Proceedings of the 5th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), 7~9 February 2020, KUET, Khulna, Bangladesh (ISBN-978-984-34-8764-3)

A CASE STUDY & LABORATORY INVESTIGATION ON THE PRESENCE OF SALINITY IN DRINKING & IRRIGATION WATER AT COASTAL AREAS IN BANGLADESH

Marzia Ashraf*[1], Ahmad Sajid Hasan[2] and Mohammad Karimul Absar Chowdhury[3]

[1]Lecturer, Department of Civil Engineering ,World University of Bangladesh, Bangladesh, e-mail: marziashorno@gmail.com
[2]Research Fellow, Rowan University, Glassboro New Jersey, USA, hasana26@students.rowan.edu
[3]Research Fellow, Rowan University, Glassboro,New Jersey,USA, chowdh63@students.rowan.edu

***Corresponding Author**

ABSTRACT

Salinity in coastal region is a common downside in Bangladesh which is predicted to be exacerbated by global climate change and sea-level rise. Salinity is largely the presence of dissolved inorganic solutes in aqueous solution. The presence of soluble salts within the groundwater and surface water bodies as well as in the soil is one of the major environmental concern worldwide. The freshly deposited alluviums in the coastal areas of Bangladesh become saline as it comes in contact with the sea water and continues to be inundated during high tides. Salt water intrusion due to reduction of freshwater flow from upstream, and over withdrawal of coastal groundwater and fluctuation of soil salinity are major problem of coastal regions. Due to the presence of salinity in groundwater further as surface water, the folks of the southwest region are plagued by issues associated with drinking, irrigation, agriculture, fisheries and alternative uses. This research was carried out in three districts (Patuakhali, Bhola and Barguna) which are located in the south-central region of Bangladesh to spot the salinity level and other water quality parameters from these areas. Relatable parameters such as salinity-Electrical conductivity (dS/m), chloride concentration (mg/l), Hydrogen ion concentration, Hardness, Salinity, and Iron concentration of the groundwater and surface water of these areas were determined by laboratory experiments. This was done by analyzing waste water samples in the laboratory of World University of Bangladesh. Besides, a questionnaire survey has been disbursed throughout field visits. To get an overall idea about the impacts of salinity on drinking water and agriculture, questionnaire interview was carried out in ten villages of these three districts. It has been discovered that in Patuakhali the highest percentage of people agreed that each drinking and irrigation water are littered with salinity. Besides, this study also found that 80% and 90% crop production in Patuakhali and Barguna is hampering for salt water in a winter season attributable to salinity and low well water layer. The study shows that the Bhola district's surface water has the highest electrical conductivity of 3749 µS/cm and the lowest electrical conductivity was found in the surface water of Barguna (190 µS/cm). An emperical equation has been used to measure the salinity of water directly from the Electrical Conductivity (EC) and compared with respective guideline. It has been found that Patuakhali district is in most vulnerable condition from the perspective of salinity. As per the opinion of the respondents, presence of salinity is creating severe problems in irrigation in all these three regions. In addtion, most of the people in these three districts agreed with the negative impact of salinity on health. Various water borne diseases like diarrhoea, skin problems, stomach pain and typhoid became very common in these regions. Again, Chloride concentration is also highest in surface water of Bhola, whereas Barguna district's surface water and Bhola district's deep tubewell water has equal and lowest value of chloride concentration. Based on the questionnaire assessment and laboratory test it is found that, overall water quality of these three areas is not advisable for both drinking and irrigation purposes.

Keywords: *Salinity, Coastal aquifer, Climate change, Sea-level rise, Freshwater, Questionnaire survey.*

1. INTRODUCTION

Salinity intrusion is among the main environmental issues throughout the globe. Bangladesh is a growing and developing country. This development is dependent on associate agricultural production system which constitutes the largest part of our economy. Along side the issues related to drinking water, salinity issues are impediments to both the agricultural and economic development. The coastal region is predicted to loss most crop in future compared to the other regions of the country (Hasan et. al, 2017). Most of the land remains fallow in the dry season (January- May) because of soil salinity, lack of good quality irrigation water and late draining condition (Karim *et al.,* 1990) At present salinity is becoming a major concern to the people of the southwest region of Bangladesh. Although Hasan et. al, 2018 showed the decrease on production of Boro and Aman rice in Bangladesh; the software DSSAT was not capable of assessing the impact of salinity on the yield of crop. This study aims at examining the presence of salinity in the water bodies of coastal regions and taking a survey on the farmers to link the results of salinity on crop yield.

Salinity means the presence of major dissolved inorganic solutes (essentially Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}) in aqueous solution. These causes reduction in agricultural productivity, decline in the quality of water supplies for drinking, irrigation, and industrial use, loss of biodiversity and conjointly injury to urban infrastructure.

Electrical conductivity is a measure of the saltiness of the water and is measured on a scale from 0 to 50,000 uS/cm. When the irrigation water salinity exceeds the crop tolerance limit, the yield of the irrigated crop decreases significantly with time.

