DACAAR

Water Expertise and Training Centre

Action Research on PVC Biosand Filter in the Afghanistan Context

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1. BACKGROUND

DACAAR's mission is to serve the Afghan poor on a sustainable way by strengthening the civil society to act on their behalf. DACAAR works in rural areas and aims at improving rural livelihoods through sustainable activities that engage Afghan communities to be agents of their own development process. DACAAR's interventions primarily target vulnerable groups such as returnees, internally displaced persons (IDPs) and vulnerable host communities.

Access to safe drinking water is vital for any population to maintain healthy life. Although many communities have access of water source, quality of water is always out of national drinking water standards. DACAAR has been introduced household water treatment technology since 2009 in their WASH programme. DACAAR believes that household water treatment is not only a technology, it is a process. All rural and urban community people have to understand the process of treatment and to do practice of drinking treated water.

2. RATIONALE OF THE RESEARCH

Different household treatment technologies are in practice in Afghanistan. MICS study (2012) shows that boiling, chlorination, SODIS, biosand filter and strain by cloth are in practice. DACAAR has a project to distribute a biosand filter in communities where people are using surface unprotected water source. We have a positive responses from the end users who expressed that they have a less diarrhea epidemic compared to past. Moreover majority of beneficaries mentioned that filtered water is looked clean and taste also good.

Our field staff always comments on the quality production of concrete box of the filter. Due to low quality of cement and sand, many concrete biosand filters have a hair crack and leakage. Replicating the technology in different districts is also challenging due to complexicity on the fabrication of mold. In this context, DACAAR WET Centre came across with PVC biosand filter which is successfully implemented in Peru[1]. DESEA has been installing PVC filters in homes and schools in remote communites. They found that PVC biosand filter is equally well suited to communites elswhere to which the concrete filters cannot easily be carried.

According to PERU experience they found that gluing (water tight) eight collars (washers) in pipe which kept at the middle of 30 cms diameter PVC pipe prevent the possible channelling effect. The plug flow test was carried out by pouring a saline solution into the filter and then measuring the filter discharge with its electrical resistance until detection of the saline water at the outlet. DESEA have found that treated water is suitable for human consumption and biological lab test results compliance with the MINSA (PERU) water quality standards

The DESEA designed PVC biosand filter is 22% larger than the CAWST Version 10 concrete filter. The design parameters of the PVC biosand filter are same as a concrete biosand filter. The change is 30 cm internal diameter, 6mm thickness and

[1] Sandy Hart, Association DESEAU, Lamay, Peru, 2014

90 cm leangh PVC pipe instead of a concrete box. Based on our observation, we have a doubt of slipstream flow due to smooth innerside surface of PVC pipe. It would be good to stick collar in the innner diameter of PVC pipe to prevent slip flow. We realized that before taking a decision to adopt the technology, it would be good to have a action research on it.

RESEARCH TOPIC: Performance Evaluation of PVC Biosand Filter in the Afghanistan Context

3. OBJECTIVES

The broder objective of this action research is to test the effectiveness of PVC biosand filter and compare with the concrete filer. The following are the specific objectives of the action reseach:

- Realize the practicality of the quality fabrication of PVC filter in Afghanistan context.
- Identify the plug flow effect through inner side 13 mm dia. PVC pipe.
- Identify the removal rate of E. coli and turbidity of source water from different filters.
- Compare the effectiveness of concrete biosand filters, PVC filters with inner side collar and without collar.
- Take a decision to do pilot study through the DACAAR's Regional Offices.
- Disseminate the efficiency of PVC biosand filter on learning exchange and Water Technical Working Grouop.

4. METHODOLOGY

PVC filter is a new technology for DACAAR; therefore before carrying out a research the following prepatory works was carried out.

First Step

- Explored the market prices of the list of filter materials such as PVC pipe, plugging cap in the bottom and diffuser basket.
- Calculated the total material costs based on Kabul market per filter which was a optimum price.
- Developed a mind map where shall we replicate the PVC filter in rural community if result gets satisfactory.
- Decided the location of research station where filters where kept in safe place and shadow from the direct sun light.
- Allocated a reliable two staff to cary out the research in professional way. Deployed staff was fully responsible to bring water from Qargha Stream and pouring water two times (9 am and 3 pm) daily (**even weekend and holidays)** into filters.
- Allocated lab staff carried out E. coli, pH and turbidity tests of the source water and filtered water every Thursday untill 10 weeks.

