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Evaluation of the Efficiency of Home Pressured Sand Filter for Pathogen Removal Based on Coliform, Fecal Streptococci and Turbidity Indices

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ABSTRACT

Process performance of pressured filtration units is complicated and depends on parameters such as filter bed granules size and shape, filter bed depth, filtration rate and so on. Present study was a pilot scale laboratory study with the aim of evaluation of the efficiency of home pressured sand filters for pathogen removal based on coliform, fecal streptococci and turbidity indices and suspended materials. Whole experiments were conducted according to standard methods. According to results, highest removal of total coliform, fecal coliform, fecal streptococci, suspended materials and turbidity obtained as 98, 97, 100, 100 and 97 percent indicating high efficiency of studied system at long- term application of above mentioned pollutants removal. Therefore, use of this system for water filtration with strict population or in house scale recommended for producing better quality water.

Keywords: Home Pressured Sand Filter; Pathogen; Coliform; Streptococci; Turbidity Indices

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INTRODUCTION

Water is essential for life and access to healthy potable water is one of the primary requirements of the human. About one billion people all around the world have no access to healthy potable water and find their water requirements from rivers, lakes and wells **[1]**. In developing countries, unhealthy potable water every day causes to death of thousands people especially child less than 5 years old **[2-4]**. High occurrence of diseases from consuming unhealthy water and in developing countries raised concerns about removing the problems which have deleterious impact on mankind health**[5, 6]**. Coliforms belong to enterobacteriacea include citrobactre, Escherichia acoli, entrobacter and klebsiella. The species found in contaminated waters and soils. Presence of fecal coliforms was considered as index for presence of fecal materials of warm-blooded animals**[7]**. Fecal streptococci mainly existed in human and animals fecal and rarely proliferated in contaminated water and shows great resistance under unfavorable growth conditions and therefore are more stable than coliforms**[8]**. Fecal streptococci was utilized as an additional index for determination of the efficiency of filtration and continuous monitoring of distribution network systems after installation of new main tubes and or identification of pollution through surface leaking to groundwater or surface waters **[9, 10]**. Recently household water treatment systems were developed for point filtration of unhealthy water. In this regard, household pressured filters are equipment that have good impact on water sources with low microbial quality for producing healthy potable water in small communities **[11-13]**.

Appropriate technology of household filtration tools depends on location, raw water quality, availability of required materials and tools, customer needs and education rate, availability of personnel for educating and required monitoring **[14]**. For years, rapid sand filter was utilized for final stage of water treatment **[15]**. Filtration process occurs with the help of sand filter through particles physical filtration processes and biological removal of pathogens at upper layers of the filter. Therefore, this technology was recognized as proper technology for water treatment in small communities **[1]**. Filters filtrate water without chemicals and could produce water with low turbidity, bacteria and viruses. Removal process through filter depends on various parameters like physical and chemical properties of suspension, coagulant utilization, filtration rate, filter bed depth and so on **[16]**. Filter having particulate medium could remove wide range of organic materials and microbial pollution with low density to minerals with high density. Suspended materials less than 0.01 µ to more than 100µ could easily remove by particulate medium **[17]**.
Particles removal has two step: at first step, particles precipitated through diffusion mechanisms and hydrodynamic impact transferred to particles and at second step, these particles absorbed by van-der-vales forces and electrical double layer **[18, 19]**. Pressured filters were considered as low cost, little heat waste and less occupies option. Body of these filters made of metal and are cylinder like at both horizontal and vertical. The most important differences between gravity filters and pressured ones include required pressure for pulling water among filter layers and water passage and also utilized box for filters **[20]**. However, in rural areas of developing countries, due to scarcity in water sources, people had no access to potable water and utilize unhealthy water for drink and hygienic uses. Application of proper technology which easily accessible, easy running, inexpensive, cost-efficient, was considered as priority of hygienic teams. Among various options, water source improvement and filtration technologies had great history. In the present study, pressured filter was designed and constructed by local possibilities through technology modification which had capability in utilizing in small communities and family level.

