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A Study on the Water Quality at Different Aquifers of Khulna District: A GIS application

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ABSTRACT

Intrusion of salinity with gradual increasing rate in coastal areas of Bangladesh leads to critical condition of water supply systems and scarcity of potable water. Arsenic contamination in tubewell water is another threat. In those regions pond water is available and comparatively less saline but turbid, colored and contaminated by pathogenic micro-organisms. During cyclone or flood disaster, sea water enters into the ponds that are used for Pond Sand Filters (PSF) and damage the whole systems. Tubewells also get contaminated with high saline water. People cannot use the water without chlorination. The aim of this paper is to present drinking water quality of Dighalia, Koyra, and Paikgassha upazilla of Khulna Division in terms of Chloride (Cl^-), Iron (Fe) and Arsenic (As) content of groundwater. Finally the possible solution of drinking water problem in coastal area was suggested.

Keywords **-** Coastal area, scarcity, salinity, drinking water, GIS.

I. INTRODUCTION

According to 2001 population census, Bangladesh has a population of about 13 crore living on 147,570 square kilometer of land. The Ganges, the Brahmaputra and the Meghna that constitute one of the largest river systems in the world, drain through the Bangladesh into the Bay of Bengal. The country has a coastline of 710 km along the Bay of Bengal. The coast of Bangladesh is known as a zone of vulnerabilities as well as opportunities. It is prone to natural disasters like cyclone, storm surge and flood.

Due to a number of environmental factors, the coastal soils are slightly to moderately saline on the surface and highly saline in sub-surface layers and substrata. The process of accumulation of salts in the soil is called salinisation. There are a number of factors responsible for the salinisation of an area, particularly a coastal area, depending on its situation. The land relief and degree of flooding have mainly affected the formation of coastal saline soils of Bangladesh. The other factors are: i) the nature of the soil, ii) precipitation, iii) tidal action, iv) the effect of the river system and their discharges, v) depth of the groundwater table and salt deposits, and vi) the slope of the ground and the proximity to drainage channels.Bangladesh has about 2.8 million hectare of land affected by salinity and poor water quality. The total area includes deltaic floodplains and also offshore islands. This comes to about one fifth of the total areas of Bangladesh and lies around the northern apex of the Bay of Bengal. The saline soils are mainly found in Khulna, Barisal, Patuakhali, Noakhali and Chittagong districts of the coastal and offshore lands. This study focuses particularly on three upazila i.e. Dighalia, Koyra, and Paikgassha upazilla of Khulna Division in the context of salinity.

II. METHODOLOGY

1. Selection of Study Area

Khulna Division lies in the coastal belt of Bangladesh. In ground water of coastal area salinity is a major problem and in shallow aquifer arsenic is also a severe problem. There is acute scarcity of suitable drinking water in Khulna Division. Moreover during any natural calamity like flood, cyclone etc. the amount of Chloride ion increases tremendously. So, to present the current situation of drinking water quality in terms of Chloride, Iron and Arsenic, three upazilla of Khulna Division i.e. Dighalia, Koyra and Paikgacha was selected for the study.

2. Collection of Field Data

In order to assess ground water quality parameter, a wide range of homogeneously distributed data is required. In this respect, for collection of field data Dighalia, Koyra and Paikgacha upazilla were further subdivided into union level. Dighalia upazilla was subdivided into Dighalia, Senhati, Gazirhat and Barakpur union. Similarly, Koyra upazilla was subdivided into Koyra, Uttar Bedkashi, Dakshin Bedkashi, Maharajpur union and Paikgacha upazilla was subdivided into Raruli, Haridhali, Kopilmoni and Gadaipur union. Department of Public Health and Engineering (DPHE) install new tubewells every year considering local people request. After installation of tubewells ground water quality are tested by DPHE. In the current study, ground water quality field data of tubewells in terms salinity (Cl^-), hardness (Fe) and Arsenic (As) were collected from the secondary source DPHE, having a sample

size of 318 at union level during the year 2006-2008.

