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ASSESSMENT OF GROUNDWATER QUALITY AND ASSOCIATED HAZARD IDENTIFICATION IN THE BETAGI PAURASHAVA, BARGUNA DISTRICT, BANGLADESH

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Abstract

BetagiPaurashava is situated in the coastal areas of Bangladesh and vulnerable to many disasters like cyclone, saline water intrusion, tidal flood, water quality hazards etc. Coastal areas of Bangladesh are suffering from the scarcity of safe drinking water that directly related to health issues. This study was carried out based on both primary and secondary data from different relevant sources and associated hazards had identified using field survey data analysis. The soil of the study area belongs to the group of coastal saline zone. The hydrostratigraphy and spatial distribution of bore logs at Betagi reveal that the groundwater aquifer system is in a critical condition with less yielding capacity of drinkable water. The aquifer material is composed of very fine to fine sand with medium sandy layer. The chemical parameters of groundwater (mainly Fe, As, Mn and Cl) were analyzed at the laboratory of the Department of Public Health Engineering (DPHE) and assessed from primary as well as secondary data sources. Analysis of all data and correlation with the field survey questionnaires, it is found that the water quality is worsening day by day in Betagi area. The amount of chloride (Cl) is in very vulnerable condition with an increasing rate. The overall groundwater quality varies from year to year. Arsenic (As) and Manganese (Mn) is about out of risk. However, Iron (Fe) and salinity is in high risk. As a result of increasing salinity, the community peoples are facing challenges like production losses, irrigation problems, soil erosions, infrastructure

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damages etc. For solving water related problems regular monitoring of groundwater withdrawal and consumptive uses, quality assessment and control as well as enhancement of research is recommended.

Keywords: Salinity intrusion, Groundwater quality, Quality assessment, Iron concentration.

Introduction

Water is absolutely essential and a vital element for livelihood. Human being uses water not only for drinking and culinary purposes but also for bathing, laundering and other domestic purposes. Surface and subsurface both water are using for consumptive uses. Due to gradual changes in water quality especially the coastal community suffers most with different water issues (Quazi, 2006; Kamruzzaman and Ahmed, 2006; WHO, 2008; Hoque, 2009; Islam et al., 2010; Abedin et al., 2013, 2014). The fresh water is contaminated with the different harmful elements and changes water composition. In Bangladesh, almost all rural water supplies and most of the urban water supplies are groundwater based. The fresh water sources are confining day by day The groundwater in Bangladesh, 59 districts are contaminated with the arsenic and in the coastal areas by the saline water (Shirazi andYussof, 2011).There is a consensus among the researchers worldwide that relatively little is known about how groundwater has or will respond to recent man-induced climate change (Holman, 2005). Groundwater salinity is occurred by seawater intrusion (Baten and Titumir, 2016). For water quality change many water borne diseases including diarrhea, cholera, typhoid, paratyphoid, hepatitis A, dermatitis, enteric fever, and many more are permanent health risks to the nearby residents especially children and elderly people (Pater and Uhlman, 1999).

More than 95% of the total population of Bangladesh now drinks from underground (Biswas et al., 2014). The coastal saline area lies about 1.5 to 11.8 meters above the mean sea level. During dry season salinity occurs in the coastal aquifers due to drop in hydraulic heads. During this critical season saline water reaches as far as north of Magura, approximately 240 km from the coast (RasulandChowdhury, 2010). High salt content is limiting crop intensification in the coastal zones of Bangladesh (Provin&Pitt, 1997). The millions of deep and shallow tube-wells that had been sunk in various parts of the country for drinking water supply are now dispensing poisonous arsenic (Shirazi and Yussof, 2011). To safeguard the long-term sustainability of the GW resources, the quality of the water needs to be continually monitored (Obiefuna and Sheriff, 2011). Heavy groundwater difficulties and insecurity were reported from southwestern coastal region for safe drinking water (Quazi, 2006; Abedin et al., 2013; Benneyworth et al., 2016).

With this view, an attempt has been made to assess the groundwater quality and to identify the associated risk of Betagi Paurashava under Barguna district of Bangladesh. The overall specific objectives of the present study are to identify lithological composition, variations of groundwater chemistry (Fe, As, Mn, Cl), salinity and associated hazards in the southern coastal area. This study provides a brief status of groundwater chemistry, water quality and associated risk in the coastal area at Betagi Paurashava, Barguna.

