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# A STUDY ON GROUND WATER CONTAMINATION BY SALINE WATER ALONG THE COASTLINE OF PATENGA IN CHITTAGONG

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**ABSTRACT**

*Groundwater has been satisfying a large portion of drinking water demand around the world for many years. But in case of coastal areas due to excessive intrusion of sea water into ground water aquifer the utility of ground water get decreased. Chittagong also known as the port city of Bangladesh, consist a large portion of coastline of the Bay of Bengal. As a result areas like Patenga, which is situated just at the sea shore, are very vulnerable to problems like saline water intrusion in ground water. In this study Patenga Thana under Chittagong metropolitan area was considered as a study area and water samples from different ground water sources was collected. Electric conductivity and total dissolved methods were used to determine the salinity of collected samples. Test results showed that the intensity of salinity varies based on distance from the shore. Sample collected from near the shore were found very high in salinity and it decreased as the distance of the sample collection spot increased from the shore. Besides, the intensity of salinity was found unsuitable for daily use. A map was developed using GIS based on the lab results showing the variation of saline intensity in study area which will help the respective authority in making decisions on drinking water supply.*

**Keywords:** *Groundwater, salinity, total dissolved solids, electrical conductivity, GIS*

## 1. INTRODUCTION

Access to potable drinking water is considered as a human right by many academics and researchers. But demand of safe drinking water is increasing day by day with increasing world population. About one third of world's population lives in water shortage areas and of them about 1.1 billion people lives without access to safe drinking water (Shaw & Thaitakoo, 2010). There is an abundance of water in Bangladesh, but scarcity of safe drinking water is the real situation now. About one fourth of the population has no access to safe drinking water (WHO, 2008) and especially the coastal region is facing extreme difficulties in accessing safe drinking water (Quazi 2006). A coastline of 710 km on the northern littoral of the Bay of Bengal flows along Bangladesh that consists of a vast network of Ganges-Brahmaputra-Meghna river system (Hossain, 2011). The coastal region covers almost 29000 $km^2$ or about 20% of the country and about 53% of the coastal areas are affected by salinity (Sohela & Karim, 2014). According to the Coastal Zone Policy 2005, 76 upazilas of 19 coastal districts in Bangladesh are likely to be seriously affected by a rise in sea level. About 15 million people already are forced to drink saline water and 30 million people are unable to collect potable drinking water due to a lack of available safe water sources (Hoque, 2009). Patenga is located in the south-east zone under Bandar Upazilla of Chittagong district. Here, the problem with drinking water is salinity. Many natural calamities in the form of cyclones and tidal surge frequently occur in coastal zones and sea level rise is an outcome of these natural hazard (Abedin & Shaw, 2013). And this sea level rise has various impacts on the coastal areas, such as land erosion, salinity-intrusion and loss of bio diversity (Azad, Jensen, Kathe & Kwei, 2009). Due to the relatively low lying land formation of Bangladesh, a small increase in sea level will cause salinity intrusion to a much longer distance in inland (Sarwar, Golam & Khan, 2007). Salinity is very important as socio-ecological life of the local people affected by it. Many studies reveal that salinity is the primary cause for the lack of safe drinking water compared to arsenic and drought hazard (Abedin, Habiba & Shaw, 2014). Moreover it is causing damage to agriculture, bio-diversity, fresh water and its resources which are absolutely degrading the quality of local people's life (Pitman & Lauchli, 2004). The coastal zone, more appropriately, exposed coast has come into focus in a number of policy and academic studies for land desertification and loss in agricultural production due to salinity. By drinking saline water people are suffering from various kinds of health problem, such as high blood pressure, diahorea, cholera and others (Pereira, Cordery, & Lacovides, 2009). People are also getting saline through various food grains more than they required (Khan & Aneire, 2011). Structures, exposed to salinity, may deteriorate as a result of combined effects of chemical action of saline water. In this context, the study is intended to explore the level of salinity in ground water at Patenga in Chittagong. A detailed study on the salinity condition of the area will provide a clear view of the problems associated with drinking water and sub-surface irrigation which will help the government and policy makers to formulate action plan in saline prone areas like this.