MATERIALS AND METHODS

In order to conducting the experiment, a pilot cylindrical pressured sandy filter mas made as vertically from galvanized tubes with dimension of 1.5 m(diameter) and 1.1 (length) . Prior to utilize the filter, inner surface colored by bilayer epoxy color and then all of mechanical tools including inlet and outlet tubes, tapes, pressure meter, nozzle and so on installed. Filter had 0.5 ml per second discharge rate and consisted of 2 tanks. Layers from up to depth are 0.16 mm, 0.25mm and 0.5 mm. Backwash is used for filter cleaning. First tank with 40 L volume contained wastewater that entered to water and installed on four metal bases. After adjusting the discharge rate, waste water entered into second tank having healthy potable water under the first tank through the outlet tap. In this tank, potable water mixed with certain amount of wastewater and then pumped into pressured filter via a centrifugal pump with discharge power of 40-5 liters per minute. Silica sand granules with different size were utilized ad filter bed granules throughout the experiment (Table 1).In order to clearance of filter granules from microbial pollution, granules were rinsed thoroughly by nitric acid. In order to prevention of penetration of sand and silt particles into lower layers, metal sieves places between each layer. Filter bed depth considered as 25 cm at all experiments. The study was conducted at 10h to 15h residence times with 5h intervals. Therefore, experiments were conducted at 30 steps. Efficiency of pressured sand filters determined by total coliforms, fecal coliforms, fecal streptococci, turbidity, solid suspended materials and pH. After ending each step of experiment, filter completely rinsed and prepared for next experiment. All of sampling and experiments were conducted according to standard instructions of water and wastewater experiments **[21]**.

Findings

According to results, changing range in efficiency during 150minfilter operation for turbidly, suspended materials, fecal coliforms and fecal streptococci were 70-95, 90-99, 28-97, 37-98 and 25-100 percent, respectively. Also, ibn the experiments, mean removal percent of total coliforms, fecal coliforms, fecal streptococci, turbidity and suspended materials were 79, 78, 82 and 86 percent respectively and mean removal percent of TSS was 95% (Figs. 1 and 2). According to results, by increasing time, removal efficiency of physical and biological parameters increased. So that pollutant removal efficiency was low at initial hours of operation but increased by increasing the time (Table 2 and 3). Results showed that pressured filters are able to decrease turbidity, suspended materials, total coliforms, fecal coliforms and fecal streptococci up to 34.0 NTU, 39.0 mg/L, 0.87 log CFU/mg, 0.39 log CFU/mg and zero. Vinay et al. **[22]** found removal efficiency of suspended materials as 89 percent which is close to our finding. According to experiments conducted on inlet and outlet samples from filter, it can be observed that the filter had well efficiency for coliforms removal and at least had ability to chlorination, since before filtration, there is no ability to chlorination due to high turbidity and coliforms.

Results showed that utilized layers had proper efficiency in suspended material and turbidity removal. Results presented in scientific journal of aquatic works association of America (AWWA) in regard to mean removal of microbial pollution including cryptodporidium and Gyardya showed logarithmic increase of removal percent at multi-layered filters **[23]**. Other authors found similar results **[24-26]**. MemarZadeh et al. **[27]**studied the efficiency of Garent mineral filter for turbidity and biological organism's removal and found that turbidity, diatoms, alga, rotifer and nematode removal efficiency at favorable layering was 92.4, 6.8, 4.97, 94.97 and 96.6 percent, respectively. Filter operation at higher operation times shows that filet efficiency increased as time increased. This could be reflected by ability of pressured filter at higher operation times so that unlike other filters, by increasing time, removal efficiency increased. This could be due to this fact that as operation time increases, more particles located on filter and this caused that particles act as filter and prevents passing of suspended solids defined by turbidity, microbial pollution and so on. In other words, in a large granules medium, early suppressed particles act as collector and assist to removal of other particles.

