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Performance on Existing Pond Sand Filter (PSF) Located at Southern Region of Bangladesh: A Case Study

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ABSTRACT

As drinking water sources people in Paikgacha (an Upazila which is located at Khulna, Bangladesh) use shallow tube-well, deep tube-well, Pond Sand Filter (PSF) and rain water harvesting. PSF is popular option of potable water supply in coastal problem areas .Although modified PSF has not been implemented in this area. Mainly due to high contents of Arsenic and Iron in shallow tube-well and salinity in deep tube-well, people prefer PSFs which treats surface water. In studied area the water quality parameters from PSFs are not fully satisfactory. Although removal efficiency of PSFs of Color, Turbidity is somewhat satisfactory but TC, E.Coli, suspended solids are less; this is due to lack of proper management & operation of Pond Sand Filter and pond. Performance assessment of PSFs was done in terms of quality of filtrated water and pond water. In this study six PSFs and six ponds are taken into account. Field visit shows among the studied six ponds, three ponds are badly managed and other three ponds are managed nicely. Besides number of PSFs compared to population is less so it hardly meets the demand of the people. Due to lack of technical knowledge and awareness, these PSFs are not performing well. This study aims at present drinking water pattern and scopes, people's perception about PSF, performance analysis of existing PSFs and to address the associated problem in PSFs and pond management. Then finally provides recommendation to recover associated problem.

Keywords: *Pond Sand Filter, Potable Water, Water Quality Parameters, Turbidity, Color, Run-off, Pond Management.*

1. INTRODUCTION

In some area tube-well is not successful especially in the coastal belt of Bangladesh because of salinity intrusion in aquifer to a depth of 700-1000 ft. (DPHE-UNICEF, 1989). Besides shallow tube-well contains high quantity of Arsenic hence the people in this area seek for alternative to ground water. This is why PSFs are popular option of drinking water in this area.

Pond Sand Filter is a slow sand filter which treats surface water in which brick chips (Khoa) and sand chambers are arranged in series in the unit. In this system, pond water is discharged by hand pump in a small unit containing filter media and water is collected through taps. (Ahmed & Rahman, 2000, ITN-Bangladesh)

The major problems of the existing PSFs were observed to be slow production, poor performance in removing fecal coliform, shorter filter run etc. Also it was found that water quality parameters of treated water are not satisfactory. This is due to failure of actual performance of filter material and another vital cause is pond mismanagement.

Other difficulties in operation of PSF are theft of tabs and tube-well and also people waste water by washing hand, pitchers etc. Some PSF don't have good drainage facility thus creating stagnant water leading to mosquito breeding. Generally in Bangladesh for drinking, cooking, washing, bathing etc. same pond is used. Also ponds are replenished by rainwater during monsoon and are not protected from surface water contamination. However PSF cannot perfectly treat this unsafe pond water.

2. HISTORICAL OVERVIEW OF WATER TREATMENT

The treatment of water intended for human consumption is a very old practice. Baker reports references in Sanskrit literature dating back to 2000 B.C to such practices as the boiling and filtering of drinking water. These early water treatment devices were used in individual households. Some of the Romans aqueducts had settling basins at the head works and incorporated "pebble catchers" in the aqueduct channel. Water-treatment practice apparently lagged during the Middle age, with a renewed interest emerging in the eighteenth century.

Development of water treatment in America lagged behind the European practice the first attempt was made by Richmond, Virginia, in 1932. During the first two-third of the nineteenth century, filtration was practiced to improve the aesthetic quality of water. More progress has been made in water purification in the last century than in all of the previous records. (Ahmed & Rahman, 2000, ITN-Bangladesh)

3. BANGLADESH WATER QUALITY STANDARDS

3.1 Surface Water Standards

Water for public water supplies should be drawn from the best available source for cost-effective treatment of water. The degree and method of treatment to make water potable and attractive to the consumers depend on the characteristics of the raw water. UK Bangladesh Water Quality Standards, (ECR. 1997) with corresponding WHO Guideline values, 1996 are presented in Table 1. However, the list of parameters presented in Table 1 is not comprehensive; it provides a general guideline for selection of a source for water supply. The concentration of hazardous and toxic substances in raw water should not be different from those allowable in drinking water. Water having hazardous and toxic substances requires special costly treatment. The impurities that can be easily reduced to permissible level by conventional treatment processes can be allowed in higher concentration in water to be used as sources of water supply.