Study Area

Betagi Paurashava, the study area is situated in the south central part of Bangladesh and along the coast of the Bay of Bengal. The location of Betagi Paurashava is 22.4150162N 90.1645057E (Fig. 1) and located at a distance of 100 km distant from the coast of the Bay of Bengal and vulnerable to cyclone, salinity, tidal flood, water quality changes etc. Bishkhali River is situated to the northwest of the study area. In general, high salinity may be found in this area due to the interaction of sea, river and groundwater and/or anthropogenic effect (Mahmuduzzaman et al., 2014; Alam et al., 2017).

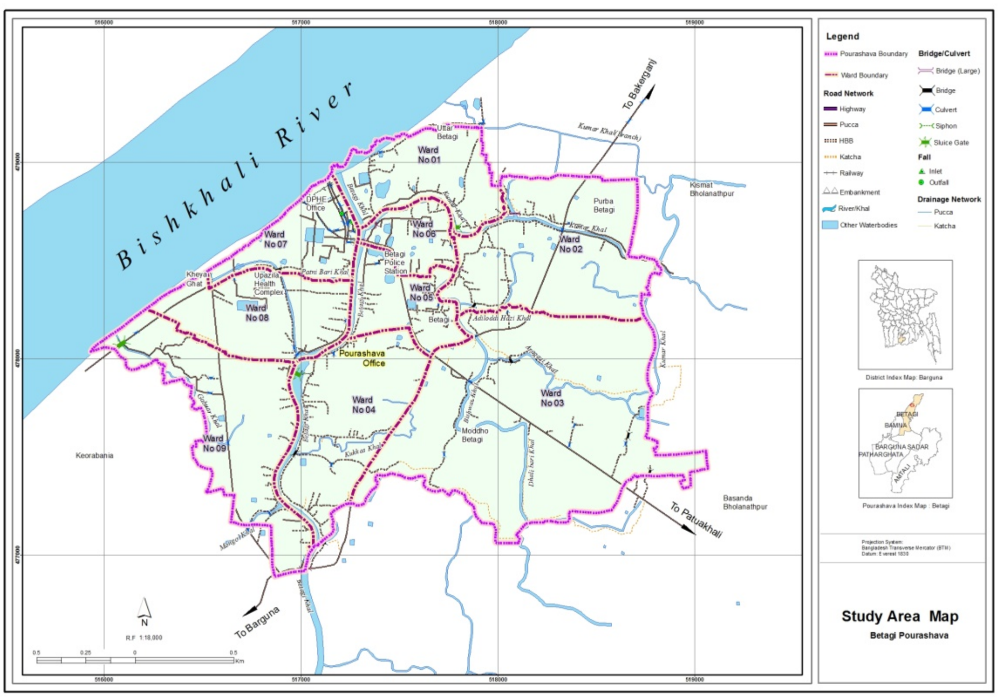

Fig. 1. Location of the study area (Source: IWM, 2013)

Materials and Methods

Primary Data Collection

A detailed field survey was carried out at southwestern coastal areas at Betagi Paurashava. During field survey, 18 tube wells location were visited several time and interview data collected from the owner of the tube well. Global Positioning System (GPS) machine was used to obtain the exact location of the individual tube wells. The field investigated area with the well locations shown in the Fig 2.

