DACAAR

WATER EXPERTISE AND TRAINING CENTRE

Action Research on Diffuser Plate and Box Effectiveness

Prepared by: **Dr. Shir Ahmad & Leendert Vijselaar**

March 2013

Paikob-e-Naswar, Wazirabad, PO Box 208, Kabul, Afghanistan
Phone: (+93)(020) 220 17 50 Mobile (+93)(0)70 28 82 32
E-mail: dacaar@dacaar.org Website: www.dacaar.org

Table of Contents

Abbreviations

CAWST	Centre for Affordable Water and Sanitation Technologies
DACAAR	Danish Committee for Aid to Afghan Refugees
SPSS	Statistical Package for Social Science
WET Centre	Water Expertise Training Centre
DDP	Dug well water poured into filers installed with Diffuser Plates
DDB	Dug well water poured into filers installed with Diffuser Boxes
DDPC	Dug well water poured into filers installed with Diffuser Plates and Cloth
DDBC	Dug well water poured into filers installed with Diffuser Boxes and Cloths
RDP	River well water poured into filers installed with Diffuser Plates
RDB	River well water poured into filers installed with Diffuser Boxes
RDPC	River well water poured into filers installed with Diffuser Plates and Cloth
RDBC	River well water poured into filers installed with Diffuser Boxes and Cloths
ABR	Average Bacterial Removal Efficiency
ABS	Average Bacteria in Source water
ABF	Average Bacteria in Filtered water
ATR	Average Turbidity Removal Efficiency
ATS	Average Turbidity in Source Water
ATF	Average Turbidity in Filtered water

Introduction & Rational

Bio-sand filtration has become a popular option for some agencies to include in the solutions for looking for providing appropriate methods for delivery of safe water to the communities. DACAAR has included the option and has constructed many thousands of bio-sand filters as the filter is a good option for scattered communities and for those communities who have a reliable surface water source nearby. The small sand filters are not giving as good results as the big filtering systems for towns but still improve the safety of the water considerably especially with contaminated sources.

There are potentially a number of teething problems, for instance with the disturbance of the top of sand layer because of the instability of the diffuser plate. At present we want to start issuing the box type diffuser as we think that the system is better and will less likely disturb the bio layer. But we are not sure of the cause and if the disturbance of sand will still happen with the boxes and therefore the action research will prove it. When the diffuser plate will be the problem of the sand layer disturbance then we might feel obliged to replace all the diffuser plates with a box. The boxes are more costly to prepare and might be therefore a disincentive when trying to commercialise the system completely.

Research Question

Does the water being poured into the filter disturb the sand layer and biolayer less in the case of diffuser plate or diffuser box

Objectives:

1. To identify the bacterial removal efficiency of filters with diffuser box in comparison to filters with diffuser plate.
2. To identify the flow rate of the filters with diffuser basin in comparison to filter with diffuser plate.
3. To identify the effect of straining added to the installed filters

Methodology

1. Eight biosand filters were fabricated and installed in eastern regional office to be monitored regularly and put water into it timely.
2. Four filters were installed with diffuser plate, four filters with diffuser box and four filters were installed with the straining cloth, of which two with diffuser plate and two with diffuser box.
3. In water (source water) for the filter was from river and dug well. The filters were marked with river and dug well filters with diffuser plate and diffusers basin.
4. A responsible person was pouring water into the filters at least two times a day.
5. Samples for bacteriological test were taken every day after installation for the first month and then every week for a month.
6. The flow rate was measured each week for at least two month.
7. Each filter had a name and against the name and all relevant information was gathered in format with same name.

Analysis

The data was entered into an excel sheet and compiled, compared, analysed and interpreted.

Requirements

A number of items were needed to ensure that the project could work. Various components were required to ensure that all work could be done properly. By making sure that all items and resources were available the project generated enough reliable data to make it possible to get a satisfying outcome.

Personnel

One person was collecting the water from the various sources, twice a day for 7 days a week, therefore two persons were assigned to do the task properly, each of them was working for an half of a month then the other person was working the rest of the month.