Table.1. The microbial contamination level in inflow and outflow of pressured sand Filter

Time, min	Total coliform, log cfu/mg		Fecal coliform, log cfu/mg		Fecal streptococcus, log cfu/mg	
	inlet	outlet	inlet	outlet	inlet	outlet
5	57	35.91	21	5.88	7.1	5.32
10	15	9	7	3.99	5.6	4.2
15	35	19.95	12	6.84	4.3	25
20	28	15.12	13	7.28	4.1	3.22
25	75	37.6	32	16	5.8	3.3
30	14	7.6	8	3.76	7.2	4.1
35	69	32.43	29	12.47	6.9	3.4
40	20	9	9	3.87	4.3	0.43
45	28	12.32	13	5.2	5.7	0.57
50	75	27	41	14.76	6.7	0.67
55	32	3.2	12	1.2	7.1	0.71
60	25	2.5	14	1.4	5.9	0.59
65	42	3.36	21	2.1	3.8	0.38
70	35	2.8	23	1.68	2.6	0
75	35	2.6	21	1.67	3.8	0
80	36	2.52	20	1.6	4.9	0
85	29	2.03	19	1.52	4.7	0
90	31	1.86	18	1.44	3.9	0
95	41	2.46	22	1.76	6.5	0
100	36	2.16	19	1.14	5.4	0
105	26	1.56	13	0.78	5.9	0
110	41	2.05	18	1.08	5.2	0
115	22	1.1	9	0.54	4.8	0
120	26	1.3	11	0.66	4.6	0
125	35	1.75	17	0.68	6.2	0
130	28	1.12	14	0.56	7.1	0
135	45	1.8	19	0.76	7	0
140	32	0.96	16	0.64	6.3	0
145	38	1.14	15	0.45	4.3	0
150	29	0.87	13	0.39	5.5	0

Results of the study are in contrast with Banejad et al. **[28]** findings in which removal efficiency decreased by filter operation time. After 60 min, microbial pollution removal efficiency increased, so that at final operation times, removal efficiency reach to more than 90 percent. By increasing time, difference between studied parameters removal efficiency decreased. One of the important and affective factors on particles suppression in the porous medium is pore size distribution. Since pore size distribution is a function of particle size distribution in porous medium, therefore it can be concluded that in the studied filter medium, due to small pore size, particles suppression rate is higher. Because medium with large particles provide less void spaces and so particles suppression is lower. In medium with small granules, van-der –vaals forces are more than large granules which assist to removal of suspended materials (15).Xu et al. (2006) found that when granules size of filter bed medium decreases from 0.78 to 0.098, removal percent of colloid particles held in porous medium increased from 1 to 50 percent **[28]**. Due to irregular forms of sand granules, by increasing particles concentration, void spaces would be narrower which appropriate places for keeping particles.

Table.2. pH, total suspended solidand turbidity level in inflow and outflow of pressured sand Filter