Table 1: Guidelines for irrigation water quality (Adapted from Victorian Irrigation Research and Advisory Committee, 1980, Quality aspects of farm water supplies)

Electrical conductivity(dS/m)	Use
0-0.3	• can be used for most crops on most soils with all methods of water application. • Little likelihood that a salinity problem will develop.
0.3-0.8	• can be used if a moderate amount of leaching occurs. • Plants with a medium salt tolerance can be grown, usually without special practices for salinity control.
0.8-2.25	• cannot be used on soils with restricted drainage. • Even with adequate drainage, special management for salinity control may be required. • not suitable for irrigation under ordinary conditions.
2.25-5.80	• Not suitable for human consumption or irrigation
Over 5.80	• Occasional emergency use for salt tolerant crops on permeable well drained soils under good management.

Table 2: The taste of drinking water is rated according to salinity as follows (Australian Drinking Water Guidelines)

Salinity (mg/L)	Quality
0-600	Good
600-900	Fair
900-1200	Poor
Over 1200	Unacceptable

Seawater intrusion is one of the major reasons behind groundwater salinity (Todd, 2001). The position of the saline-fresh water interface is dependent on through flow from the upper basin and local seasonal recharge. Groundwater salinity may also occur due to the following reasons-

i) Change in the position of saline-fresh water interface

ii) Presence of a saline front in the upper aquifer
iii) Presence of the saline wedge in deeper aquifer
iv) Up-coming of sea water.
v) Low seasonal recharge.

The main objective of the study is to evaluate aquifer salinity situation and its impacts on drinking water and agriculture in Patuakhali, Bhola and Barguna district's few selected areas. Besides, studying about the existing water use pattern of the people at coastal areas and assessing the quality of the water used in daily life were investigated in this research.

2. METHODOLOGY

The methodology employed in the study are questionnaire interview and application of participatory rural appraisal (PRA) tools to urge an understanding of the salinity condition in the study space, collection of secondary data, and eventually analysis of the information through questionnaire interview and PRA tool as well as secondary data in the context of research objectives. The data collected in the study area were mostly qualitative.
The study area was visited several times for assortment of water sample, photographic data collection and questionnaire survey. There we have meet native folks, farmers, fisherman and workers for concisely understanding the present environmental condition of our study area. Brief information about water salinity, water quality, problem with households and irrigation water quality of that area were collected. Figure 1 shows the flow chart of the methodology.

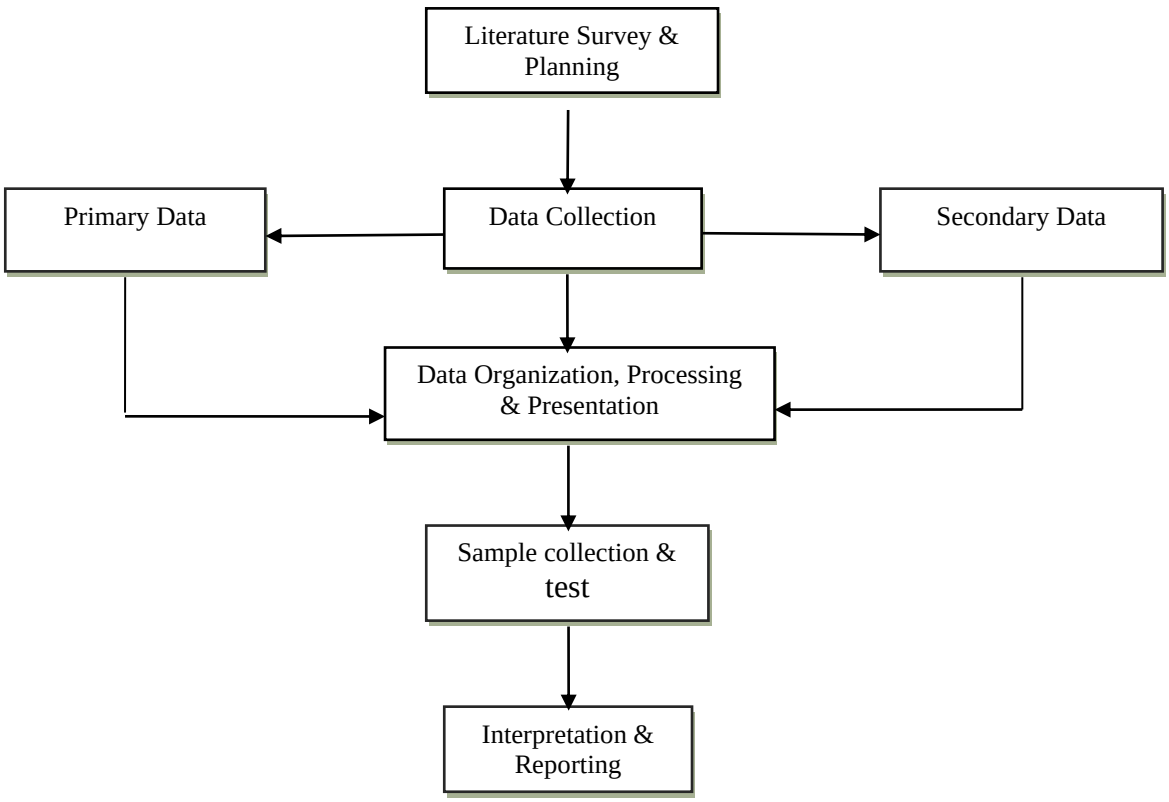

Figure 1: Flow chart presenting the methodology followed for the present study.