Table 1: Bangladesh Water Quality Standards for Surface Water for Water Supply

Water Quality parameters	Unit	Value for Water Supply by	
		Bangladesh Standards (ECR,1997)	Who Guideline Values (1996)
pH	……	6.5-8.5	6.5 – 8.5
Biochemical Oxygen Demand	mg/L	0.2 or less	- - - -
Dissolved Oxygen	mg/L	6 or less	6 Or less
Total Coliform	No./100ml	50 or less	5000 or less
Chloride	mg/L	150-600*	250
Color	Hazen Unit	15	15
Turbidity	NTU	10	5
Suspended Solids	mg/L	10	- - -
Total Dissolved	mg/L	1000	1000

(Source: Ahmed & Rahman, 2000, ITN-Bangladesh)

3.2 Surface Water-Treatment Process

Surface waters often contain a wider variety of contaminants than ground water, and treatment processes may be more complex. Most surface waters contain turbidity in excess of drinking-water standards. Although fast-moving streams may carry larger material in suspension, most of the solids will be colloidal in size and will require chemical coagulation for removal. Depending on the geology of the watershed; hardness may or may not be a problem in surface waters. If low levels of color and other organic material are present, adsorption onto surface-active material, a process not significant in natural water systems, may be necessary. A wide variety of microorganisms, some of which may be pathogenic, are also common constituents of surface waters. Treatment systems commonly used in treating surface waters are (Peavy et al, 1985):

Pre-sedimentation: May be necessary if water comes from fast-flowing streams. Remove larger suspended solids. Chemicals may be added to oxidize organics or to arrest their biological oxidation.

Mixing, flocculation, settling: Removes turbidity by coagulation colloids and settling them out, may also remove color caused by larger organic molecules.

Filtration: Polishes to remove remaining turbidity; disinfectant may be added to prevent biological growth on filter medium.

Adsorption: May be necessary if water contains dissolved organics; may consist of activated carbon columns.

Disinfection: Destroys pathogens; enough added to provide residual in the distribution system.

Storage: Provides contact time for disinfection and stores for peak demand.

3.3 Water Quality Indicator

pH: pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. It is a measure of the concentration of free hydrogen ions (H^+) in water and expressed as pH = -log (H^+). In water supply pH is biological treatment of water pH is very important as and corrosion control to seek an alternative colorless source of water for aesthetic reasons.

Color: Color in water is primarily due to the presence of colored organic substance, metals such as iron, manganese or highly colored industrial wastes. The supply of visibly colored water may lead consumers to seek an alternative colorless source of water for aesthetic reason.

Turbidity: Turbidity occurs in most surface waters due to the presence of suspended clay, silt, finely divided organic and inorganic matters, plankton (algae) and micro-organism. The suspended particles that cause turbidity range in size from colloidal dimensions to diameters in the order of 0.1 mm. Turbidity in excess of 5 NTU is generally objectionable stimulate the growth of bacteria and exert a significant chlorine demand.

Total Dissolved Solid (TDS): Total dissolved solids comprise inorganic salts and small amounts of organic matter. The common dissolved mineral salts are claimed to affect the taste, hardness, corrosion, and encrustation. Depending on the TDS water is often classified as follows (Ahmed & Rahman, 2000, ITN-Bangladesh).

Excellent	TDS$\leq$ 300 mg/l
Good	300-600 mg/l
Fair	600-900 mg/l
Poor	900-1200 mg/l
Unacceptable	1200 mg/l

Indicator Organisms

A number of micro-organisms have been evaluated as indicators, including total coliform, faecal coliform, E.Coli, faecal streptocococci, pseudomonas aerugionsa, enterococci and HPC Yeast’s have also recently been proposed as effective indicators. However Total Coliform and Faecal Coliform remain the indicators of choice for decades, mainly because no other indicator has been proven to be more comprehensive than these two (Alam, 1996)

Total Coliform (TC): The term coliform organisms (total coliform) refers to any rod-shaped, non-spore forming, gram-negative bacteria capable of growth in the presence of bile salts or other surface active agents with similar growth inhibiting properties, which are cytochrome-oxidase negative and able to ferment lactose either 35^{o} C or 37^{o} C with the production of acid, gas and aldehye within 24-48 hours. Total Coloiform includes E.Coli, Enterbacter, Klebsiella and Citrobacter.

