Terafil water filter for sustainable drinking water programme

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ABSTRACT
Terafil water filter is a low cost house hold filtration and treatment device. Terafil, a burnt red clay porous media, is being produced from the mixture of red clay, sand and wood saw dust by micro enterprisers in Orissa, India. It can be fitted at the bottom of any water container easily for filtration & treatment of raw water in to clean drinking water. Terafil removes sediment, suspended particles, microbes, dissolved iron, many heavy metals, colour, bad odour etc from raw water effectively during filtration process. The pores in the Terafil are not interconnected but separated by clay membranes, which is responsible for efficient filtration without clogging the core of the Terafil. The filtration rate is rejuvenated by periodic scrubbing and cleaning the top surface of Terafil. The domestic filter design is scaled-up to community size, from average flow rates 2 lit/hr to 1500 lit/hr. Operational life of Terafil is more than five years.

Key words
Terafil, Red clay filtration media, clay membrane, disconnected pores, local materials, Filtration & treatment of raw water, long life, sustainable device.

INTRODUCTION

Supply of clean and safe drinking water is an important issue in many developing countries. The surface water sources are being polluted by degradation of environment and industrialization. Excessive draw of ground water is also one of the causes for leaching Arsenic into the ground water from the soil in few patches of Asian countries. It is well noticed that the water from 48 % of tube wells installed in many parts of India are not being used for drinking due to high iron content in the ground water, besides a large number of tube wells are getting dried in summer for low water level. Household water filters containing ceramic candle are also not popular among the poor people of rural areas, although it has been considered as cheapest domestic water filter system in the past. The operational life of the ceramic candle is quite less, within one year. It requires frequent maintenance and replacement. Moreover the ceramic candles are unable to remove microbes, iron and other undesirable minerals from raw water significantly as well as provide high filtration rate. So the ceramic filter candle is not sustainable in rural areas of India.

Fig .1: Terafil water filter in clay container and Terafil

In this context, Regional Research Laboratory (Council of Scientific & Industrial Research), Bhubaneswar, India has invented a low cost burnt red clay porous disc, called as Terafil, for filtration and treatment of turbid raw water into clean drinking water. The main objectives of this development are to provide clean & safe drinking water in each household through people's participation and use of inexpensive local raw materials for production of the filters by the traditional village artisans & micro-enterprisers. The traditional water pitchers (drinking water storage pot) can be replaced by low cost water filter in rural households. When the turbid raw water is allowed to pass through the Terafil, all suspended particles, sediment, microorganisms are separated from raw water significantly on the top surface of the Terafil i.e. the surface of Terafil exposed to raw water. Besides above, substantial quantities of soluble iron, many heavy metals, fluoride, colour, bad odour etc are also removed. Rate of filtration is remarkably high

when it is compared with the existing ceramic candle filters.

Fig.2: Terafil water filter in GI container used in super cyclone affected areas of Orissa

A super cyclone was passed over the costal areas of Orissa, India on 29th Oct. 1999, when more than two hundred thousands animals and 30,000 human beings were perished. All water sources including ground water were highly polluted and availability drinking water was one of the main problems after cyclone. RRL, Bhubaneswar had distributed 1000 sets of Terafil water filters to the victims of super cyclone in the badly affected areas for filtration of raw water into drinking water. This gave us an opportunity to monitor and evaluate the performance of the Terafil water filters in worst possible environmental conditions. Three types of Terafil water filters were distributed; Terafil fitted with earthen container, galvanised iron (G.I) container and galvanised iron (G.I) bucket. Each set of container type filter has two pots. Terafil is fixed at the bottom of top pot wherein the raw water is used to store over the Terafil for filtration. Bottom pot collects the filtered water. The bucket type filter had no storing facility of the filtered water and Terafil was fitted at bottom of the bucket for filtration of raw water. The Terafil is fixed with the container by grey cement and /or epoxy resin. Operation of all the filters were rigorously monitored for more than one year and performance was evaluated. Different Govt. departments, NGOs, International organizations like UNICEF, OXFAM etc and voluntary organizations have disseminated about 30,000 sets of water filter in rural sector of Orissa. The domestic size Terafil filter has been scaled-up for community use and further modified for pressure filtration.

Presently Terafil filter is becoming a low cost sustainable device for supply of potable water in Orissa, India.

PRINCIPLES

The Terafil is prepared from of a mixture of ordinary pottery clay (red clay), river sand and wood saw dust which are available abundantly in rural areas of developing countries. The mixture is sintered in a low cost furnace to the desired shape. Circular disc shape of Terafil is more suitable for its production, fixing with the containers, strength and long life. Generally a set of filter has two pots, one always rest over another. The top pot of the filter has a small opening at its bottom, over which the Terafil is fixed through grey cement or epoxy resin. The filtered water can be drawn from the bottom pot through a tap. The Terafil can also be fitted with a separate holder, which can be assembled with the top pot for filtration of raw water.