2.1 Collection of water samples

Water sample was collected from midstream by dipping each bottle at approximately 20 to 30 cm below the water surface. The sampling containers were property cleaned before use and rinsed with the water to be sampled before sampling.

2.2 Primary Data Collection

2.2.1 Questionnaire survey

A questionnaire survey has been carried out during two field visits. To get an overall idea about the impacts of salinity on drinking water and agriculture, questionnaire interview was carried out in thirteen villages under some Unions in these three districts. The information regarding demographic view of theses village under various union, the statistics of the number of people surveyed in this regions and total number of people living in those areas are provided in Table 4. It is to be noted that the data was directly collected from community report of population and housing census 2011 by Bangladesh Bureau of Statistics (BBS)

2.2.2 Primary data collection through PRA

Participatory Rural Appraisal (PRA) is extensively used in socio-economic survey. The PRA approach was employed in this study to assess people's perception about the salinity impact on drinking water and agriculture. The PRA has different type tools of which the Key informant interview and Transect walk were used.

2.2 Secondary Data Collection

Any research work requires the combination of field data (primary data) and existing data (secondary data) on the particular study area. The impacts of salinity for irrigation in the study areas, was estimated based on the secondary data sources.

2.3 Data analysis and plotting graphs

All the major and secondary data collected has been analyzed separately and carefully to confirm that the collected data is dependable and true. Finally, all the analyzed data have been integrated and presented as paragraphs, tables and graphs and putted in the report.

2.4 Laboratory Tests and Results

2.4.1 Measurement of Electrical Conductivity

Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related. Conductivity is measured by a probe, which applies voltage between two electrodes. The drop in voltage is used to measure the resistance of the water, which is then converted to conductivity. The most commonly used EC units is deci-Siemens per metre (dS/m).

2.4.2 Measurement of Salinity

Salinity can be measured in various way. In most cases, it is directly calibrated from specific gravity, total dissolved solid (TDS), Electrical Conductivity and such other parameters. In this research, a calibration equation has been directly used to convert Electrical Conductivity to salinity.

$$Salinity = EC^{1.0878} \times 0.4665 \times 1000 \quad (1)$$

Where Electrical Conductivity is in ds/m and Salinity will be found in mg/L.

Along with the measurement of salinity some other essential parameters like Hardness, Chloride, Iron and Arsenic Concentration was also measured in conventional method.

3. RESULTS AND DISCUSSIONS

3.1 Results from Questionnaire Survey

The results of the study are presented in graphical form along with a discussion on the overall salinity situation in our study areas**.** Questionnaire survey was carried among people of different occupation. Besides, the statistical view of total number of people in various regions of the Unions in these three districts and the number of people surveyed in those area are provided in Table 4.

Table 3: Occupation of the respondents

Occupation	Patuakhali	Barguna	Bhola
Farmer	50%	90%	60%
Businessman	40%	-	-
Boat Craftman	-	-	10%
Motorcycle driver	10%	-	-
Fisherman	-	-	30%
Student	-	10%	-

Table 4: Statistical Data of the surveyed areas

Districts	Total Number of Unions in District	Name of the Unions surveyed	Villages surveyed	Total Population (adapted from community report of population and housing census 2013)	Number of people surveyed
Patuakhali	71	Mohipur	Mohipur	3569	35
			Bipinpur	2132	21
		Mithaganj	Mithaganj	1108	12
			Aramganj	1005	12
			Tegachhia	4526	44
Barguna	42	Barabagi	Natun Para	480	24
			Pajrabhanga	759	37
			Chowla	779	38
		Gulisakhali	Gulisakhali	4133	40
Bhola	68	Char Manika	Dakshin Char Aicha	5246	50
			Char Faruquee	472	22
		Hazariganj	Char Fakira	7211	50
		Char Fasson	Char Fasson	1590	16

Table 4 illustrates the various unions those were surveyed for this case study. Total population in corresponding areas was collected from community census reports of Patuakhali, Barguna and Bhola zilla published by Bangladesh Bureau of Statistics (BBS) Statistics and Informatics Division (SID).
It is noteworthy to mention that the quantity of respondents was taken as 5% of total population for the area having population less than 800 and 1% for the other regions.

3.1.1 Proportion of various water borne diseases due to presence of salinity

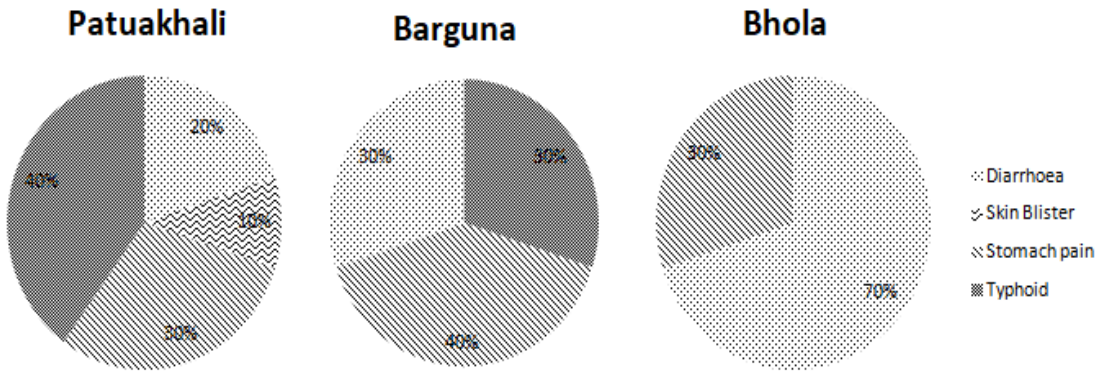

Figure 2: Water-borne diseases due to salinity according to the view of respondents