Table 1: Summary of Collected Data

Upazilla	Year 2006			
	Number of Tube-well	Cl^- (mg/l)	Fe (mg/l)	As (ppb)
Dighalia	43	298	0.62	<.01
Koyra	33	507	.62	<.01
Paickghacha	-	-	-	-
Upazilla	**Year 2007**			
	Number of Tube-well	Cl^- (mg/l)	Fe (mg/l)	As (ppb)
Dighalia	84	485	0.61	2.02
Koyra	33	590	1.54	2.24
Paickghacha	38	726	2.42	4.84
Upazilla	**Year 2008**			
	Number of Tube-well	Cl^- (mg/l)	Fe (mg/l)	As (ppb)
Dighalia	23	564	2.10	2.52
Koyra	34	517	0.97	4.88
Paickghacha	30	441	3.31	16

3. GIS Application

Salinity intrusion analysis was performed using ArcGIS 9.2 software. For displaying and subsequent processing and enhancement of the salinity map, ArcGIS 9.2 is a proven instrument. Dighalia, Koyra and Paikgachha upazilla was carved out from the whole Khulna Division using the union boundary map of Khulna Division through ArcGIS 9.2. For figuring out the year wise salinity maps at union level of the three upazilla using GIS, following procedure was maintained sequentially

- Khulna Division map was digitized using the union shape file of Bangladesh.
- Dighalia, Koyra and Paikgachha Upazila were located in the Khulna Division shape file.
- Tube well salinity data for the selected upazillas were inputted in the shape file as attributes.
- Salinity condition of the three upazillas being considered for this study was represented by color shades in a map on year basis.

Potable water supply condition in the selected areas was identified.

III. Analysis Of Collected Data

Drinking water quality of Dighalia, Koyra and Paikgassha upazilla of Khulna Division in terms of Chloride (Cl^-) Iron (Fe) and Arsenic (As) content were analyzed year wise. Average value of Chloride (Cl^-), Iron (Fe) and Arsenic (As) were plotted against year.

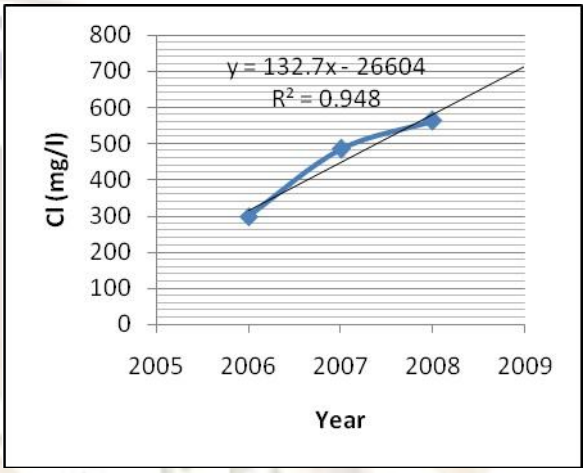

Figure 1: Chloride content (mg/l) with respect to time (year) at Dighalia Upazila