Resources

1. Various water containers as being mentioned in the processes. For each raw water source a container that was big enough to contain the water required, a box to hold the containers so that the containers did not spill or break.
2. Containers to collect the filtered water.
3. Transport, twice a day available for up to 2 x 2 hours.
4. A camera was occasionally required to make a picture of set-up, raw water collection points and water samples to be pictured.
5. Stop Watch
6. Graduated measuring jug, preferably for half a litre
7. Identified the water sources that go with bio-sand filter and filter and containers was not interchanged and had clear markings
8. Turbidity measurement was done
9. Equipment and supplies were available for doing the bacteriological test of the raw water and the filtered water
10. The forms for filling were available in hard copy and as an excel sheet for sending to Kabul on two weekly basis
11. Fabrication of 8 bio-sand filters of version No. 10 were done
12. 4 diffuser plates and 4 diffuser boxes were made with hole numbers 12*12 and with 2 mm diameter
13. Cloth for filtering for four of the filters, as an extra pre-caution in the case of use of raw river water were provided. The cloth quality was noted it was locally available and was able to filter out fine organic materials and sand particles.
14. Bacteriological kit was available that was large enough to do the sampling as planned.
15. All the necessary ingredients to have sufficient broth were available

Processes and Procedures

Three processes were done and each process might had repeated occasionally or on a daily basis.

Start-up

1. Containers were acquired and were robust enough to last 3-4 months
   Two types of containers, namely for the raw water and the filtered water.
2. All containers were labelled with labels or writing that are clearly marked in English and Dari and Pashto.
3. The marking was done with undeletable ink and when getting faint must be relabelled. Initial marking should was done with paint, as that will last longer than writing with felt pen.
4. The water filters were marked in similar manner so that no confusion was possible, each filter was clearly marked if having a diffuser plate or box.
5. The field officer or the appointed representative and the Research Responsible person approved the markings.

Actual collecting water and pouring

1. The research was started in November 2012 and completed in first week of January 2013
2. The amount of water was the same every day and time (09:00 & 15:00).
3. Collected 20 litre from each of the water sources as identified
4. On the arrival stirred the water with a plastic or metal spoon like to mix what was originally collected from the source in the case of sedimentation or we allow sedimentation but then we should do so in an organised manner.
5. Poured the water in one go into the basin, amount with version 10 filter should 12 litre at a time.
6. It was made sure that the bio-sand filter was not over filled
7. Ensured that the jerry-can that stands below the water outlet of the filter is emptied (inspected the water if there was any turbidity)
8. Check after the water has gone through the filter if the sand layer did get disturbed and in what way, photos was made if sand layer was disturbed.

Measurement

Various measurements were needed and it were important to follow the standard procedures for turbidity and the bacteriological measurements.

Turbidity

Turbidity might been an indication of heavy silt load, but if a heavy load is noted then samples should be taken as noted under point 5. Light loads are not a problem for the bio-sand filters but heavy loads will clog the filter quickly. A short time (one hour) of letting the heavy particles sink will be in order, otherwise the filter needs to be cleaned and that will disturb the sand layer and will affect the bacteriological experiment and the diffuser plate experiment at the same time.

1. Turbidity of the raw water and filtered water was measured on a weekly basis for the

whole research life time.

2. After the container is 1/4 full the speed of the filtered water coming from the filter was measured with the stopwatch and the half a litre jug.
3. The findings were filled on the form for measuring the out-coming water from the filters

Bacteriological

1. Water samples were taken during the first month from the raw water and filtered, and thereafter on a weekly basis.
2. The manner of taking the sampling followed the laid down procedures as used by the WET Centre lab.

Findings

First Week

It was good that all the filters installed with diffuser boxes and plates had good removal efficiency of bacteria within the first week of operation with little differences among them in bacterial removal. The first week average bacterial removal for filters installed with diffuser plate and the source water was from river (RDP) was 94.1%, average bacteria in source water was more than 250 cfu/L and in filtered water it was 14.7 cfu/L, while for filter installed with diffuser box and source water was river (RDB) the average bacterial removals efficiency was 94%, average bacteria in source water was more than 250 cfu/L and in filtered water it was 14.9 cfu/L. The difference in removal efficiency between both filters was 0.1%, more removal for RDP.