Faecal Coliform: Faecal Coliform is a subgroup of Total Coloiform, which ferments lactose and other suitable substrates such as mannitol at 44.5^{o} C±0.2^{o} C with the production of acid and gas. These more stringent conditions eliminate mist of the non-faecal component while still permitting to faecal component to survive (WHO, 1984).

4. METHODOLOGY

4.1 Research Procedure

To conduct the study some chronological steps were taken. Firstly suitable location was selected for the study. Then preliminary investigation conducted in the selected area also a questionnaire survey was conducted; the steps are shown in Figure 1.

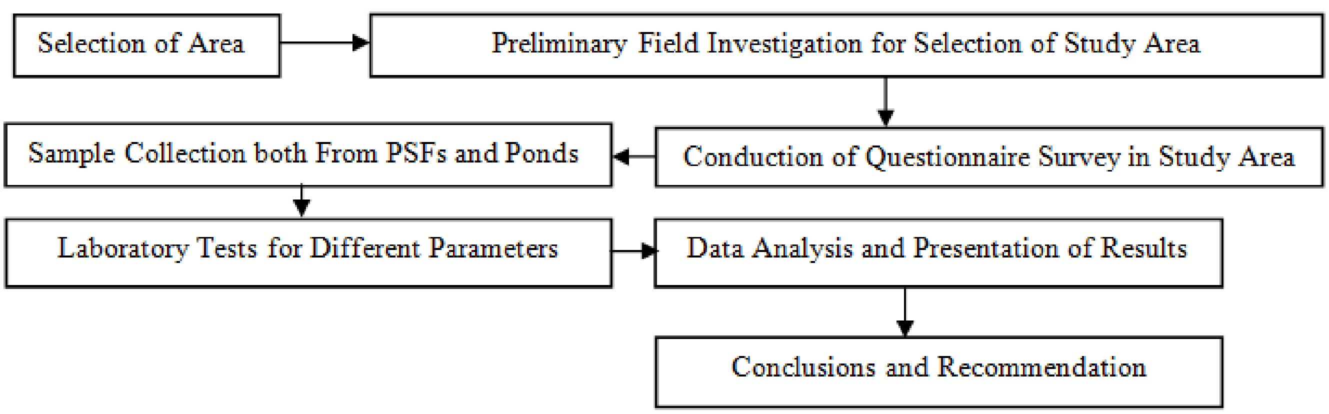

Figure 1: Outline of Research Strategy

4.2 Study Area of the Existing PSFs

Study area was selected at Haridali-Kapilmuni union in Paikgacha Upazila. Five locations having six PSFs and six ponds were brought under study. All the PSFs under study were constructed by DPHE. The geographical position of the study area has been shown in Table 2 also present conditions of existing PSFs and other alternative sources in paikgacha upazila are shown in Table 3

Table 2: Geographical Location of Studied PSF in Paikgacha Upazila

Location	Latitude	Longitude
Sreerampur	22^{0}40'56"N	89^{0}18'12"E
Howly	22^{0} 40'44"N	89^{0}19'06"E
Protapkati	22^{0}40'40"N	89^{0}18'59" E
Nowakati	22^{0}40'46"N	89^{0}17'38"E
Solua	22^{0}39'51"N	89^{0}17'43"E

Source: Field studies

Table 3: Present situation of drinking water alternatives in Paikgacha Upazila

Total Union	Total Population	PSF Condition			Rain Water Harvesting Unit	Commercially based selling unit @Tk. 1/lit
		Running	Chocked Up	Total		
10	3053597	199	65	264	380	Approximately 600 lit/day

Ground water contains excessive arsenic & salinity that exceeds the allowable limits. Peoples are depending mainly on PSF to meet their fresh water demand throughout the year. Recently rain water harvesting is alternative source for drinking purpose. Commercial based unit, such as SIDCO (iron and arsenic removal plant) selling door to door service @ 1.00 Tk/lit/day).

Source: Field studies

4.3 Existing Condition of PSFs

4.3.1 Physical Condition of Existing PSFs

Hand Pump: Among eight PSFs, six hand pump was operational and two was un-operational although among operational hand pump there were problem of check valve, piston etc. Due to lack awareness missing of parts often occurs.