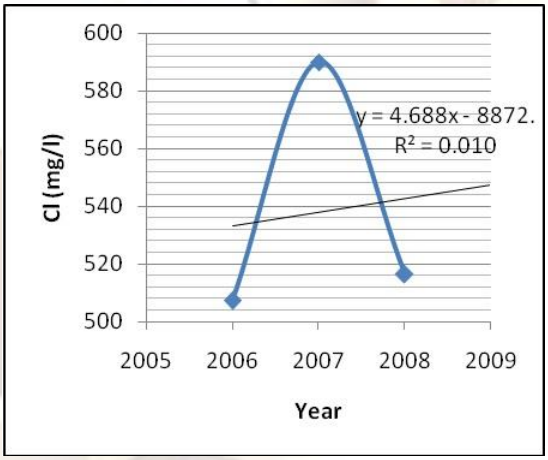

Figure 2: Iron content (mg/l) with respect to time (year) at Dighalia Upazila

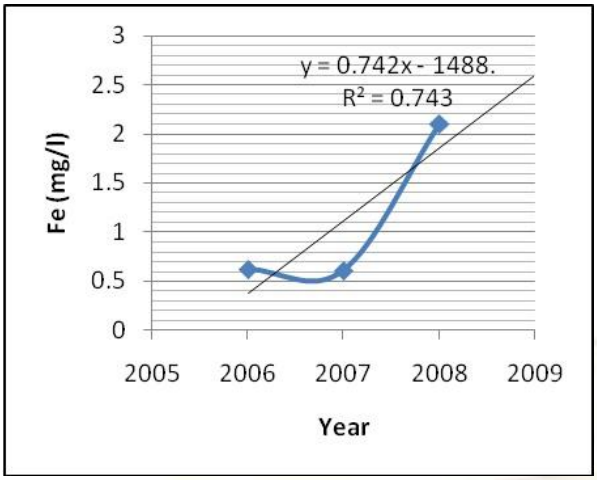

Figure 3: Arsenic content (ppb) with respect to time (year) at Dighalia Upazila

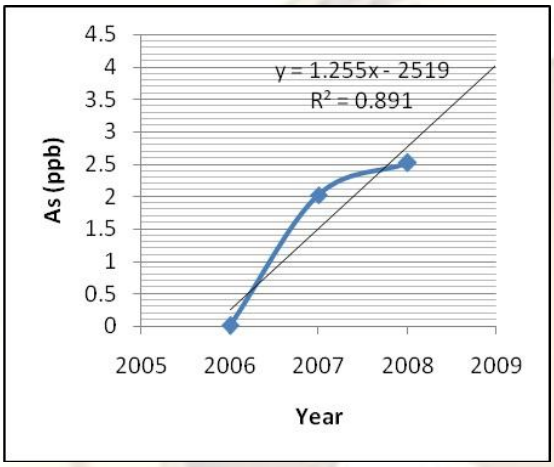

Figure 4: Chloride content (mg/l) with respect to time (year) at Koyra Upazila

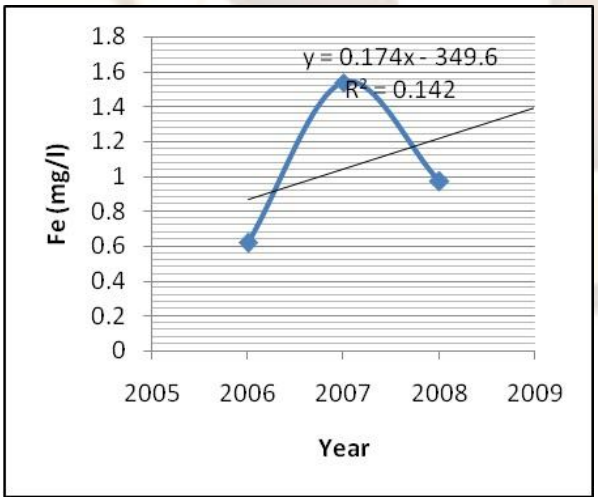

Figure 5: Iron content (mg/l) with respect to time (year) at Koyra Upazila

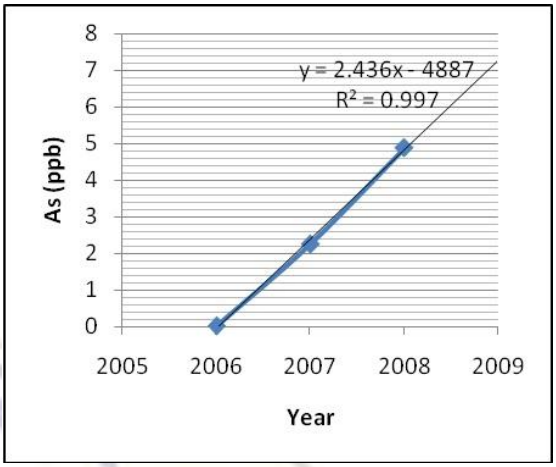

Figure 6: Arsenic content (ppb) with respect to time (year) at Koyra Upazila

In Dighalia upazilla, it was observed that, Chloride (Cl^-) content in ground water is increasing day bay day (figure-1). Though Iron (Fe) content dropped in the year 2007 (figure-2), even than it has an increasing pattern of growth rate. In the base year (2006) Arsenic (As) content was below 0.01ppb (acceptable limit of drinking water quality in Bangladesh), but after that Arsenic content crossed the limit of drinking water quality with a trend of increasing growth rate (figure-3).