The first week average bacterial removal efficiency for filters installed with diffuser plate and cloth and the source water was from river (RDPC) was 92.9%, average bacteria in source water was more than 250 cfu/L and in filtered water was 17.7 cfu/L, while for filters installed with diffuser box and cloth and source water was from river (RDBC) the average removals efficiency was 92.7% average bacteria in source water was more than 250cfu/L and in filtered water was 18.1 cfu/L. The difference in removal efficiency between the two filters was 0.2%, more removal for RDPC.

Again the first week average bacterial removal for filters installed with diffuser plate and the source water was from dug well (DDP) was 76.8%, average bacteria in source water was 21.6 cfu/L and in filtered water was 5 cfu/L, while for filters installed with diffuser box and source water was dug well (DDB) the average bacterial removals efficiency was 77.5% average bacteria in source water was 21.6 cfu/L and in filtered water was 4.9 cfu/L. The difference in removal efficiency between both filters was 0.7%, more removal for DDB.

Furthermore, the average bacterial removal for filters installed with diffuser plate and cloth and the source water was from dug well (DDPC) was 74.8%, average bacteria in source water was 21.6 cfu/L and in filtered water was 5.4 cfu/L, while for filter installed with diffuser box and cloth and source water was form dug well (DDBC) the average removals efficiency was 76.2% average bacteria in source water was 21.6 cfu/L and in filtered water was 5.1 cfu/L. The difference in removal efficiency between both filters was 1.4%, more removal for DDBC.

Turbidity removal efficiency was also good with 0.5 to 2.5%, difference among filters poured with river water and dug well water, it means that the removal efficiency of filters poured with river water was better than filters poured with dug well water, for details refer to following table-1.
Abbreviations in Table-1 and subsequent tables: BRE (Bacterial Removal Efficiency), ABS (Average Bacteria in Source Water), ABF (Average Bacteria in Filtered Water), TRE (Turbidity Removal Efficiency), ATS (Average Turbidity in Source water) and ATF (Average Turbidity in Filtered Water).

Table-1: Finding for first week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	94.1	250	14.7	82.6	28.9	5
02	RDB	94	250	17.9	76.9	28.9	6.7
03	RDPC	92.9	250	17.7	79	28.9	6
04	RDBC	92.7	250	18.1	76.8	28.9	6.7
05	DDP	76.8	21.6	5	76.2	5.4	1.3
06	DDB	77.5	21.6	4.9	74.3	5.4	1.4
07	DDPC	74.8	21.6	5.4	75.4	5.4	1.2
08	DDBC	76.2	21.6	5.1	74.3	5.4	1.4

Second Week

The bacterial removal efficiency improved substantially for filters poured with dug water from 1.8% to 7.9% and 3.1% to 4.2% for filters poured with river water as well. On the other hand the turbidity removal efficiency of filters poured with river water was improved significantly from 16.4% to 20.4% in comparison to filters poured with dug well water from 9.9% to 11.5%.

Differences for bacterial removal between RDP and RDB was 0.2%, more removal for RDP. Difference between RDPC and RDBC was 0.2%, more removal again for RDPC. Difference between DDP and DDB was 2.5%, more removal for DDB and Difference between DDPC and DDBC was 0.3%, more removal for DDPC which suggest no much differences among filters installed with diffuser plates and boxes.

Turbidity removal efficiency for RDP was higher than DDB by 1.3%, but it was higher for RDBC than RDPC by 0.1%. Turbidity removal efficiency of DDB and DDBC was higher than DDP by DDPC by 3.9% and 1.2% respectively. For details information refer to table No 2.

Table-2: Finding for second week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	97.2	250	6.9	99	29.9	0.3
02	RDB	97	250	7.6	97.7	29.9	0.7
03	RDPC	97.1	250	7	97.2	29.9	0.8
04	RDBC	96.9	250	8	97.3	29.9	0.8
05	DDP	84.1	11.7	2	83.8	3.9	0.6
06	DDB	86.6	11.7	1.6	87.7	3.9	0.5
07	DDPC	85.4	11.7	1.7	84.2	3.9	0.6
08	DDBC	84.1	11.7	2	85.4	3.9	0.6

Third Week

The bacterial removal efficiency improved very little for filters poured with river water from 0% to 0.4% and for filters poured with deg well was decreased from 3.4% to 4.2% as the bacterial amount in source water increased. On the other hand the turbidity removal efficiency of filters poured with river water was also decreased very little from 0.4% to 0.6%, while it was increased for filters poured with dug well water from 0% to 0.6%.