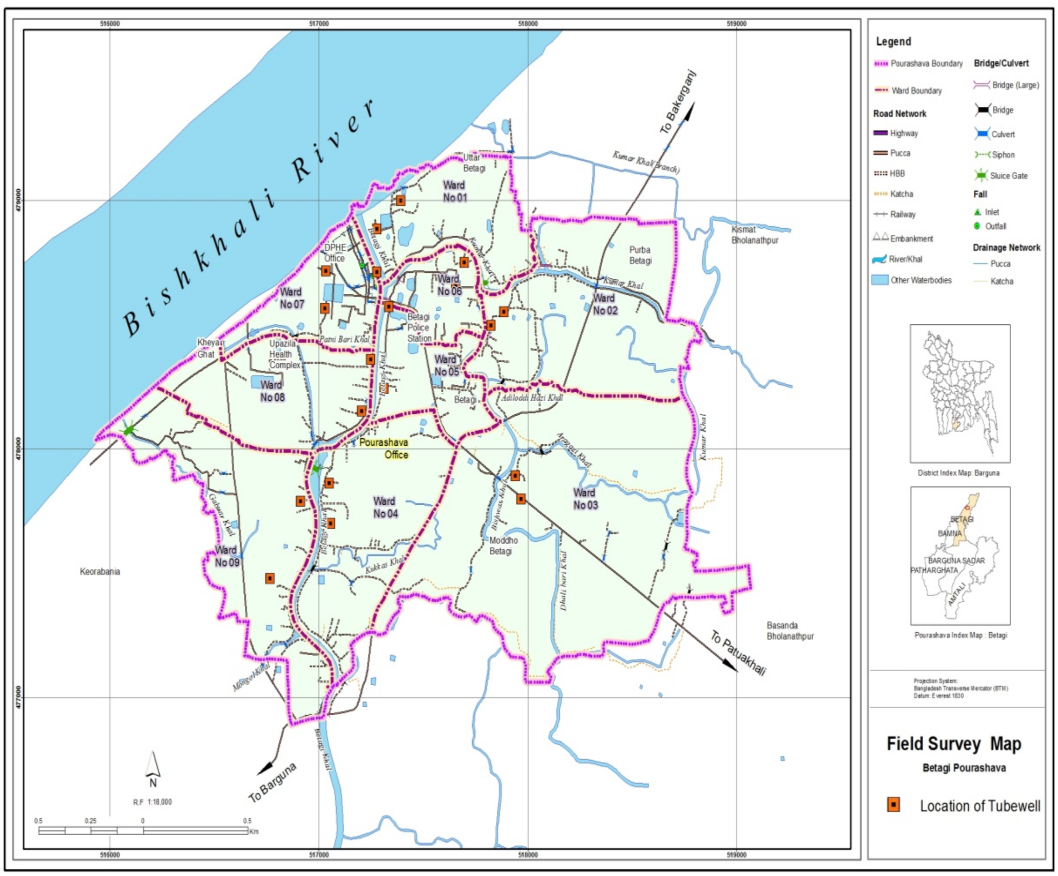

Fig. 2. Location of the Tubewells at Betagi.

Personal Interview

For personal interview, a total number of 36 (both men and women) were interviewed in the study area (Plate 1). A semi-structured questionnaires were used to collect data from well owners to know their drinking water sources, water related problems, health problems due surface water use, water logging and logging period in surrounding areas as well as water borne diseases and water management procedures etc. The interview were designed considering government, NGO and private tube well ownership.

Plate 1. Personal Interviews and Focus Group Discussion (FGD) at Betagi.

Focus Group Discussion

Using qualitative approach, one focus group discussion was conducted which helps to gather a wide range of information in a relatively short time. The participants were men and women of various professions to get the information about quality of surface and groundwater and related hazards, sources of drinking water, health risk and for requirements for water quality treatment plant etc.

Secondary Data Sources

Secondary water quality (1995-2013) and borelog data were collected from the Bangladesh Water Development Board (BWDB), Institute of Water Modelling (IWM), Department of Public Health Engineering (DPHE), and Japan International Cooperation Agency (JICA). Water quality information was extracted from evaluation and interpretation of those data. The borelog and water quality data were analyzed by using IWM customized software.

Result and Discussion

Soil Condition

The study area is mainly composed of non-calcareous gray and some calcareous brown floodplain soils (FAO-UNDP, 1988). This tract represents the flat low lying areas along the coastal belt and the estuarine islands. The soils are saline and the pH values are neutral to slightly alkaline with silty clay texture (Hussain, 1992).

Hydrological Setting

The Paurashava area is under the physiographic unit of Ganges tidal floodplain of Bangladesh (Khan, 1991). The boundary between this unit and the Ganges floodplain is traditional. The sediments are mainly non-calcareous clays, but they are silty and slightly calcareous on riverbanks. The Quaternary climatic fluctuations were the controlling factors in depositing recent and late Quaternary sedimentary sequences (Khan, 1991). The Quaternary sequence provides good aquifers, which have been extensively exploited in Bangladesh (BWDB, 2004). From the subsurface hydrostratigraphy, Betagi area is composed of fine to medium sand aquifer layer and which is separated by intermittent clay layers.

Hydrogeology of the Study Area

Hydrogeological investigation for the BetagiPaurashava has been carried out to define the hydrostratigraphic units and aquifer properties.Spatial distributions of selected 6 striplogs along with their locations are projected to show depth of the aquifer system in and around the Paurashava area (Fig. 3).