It is seen from figure above that, In Patuakhali 40% and Barguna 30% people are effected by typhoid fever. In Patuakhali 30%, Barguna 40%, Bhola 30% people are affected by stomach pain. In Patuakhali 20%, Barguna 30%, Bhola 70% people are effected by diarrhoea and 10% people in Patuakhali have skin blister by using salt water.

3.1.2 Wastage of crop due to presence of saline water

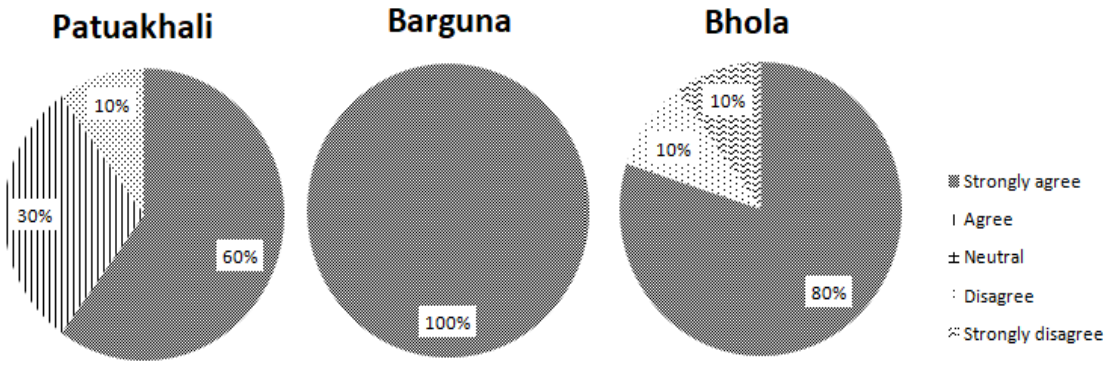

Figure 3: Respondents' thought about the wastage of crop due to presence of saline water

It is observed from figure 3 that the proportion of people who strongly agree that salt water destroys crop production are predominant in all three districts. Only 10% people both in Patuakhali and Bhola disagree with these phenomena.

3.1.3 Salinity Problem in drinking water

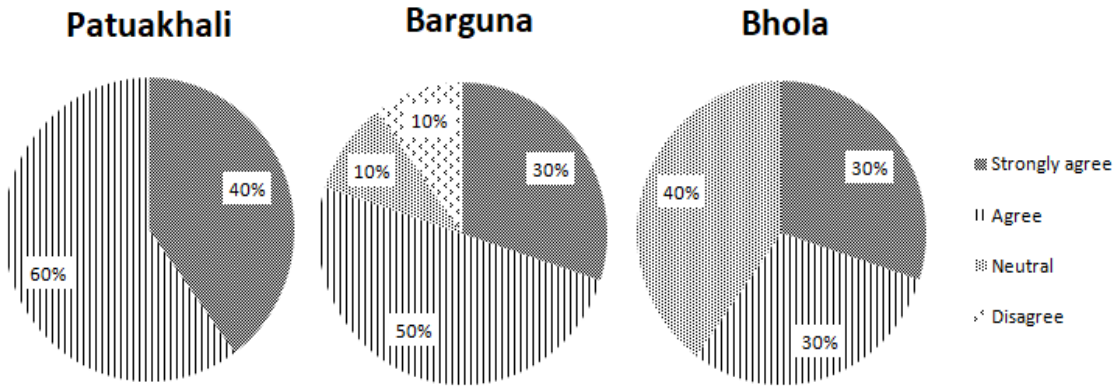

Figure 4: Percentage of people drinking salt water

Figure 4 represents that- majority of people in these three districts think that the drinking water contains salinity.