In Koyra upazilla, Chloride (Cl^-) and Iron (Fe) content showed similar characteristics. Both Chloride and Iron content of ground water increased rapidly during the year 2007 (from the base year 2006) and then dropped in the year 2008 (figure- 4 & 5). It can be noted that, among the three upazilla being considered for this study, Koyra upazilla is mostly exposed to the Bay of Bengal. Abrupt rise of Chloride and Iron content during the year 2007 in this upazilla may have the indication related to after effect of cyclone Sidr. Though there was a dropping characteristic observed in the year 2008 for Chlorine and Iron, it can be said that these two water quality parameter is increasing day by day as the trend of growth rate is increasing. On the other hand, Arsenic (As) content was again below 0.01ppb in the base year which shows the same increasing growth trend in the following years (figure-6). Found

In Paikgassha upazilla, only two year data was available (year 2007 & 2008). It was observed that, from the year 2007 to 2008, Chloride (Cl^-) content decreased in this upazilla, whether Iron (Fe) content was increased. The most alarming situation observed in this upazilla was the tremendous increment of Arsenic (As) content in 2008. Average value of ground water Arsenic (As) was 4.41 ppb in 2007, which becomes 16 ppb in 2008.

IV. YEAR WISE SALINITY MAP

After performing salinity intrusion analysis using ArcGIS 9.2 software, salinity condition based on tube well data of Dighalia, Koyra and Paikgachha upazilla was represented by color shades in the upazilla map with respect to year.

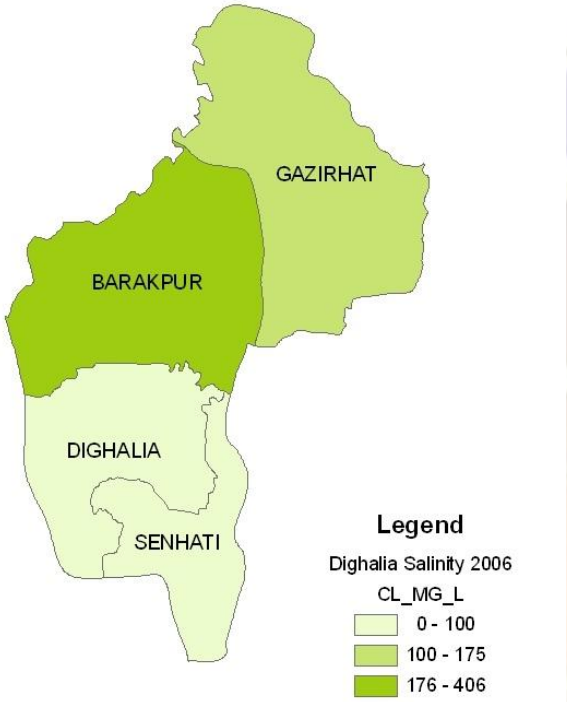

Figure 7: Variation of salinity at different unions of Dighalia upazilla (year 2006)

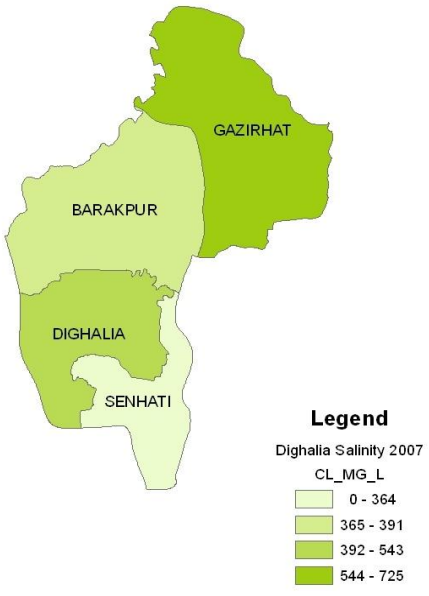

Figure 8: Variation of salinity at different unions of Dighalia upazilla (year 2007)