Differences for bacterial removal between RDP and RDB was 0.6%, more removal for RDP. Difference between RDPC and RDBC was 0.1%, more removal for RDBC. Difference between DDP and DDB was 0.9%, more removal for DDP and Difference between DDPC and DDBC was 1%, more removal for DDBC which suggest no much differences among filters installed with diffuser plates and boxes as it was higher for RDP, DDP, RDBC and DDBC.

Turbidity removal efficiency of RDP and RDPC is higher than RDB and RDBC by 0.1% and 0.7% respectively. Again the turbidity removal efficiency of DDP and DDPC is higher than DDB and DDBC by 2.7% and 1.1% respectively. Refer for details information to table No 3.

Table-3: Finding for 3rd week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	97.6	250	6	98.6	37.3	0.5
02	RDB	97	250	7.4	98.5	37.3	0.6
03	RDPC	96.9	250	7.7	98.5	37.3	0.5
04	RDBC	97	250	7.4	97.8	37.3	0.8
05	DDP	81.6	15.6	2.9	85.9	3.6	0.5
06	DDB	80.7	15.6	3	83.2	3.6	0.6
07	DDPC	81.6	15.6	2.9	88.9	3.6	0.4
08	DDBC	82.6	15.6	2.7	87.8	3.6	0.4

Fourth Week

The bacterial removal efficiency improved very little for filters poured with river water from 0.5% to 0.7% and for filters poured with deg well was improved significantly from 3.9% to 12.9%. On the other hand the turbidity removal efficiency of filters poured with river water was decreased very little from 0.5% to 0.6%, while it was prominently decreased for filters poured with dug well water from 8.6% to 12.6% since the turbidity of source wasdecreased as well.

Differences for bacterial removal between RDP and RDB was 0.5%, more removal for RDB. Difference between RDPC and RDBC was 0.4%, more removal for RDBC. Difference between DDP and DDB was 1%, more removal for DDP and Difference between DDPC and DDBC was 1.9%, more removal for DDBC which suggest more bacterial removal among filters installed with diffuser boxes as it was higher for RDB, DDP, RDBC and DDBC.

Turbidity removal efficiency of RDP and RDBC is higher than RDB and RDPC by 0.3% and 0.3% respectively. Again the turbidity removal efficiency of DDP and DDBC is higher than DDB and DDPC by 3.5% and 4.3% respectively. Refer for details information to table No 4.

Table-4: Finding for fourth week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	97.8	250	5.4	98	38.9	0.7
02	RDB	98.3	250	4.3	97.7	38.9	0.8
03	RDPC	97.9	250	5.1	97.3	38.9	1
04	RDBC	98.3	250	4.3	97.6	38.9	0.9
05	DDP	84.6	14.9	2.3	74.1	2.7	0.7
06	DDB	83.6	14.9	2.4	70.6	2.7	0.8
07	DDPC	84.6	14.9	2.3	76	2.7	0.6
08	DDBC	86.5	14.9	2	80.3	2.7	0.5

Fifth Week

The bacterial removal efficiency improved very little for filters poured with river water from 0.9% to 1.7% but for filters poured with deg well was improved significantly from 1.9% to 8.4%. On the other hand the turbidity removal efficiency of filters poured with river water was increased very little from 0.4% to 1%, while it was prominently decreased for filters poured with dug well water from 19.2% to 26.9% as the cold weather affecting turbidity level in source consequently on filtered water as well in absence of rain and flooding.

Differences for bacterial removal between RDP and RDB was 0.2% more removal for RDP. Differences between RDPC and RDBC was 1.3%, more removal for RDBC. Differences between DDP and DDB was 3%, more removal for DDB and Differences between DDPC and DDBC was 6.4%, more removal for DDBC which suggest more bacterial removal among filters installed with diffuser boxes as it was higher for RDP, DDB, RDBC and DDBC.

Turbidity removal efficiency of RDP and RDBC is higher than RDB and RDPC by 0.1% and 0.1% respectively. Again the turbidity removal efficiency of DDB and DDBC is higher than DDP and DDPC by 1.5% and 3.6% respectively. Refer for details information to table No 5.

