Assessing drinking water quality at high dependent point of sources and potential health risk of massive population: A view from Tala Upazila of Satkhira District in Bangladesh

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ABSTRACT: Drinking water is the important indicator to assess environmental health. Aim of the present research is to investigate water quality at highly dependent drinking water sources and population exposed to potential contamination. Tala *upazila* of Satkhira district in Bangladesh was selected as study area. Drinking water temperature, EC, Fe, As, total coliform, *E. coli*, fecal coliform were tested following standard procedure in 649 highly dependent drinking water sources including DTW, STW and PSF. Besides, corresponding 260 dependent households' coliform bacteria were tested and semi-structured questionnaire survey was conducted. According to WHO, 99%, 83% and 74% water sources exceeded the drinking water standard for EC, Fe and As, respectively. WQI suggested that majority (77%) of highly dependent drinking water sources were unsuitable for drinking and 40% population (0.12 million) in the study area were exposed to potential health. Most frequently people were suffered from fever, diarrhea and high blood pressure and usually they were spending \$ 3–13 per month for their health-related expenditure. Regular water testing facilities, keeping water sources at a safe distance from contamination, practicing hygiene behavior, etc. could be taken for improving situation.

1 INTRODUCTION

Safe drinking water is enormously essential requirement for humans as well as all living organisms (Das and Acharya, 2003) and potential indicator of environmental health. Groundwater is one of the most important sources of drinking water to many people around the world (Chatterjee *et al.*, 2010) and also used for various purposes (Khan *et al.*, 2003; Sargaonkar & Deshpande, 2003). Bangladesh is a densely populated country with 139 million population (BBS, 2014). About 20% of total area (about 29000 km²) is considered as coastal zone, especially characterized by influence of tidal waters, salinity intrusion and cyclones/storm surges, etc. (MoWR 2005). In coastal area, 53% aquifer area has been affected by saline water intrusion from Bay of Bengal (MoFDM, 2005). In Bangladesh, shallow aquifer in *Meghna* river basin and coastal plain are extremely As enriched and, in this area, more than 80% TW were As contaminated (Ahmed *et al.*, 2004). High Fe concentration, turbidity and to some extent bacterial contamination are also associated with the water sources/extraction devices in the south-western coastal areas. According to WHO, about 80% of human diseases are caused by contaminated water. Thus, dependent drinking water sources need to be free from high level elemental concentration and pathogenic microorganism (Javed *et al.*, 2014) and it is essential to obtain precise and appropriate information on water quality for essential life-saving and other beneficial uses (Donadkar *et al.*, 2016; Gadhave

et al., 2008; Ilangeswaran *et al.*, 2009; Shyamala *et al.*, 2008; Talawat & Chandel, 2008). Overall aim of the study was to examine water quality at high dependent water sources and estimating populations exposed to potential contamination. Study findings will provide sufficient information of drinking water quality of highly dependent point of sources which will help to reduce risk of potential acute and chronic diseases in massive population.

2 METHODS/EXPERIMENTAL

2.1 Subsection

Tala *upazila* of Satkhira district, in the coastal area of Bangladesh, has been selected as the study area because incidences of frequent natural calamities and scarcity of safe drinking water (Fig. 1). A total of 649 high dependent drinking water sources were identified including deep tube-well (DTW), shallow tube-well (STW) and pond sand filter (PSF). *In-situ* measurements were done for temperature and electrical conductivity (EC) by Hach Pocket Pro High Range Conductivity Tester; total iron (Fe) by Hach Iron Test Kit-Model IR-B Color Disc; arsenic (As) by Hach Dual Range Arsenic Test Kit-Test Strip EZ and coliform bacteria (total coliform, *E. coli* and fecal coliform) by membrane filtration technique based Hach Microbiology Test Kit. Weighted arithmetic water quality index (WQI) was used to calculate suitability of

Figure 1. Location of water sampling PoS and corresponding PoU in the study area.

Table 1. Basic statistics of water quality parameters.

WQ Para	Unit	Range	Mean $\pm$ SD	Ex. WHO Stand (%)
<i>High dependent drinking water PoS</i>				
Temp	$^{\circ}\text{C}$	25.8–36.6	30.53 ± 1.38	100
EC	$\mu\text{S cm}^{-1}$	165–8715	2494.14 ± 2192.95	100
Fe	mg L^{-1}	0–18	3.07 ± 2.90	83
As	$\mu\text{g L}^{-1}$	0–500	61.69 ± 67.66	74
TC	CFU/100 mL	0–208	16.81 ± 32.67	38
<i>E. coli</i>	CFU/100 mL	0–160	3.90 ± 15.79	24
FC	CFU/100 mL	0–212	25.25 ± 44.97	45
<i>Corresponding dependent HHs' PoU</i>				
TC	CFU/100 mL	0–220	27.47 ± 42.72	54
<i>E. coli</i>	CFU/100 mL	0–166	5.17 ± 15.03	35
FC	CFU/100 mL	0–228	32.05 ± 46.21	55

drinking water. As, Fe, EC and temperature were tested in 649 high dependent water sources and coliform bacteria were tested in only 377 water sources and 260 corresponding dependent households. At the corresponding households (HH) a semi-structured questionnaire survey was conducted.