3.1.4 Salinity Problem in irrigation water

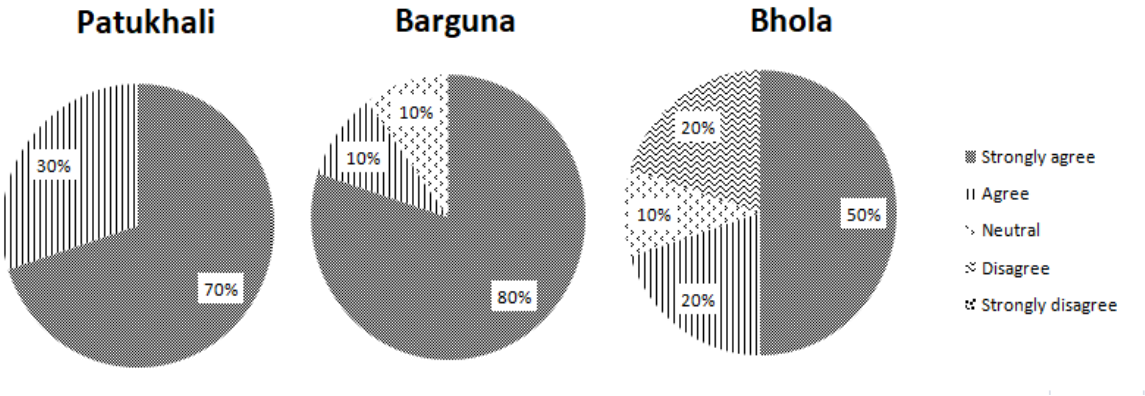

Figure 5: Respondents' opinions about the presence of salinity in irrigation water

It is clearly seen from the figure 5 that more than 50% people in Patuakhali, Barguna and Bhola experienced moderate level of salinity content in irrigation water. The proportions of people who disagreed with salinity problem in irrigation water are much lower in all three regions.

3.1.5 Respondents' opinion about effect of saline water on crop production

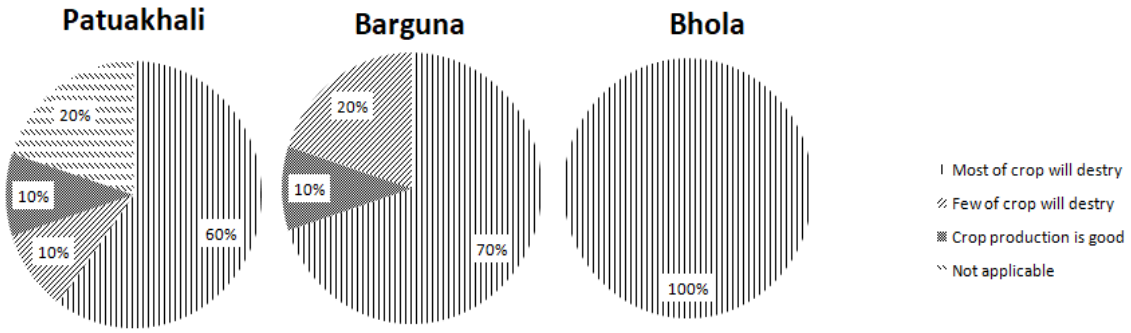

Figure 6: Effect of saline water on crop production:

Again, it has been found that 60% people in Patuakhali, 70% in Barguna and around 100% people in Bhola zilla gave their opinion on destruction of crop due to salinity.

3.1.6 Difficulties of collecting fresh water

Besides, another questionnaire survey was carried out about the difficulties of collecting fresh water which contains no salinity problems. The results are shown in figure below:

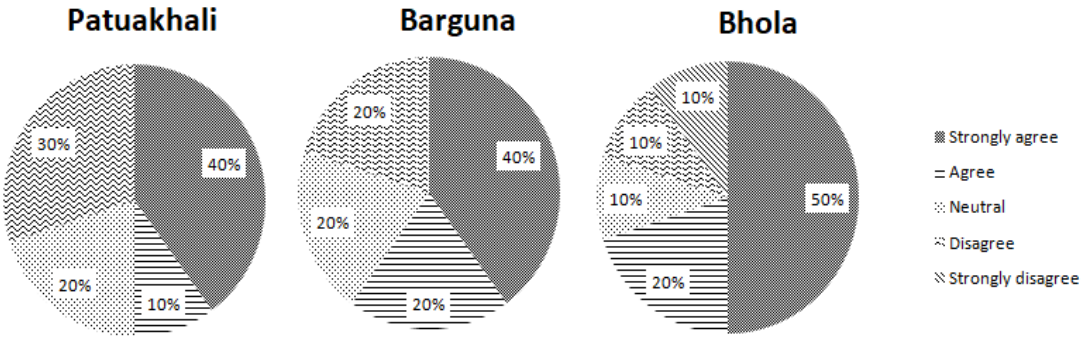

Figure 7: Difficulties in collecting fresh water

It is seen from figure 7 that, around 50% respondents in Patuakhali agree (Strongly agree 10% and agree 40%) and 30% disagree about their difficulties of collecting fresh water. In Barguna the proportion of people who agree with this problem is much higher (60% in total). In Bhola strongly 50% people rigidly agree and 20% nearly agree about this problem of collecting fresh water.

