

## Access to Secure Drinking Water for the Foot of Pyramid

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### ABSTRACT

Safe drinking water must be among the highest priorities for every nation on earth. Today contaminated water kills more people than CANCER, AIDS. To design and construct a water filter from the locally available materials. To access and evaluate the function and efficiency of the filter in removing impurities. To analyze the physico-chemical characteristics of various surface source of water pre and post filtration. To assess the acceptance of the filter by rural population. Following physico-chemical analysis were carried out as per the standard methods of APHA, 2005. pH, Turbidity, Colour, Cholrides, Hardness, E-coli. The performance of the filter with reference to the above parameters was found to be good with 60%-70%.removal of the impurities. From the laboratory analysis results and also the feedback from the field where the filter has been adopted, it can be concluded that the filter proved to be efficient in removal impurities and E-coli. People who adopted filter expressed their satisfaction with the performance of filter and also reported reduced frequency of common ailments after using the filtered water.

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### Introduction:

One in eight people in the world today lack access to clean drinking water. A child dies every 15 seconds from a lack of clean water. One in four children who die before age five worldwide, die of water related disease. Most people without access to clean water live right above it. In many cases the only thing preventing access to clean water is money. To clean water is the foundation of development. Food, health, hygiene, habitat, education, employability, productivity are all dependent upon access to water. Without clean water, none of these is possible and poverty is inevitable. Majority of these people are in the developing world. Over the years, India has made improvements to both the availability and quality of municipal drinking water systems. However the exponentially growing population has stressed existing water systems and resources. The pressures of urbanization have stretched government solutions. Rural areas are still left out. Many water sources are contaminated with both bio and chemical pollutants, and over 21% of the country's diseases are water-related.

Safe drinking water must be among the highest priorities for every nation on earth. Today contaminated water kills more people than cancer, AIDS, wars or accidents. It is vitally important that the water which humans drink be free of disease-causing germs and toxic chemicals that pose a threat to public health. Moreover, given that more than 80 percent of the world's population lives in

developing countries, technologies for making drinking water safe must be accessible, affordable, environmentally sound, and tailored to a nation's cultural norms. Technological options fall into two broad categories – those used by municipal authorities at centralized points from where water is then distributed, and those that can be practiced in individual homes. Chlorination is the most common and effective method for purifying water. Even under poor sanitary and hygienic conditions, in which people collect whatever water that is available from community tanks, wells, pumps and taps for use in their homes, if water is chlorinated, a dramatic decline in the incidence of water-borne diseases follows.

Low-cost and readily available materials which are efficient in removing contaminants from drinking water are considered to be a solution for providing clean water in rural areas of Developing countries. These materials include activated alumina, agricultural by-products (e.g. rice hulls), apatite, clay minerals, granular activated carbon (GAC), industrial by-products, iron oxide (coated sands), manganese oxide (coated sands), metallic iron (Fe), peat and peat moss, phosphate rocks, seaweeds and their derivatives, wood chips, and zeolites (Malik et al., 2009). Biosand filters (BSFs) form part of the many emerging technologies being developed from locally available materials, for the removal of contaminants from water in rural areas to make the water suitable for use by low-income rural people of Developing countries. As BSFs are cheap to

construct and maintain they could be promoted and utilised in the rural areas of many Developing countries. This study focuses on design, working, efficiency and application of the Biosand filter. The main goal of the project has been to make these types of filters more effective for treating water and more acceptable by populations in need of clean water. Cultural factors and social wisdom, therefore, has been considered strongly in designing filters and development of effective and innovative educational programs for their applications. The purpose of the study is to facilitate knowledge transfer with the goal to empower vulnerable, poorest-of-poor populations in rural and peri-urban communities and to also promote using naturally occurring biology and readily available materials that they already possess as a cost-effective practical approach to combat poverty and inequality and achieve the health benefits of safe water by developing their own household water security solutions.

**Methodology**

**Design and description:** The sand filter has six distinct zones: The first zone is the inlet reservoir zone where water is poured in during filtration. This was constructed by removing the lid of a 25 l bucket. The second zone is the standing water zone. This zone is a separate container that is kept at attached to the top container to collect water. The third zone is the bio-layer which develops a few centimetres (1 to 2 cm) above the top sand layer. This layer comprises slime, sediments and micro-organisms (CAWST 2008). The fourth layer is the biological zone that develops at the top 5 to 10 cm of the sand surface and is useful for the removal of chemical and microbial contaminants (CAWST 2008). The fifth layer is 15 cm deep and forms the largest part of the filter media, this layer is composed of sand. The sixth zone is the gravel zone composed of coarse sand (0.95 mm) and gravel (1 to 3 mm). The gravel layer (2.5 cm thick) is very useful in ensuring that there is an easy flow of water. The coarse sand layer (also 2.5 cm deep) helps in retaining the sand and preventing it from being flushed down into the gravel layer. In order to prevent poured water from disturbing the biological layer, a diffuser plate was made trimming a stainless steel mesh radically until it fitted into the plastic bucket. The diffuser plate distributes water at a steady rate, maintains the flow rate of the sand filter and also traps larger particles such as grass and leaves. The sand filter was produced with natural materials.