3 RESULTS AND DISCUSSION

3.1 Water quality status at high dependent PoS

All the PoS exceeded WHO drinking water standard for temperature and EC (Table 1). Range of Fe levels was $0\text{--}18\text{ mg L}^{-1}$ with low variability and 83 water sources crossed drinking water standard. Minimum and maximum As concentrations were 0 and $500\text{ }\mu\text{g L}^{-1}$ (mean 61.69) and the variation of tested results was quite high ($\text{SD} \pm 67.66$). According to WHO standard, three-fourth (74%) of highly dependent water sources exceeded standard limit. The content of coliform bacteria and the proportion of bacterial contamination was found to be much higher in the corresponding dependent HH than dependent water sources.

EC is a good measure of dissolved solids in water. It is dependent on concentrations of ions and nutrient

Figure 2. Status of coliform bacteria in PoS and corresponding PoU.

status (Gupta *et al.*, 2009). To survive, groundwater is uplifted for drinking water and high level of salinity threatening environmental health (Ahmed, 2006; Minar *et al.*, 2013; National Water Policy, 1999). Excess amount is responsible for the objectionable taste of drinking water (Gupta *et al.*, 2009). High Fe concentration is understood to be non-toxic and health impacts are not widely documented (Merrill *et al.*, 2011). Besides, intake of As through drinking water and the food chain could be a potential health hazard for the local population (Rahman *et al.*, 2008). Because As is transported by blood to different organs in the body, mainly in the form of monomethylarsonic acid, bladder cancer risk is increased 2.7 times if As concentration exceeded $10\text{ }\mu\text{g L}^{-1}$ in drinking water (Akter *et al.*, 2016) and it has a variety of adverse health effects in the form of acute and chronic exposures such as dermal changes, respiratory, pulmonary, cardiovascular, renal, neurological and other carcinogenic effects (Mandal & Suzuki, 2002).

3.2 Contamination pathway from PoS to PoU

In all tested Point of Uses (PoU), range of TC was $0\text{--}220\text{ CFU/100 mL}$ (mean 27.47) and proportion of contaminated PoU (50%) was much higher than corresponding PoS (45%) (Fig. 2). Besides, minimum and maximum values of *E. coli* were 0 and 166 CFU/100 mL (mean 5.17). *E. coli* contaminated PoU (55%) was much higher than corresponding PoS (45%). In all tested PoU, FC range were $0\text{--}228\text{ CFU/100 mL}$ (mean 32.05). Similarly, large proportion of PoU (60%) were FC contaminated which was about double of the corresponding contaminated PoS (32%).

Coliform bacteria have many adverse effects on public health such as urinary tract infections, cystitis and kidney infections and these bacteria are also responsible for environmental degradation, for instance, *E. coli* is responsible for damaging vegetables (Javed *et al.*, 2014; CCME, 2009).

3.3 Water Quality Index (WQI) in PoS

Range of calculated value of WQI was from 0.8 to 7352 (mean 200). In all tested water sources, 89 (14%)-excellent, 90 (14%)-good, 41 (6%)-poor, 27 (4%)-very poor and 402 (62%)-unsuitable for drinking. More

Table 2. Population exposed to potential water borne diseases in the study area.

Dependency classification/ Exp population	No. of PoS poor-unsuitable	No of dependent HH	Population exposed (5 per HH)	Population exposed (million)
Fairly high	146	1941	9705	0.01
Moderately high	160	5013	25065	0.03
High dependent	122	8507	42535	0.04
Most high dep	42	7975	39875	0.04
Total	470	23436	117180	0.12

than half of DTW (52%) were good to excellent and almost all STW (98%) and PSF (94%) were unsuitable as drinking water sources.

3.4 Population exposed to potential diseases and approaching for solving

According to WQI, majority of usable PoS were unsuitable for drinking. HH dependency basis calculation suggested that about 0.12 million people (40% population of the study area) were directly consuming contaminated water (Table 2). As a consequence, massive number of population were at potential health risk of acute and chronic diseases. In the last 15 days of survey date, dependent HH members most frequently suffered from fever, diarrhea, dysentery, colds and high blood pressure. Dependent HH regularly spent significant amount of money (\$3–13 per month/HH) for health-related expenditure, even though more than half of them were poor. To get safe drinking water, majority of dependent HH (62%) expressed willingness to pay. Among them, 58% people wanted to pay \$ 1 per month and only 20% HH showed willingness to pay \$ 2.6 per month.

Once groundwater is contaminated, its quality cannot be restored, so it is highly necessary to have a concern to protect and manage groundwater quality (Singh *et al.*, 2012). It is imperative to investigate water quality in the dependent water sources. Regular monitoring is needed for securing public health and protecting the groundwater system from further deterioration (Rahman *et al.*, 2000; Ramakrishnaiah *et al.*, 2009). To improve the health risk situation and ensure safe drinking water to rural communities, immediate steps should be taken.

4 CONCLUSIONS

In the studied area, a majority of highly dependent drinking water sources have been contaminated by arsenic, iron, salinity and coliform bacteria. Therefore, inadequate safe drinking water options have been observed and an increasing number of people are demanding water from single water sources. Study findings revealed that one third of the population in the studied area are exposed to potential health risks because a majority of drinking water

sources are unsuitable for drinking. To improve the safe water crisis situation, certain steps might be effective such as keeping a safe separation of source of contamination from water sources, water quality testing facilities at regular intervals, awareness raising, practicing hygiene behavior, providing adequate health service facilities, water treatment plants and sufficient safe drinking water options for local communities, etc.

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