Table-5: Finding for fifth week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	99.8	250	0.3	98.4	42.7	0.7
02	RDB	99.6	250	1	98.3	42.7	0.7
03	RDPC	98.7	250	3.3	98.4	42.7	0.7
04	RDBC	100	250	0	98.3	42.7	0.7
05	DDP	92	21	1.7	56.2	1.6	.07
06	DDB	95	21	1	57.7	1.6	0.7
07	DDPC	92	21	1.7	57.5	1.6	0.7

08	DDBC	98.4	21	0.3	61.1	1.6	0.6

Sixth Week

The bacterial removal efficiency was 100% in the both types of filters, installed with diffuser plate and box, while average bacteria in river water was more than 250 cfu/L and in dug well water was 6 cfu/L and no bacteria was seen in filtered water for both type of the filters installed with diffuser plates and boxes.

Turbidly removal efficiency for dug well water was dropped prominently due to the drop of the turbidity of source water such as form 5.1% to 14 %. But for river water it remained the same with no difference in total. While the average turbidity of filtered water for all filters poured with dug well water was 0.5 NTU and in its source was almost 1NTU and for filters poured with river water was 0.5 NTU and in its source was 29.5 NTU with no obvious difference for filters installed with plates and boxes. Refer for details information to table No 6.

Table-6: Finding for sixth week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	100	250	0	98.4	29.5	0.47
02	RDB	100	250	0	98.3	29.5	0.48
03	RDPC	100	250	0	98.3	29.5	0.50
04	RDBC	100	250	0	98.4	29.5	0.51
05	DDP	100	6	0	52.6	1	0.46
06	DDB	100	6	0	45.9	1	0.53
07	DDPC	100	6	0	51.4	1	0.47
08	DDBC	100	6	0	42.2	1	0.56

Seventh Week

The bacterial removal efficiency was 100% for filters poured with dug well water and one of the filter (RDBC) poured with river water and for the rest of the three filters (RDP and RDB was 99.2% and RDPC was 99.6%) was decreased due to cleaning of the sand layer . While average bacteria in river water was more than 250 cfu/L and in dug well water was 4 cfu/L and no bacteria was seen in filtered water poured with dug well water and one of the filter (RDBC) poured with river and for the rest of the tree filters there were 2 cfu/L in RDB, 2cfu/L in RDP and 1 cfu/L in RDPC.

Turbidly removal efficiency for dug well water was improved prominently due to increase of turbidity of source water such as it was improved from 4.2% to 29.8%. But for river water it improved very less by 0.2% in total. While the average turbidity of filtered water for all filters poured with dug well water was 0.6 NTU and in its source was almost 2.4 NTU and for filters poured with river water was 0.8 NTU and in its source was 46.9 NTU with no obvious difference for filters installed with plates and boxes. It suggested that there is direct proportion between turbidity removal and turbidity level in source water. Refer for details information to table No 7.

Table-7: Finding for seventh week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	99.2	250	2	98.3	46.9	0.8
02	RDB	99.2	250	2	98.2	46.9	0.9
03	RDPC	99.6	250	1	98.3	46.9	0.8
04	RDBC	100	250	0	98.7	46.9	0.6
05	DDP	100	4	0	82.4	2.4	0.42
06	DDB	100	4	0	77.7	2.4	0.53
07	DDPC	100	4	0	76.6	2.4	0.55
08	DDBC	100	4	0	71.6	2.4	0.67

Eighth Week

The bacterial removal efficiency was 100% for both filters, installed with diffuser plate and box, while average bacteria in river water was more than 250 cfu/L and in dug well water was 8 cfu/L and no bacteria was seen in filtered water for both type of the filters installed with diffuser plates and boxes.

Turbidly removal efficiency for dug well water was improved prominently due to increase of turbidity of source water such as it improved from 4.4% to 6.2%. But for river water it dropped due to drop of turbidity in source water by 0.5% to 0.6% in total. While the average turbidity of filtered water for all filters poured with dug well water was 0.6 NTU and in its source was almost 3.6 NTU and for filters poured with river water was almost 1 NTU and in its source was 37.5 NTU with no obvious difference for filters installed with plates and boxes.