**Source of the filter media** – from the literature it has been understood that the crushed rock is the best type of filtration sand since it has less chance of being contaminated with pathogens or organic material. This sand also has less uniform sizing of the grains. A mixture of grain sizes is required for the proper functioning of the filter. Gravel pits or quarries are the best place to obtain crushed rock, and are common in most parts of the world. In this work it has been obtained from a local road works where granite is being crushed into various sizes. Sand with a lot of gravel, up to 10 mm in diameter, was used. Care has taken that it should not contain any organic material (e.g. leaves, grass, sticks, loam, and dirt).

**Collection of water samples:** Surface water samples were collected from naturally formed small lakes and reservoirs of Visakhapatnam (Samples 1 – 4). The surface water samples were collected in 24 litre plastic containers. The temperature, visual colour and odour of

water were recorded on site. The turbidity and the pH were recorded immediately upon arrival at Environmental Monitoring Laboratory, GITAM University before the water was filtered through the sand filter. The pre and post analysis of the physic-chemical parameters like, colour, turbidity, pH, chloride, hardness and e.coli presence (H<sub>2</sub>S strip test) were tested.

**Sampling Sites**

**Visakhapatnam Zone**

- 1 Mudasarlova 3 P.M.Palem
- 2 Kambala konda 4 GITAM University

**Performance of the Filter:** An infiltration test was conducted by the falling-head method and the flow rate was observed and noted down. The filter was initially tested with synthetic prepared water of two different turbidities i.e. 70 NTU and 140 NTU, namely Sample 1 and Sample 2 respectively. After that the source water samples were collected from four different zones in the greater Visakhapatnam area. The tap water samples were collected from GITAM, Yendada and Arilova, namely Sample 3, Sample 4 and Sample 5 respectively. A groundwater sample, namely Sample 6 was then collected. Finally a water sample from the Mudasarlova reservoir, namely Sample 7 was collected.

The source water samples were collected in 24 litre plastic containers. A single 500 ml aliquot of source water was added to the filter. The total output was recorded thirty minutes later. Samples collected from the source water and from the filtered water produced by the filter were analysed for the various physico-chemical parameters. The collected samples, both pre-filtered and post-filtered were subjected to the following physico-chemical analysis:

Parameter	Measurement	Unit
Colour	Spectrophotometry	Pt-Co Scale
Turbidity	Nephelo turbidimeter	NTU
Total Hardness	Titrimetry analysis	mg/l
Chlorides	Argentometric method	mg/l
E-coli	H <sub>2</sub> S Strip Test	+ / -

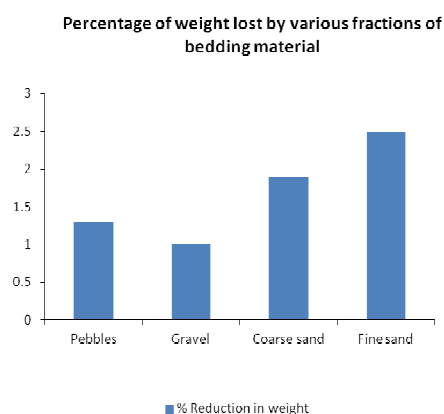
Data quality was checked with regular standards and blank samples.

**Results:** For the present study the bedding material for the filter was selected as granite and its crushed rock in various fractions. The crushed granite rocks were sieved and separated into 4 different fractions. The filter media was initially tested for its physical properties like mechanical strength, additional shocks and resistances towards various chemical compositions of water by allowing all the sieved and washed fractions to stand in dilute hydrochloric acid for 24 hours. It was observed that all the fractions proved suitable for the filter media as the weight reduction was not more than 5% of their initial weight.

**Table: 1.** Percentage of weight lost by various fractions of bedding material

Fraction of Granite	Initial Weight (g)	Final Weight (g)	% Reduction in weight (%)
Pebbles	20	19.74	1.3
Gravel	20	19.8	1
Coarse sand	20	19.62	1.9
Fine sand	20	19.5	2.5

The sieved and washed fractions were laid from bottom to top ranging from pebbles, gravel, coarse sand and fine sand respectively in a durable plastic container.



**Figure: 1.** Percentage of weight lost by various fractions of bedding material

The infiltration tests are used to measure the rate at which the water can infiltrate downwards through the sediment/soil profile which is a function of vertical hydraulic conductivity. For the present study, a falling – head method where water is added to reach a target level in the filter was adopted after which the subsequent decline in the water level is recorded as infiltration occurs. It was observed that the flow rate of the filter was 1000ml/hr.