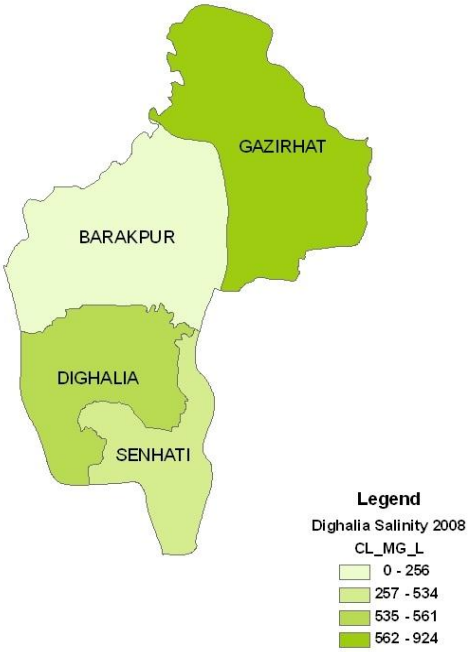

Figure 9: Variation of salinity at different unions of Dighalia upazilla (year 2008)

From the GIS map, it has been seen that the salinity is increasing from year to year. Therefore it can be said that saline intrusion is continuous in Dighalia upazila. Tube well depth for the collected data varies from 130-300m. But there is no correlation found between tube well depth and salinity of tube well water.

Variation of salinity based on deep tube well data at different unions of Koyra upazila (2006, 2007 and 2008) are shown in the following figures.

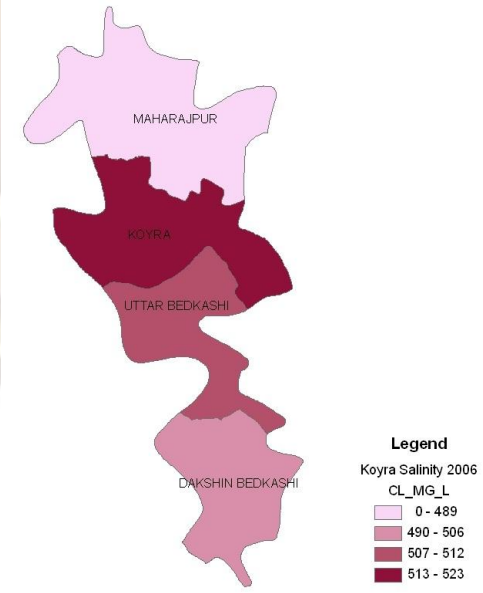

Figure 10: Variation of salinity at different unions of Koyra upazilla (year 2006)