3.1.7 Seasons when crop production is hampered due to salinity

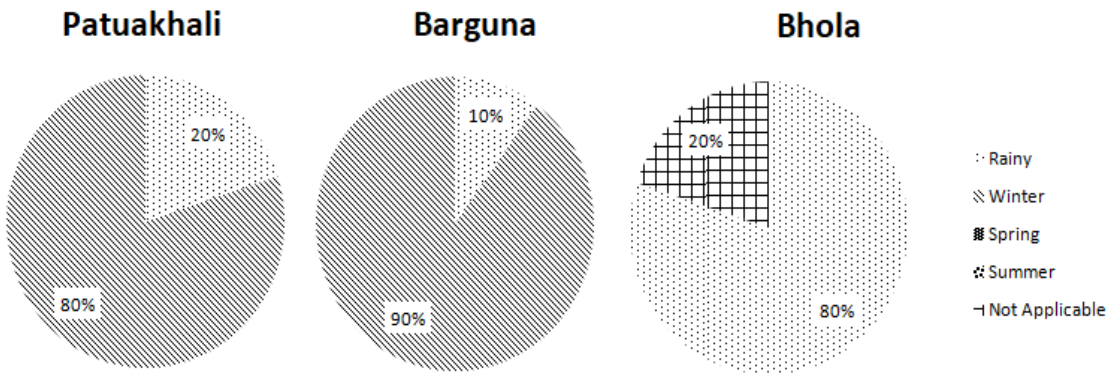

Figure 8: Seasons when crop production is hampered due to salinity

According to Figure 8, it is clearly observed that around 80%-90% crop damaged due to salt water is occurred during winter season both in Patuakhali and Barguna. Only exception is in Bhola where 80% crop production is hampered due to salinity in winter.

3.2 Results from Laboratory test

3.2.1 Electric Conductivity

The Standard value of EC of water according to Bangladesh Environment Conservation rule is 0.5-1.5 ds/cm. According to WHO standard the value is same. The EC value of surface water in Patukhali was 3.78 ds/m which was much higher than the values found in Barguna and Bhola zilla.(0.42 and 0.19 respectively). On the contrary, EC values of ground water were found 2.24 ds/m and 2.19 ds/m in Barguna and Bhola which are higher than that of Patuakhali. These higher values exceed both Bangladesh and WHO standards. On the authority of Table 1, Ground water of Bhola and Barguna districts is recommended for drinking purposes but special treatment and drainage should be provided prior to use for irrigation. But surface water of Patuakhali is absolutely unsuitable for drinking and not recommended for agriculture.

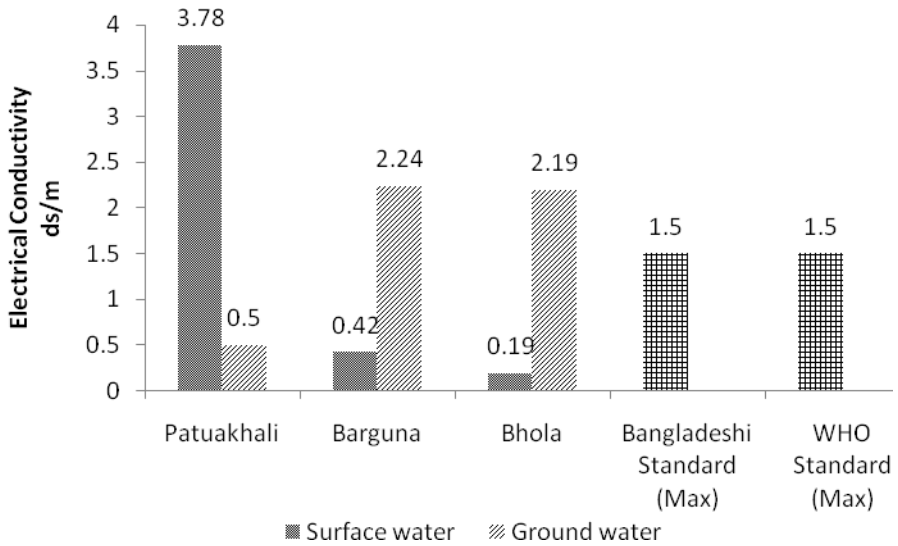

Figure 9: Electrical Conductivity of deep tube well water and surface water

3.2.2 Salinity

As mentioned before, salinity was determined using an imprical equation (stated as equation 1). Figure 10 shows that salinity is direct proportional to the values of EC measured. According to Table 2 surface water quality of Patuakhali zilla is considered as impermissible for drinking purposes as the salinity is over 1200 mg/L. Besides, the ground water quality in Barguna and Bhola districts are also very poor the since the salinity (1122 mg/L and 1094 mg/L) falls in the range of 900-1200 mg/L.

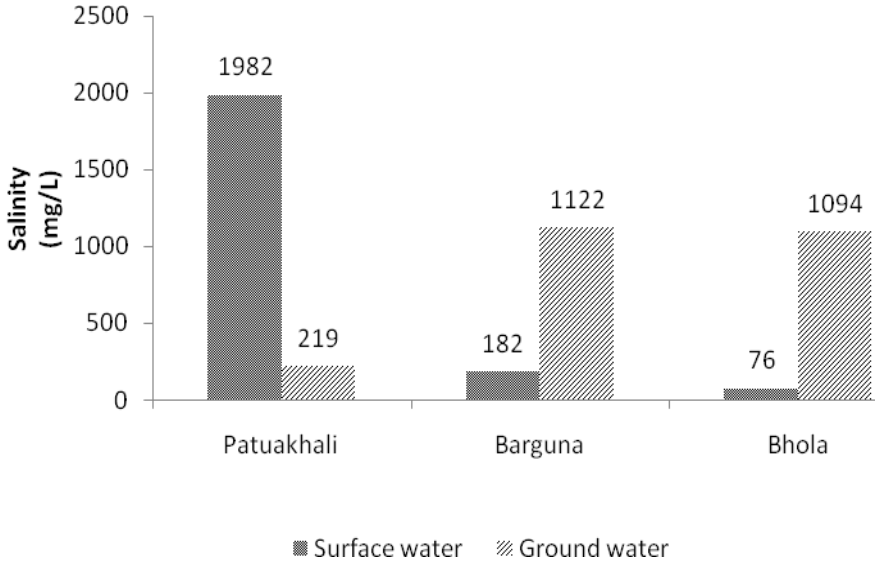

Figure 10: Salnity of surface water and ground water of three districts

3.2.3 Iron Concentration

According to Figure 11 both the surface water and ground water of Barguna contain high Iron concentration and both values exceed ECR 1997 and WHO standards, whereas the water quality of Patuakhali and Bhola seem satisfactory regarding Iron content.