Filter Chamber: Roofs covers were not found in two PSFs out of 8 PSFs. One filter chambers were found with deposited clay layer on the top of the filter bed.

Here two existing PSFs are shown in Figure 2 and Figure 3

Figure 2: PSF at Nowakati

Figure 3: PSF at Solua

4.3.2 Physical Condition of Ponds

Out of six ponds three ponds are owned by individuals and rest threes are joint owner ship. Among the studied six ponds, three ponds are badly managed. Often garbage, wastes are disposed in the pond also direct run-off enters into the pond i.e. banks are not protected. However other three ponds are managed nicely; banks are protected so that run-off cannot enter into the pond. Also bathing is prohibited in these ponds. Pictures in Figure 4 & Figure 5 reveal the physical condition of pond.

Figure 4: Pond at Sreerampur

Figure 5: Pond at Howly

4.4 Analysis of Questionnaire Survey Data

The questionnaire survey conducted in the study area on 300 families. Based on these data following results were found:

Drinking water pattern and consumption of water: People in this area are not conscious about Arsenicosis; they are using their shallow tube-well neglecting red mark that stands for arsenic contamination**.** Mainly people close to PSF collect water from PSF for drinking. Deep tube-well in this area extracts saline water. Others alternatives such as rainwater harvesting, purchase of commercial water are also used in the area. In Figure 6 & Figure 7 percentage users of different water sources and water consumption are shown:

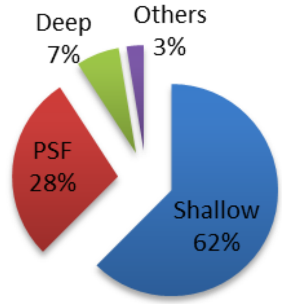

Figure 6: Percentage of users

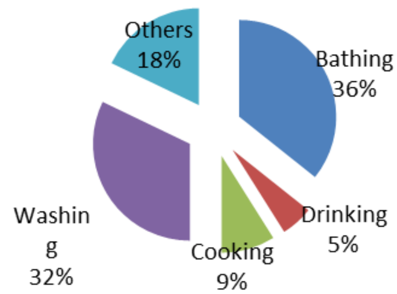

Figure 7: Percentage of water consumption

Water collection time and collector: From PSFs water is collected mainly by women and children. Sometimes men collect water from PSFs and the water collection time is morning and evening. These phenomena are shown in Figure 8 & Figure 9.

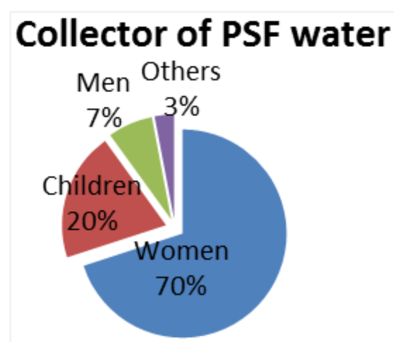

Figure 8: Type of collector of PSF water

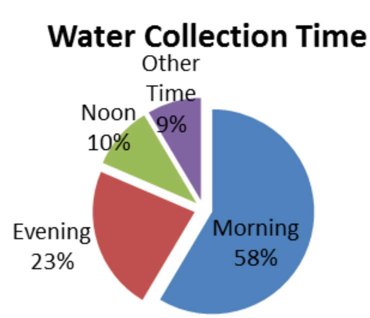

Figure 9: Time of collection of water

Distances travelled by the water collectors: Maximum collectors are close to PSFs location within one half kilometer and collectors decreases with increase in distance this phenomenon is shown in Figure 10

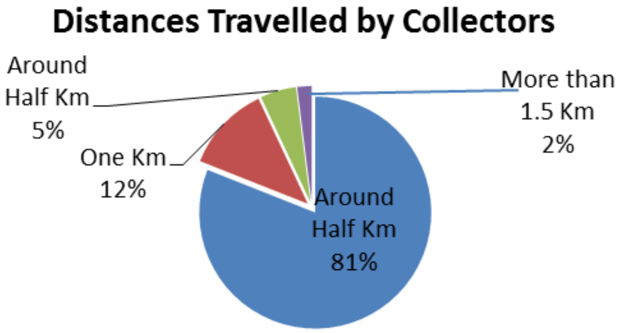

Figure 10: Distances travelled by collector to collect water from PSF

5. LABORATORY TEST RESULTS AND DISCUSSION

Samples from ponds and PSFs were collected in successive three month and brought to laboratory to determine water quality parameters. From the test result removal efficiency of different parameters was estimated and tabulated. All the tests were performed in accordance with standard method.