Table-8: Finding for eighth week and comparison among different type of filters

S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	100	250	0	98	37.5	0.75
02	RDB	100	250	0	97.6	37.5	0.91
03	RDPC	100	250	0	96.6	37.5	1.2
04	RDBC	100	250	0	96.9	37.5	1.2
05	DDP	100	8	0	82.8	3.6	0.62
06	DDB	100	8	0	85.3	3.6	0.53
07	DDPC	100	8	0	85.6	3.6	0.52
08	DDBC	100	8	0	86.8	3.6	0.48

Ninth Week

The bacterial removal efficiency was 100% for both filters, installed with diffuser plate and box, while average bacteria in river water was more than 250 cfu/L and in dug well water was 8 cfu/L and no bacteria was seen in filtered water for both type of the filters installed with diffuser plates and boxes.

Turbidly removal efficiency for dug well water was decreased to some extent due to decrease of turbidity of source water such as it decrease from 3.4% to 11.8%. But for river water it improved by 0% to 1.1% in total. While the average turbidity of filtered water for all filters poured with dug well water was 0.5 NTU and in its source was almost 2.4 NTU and for filters poured with river water was 0.7 NTU and in its source was 42.4 NTU with no obvious difference for filters installed with plates and boxes.

Table-9: Finding for ninth week and comparison among different type of filters

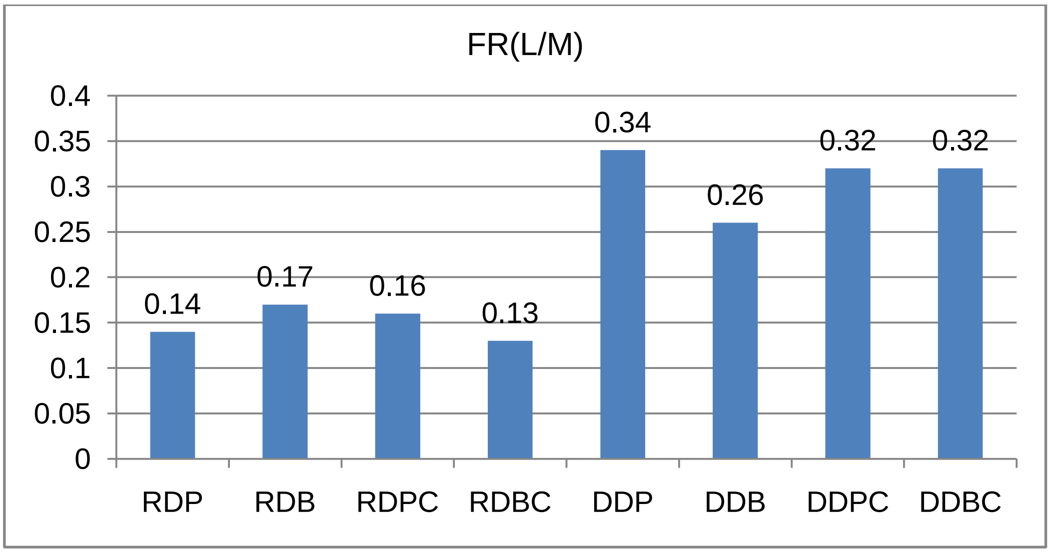
S.No	Type	BRE (%)	ABS	ABF	TRE(%)	ATS	ATF
01	RDP	100	250	0	98	42.4	0.8
02	RDB	100	250	0	97.9	42.4	0.9
03	RDPC	100	250	0	98.8	42.4	0.52
04	RDBC	100	250	0	98.9	42.4	0.55
05	DDP	100	8	0	83	2.4	0.41
06	DDB	100	8	0	81	2.4	0.46
07	DDPC	100	8	0	80.6	2.4	0.47
08	DDBC	100	8	0	81.1	2.4	0.42

Flow Rate Measurement

Flow rate was decreased obviously for filters poured with river water than the filter poured with dug well water during the eights weeks as the water from dug well was clear than river water. The flow rate of filters installed with diffuser boxes was not different than the filters installed with diffuser plates.