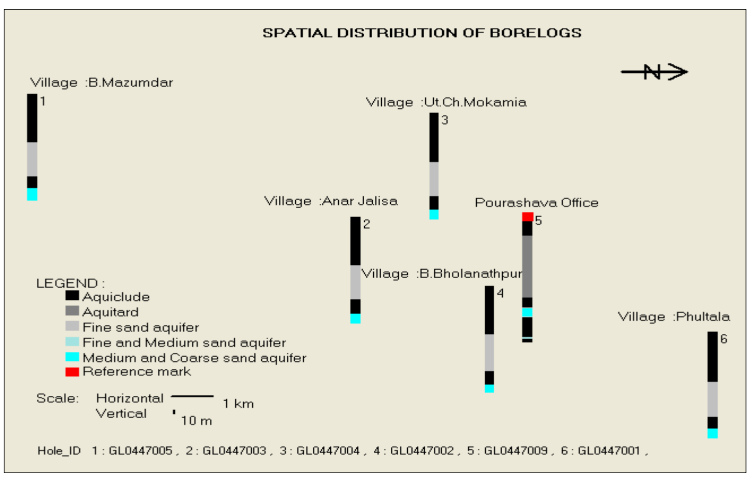

Fig. 3. Striplogs and distribution of borelog location in and around Betagi Paurashava (IWM, 2013)

Spatial distribution reveals that medium to coarse sandy aquifer exists in the Paurashava area comprising medium to coarse sand formation and laterally extended around the Paurashava area. Fine sand aquifer present besides the Paurashava area.

Lithology of Betagi Area

Hydrogeological field investigation including test borehole and lithology identification has been carried out by DPHE and IWM at depth 341.46 m (Fig. 4). From the (Fig. 4), it is evident that the area is composed of mainly fine and medium sand aquifer with a varying thickness illustrating poor storage of drinking water. Most of the lithology indicates very fine to fine sandy aquifer illustrating safe drinking water storage crisis in and around the study area (DPHE and IWM, 2013).

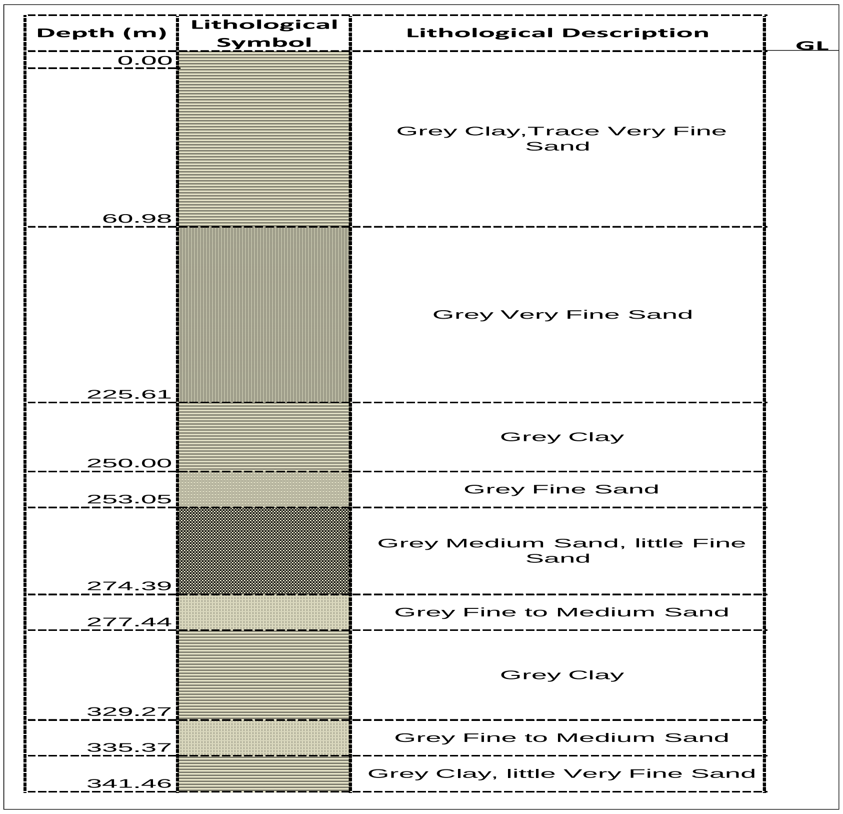

Fig. 4. Borelog and lithology of Betagi Paurashava (Source: DPHE and IWM, 2013)

Groundwater Quality

To study the groundwater quality of Betagi Paurashava, chemical parameters of water have been collected from IWM, DPHE, BWDB and JICA and other secondary sources. These data and questionnaires survey (local people perception and awareness on drinking scarcity, impacts of water quality etc) were used to find out the possible relation of chemical parameters, water quality and associated risk. The following Table 1 (DPHE and IWM, 2013) is considered as a model to analyze the quality of the water giving emphasis on Fe, As, Mn and Cl parameters which are more considerable for drinking purpose. The changing scenario of groundwater quality for the year of 1995, 1998, 2005, 2011 and 2013 are also studied and are presented in bar diagram in Fig. 5-8.