Different salinity level in different areas showing in a GIS map will help to identify points of suitable water source for residential areas and future development works like multistory buildings and industries. The type of crop also can be selected using this map. Using the database authority will be able to take necessary steps, based on severity of salinity, to determine remedial actions against drinking water problems. Even alternative drinking water option like desalination plant, rainwater harvesting may be checked out based on the data obtained.

## 2. SALINITY INTRUSION IN BANGLADESH

The encroachment of saline water into fresh ground water regions in coastal aquifer settings is termed as sea water intrusion. Saline water intrusion is affected by both natural and manmade processes. Sea-level rise along with climate change play a vital role in sea water intrusion (Werner & Simmons, 2009). According to Intergovernmental Panel on Climate Change (IPCC, 2001), global warming will lead to a sea-level rise of between 110 and 880 mm by 2100. Bangladesh is a country nearby the Bay-of-Bengal and vulnerable to climate change (Karim & Mimura, 2008). So, salinity intrudes into the groundwater naturally at various parts of the coastal regions of the country. Some anthropogenic activities like, excessive and unplanned extraction of the groundwater, shrimp culture, unplanned construction of drainage and canal networks accelerates salinity intrusion day by day (Sherif & Singh, 1999). The increasing salinity has negative impact on human life and biodiversity. Many studies showed that there has an adverse effect of high salinity levels on rice. Salinity in soil in high level prevents growth (Tho, Vromant, Hung and Hens, 2008), hinderers germination, rice fields gets brown (Gain, 1995), and reduces rice production (Ali, 2006).The increasing trend of salinity in ground water impedes human health, livelihood, infrastructure, ecological balance as well.

## 3. METHODOLOGY

A literature review and preliminary survey was done through Chittagong city to explore the severity extend and of saline degraded drinking water. Patenga was selected as a study area because it is fairly close to seashore and there is no water supply facility from WASA. Patenga is a thana/upzilla located in the south-east corner of Chittagong district consisting of ward no. 39(part), 40 and 41. The area specifically Nazirapara, Fulsoripara, West Musilamabad Residential Area & Kathgar were selected by preliminary field investigation. Figure 1 shows a typical map of Patenga thana. The study area was divided into two zones named North Patenga (West Muslimabad R/A & Kathgar) and South Patenga (Fulsoripara & Nazirapara). The samples were collected from the area of about 1 km along sea beach and about 2.5 km approached longitudinally. Geographical co-ordinate of each sample collection point was taken. The locations of each sample collecting point are shown in figure 2a and figure 2b. A questionnaire survey was conducted to collect data about depth and age of tube-wells. To measure salinity, Gravimetric method for TDS and Electrical Conductivity (EC) methods were applied. In Gravimetric method TDS was determined by evaporating the liquid solvent and measuring the mass of residues left. A 100ml beaker was used and finally the result was converted in mg/l. Electrical Conductivity (EC) was measure by a digital electrical conductivity meter (Model: JK-COM-006). The range of measuring EC of this device was 0μs to 199.9ms. ArcGIS by Environmental Systems Research Institute (ESRI) was used to generate GIS map. All co-ordinate data were converted to decimal degree. A digital map of Chittagong was collected from Chittagong Development Authority (CDA). All the position of the tube-wells was marked by completing the geo-referencing and projection of the map using the collected data. Using the measuring tool in the GIS map the distance of different tube-wells from a reference point was obtained. Different maps were then exported as images. A general flowchart of working processes followed in the study has been shown in figure 3.