The differences of flow rate between RDP and RDB was 0.03 litter/minute more flow rate for RDB, again the difference between RDPC and RDBC was 0.03 litter/minute more flow rate for RDPC. While flow rate for DDP was more than DDB by 0.08 litter/minute and there was no difference between DDPC and DDBC and had the same flow rate. Refer to chart-1 for comparison of flow rate between filters poured with river and dug well water.

Chart-1: comparison of flow rate for filters poured with river and dug well water



Biolayer Disturbance

Biolayer disturbances were observed in both type of filters installed with diffuser plates and boxes. These disturbances were very obvious in filters installed with diffuser plate, they have been mostly in the corner and in the shape of depression and in centre they were diffused looked liked big spots but in filters installed diffuser boxes they were very small and diffused on the whole sand layer looked like pin points. Disturbances occurred in the first week of research and then remained the same to the end of the research. Refer to following pictures of sand layer disturbances in filters installed with diffuser plates in first few day of operation.

Discussion

Research was started on 3rd of November 2012 and end at 8th January 2013. During this period the weather got colder and lift effects on bacterial and turbidity amount in source water, which was very obvious for dug well water as the average amount of bacteria in the source water was 21.6 cfu/L in beginning of the research and reached to 8 cfu/L and turbidity was 5.4 NTU and reached to 2.4 NTU in the end of the research with some variations during this period due to rain and flooding such as in week seven the bacteria amount was 4 cfu/L and turbidity amount was 2.7 NTU respectively.

Bacterial and turbidity removal efficiency for filters poured with dug water and river water was different in the beginning of the study. The filters poured with river water had higher turbidity and bacterial removal from very beginning, but in the end of the study the turbidity and bacterial removal efficiency was equal for both types of the filters poured with dug well and river water. The good removal efficiency of filters would been due to the selection of good source (crashed) and size of sand, proper installation and proper operation and maintenance of filters.

Turbidity and bacterial removal efficiency for both types of filters installed with diffuser plate, boxes and cloth was variable, sometimes filters installed with diffuser boxes had good removal efficiency and another time the filters installed with diffuser plate had good removal efficiency. Therefore there was no constant preference for any type of the filters. In all the times cloth did not make any difference, only helped in removal of big organic particles. Again the turbidity removal efficiency was depended on the turbidity level of source water, if the source water had high turbidity the removal efficiency was increased obviously and the same for bacteria removal as well.

Disturbances in sand layer were observed in both type of filters installed with diffuser plates and boxes, but they were very obvious disturbances in filters installed with diffuser plate. All the disturbances occurred in the first week of the study and remained the same to the end of the study. It means that the biolayer development did not disturb by pouring water into the filters afterward the first few days of the study. Disturbances in the sand layer of the filters installed with diffuser plates were very big in the corner and big spot in the centre but in the sand layer of the filters installed with diffuser boxes were small diffused such as pin point spots.

Flow rate was decreased prominently in filters poured with river water as the turbidity of river water was very higher the river water varied from 28.9 NTU to 46.9 NTU due to weather variation. In rainy weather it was increasing as the rain was flushing the surface of the earth and flowing to the stream. The weather condition was affecting dug well water as well, since the dug well was not well protected to keep it from the contamination of the surface water.

Conclusion

Pouring water into biosand filters results more disturbances of the sand layer of the filters installed with diffuser plates than the diffuser boxes, but it deos not have effects on turbidity, and bacterial removal and maintaining of flow rate too close to the accepted ranges. It helped in removal of organic materials. The cloth added to filters helped in removal of big organic particles as well.

Recommendations

1. The diffuser box is still recommended for other reasons rather than bacterial and turbidity removal efficiency such as durability and ease of cleanliness. It is more durable in compression to plate and easy to be cleaned frequently with no much disturbances to sand layer.

2. Adding extra cloth to the top of the filters will have its benefit such as removal of big organic particles and big sand grain if it is used properly, means cover the entire top of the filters while pouring water into filter.

3. Standing water of sand layer has its own effect on sand layer disturbances, if we maintain the standing water level on sand layer from 4 to 6 cm the disturbance will be very rare for both, diffuser plate and box.

4. Hole sizes and numbers in a diffuser plate and box affecting on the sand layer disturbances as well. hereby small size (2-3 mm) of holes and more numbers of holes (100-121) will not disturb the sand layer to extent resulting to the damage of biolayer.