Table 1. Water Quality Parameters (Source: DPHE & IWM, 2013).

SL No.	Water quality parameter	Allowable limit (Bangladesh Standard, mg/L)	Water quality (mg/L)
1	Iron (Fe)	0.03-1.0	0.88
2	Arsenic (As)	0.05	0.01
3	Manganese (Mn)	0.10	0.09
4	Chloride (Cl)	150-600	584

3.5.2. Water Quality (WQ) Scenario in 1995.

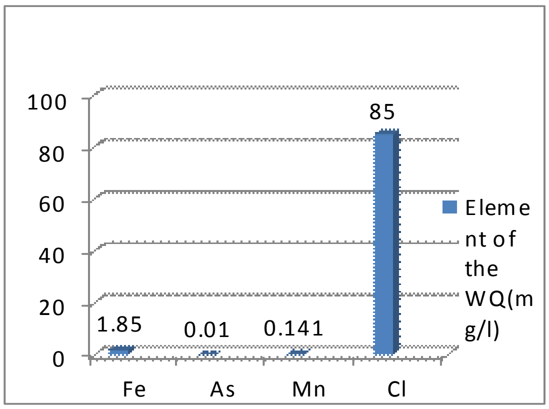

Fig. 5. Water quality scenario in 1995.

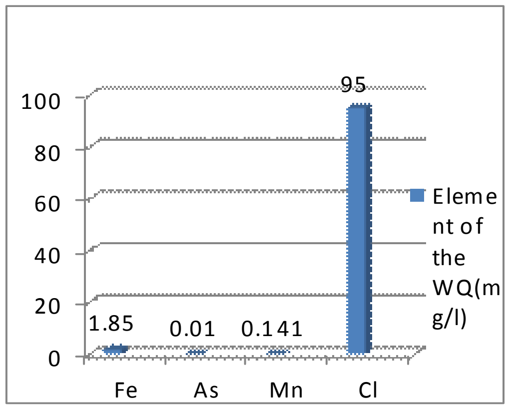

Fig. 6. Water quality scenario in 1998.

The graphical representation (Fig. 5) of the water quality parameters like Fe, As, Mn and Cl (in mg/L) is expressed as 1.85, 0.01, 0.141 and 85 respectively. According to Bangladesh Drinking Water Standard(BDWS), Iron and Manganse have higher concentration values and other elements(As and Cl) are within the allowable limit in 1995 at Betagi Paurashava.

Water Quality Scenario in 1998.

The water quality scenario for the year of 1998 (Fig. 6) shown concentration (mg/L) of Fe, As, Mn and Cl as 1.85, 0.01, 0.141 and 95 respectively. According to Bangladesh Drinking Water Standard (BDWS), Iron and Manganse have higher concentration and other elements(As and Cl) of water are in the allowable limit in 1998.

Water Quality Scenario in 2005

The graphical representation (Fig. 7) of water quality parameters shows the values(mg/L) of Fe is 0.6, As is 0.015, Mnis 0.06 and Clis 100. According to Bangladesh drinking water standard, the parameters of water (Fe,As, Mn Cl) are within the allowable limit in 2005 without any sorts of quality related hazards.

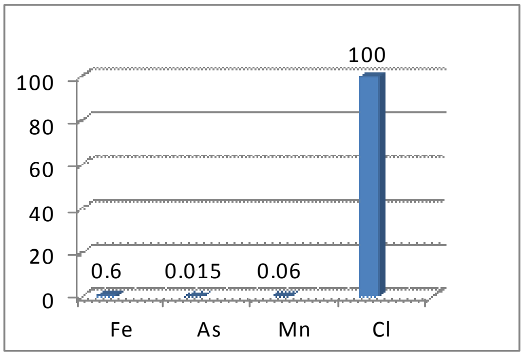

Fig 7. Water quality scenario in 2005.

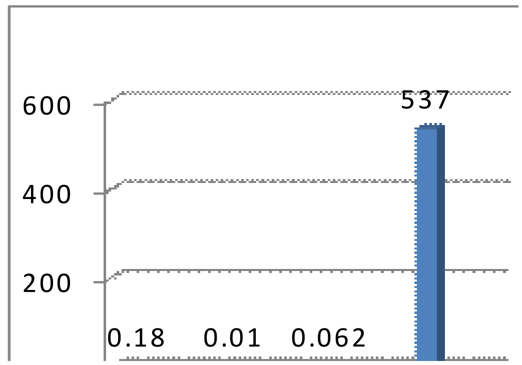

Fig 8. Water quality scenario in 2011.