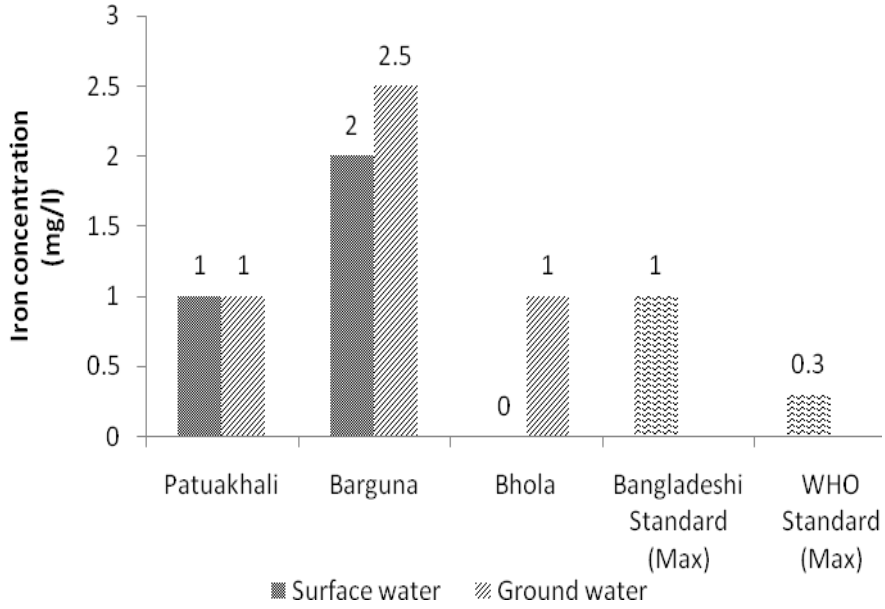

Figure 11: Iron Concentration in surface water and ground water of three districts

3.2.4 Hardness and Chloride Concentration

Figure 12 and 13 illustrate the hardness and concentration of Chloride in surface water and ground water in these three coastal areas. Only the hardness value surface water in Bhola and ground water in Barguna cross the maximum limit of hardness according to ECR 1997 and WHO standard. Turning to figure 13, it is seen that surface water in Bhola is about more than double than the maximum limit specified by ECR 1997 and WHO. Otherwise the amount of Chloride in water of other two districts are equal or below the maximum limit.