After obtaining successful results in the infiltration tests, the study was ensued towards testing the efficiency of the filter with water with and from different compositions and sources respectively. For this the study was designed and executed in three stages.

In the first stage two synthetic samples were prepared with turbidity 70 NTU and 140 NTU which were named as Sample 1 and Sample 2 respectively. The physico-chemical parameters of these water samples pre and post filtration in the sand filter were

analyzed. After the filtration considerable results were achieved. The water obtained after filtering Sample 1 showed a turbidity and chlorides reduction of 50 % and 46.88% respectively.

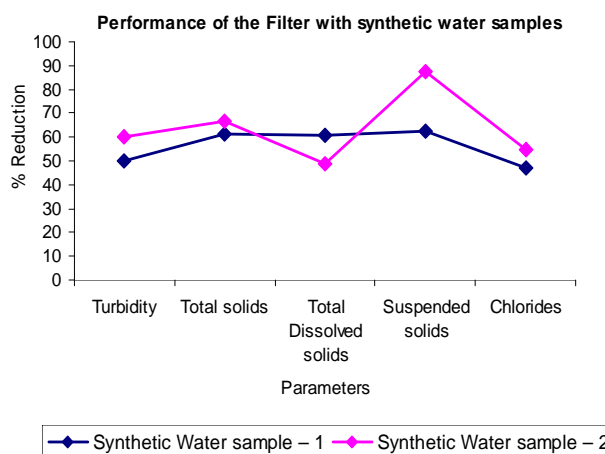
There was nearly 61.11% reduction in the total solids followed by 60.86% in total dissolved solids and 62.5% in suspended solids. The water attained after filtration of Sample 2 was observed to be purged out of impurities having a reduction of around 66.66% in total solids, 48.64% in total dissolved solids, 87.5% in suspended solids, 54.93% in chlorides and 50% in turbidity.

**Table: 2.** Performance of the Filter with Synthetic Water Samples

Parameter	Before Filtration	After Filtration	% Reduction
Synthetic Water sample – 1			
Turbidity	70	35	50
Total solids	10800	4200	61.11
Total Dissolved solids	9200	3600	60.86
Suspended solids	1600	600	62.5
Chlorides	799.9	424.9	46.88
Synthetic Water sample – 2			
Turbidity	140	56	60
Total solids	13800	4600	66.66
Total Dissolved solids	7400	3800	48.64
Suspended solids	6400	800	87.5
Chlorides	598.9	269.9	54.93

\* Except for Turbidity all the other values are given in mg/l;

\* Turbidity is given in NTU



**Figure: 2.** Performance of the Filter with Synthetic Water Samples

The sand filter was evaluated for its efficiency to reduce chemical contaminants from environmental water sources (surface water) with low and high turbidity. Filtration was carried out in the Environmental Monitoring laboratory (GITAM University) to mimic filtration in rural homes. The collected water samples were

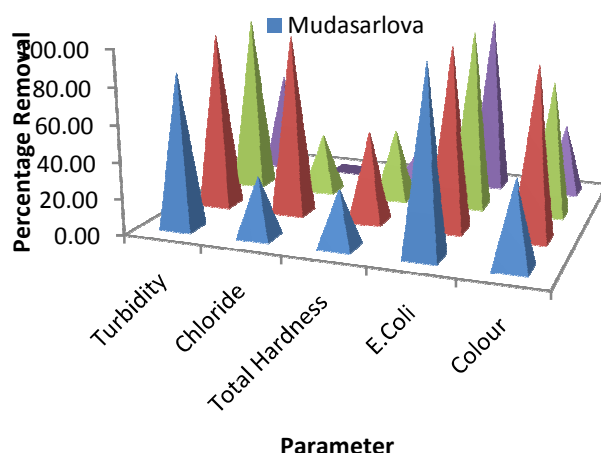
filtered through the sand filter upon arrival in the laboratory after analyzing the samples for various physico-chemical parameters. Filtration was carried out for 3 h with the assumption that enough purified water would have been produced over this period of time for drinking and cooking. Different volumes of filtrates were collected at 1 h intervals over the 3 h period of filtration. This was done to establish whether there was a difference in the reduction of chemical contaminants at different times and to make the necessary adjustments and recommendations. The collected samples were analysed in triplicate to determine the water quality after filtration.

