caretaker, health & hygiene education, formation of water user group and village committee, provisions of fund raising system are also essential for the smooth operation and maintenance of PSF.

Conclusions

The present design of the pond sand filter improves water quality, but fails to bring the Fecal Coli number below the standard level. It was found that the frequency of re-sanding the filter is very high. This reduces treatment efficiency and complicates the O&M of the system. The proposed design improvement for pre-treatment unit, the depth of the sand bed, and inlet and outlet structures and controls requires field testing and close monitoring. Such design modifications along with improved community participation, O&M training and procedures can improve water quality, increase the filter run time and reduce the O&M activities.

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