During sintering process of the green Terafil, the wood particles are burnt, clay particles are sintered around the sand particles leaving circular shape pores in between. The pores are not connected and separated by thin clay membrane of 50 – 100 micron thickness. When the sintering process of Terafil is completed at the desired temperature, the circular pores are squeezed due to shrinkage of clay. The final shape of the pores became irregularly elliptical. If the Terafil is over sintered, then size of the pores is reduced. Sintering of Terafil is more important to obtain the proper thickness of membrane as well as shape of pores and strength of Terafil. The pores work like micro water reservoirs in side the Terafil. The filtered water flows from one micro reservoir to another through the water films in the layers of clay membrane due to semi permeability nature of clay. The flow through water films is possible by the pressure of the water column over the Terafil. The scanning Electron Microscopic pictures of the Terafil are shown in figure 3 & 4.

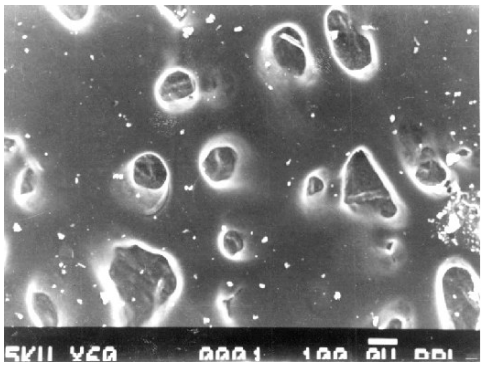

Fig. 3 : SEM picture of semi sintered Terafil.

It is confirmed from the figures 3 & 4 and performance of the Terafil water filters that, the pores of Terafil are not interconnected but separated by thin clay membranes. So, the core of the Terafil is not clogged, hence a long life is achieved. This clay membrane is responsible for separation of turbid particles, micro-organism, iron and heavy metals

from raw water during filtration through Terafil. Removal of suspended particles, iron, micro-organism etc occurs at the top surface of the Terafil i.e. the surface of Terafil exposed to raw water inside the water filter. The filtrates clog the Terafil surface over time during use and hence reduce the flow rate. Therefore, it is necessary to scrub the top surface of the Terafil with a nylon brush or similar material to remove the sediment, open new pores and rejuvenate the flow rate. Since the sintered clay membrane is semi-permeable in nature, rate of flow of water through the membrane depends on hydraulic head of water column over the Terafil.

PERFORMANCE

Nearly 30,000 Terafil water filters in different containers have been used by rural people of Orissa since 1999. The Terafil filters are tested by various organizations in the world such as UNICEF, ENPHO – Kathamandu,[4] Massachuete Institute of Technology USA (MIT), Shriram Institute of Industrial Research - New Delhi (SIIR), EAWAG – Switzerland, SDC – Watsman Bangladesh, Public Health Engineering Laboratory (PHEL), Bhubaneswar, India, Orissa Pollution Control Board (OPCB) Bhubaneswar & Regional Research Laboratory (CSIR), Bhubaneswar (RRL) . Important parameters such as pH, turbidity, iron, coliform bacteria & rate of filtration were studied by the organizations. The consolidated laboratory test results are mentioned in Table – I.

Table- I: Performance of Terafil Water filter.

Name of organizations	Turbidity removal (%)	Flow rate (lit/hr)	Iron Removal (%)	Total Coliform removal (%)
PHEL, India	97.67	2.4	95.0	99.36
OPCB, India.	98.2	-	91.0	100
SDC – WPP Bangladesh	94.3	1.92	96.0	94.0
EAWAG Switzerland	-	2.15	-	96.0 (E - Colli)
SIIR, India	96.0	2.7	92.45	97.0
MIT, USA	94	1.9	-	97.5
ENPHO Nepal.	99	5.0	99.5	95
RRL (BBSR), India.	99	2.75	94.6	99

SCALE UP DESIGN

The demand of Terafil water filters has been increased by various government departments, agencies, NGOs etc. RRL, Bhubaneswar has scaled up the design of household water filter to community size water filters. The community size Terafil filters are made with ferro-cement tanks and metallic containers.

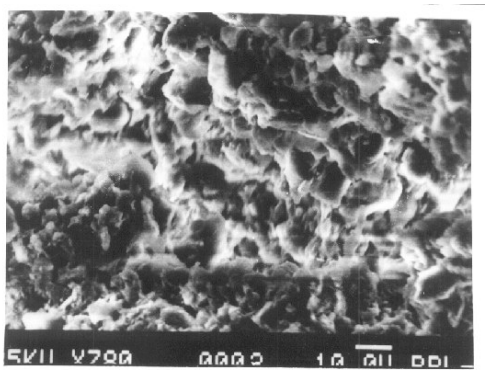

Fig. 4 : SEM picture of well sintered Terafil.