5.1 Assessment of Water Quality Parameters

For laboratory investigation, it has been intended to determine the relevant parameters of collected water from PSF and source pond located at selected places. And results as removal efficiency are presented in Table 4, Table 5 and Table 6.

Table 4: Removal Efficiency of PSF Located at Sreerapur & Protapkati

Places	Sreerampur			Proptapkati		
Name of the Parameters	Removal Efficiency (%)			Removal Efficiency (%)		
	November,2011	December,2011	January,2012	November,2011	December,2011	January,2012
Total Coliform	73	72	77	72	70	9
E.Coli	52	62	60	72	68	78
Suspended Solid	21	28	41	44	50	16
Total Solid	25	39	17	27	38	26
Total Dissolved Solid	28	60	48	19	18	36
Chloride(Cl-)	5	4	4	73	28	27
Color	68	61	62	56	77	74
Turbidity	30	36	38	63	77	60
Dissolved Oxygen(DO)	23	21	20	19	20	19
BOD5	39	46	38	44	85	35

Table 5: Removal Efficiency of PSF Located at Noakati & Solua

Places	Noakati			Solua		
Name of the Parameters	Removal Efficiency (%)			Removal Efficiency (%)		
	November,2011	December,2011	January,2012	November,2011	December,2011	January,2012
Total Coliform	68	54	35	42	30	13
E.Coli	65	42	50	58	50	29
Suspended Solid	35	10	98	28	70	34
Total Solid	20	40	13	24	32	45
Total Dissolved Solid	2	65	39	19	26	46
Chloride(Cl-)	41	14	14	35	19	16
Color	78	86	87	70	98	77
Turbidity	95	85	79	68	91	91

Dissolved Oxygen(DO)	35	8	8	42	24	28
BOD5	10	76	64	64	82	74

Table 6: Removal Efficiency of PSFs Located at Howly

Name of the Parameters	Removal Efficiency (%)					
	November,2011		December,2011		January,2012	
	PSF-1	PSF-2	PSF-1	PSF-2	PSF-1	PSF-2
Total Coliform	52	71	49	60	55	67
E.Coli	37	40	52	26	36	44
Suspended Solid	64	60	54	41	88	73
Total Solid	61	54	62	44	45	37
Total Dissolved Solid	55	42	72	47	23	19
Chloride(Cl-)	30	14	25	18	53	47
Color	76	73	80	67	80	67
Turbidity	90	71	94	70	83	76
Dissolved Oxygen(DO)	15	30	18	25	34	25
BOD5	74	36	87	51	81	37

6. RECOMMONDATIONS TO OVERCOME ASSOCIATED PROBLEMS

- Pond should be well protected from external pollution loads for efficient filter operation.
- Fishing, bathing and washing should not be allowed in the pond.
- Small embankment should be provided to ensure sufficient protection from surface runoff entering into the pond
- Re-excavation may be required in case of deposited clay or organic loaded shallow depth of pond
- User group should be formed among the beneficiaries for regular monitoring and maintenance work in some areas
- Occasionally, it may be necessary to control algae growth by means of appropriate algaecide such as by adding copper sulfate ($CuSO_{4}.5H_2O$) of appropriate dosing.

7. CONCLUSION

Many people in the study area relies on the PSFs but they devoid of technical knowledge about PSFs. Removal efficiency of different parameters was highest 91% PSF located at south solua because it is newly constructed. From efficiency of other PSFs, it is concluded that with the passage of time efficiency decreases. Performance of the PSFs is somewhat dependent on the operation and maintenance and continuous monitoring. Also physical condition of PSF is liable to this.

Most of the shallow tube-wells in studied area are Arsenic affected and deep tube-wells extract water having high salinity. So people seek for alternatives source of drinking water hence PSFs are popular in this area. DPHE builds some PSFs in this locality to ensure safe drinking water but users are not aware or conscious about their proper operation and maintenance.

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