Second step

- Four PVC filters were fabricated and installed as shown in Appendix 1 which is designed by Sany Hart Association DESEA in Peru.

- Two PVC Filters were fabricatd and stuck a collar at the innerside of PVC. The collar was stuck 40 cm height from the bottom.
- After fabrication of complete filter installed with filtration sand according to the standard process mentioned in the filter manuals.
- Two concrete biosand filter version 10 were installed parallel to the PVC filter with similar filtration sand and specifications.
- After installation of four set of PVC filters carried out plug flow test. Prepared 12 L volume of tap water by mixing 200 mg/L NaCl solution. Measure a conductivity of 12L water with NaCl solution and pour into the filter. Record the conductivityof every 500 ml filtered water to test the plug flow. Plot the records of conductivity to know the plug flow. If conductivity curve started to increase after 12 L volume of water, therewas no slip stream flow.

Third step

- Used the same source of water (Qargha Stream) to pour into the filters and handled by the sameperson at on time.
- For the standardization, always pour Qargha Stream water into six filters at 9 am and 3 pm everyday.
- Maintained a logbook of pouring water with name, time and date.
- Carried out turbidity, pH and E. coli lab tests of river water and filtered water in every Thursday.
- Gave a speicifac name to each filter to record the result into a format with the same name.
- Carry out the forward mentioned tests on weeklly basis; each Thursday on 9:00 am. The membaran filteration system method of bacteriogical quality testing was used with no dilution for any of the tests.
- Intered the result of the tests to a readily made format, labeled for each filter.

5. RESEARCH WORK PLAN

Sn.	Activities	*June*		*July*				*August*				*September*				*October*			
1	Purchase all necessary materials for the PVC filters																		
2	Establish reseach station																		
3	Fabrication of two PVC filters set including diffuser plate and Lid.																		
4	Fabrication of two PVC filters set with collare in inner side including diffuser plate and Lid.																		
5	Layout two set of concrete filters for the comparison of the results.																		

Sn.	Activities	June	July	August	September	October
6	Install PVC filters and concrete biosand filters according the specification of CAWST and Peru filter manuals.					
7	Carry out plug test for PVC filters					
8.	Allocate bucket to store filter water in the research station					
9	Allocate containers to carry water from the Kabul river source					
10.	Prepare 10 weeks routine to transport Kabul river water for the filters					
11	Water quality testing-E. coli (source , before pouring into the filter and filtered water)					
12	Turbidity test- (source and filtered water)					
13	Analysis data and prepare a report					

6. TENTATIVE BUDGET FOR THE PVC FILTER ACTION RESEARCH

Sn.	Description	Unit	Rate	Total Amount in $	Responsiblity
	Establish a research station				SA and SH
1	Fabrication of four PVC filter set including diffuser plate and lid.	No	65	260	SA and SH
2	Lay out of two concrete filters in the research station	No	0	Exist	SA and SH
3	Installation of 6 filters with standard filtration sand according to the specification.	No	Lump sum	30	SA and SH
4	Plug flow test of PVC filters -NaCl test	No	Lump sum	2	SA and SH
5	Bucket to store filter water	No	6	40	SA and SH
6	containers to carry water from the source (Qargha Stream)	No	20	50	SA and SH
7	Water sample (Qargha Stream)transportation cost	No	Lump sum	400	SA and SH
8	Water quality testing-E. coli (source and filtered water)	No	20	2400	SA and SH
9	Turbidity test- (source and filtered water)	No	No cost	Included in bacteriological test	SA and SH
10	Report preparation-stationery and printing costs	No	Lump sum	10	SA and SH
11	Analysis data and prepare a report	No		No cost, by DACAAR Staff	Betmand and Shir Ahmad
		Grand total		3,192	

7. FINDINGS OF ACTION RESEARCH

7.1 Plug flow effect through inner side 13 mm diameter PVC pipe.

Tests were conducted to confirm that the PVC filter is achieving a condition referred to as 'plug flow'; that is, that water passes slowly through the filter media and not more quickly along the filter wall nor along the interior standpipe as 'slipstream flow'. This testing was carried out by pouring a saline solution into the filter and then measured the filter discharge and its electrical resistance until detection of the saline water at the outlet. The calculated filter treatment volume was fully discharged prior to detection of the saline water; therefore it was assumed that no slipstream flow was taking place.

7.2 Removal rate of E. coli and turbidity of source water from different filters.

One of the obejective of the action research was to identify the removal effeciency of PVC filter in E. coli and in turbidity and comppare the result with concrete biosand filters. The research found that removal efficiecy of E. coli and turbidity of the PVC filter with collar and with out collar was the same as concrect biosand filter . Refer to follwoing table for comparison.