Water Quality Scenario in 2011.

Fig. 8. shows four chemical parameters (Fe,As,Mn, Cl) in bar diagram where the concentration of chemical (mg/L) parameters are Fe(0.18), As(0.01), Mn(0.06) and Cl(537). According to BWDS all the three chemical parameters of water(Fe, As and Mn) are in allowable limit but the chloride (Cl) has very high value in groundwater in 2011.

Water Quality Scenario in 2013.

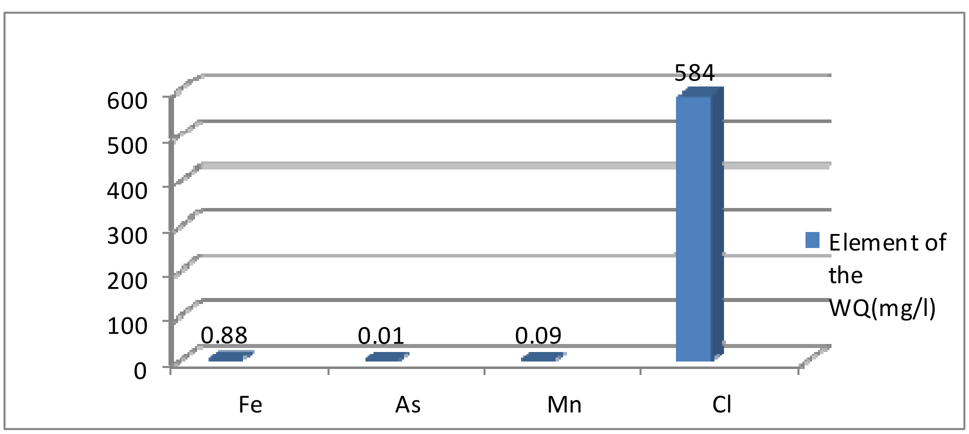

Fig 9. Water quality scenario in 2013

The concentration of the chemical parameters like Fe, As, Mn and Cl are shown in Fig. 9. The diagram shows that the concentration values(mg/L) of the chemical parameters are 0.88, 0.01, 0.09 and 584 respectively. Here chloride concentration is higher than 2011 indicates increasing trend of salinity at Betagi.

Iron (Fe) Concentration (mg/L) from1995 to 2013.

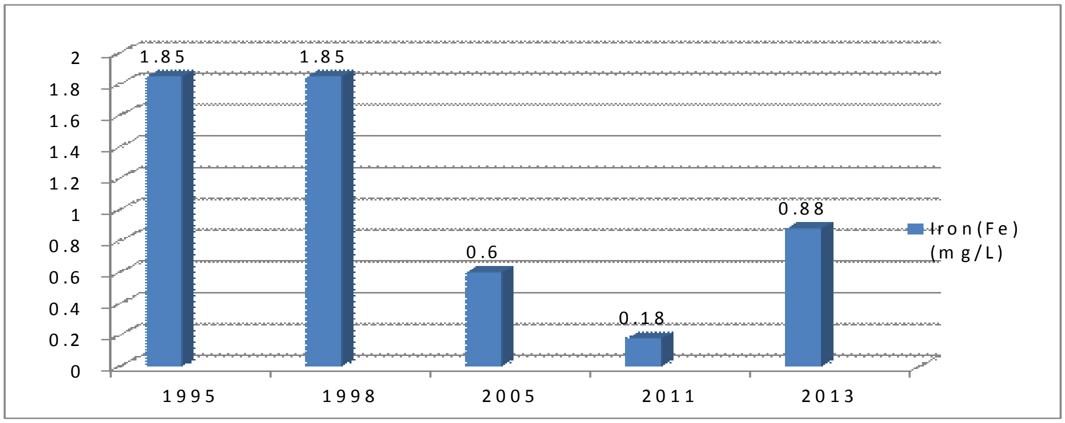

Fig 10. The concentration of iron(Fe) from 1995 to 2013

The graphical representation (Fig. 10) shows iron (Fe) concentration (mg/L) in water for 1995-2013. Here in 1995 and 1998 the values (mg/L) of the iron(Fe) in the groundwater is same and according to BWDS, the iron(Fe) concentration is higher than the allowable limit. On the other hand from 1998-2011 the concentration of iron(Fe) is in decreasing state but from 2011 to 2013 the value(mg/L) of the iron(Fe) concentration is in increasing state at Betagi.

Arsenic (As) Concentration(mg/L) from 1995 to 2013.