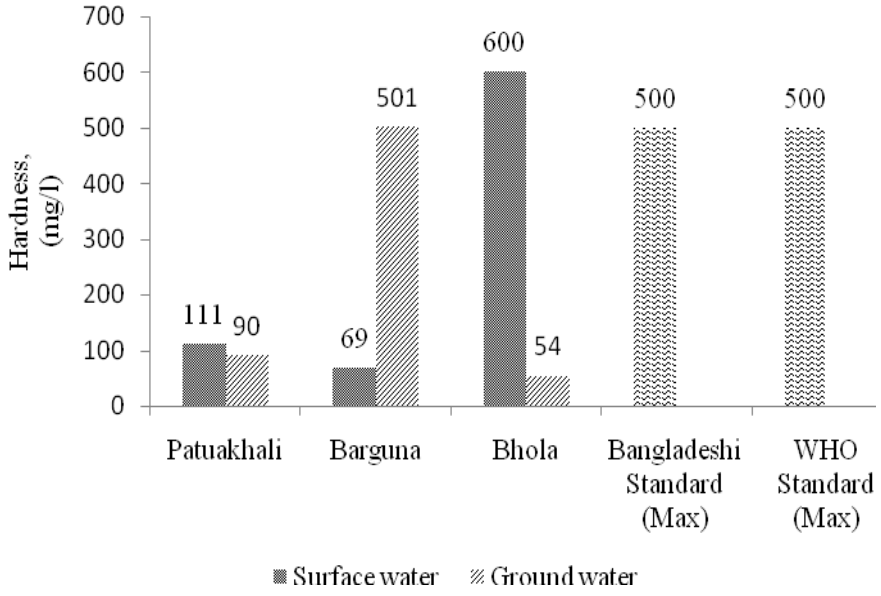

Figure 12: Hardness of surface water and ground water of three districts

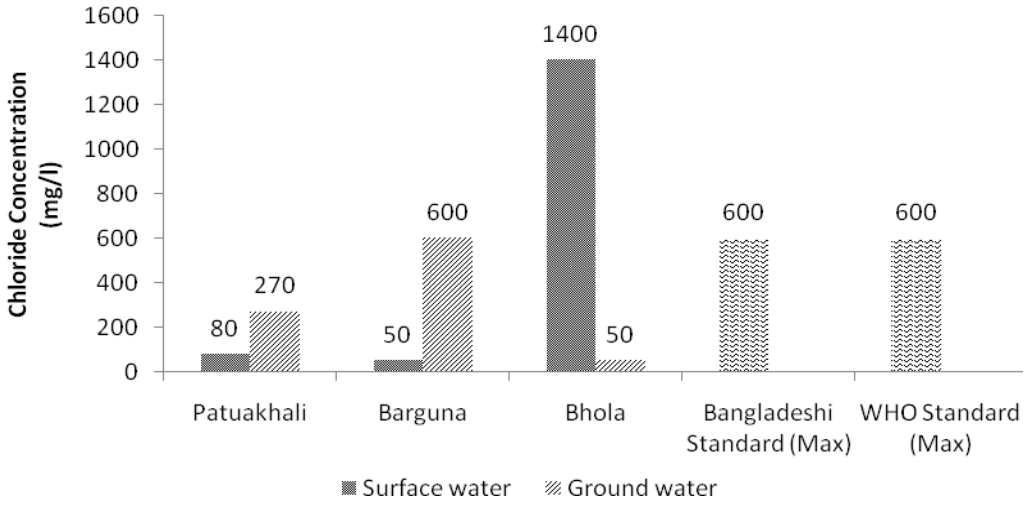

Figure 13: Chloride of surface water and ground water of three districts

4. CONCLUSIONS

The research has portrayed the impact of salinity on drinkable water and agriculture in the studied areas. From this investigation we came to know about the prevailing water use pattern of the people at coastal areas. From the questionnaire survey, it has been assessed that majority of respondents believe that both the drinking water and irrigation water contains moderate level of salinity and crop prduction is hampered undoubtedly. Specially salinity condition in Barguna is most vulnerable among

these three districts keeping with the read of individuals. From the laboratory test, it has been found that surface water in Patuakhali has huge amount of Electrical Conductivity and salinity (3.78 ds/m and 1982 mg/L respectively) which surpass the utmost limit of these parameters specified by ECR 1997 and WHO Standard. Similarly, ground water in the other two districts also has moderate level of salinity. The experimental study also shows that, hardness and chloride concentration of Bhola surface water exceed the standard limit. Again, an excessiveness in Iron concentration in water of Barguna has found from this study. So it is an exigency to monitor the water quality from the perspective of salinity and quality parameters to ensure a sustainable water resource development.

ACKNOWLEDGEMENT

The author would like to express sincere gratitude to World University of Bangladesh for providing laboratory facilities for conducting this study**.**

REFERENCES

Australian Drinking Water Guideline.(2011) Website: https://www.epa.sa.gov.au/environmental_info/water_quality/threats/salinity

BADC (2007), Water Quality for Irrigation (2004-2007), Survey and Monitoring Project for Development of Minor Irrigation, Bangladesh Agricultural Development Corporation, Ministry of Agriculture, Dhaka.

BBS. (2011). Bangladesh Population and Housing Census 2011, Community Report: Barguna Zila, Bangladesh Bureau Of Statistics (BBS) Statistics And Informatics Division (SID) Ministry Of Planning, July 2013.

BBS. (2011). Bangladesh Population and Housing Census 2011, Community Report: Bhola Zila, Bangladesh Bureau Of Statistics (BBS) Statistics And Informatics Division (SID) Ministry Of Planning, July 2013.

BBS. (2011). Bangladesh Population and Housing Census 2011, Community Report: Patuakhali Zila, Bangladesh Bureau Of Statistics (BBS) Statistics And Informatics Division (SID) Ministry Of Planning, July 2013.

BWDB (2005), Southwest Area Integrated Water Resources Planning and Management Project in Bangladesh, Bangladesh Water Development Board, July 2005.

Hasan, A.S., Akhter, F and Rahman, M.M. (2018). "A study on the impact of high end emission on the crop yields at the coastal regions of Bangladesh." *1st national conference on water resource engineering (NCWRE 2018), 21-22 March 2018 pp (51-56), CUET, Chittagong, Bangladesh.*

Hasan, A.S., Islam, A.K.M.S. and Bala, S.K. (2017). Impact of extreme climate change on the production of BORO rice in Bangladesh using DSAAT 4.6. *Proccedings of the 6th international conference on water and flood management (ICWFM 2017) 4-5 March 2015 (384-397), IWFM, BUET, Dhaka, Bangladesh.*

Karim, Z., Hussain, S.G., Ahmed, M. (1990), Salinity problems and crop intensification in the coastal region of Bangladesh, BARC Soil Publication no.33, Dhaka

Mohammad, N (2009), Addressing Salinity to improve the well-being of vulnerable people in the southwest, RVCC Project, IDEAL Bangladesh.

Quality aspects of farm water supplies.(1980).Victorian Irrigation Research and Advisory Committee.Website: http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/salinity/measuring-the-salinity-of-water.

Standard, B. (1997). The environment conservation rules 1997. *Government of the People's Republic of Bangladesh, Dhaka*.