Table # 1: E.coli Removal Efficiency (CFU/100mL)

Weeks	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
Source Water	280	90	245	107	40	100	40	80	75
Concret Filter (A)	6	2	14	3	3	2	4	2	1
Concret Filter (A1)	7	4	11	5	5	<1	3	1	<1
PVC without Collar (B)	11	10	5	8	1	4	1	1	<1
PVC without Collar (B)	8	10	12	1	4	2	1	1	2
PVC withCollar (C)	10	2	4	4	2	<1	<1	<1	<1
PVC with Collar (C1)	6	8	<1	3	1	<1	<1	<1	<1

based on above data the PVC filters with collar were more effective in bacterail removal than PVC filter without collar and concrete biosand filter as the bacterial count in filtered water became zero in the sixth week of the study with PVC filters with collar .

The research was started in Fall and continued to Winter, therefore the bacterial counts in source water was decreasing week by week as the source water was becoming clear week by week . On the other hand with occsional raining was plushing the dirt to the stean therefore the bacterial counts were increaing, which was affecting the bacterial acounts in filtered water as well.

Table # 2: Turbidity Removal Efficiency (NFU)

Weeks	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Source Water	33.8	18.62	31.5	18.94	22.5	50.11	110.1	70.37	84.01
Concret Filter (A)	0.68	0.64	0.88	1.2	0.3	1.21	0.75	1.66	0.48
Concret Filter (A1)	1.64	1.35	1.18	1.23	0.1	0.91	0.85	1.17	0.31
PVC without Collar (B)	0.26	1.09	0.64	0.51	0.01	0.91	0.75	1.14	0.84
PVC without Collar (B1)	0.52	2.04	0.5	0.89	0.14	1.2	0.48	1.26	0.67
PVC withCollar (C)	0.6	1.46	.64	0.31	0.01	0.79	0.39	2.5	0.4
PVC with Collar (C1)	0.6	0.84	0.5	0.65	0.03	0.7	0.5	2.48	0.52

based on the above data, all of the filters were almost equally effective in turbidy removal, the differneces in turbidty removal among all the filters were not cosiderable and comparable. It is worth mentioning that the filters removed 83.5 NTU turbidy from 84 NTU and the everage turbidiy removal efficiency for all filters in week nineth was 0.5 NTU.

again as the research was started in Fall and continued to Winter, the source water was becoming clear week by week and the turbidty of source water was decreasing week by week. On the other hand with occsional raining, which was plushing the dirt to the stean, therefore the turbidy measures was intermetantly increasing decreasing, which was affecting the turbidiy measures in filtered water as well.

7.3 Realization the practicality of the quality fabrication of PVC filter in Afghanistan context.

Market was searched and indentified that the items which were required for PVC biosand filter fabrication were available in central level and regional level with a little difference in the cost, as they were costly in regional level but in some regions it was cheaper than centre depended on transportation cost.

All the required items for fabrication of PVC filter were purchased and two staff were trained on PVC filter fabrication and four PVC filter were fabricated; two with collar and two without collar inside the filters. All of the four PVC filters and tow of the concrete filters, which were readily available, were installed with the same source of sand and gravel in a safe place protected from sun, rain and people movement.

The expensive item of the PVC biosand filter was the End Cap, which was alone 1400 AFN and it was difficult to be built everywhere. But if give order to a company in big amount it will become cheaper as we order and need only four pieces, therefore it was costly.

If we compare the total cost of concrete biosand filter with the PVC biosand filter, the PVC biosand filter cost is triple of the concrete biosand filter, but if someone order in big amount to a accompany the cost will reduce obviously and will be equal or very little expensive than the concrete one. Refer to table # 3 for cost of different item of the PVC filter.