Table- II: Performance of 1,000 sets of Terafil water filter distributed in super cyclone affected areas in Orissa, India.

1.	Average flow rate	2.5 – 3 lit / hr.
2.	Turbidity removal Maximum Turbidity of raw water – 133 NTU Average turbidity of raw water – 60 NTU Average turbidity filtered water – 01 NTU	97 – 99.5%
3.	% of Iron removal	90 – 99%
4.	% of filters removes 100% coliform & Ecoli (By H_2S Strip Test)	83%
5.	Change in pH	Within 1

Ferro-cement tank is low cost and fixed in position. The Terafils are fitted in the upper chamber of the ferro-cement / metallic tank and filtered water is collected in the bottom chamber, like domestic filter. The rate of filtration of the community filter is 50 – 80 lit/hr depending on turbidity of raw water. These type of filters are being installed in schools, community centres, villages etc in Orissa by Rural Development (RD) Department, Govt. of Orissa. RRL, Bhubaneswar has also developed semi-continuous type ferro-cement Terafil water filter for removal of iron from the water of tube wells. Few pilot plants have been installed in different parts of Orissa by RD Department, Govt of Orissa at present, which are found quite successful. About 70 – 95% iron is being removed from the iron-contaminated ground water by these low-cost plants.

RRL, Bhubaneswar is also developing online high capacity Terafil water filter for filtration and treatment of raw water at a flow rate of 1500 lit / hr at present.

Approach for sustainable drinking water programme

The Terafil can easily be applied to obtain a sustainable programme for eradication of drinking water problems in developing countries. The village potters & micro enterprisers can be trained to fabricate the Terafil and terracotta containers in the rural places as the required raw materials are available abundantly. The infrastructure necessary for mass production, such as a low cost coal/wood fired pottery kiln, mould, pulveriser and other tools should be provided to the village artisans. The production and marketing of Terafil water filter can easily be carried out in the villages, in place of water pitchers, as the cost of a Terafil is within Rs.25/-(US $ 0.5) and cost of complete set of Terafil filter with clay container is within Rs 200/-(US $ 4.00).

Both the surface and ground water can be utilised for drinking through use of Terafil. As it is low cost and able to supply potable water with minimal investment, the drinking water problems of developing countries can easily be eradicated by people's participation.

CONCLUSION

The following conclusion can be obtained from the present work.

(i) A sustainable drinking water programme can easily be obtained through use of Terafil water filters.

(ii) The Terafil is able to remove more than 95% of turbidity, 90%of iron, 95% of microorganism, bad odour and colour from raw water efficiently.

(iii) The Terafil also removes fluoride, Chromium, Nickel, Cobalt, Lead, and Chloride etc from raw water to some extent.

(iv) A very small dose of disinfectant i.e 0.01 gm of bleaching powder per litre of filtered water is enough to get 100% bacteria free water, equivalent to WHO standard.[1]

(v) The operating life of a piece of Terafil is approximately five years.[2]

(vi) Domestic Terafil filters having earthen containers are well accepted by the villagers as it keeps the water cool and tastes better.

(vii) Periodical scrubbing and cleaning of the exposed surface of the Terafil is quite important to rejuvenate the flow rate and high bacterial removal efficiently.

(viii) The rate of filtration & treatment of raw water through Terafil can be scaled up easily as per the need of a village.

(ix) Terafil water filter has been well accepted for its un-attentive operation.

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REFERENCE

1) Ferdausi, S.A., SDC-WPP, Dhaka, Bangladesh, personal communication.
2) Khuntia. S, Sahu. A.K, Beuria. P.C. & et al., A report on performance of Terracotta water filter (fitted with TERAFIL) distributed in super cyclone affected areas of Orissa during October 1999 to March 2000, Regional Research Laboratory (CSIR), Bhubaneswar, India, May 2001.
3) Koster. W. and Birkhofer. B.H. & et al, Report on Removal of Bacteria and Bacteriophages with the Help of the 'TERAFIL' Filter Device, Swiss Federal Inst. for Environmental Science and Technology, Switzerland.
4) Low. C.S, Master in Engineering thesis on Appropriate Microbial Indicator Test for Drinking water in Developing Countries and Assessment of Ceramic water filters, Department of Civil & Environmental Engineering, MIT, USA June- 2002.
5) Final report on Study of the Effectiveness of TERRACOTTA FILTER - A Household Water Treatment Device by Shriram Institute for Industrial Research, Delhi, India.