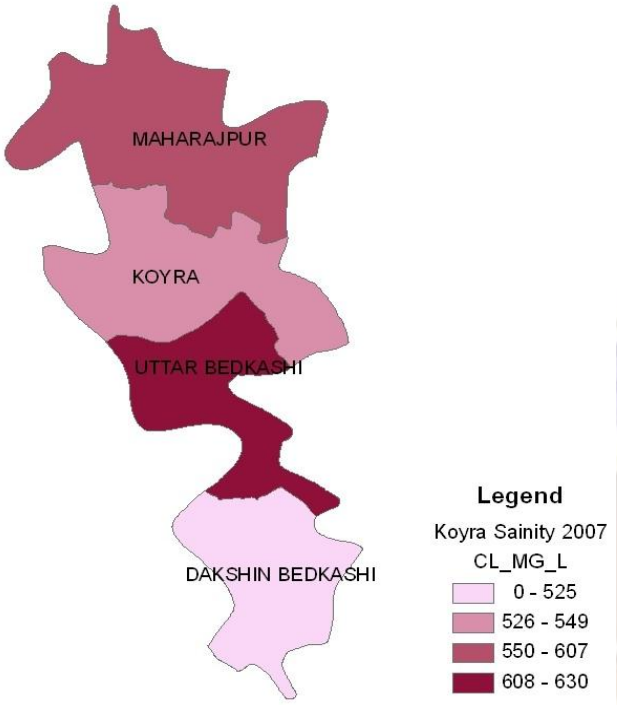

Figure 11: Variation of salinity at different unions of Koyra upazilla (year 2007)

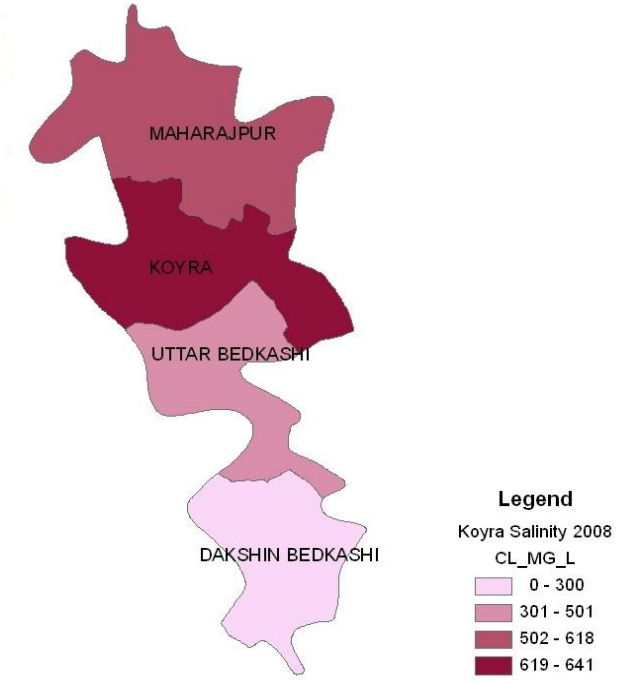

Figure 12: Variation of salinity at different unions of Koyra upazilla (year 2008)

In Koyra upazila, saline water also enters continuously from year to year like Dighalia upazila, and similarly, there is no correlation between tube well depth and salinity of tube well water.

In Paikgachha upazila, only Shallow Shrouded Tubewells (SST) was installed during study period. Variation of salinity based on SST at different unions of Paikgachha upazila (2007 and 2008) are are shown in the following figures.

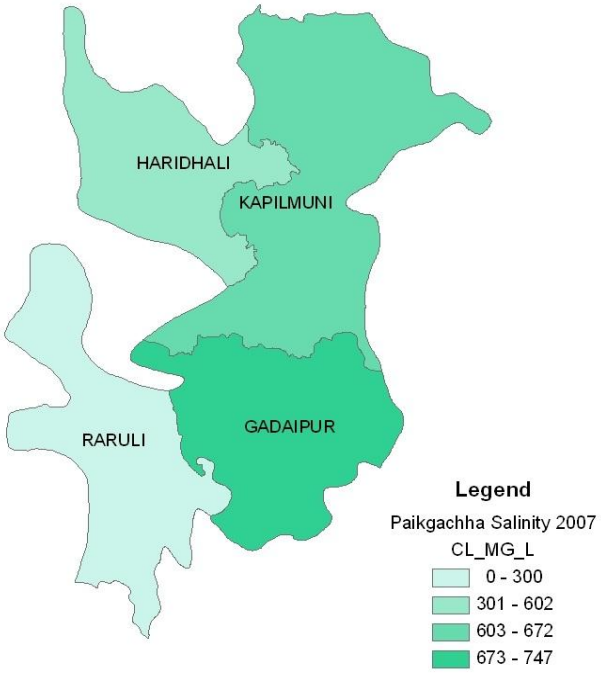

Figure 13: Variation of salinity at different unions of Paikgachha upazilla (year 2007)