Table #3: Cost of Different Items of PVC Filter

S #	Items	AFN Cost	US$ Cost
1	PVC Pipe 12" diameter (90cm long)	1,230	21.5
2	PVC Pipe for out let pipe support	25	0.43
3	End cap 12"	1400	24.50
4	PE Pipe 1" stand pipe collars	40	0.70
5	PE Unthreaded Elbow 3Nos	30	0.52
6	PE Tee 1No	30	0.17
7	PE Plug 2No	20	0.34
8	Male/female threaded adapter	40	0.70
9	PVC Pipe Solution	120	2.10
10	Threaded PE Elbow	40	0.70
11	Difuser	40	0.70
Total		2,975	33.26

7.4 Filter loading and flow rate

The DESEA biosand filter has a cross-sectional area of 0.072 m2, which is 22% larger than the CAWST Version 10 concrete filter. Given this surface area and its fine sand column depth of 54.5 cm, CAWST has recommended a maximum loading rate of 0.4 m3/m2/h and a maximum outflow rate of 0.5 L/min (Sanmartin, pers. comm.), while in the DACAAR's fabricated PVC filter the flow rate was ranging 0.3 to 0.45 L/min at the beginning and later on it decreased intensively to 0.2 L/min.

7.5 Pilot study through the DACAAR's regional offices.

It will be shared with the DACAAR's program and regional offices to decide on pilot project in their respective region, considering the availability of fund and selection of an appropriate place for the pilot project implementation, where the concrete biosand filter fabrication and finding of concrete materials is a problem. Different pipes construction companies to be visited to get reasonable cost for fabrication of PVC biosand filter. Fabrication of PVC filter in small amounts by DACAAR,s staff will not be cost -effective.

7.6 Dissemination of the efficiency of PVC biosand filter on learning exchange and WTWG.

Findings of action research on PVC biosand filter was shared with 46 members of 20 different INGOs, NGOs, private sector and government organizations and welcomed by most of the participants and many organizations were interested to have further meeting to understand the fabrication and installation of the PVC biosand filter.

8. CONCLUSIONS AND DISCUSIONS

In some part of the country good quality and required sizes of sand and graval are not available and transportation of fabricated filter form other place is alos problem as during transportaton of the filer will break down and will get crack therefore, the PCV biosand filter is an altenative option to be used in such situation.

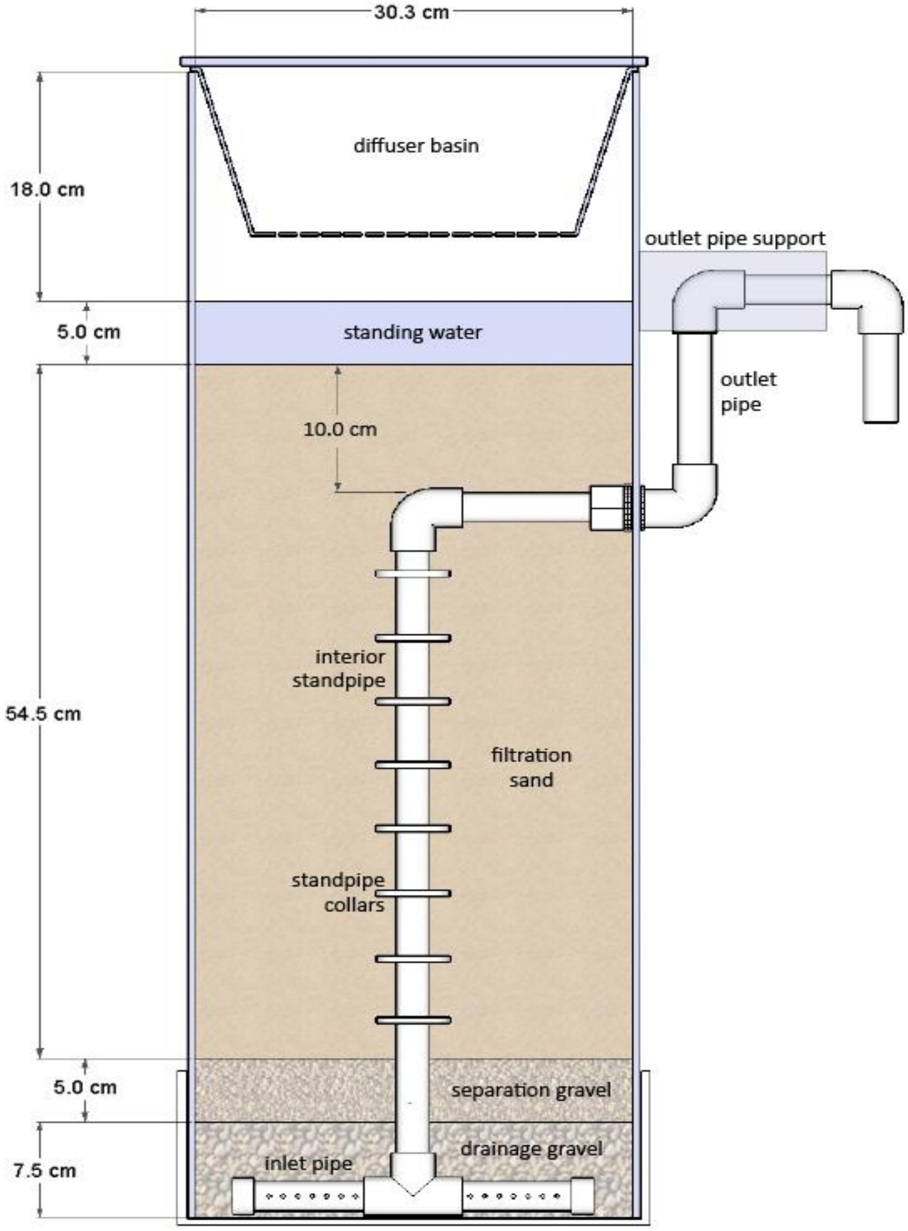
The PVC biosand filter bacterail and turbidity removal efficiency is the same as the concrete biosand filter, the only limitation is the End Cap of the PVC biosand filter which is expensive and dificult to be made everwhere. If an order given to a company in a big amount, it will reduce the cost of the filter by two times at least. PVC filter with collar was more effective in bacterail removal than PVC filter without collar and concrete biosand filter. Overall the PVC bisand filter was equally effective in bacterial and turbidity removal with concrete biosand filter.