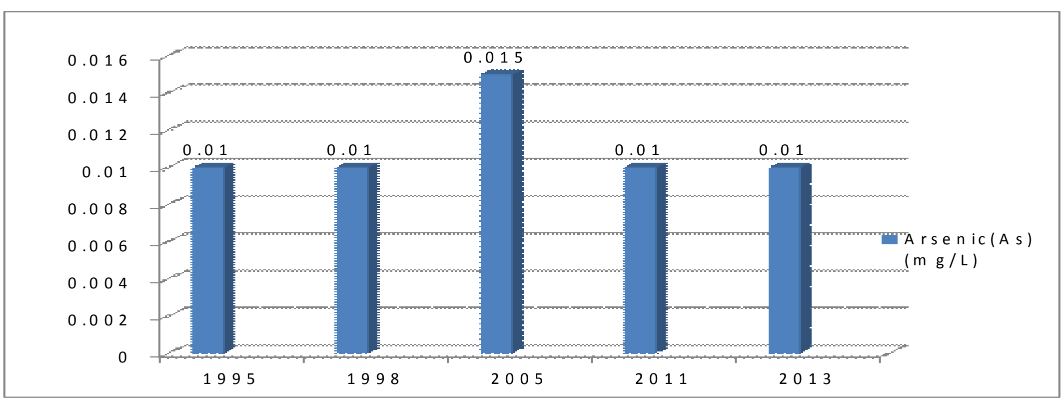

Fig. 11. Bar diagram represents As concentration from 1995 to 2013.

The As concentration (mg/L) in groundwater from 1995 to 2013 is shown in Fig. 11. It reveals that the concentration is within allowable limit of BWDS without any significant changes in trend.

Manganese (Mn) Concentration(mg/L) from 1995 to 2013.

No visible change inthe manganese(Mn) concentration(mg/L) of time series data from 1995 to 1998 is observed and is shown in Fig. 12. After 1998, the concentration(mg/L) of manganese(Mn) has decreased but from 2005 to 2013 the concentration(mg/L) has increased frequently at Betagi Paurashava.

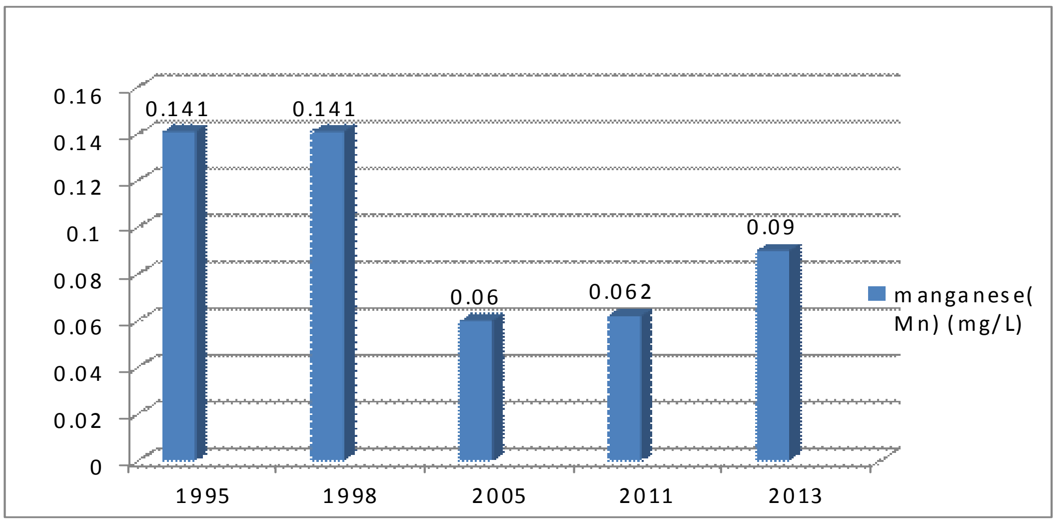

Fig 12. Bar diagram represents Manganese(Mn) concentration from 1995 to 2013.

Chloride (Cl) Concentration(mg/L) from 1995 to 2013.