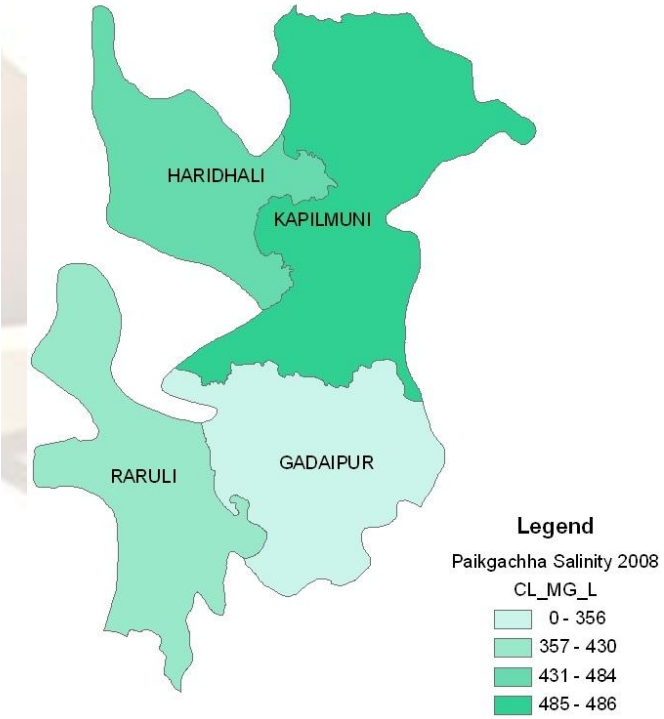

Figure 14: Variation of salinity at different unions of Paikgachha upazilla (year 2008)

The maximum depth of installed SST in Paikgachha upazilla was 18 m. Therefore, intrusion of salinity in deep aquifers was not assessed. Moreover, in this upazilla, deep tubewells installed previously before the study period up to 300m depth, were found unsuccessful. After analysis, it was observed that, salinity of SST varies from 350-750mg/l, which are in acceptable range for drinking water in the coastal belt (1000 mg/l as per Bangladesh Standard). As deep tubewells were unsuccessful in this upazilla, DPHE installed some Pond Sand Filter (PSF) and Rain Water Harvesting (RWH) on experimental basis. After installation and careful observation, it was found that these PSF and RWH may be potential source of drinking water in Paiksachha upazilla.

V. RECOMMENDATIONS

- In Dighalia and Koyra upazilla, average salinity is 600 mg/l which is within acceptable range according to Bangladesh Standard for coastal belt regions. At present deep tubewells are best solution for drinking purpose of these two upazilla, but as saline enters continuously, so for future, other alternative options like PSF and RWH can be actively considered and exercised.
- In Paikgachha upazilla, deep tubewells up to depth of 300 m were found unsuccessful option for collecting drinking water. Increasing the tubewell depth beyond 300m can be examined for getting potable drinking water. Again PSF and RWH were successful in some areas of Paikgachha upazila. So for future, these two options can be potential source of drinking water in Paikgachha upazilla.
- The boundary of the ponds that are used as PSF should be protected in such a way that saline water cannot wash the pond. Earthen dam can be made at the boundary of the ponds. So that it can give pure drinking water at the time of disaster.
- Rainwater harvesting is a potential water supply option in the acute arsenic and saline affected areas of Bangladesh. Rainwater collection in Bangladesh has been practiced for a long time on a limited scale. So it is recommended that rain water is the good solution for drinking purpose in these areas.

VI. CONCLUSION

The collected data shows that many deep Tube well of these coastal area contain high salinity. Due to high salinity this water is not suitable for drinking purpose .SST also contains high salinity which does not satisfy the good water quality Standard maximum time. The People of this area also use surface water by PSF. But during flood PSF gets thoroughly corrupted and becomes unsuitable for drinking. On the basis of the data analysis some recommendations are made which can be followed. Pond Sand Filter (PSF) and Rain Water Harvesting (RWH) can be treated potential source of drinking-water.

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