9. RECOMMENDATIONS

1. Pilot project to be implemeted to better understand the actual cosst of a PVC filter when order in bulk.
2. PVC Biosand Filter is also feasible option for household water treatment technology in terms of pathogen removal.
3. Even though all tested filters have not internal channel flow, PVC filter with collar have 100% removal compared to others in very first few weeks.
4. Costing is a major issue; therefore search different options to get end cap in cheaper price.
5. After 5 weeks removal effectiveness is high.
6. Best alternative option for areas, where materials for costruction of concrete biosand filter is dificult or trasportation of fabricated filter form other areas is dificult.

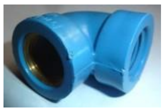
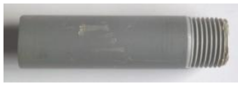
10. APPENDIXES

10.1 PVC Filter with all dimension



10.2 List of materials to fabricate the PVC Filter

Part	Quantity	Dimension	Total cost (USD	Photo (not to scale)
PVC pipe with fabricated end cap glued in place (S-25 grade)	1	31.5-cm diameter; 90- cm depth; 6.2-mm thickness	38.69	
standpipe inlet with 3- mm holes 1 cm apart	2	11-cm length; nom. ½” PVC pipe	0.21	
slip socket end caps	2	nom. ½” PVC	0.36	
slip socket tee	1	nom. ½” PVC	0.43	
vertical segment of interior standpipe (with collars)	1	51-cm length; nom. ½” PVC pipe	0.48	
PVC standpipe collars(fabricated in DESEA shop)	8	5-cm diameter, 6.2-mm thickness PVC	0.00	
slip socket elbow	2	nom. ½” PVC	0.58	
horizontal segment of interior standpipe; threaded one end	1	13-cm length; nom. ½” PVC pipe	0.21	

Part	Quantity	Dimension	Total cost (USD	Photo (not to scale)
male/female bronze adapter	1	nom. ½”; 2-cm male thread length	1.36	
rubber washers	2	4-cm O.D.; 2.2- cm I.D.	0.07	
semi-rigid plastic gasket	1	4-cm O.D.; 2.2- cm I.D.	0.05	
threaded high-pressure PVC elbow	1	nom. ½” PVC	1.60	
vertical segment of exterior outlet pipe; threaded one end	1	14.5cm length; nom. ½” PVC pipe	0.12	
mixed slip socket-threaded elbow	1	nom. ½” PVC	0.18	
horizontal segment of exterior outlet pipe	1	8-cm length; nom. ½” PVC pipe	0.08	
vertical outlet spout	1	8-cm length; nom. ½” PVC pipe	0.08	
outlet pipe support with 22-mm hole	1	40-cm length, 6.2-mm thickness PVC	0.00	
diffuser basin with 2- mm holes on 1.5-cm grid	1	31.7-cm O.D., 13-cm depth plastic	1.53	

Part	Quantity	Dimension	Total cost (USD	Photo (not to scale)
hexagonal plywood lid	1	33-cm width; 6-mm thickness	0.68	
Bucket and lid (with 22-mm hole)	1	20 litre	2.00	
spig ot	1	NA	0.70