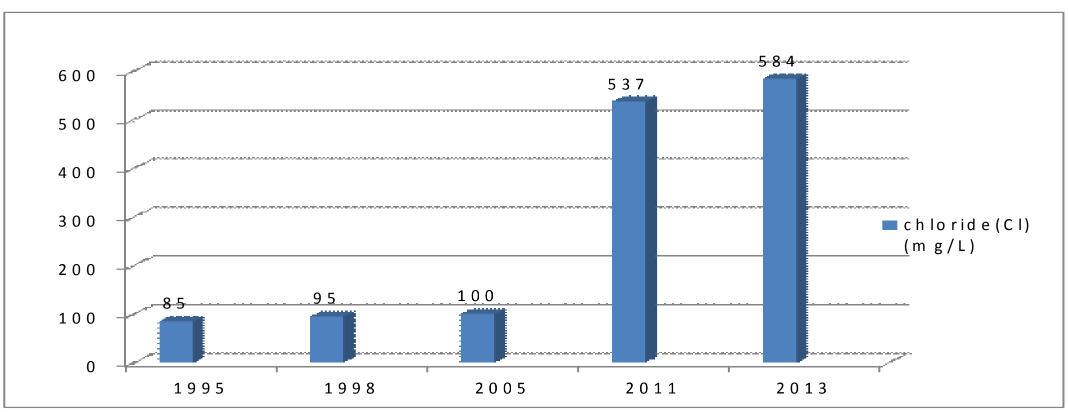

Fig 13. Bar diagram represents Cl concentration from 1995 to 2013.

The graphical representation (Fig. 13) of chloride(Cl**)** concentration(mg/L) in groundwater of time series data shows that from 1995 to 2013 the concentration(mg/L) of the chloride(Cl) is in severely increasing trend. From 1995 to 2005 the concentration (mg/L) of the chloride (Cl) has increased with normal rate but from 2005 to 2013 the concentration(mg/L) has increased in an alarming rate in the study area. The graph clearly indicates that the concentration of choride or the salinity is increasing day by day in an alarming rate.

Hazards Identification at Betagi Paurashava

To identify water-borne risk and hazards groundwater related questionnaires had been asked to the respondents of Betagi Paurashava. The percentage of those risks is given in Table 2.

Table 2. Water born hazards identification through questionnaire survey (36 Respondents).

List of problem	Yes (%)	No (%)	Remark
Arsenic	0	100	No Hazard
Iron	5.5	94.5	Little Hazard
Chloride	100	0	High Hazard
Manganese	0	100	No Hazard

From questionnaire survey it is evident that the area is free from arsenic and manganese hazards with slide Iron and is facing high risk of Chloride or salinity.

Salinity Problems

From field survey it is evident that the area is facing scarcity in safe drinking as well as irrigation which create hazards like agricultural activity, soil erosion, infrastructure etc. (Plate 2) due to increasing salinity day by day. Salinity affects production in crops, pastures and trees by interfering with nitrogen uptake, reducing growth and stopping plant reproduction. Due to saline water intrusion in groundwater the irrigation problems in the study area is happening recently. The crop production is reducing for same phenomena. As a result of increasing salinity into the groundwater, the salinity of the dry land is increased. Dry land salinity is closely linked to other soil degradation issues, including soil erosion. Damages to infrastructure including houses, roads, farm tracks and playing fields have been particularly high atthe study area in recent times.

Plate 2. Salinity impacts on water body (a), soil erosions (b) and on infrastructures (c, d) at Betagi Paurashava.

Conclusions and Recommendations

Conclusions

This paper presents the groundwater quality assessment carried out for the coastal area at Betagi Paurashava. Assessment of the concentration of iron, arsenic, manganese and chloride in groundwater for drinking, domestic and other purposes and the identification of associated hazards. Latest concentration(mg/L) of arsenic, iron and manganese are 0.01, 0.88 and 0.09 which are in allowable limit according to Bangladesh Drinking Standards for drinking purposes but the value of Chloride 584(mg/L) is vulnerable and concern issue for drinking, domestic and crop production purposes in the recent years at Betagi Paurashava and its surrounding areas. The assessment of Chloride (Cl) from 1995 to 2013 is the clear indication of increasing salinity in the study area in alarming rate. So, water quality parameters are changing day by day and water related hazards are mounting high throughout the country with a greater concentration of Fe, Mn, As and Cl.

Recommendations

Considering all the analytical results in the present study following recommendations are made to overcome the hazard issues:

i. As the groundwater aquifer of the area is limited, other sources of water like surface water and portable water usability should be enhanced.

ii. Groundwater quality monitoring for safe drinking water is strongly recommended.

iii. Through proper scientific way salinity tolerant crop varieties should be improved to keep up the food security.

iv. For safe drinking water, water treatment plant should be considered from governmental and NGO levels.

v. Artificial recharge should be made to reduce salinity in the aquifer

vi. Different training and awareness programs should be taken to aware the people or the community related to water.

vii. Research should be enhanced in the groundwater related risk issues during and after disasters at Betagi area as well as the whole coastal areas of Bangladesh.

Acknowledgement

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