The results pertaining to the efficiency of the sand filter with various surface water sources is presented in table - 3

**Table: 3.** Performance of the Filter with Surface Water samples from Visakhapatnam

Parameter	Before Filtration	After Filtration	% Reduction
<b>Mudasarlova</b>			
Colour	13	7	46.15
Turbidity	2.7	0.4	85.19
Total Hardness	75	50	33.33
Chlorides	390	270	30.77
E.coli	1	0	100
<b>Kambala Konda</b>			
Colour	14	1	92.86
Turbidity	5	0.1	98.00
Total Hardness	75	0	100.00
Chlorides	380	190	50.00
E.coli	1	0	100
<b>P.M.Palem</b>			
Colour	28	7	75.00
Turbidity	21.2	0.1	99.53
Total Hardness	75	50	33.33
Chlorides	400	240	40.00
E.coli	1	0	100
<b>GITAM</b>			
Colour	10	6	40.00
Turbidity	3	1.3	56.67
Total Hardness	20	20	0.00
Chlorides	60	50	16.67
E.coli	1	0	100

The turbidity of samples from Visakhapatnam is presented in table - 3. The initial turbidities were in the order of 21 to 2 NTU, which has shown a reduction of 56% (GITAM) to 99% (P.M.Palem). Colour of the samples ranged from 28 (P.M.Palem) to 10 (GITAM) on platinum cobalt scale. The reduction in colour was up to an extent of 92% for sample from kambalakonda and the least was observed with GITAM resulting in 40% reduction.



**Figure: 3.** Performance of the Filter with Surface Water Samples from Visakhapatnam

Hardness removal was 100% for kambalakonda sample and minimum obtained was 33.3% for both Mudasarlova and P.M.Palem. The chlorides decreased upto 50% for kambalakonda sample.

**Discussion:** Provision of safe drinking water has been of primary concern in rural India [Bilas and Singh, 1981; Kang, *et.al.*, 2001]. Far too many people live without access to safe drinking water, and this is a primary determinant of continuing poverty. Progressive expansion of improved water supplies is important but often fails to address the immediate needs of the most disadvantaged. This study has implications for the development and evaluation of household water treatment strategies in general. A promising household water treatment technology is the biosand filter (BSF). It is a slow-sand filter adapted for use in the home. Filtration is the least-studied HWTS intervention being taken up in India and hence this study was executed. The study has focused on the construction of a filter by utilizing locally available and accessible material as the components of a filter media. For this study fractions of granite (crushed rocks of granite) have been used, the reason being that crushed rock is the best type of filtration sand.

Low filtered water turbidity can be correlated with low bacterial counts and low incidences of viral disease. Positive correlations between removal (the difference between raw and filtered water samples) of pathogens and turbidity have also been observed in several studies. In fact, in every study to date where pathogens and turbidity occur in the source water, pathogen removal coincides with turbidity/particle removal as in this work it has been seen that the removal of e-coli was good.

Chlorides are leached from various rocks into soil and water by weathering. The chloride ion is highly mobile and is transported to closed basins or oceans. Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. The efficiency of the filter in removing chloride was observed from 20 to 50%. Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride

metabolism, e.g. in congestive heart failure (1978 Department of National Health and Welfare (Canada). Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water. Little is known about the effect of prolonged intake of large amounts of chloride in the diet. As in experimental animals, hypertension associated with sodium chloride intake appears to be related to the sodium rather than the chloride ion (Fox, et al., 1995).

Increased intake of magnesium salts may cause a temporary adaptable change in bowel habits (diarrhoea), but seldom causes hypermagnesaemia in persons with normal kidney function. Drinking-water in which both magnesium and sulfate are present at high concentrations (above approximately 250 mg/l each) can have a laxative effect, although data suggest that consumers adapt to these levels as exposures continue. (Gregory, 1990).

A suggested explanation relative to hard water is that increased soap usage in hard water results in metal or soap salt residues on the skin (or on clothes) that are not easily rinsed off and that lead to contact irritation (Langan, 2009). There are reports of a relationship between both 1-year and lifetime prevalence of atopic eczema and water hardness among primary-school children. Eczema prevalence trends in the secondary-school population were not significant (Thomas and Sach 2000).

Highly colored water has significant effects on aquatic plants and algal growth. Light is very critical for the growth of aquatic plants and colored water can limit the penetration of light. Thus highly a colored body of water could not sustain aquatic life which could lead to the long term impairment of the ecosystem.

#### Conclusion:

Poor water quality spreads disease, causes death and hampers socio-economic progress. Around five million people die due to waterborne diseases. The sand filter is easy to construct, maintain and operate. The sand filter is cost effective and could be afforded by most rural people. There is no additional maintenance. The filter was observed to have higher flow rates which make it suitable for use by a larger family for the production of clean water for both drinking and cooking purposes. The size of the filter makes it convenient for the users to position it in an area where food is prepared and hence encourages the use and maintenance of the filter. The sand filter had higher removal efficiency of chemical contaminants and hence can be used for production of higher quality water at lower costs.

As this filter improves water quality by removing turbidity, organic matter and reducing microbes under a wide range of source water quality conditions, it is bound to provide households with high quality water regardless of source water quality. It will also educate the unprivileged community to construct their own sand filters using locally available materials.

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