Time, min	Turbidity, NTU		Total Suspended Solid (TSS) (mg/l)		pH	
	inlet	outlet	inlet	outlet	inlet	outlet
5	10	3	50	0.5	7.63	7.81
10	10	2.9	55	5.4	7	7.12
15	9.8	2.54	48	4.32	7.41	7
20	9.5	3.1	42	3.36	7.78	7.24
25	9	2.97	51	3.57	7.32	7.65
30	8.5	1.7	48	3.36	7.35	7.42
35	8	1.61	52	3.64	7.24	7
40	7.6	1.26	39	2.34	7.52	7.64
45	7	1.05	46	2.76	7.64	7.83
50	7	0.98	55	2.75	7.89	7
55	9	1.26	55	2.7	7.78	7.28
60	11	1.54	48	1.92	7	7.41
65	9	1.17	51	2.04	7.52	7.49
70	9	1.16	49	1.96	7.47	7.82
75	8	1.6	55	1.64	7.81	7.78
80	10	0.1	39	1.17	7.85	7.37
85	7	0.7	37	1.11	7.81	7.61
90	8	0.72	56	1.68	7.85	7.37
95	10	0.1	31	0.93	7.23	7.14
100	10	0.8	46	0.92	7.42	7.71
105	11	0.77	53	1.06	7.29	7.16
110	7	0.49	54	1.08	7.22	7
115	6	0.36	49	0.84	7.61	7.26
120	7	0.35	41	0.82	7.12	7.33
125	7	0.34	39	0.39	7.67	7.89
130	9	0.45	44	0.11	7.98	7.71
135	8	0.24	43	0.11	7	7.82
140	9	0.27	52	0.52	7.87	7.71
145	9	0.26	57	0.56	7.37	7.65
150	6	0.18	54	0.54	7.59	7.19

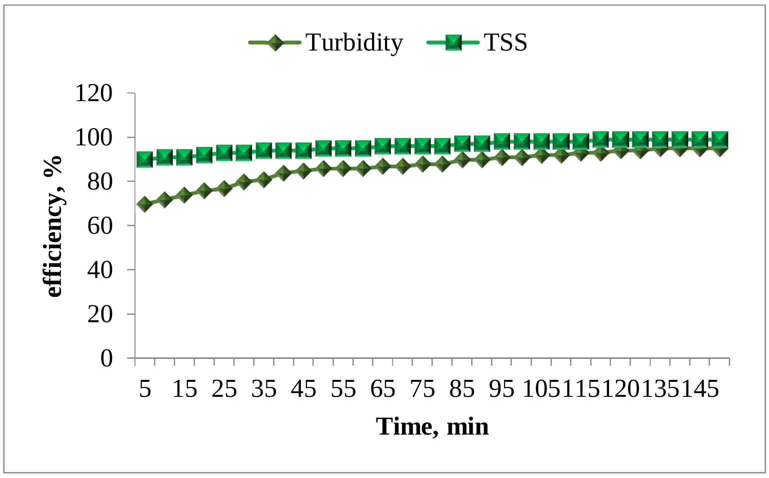

Fig.1. Pressured sand filter efficiency in physical pollution removal

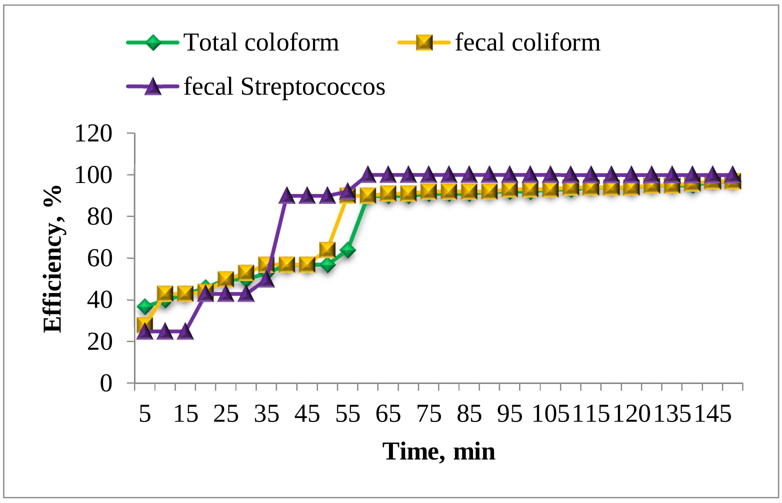

Fig.2. Pressured sand filter efficiency in biological pollution removal

CONCLUSION

Since people in small and rural communities utilize well and spring waters, and almost fecal pollution is relatively low, therefore it can be concluded that removal percent of fecal coliforms is well and if chlorination will be used after the fecal coliforms removal, great amount of fecal and non-fecal pollutions could be removed from water.

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