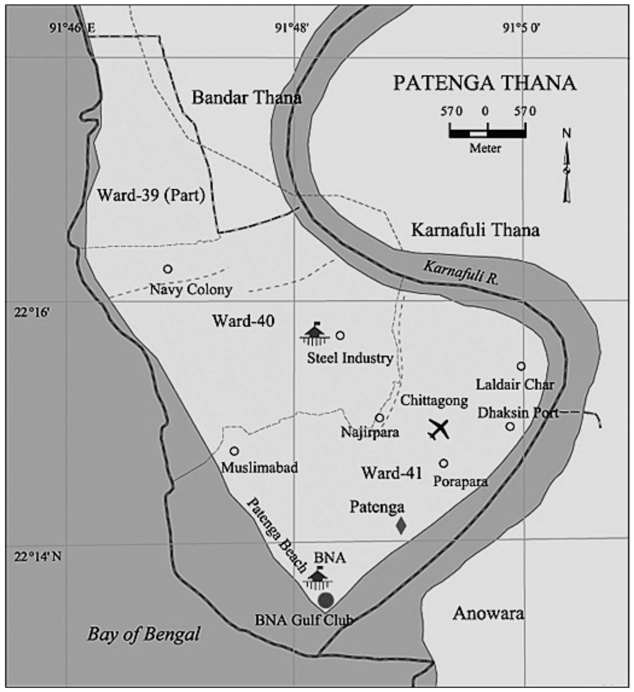


Figure 1: Study area

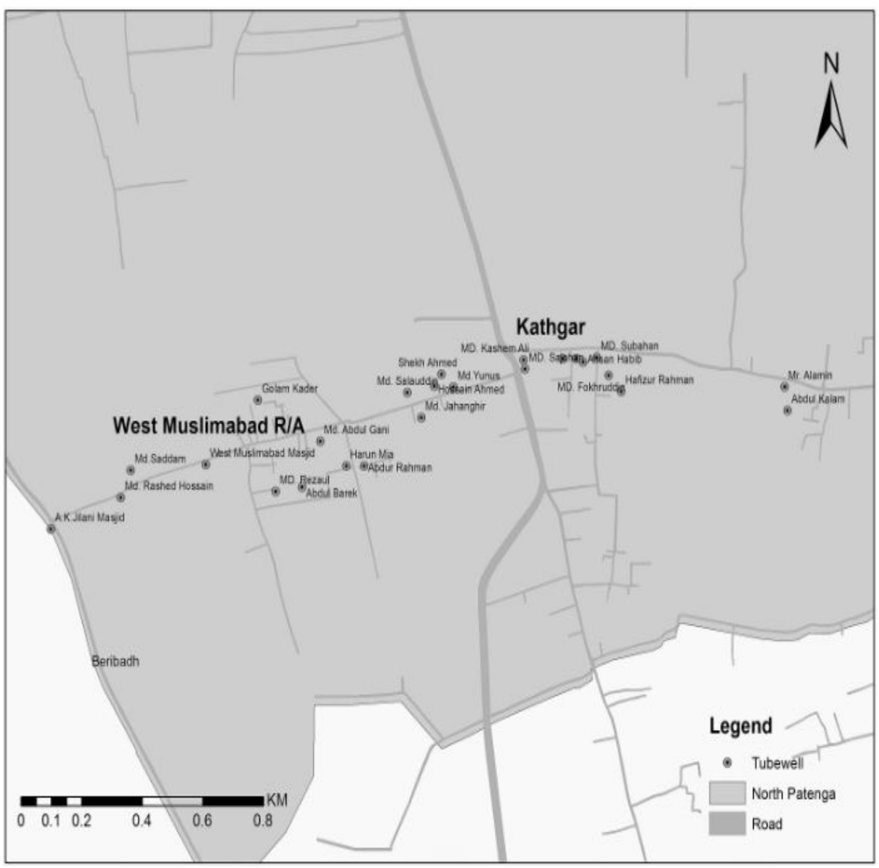


Figure 2a: Tube well locations of West Muslimabad & Kathgar

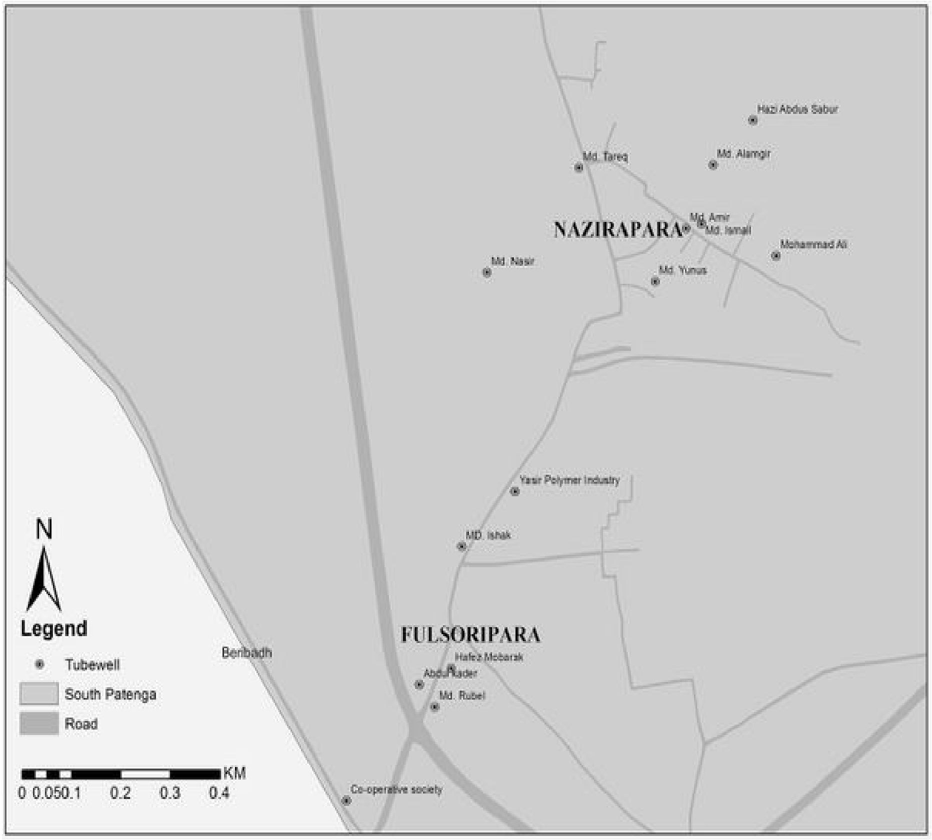


Figure 2b: Tube-well locations at Fulsoripara & Nazirapara

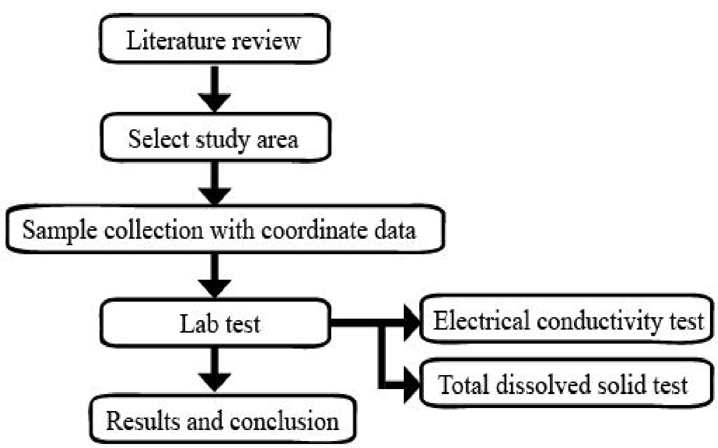


Figure 3: Flow chart

### 3.1 Measurement of Salinity

There are a range of methods available for measuring salinity such as Electrical Conductivity (EC) Test, Total Dissolved Solid (TDS) Test, and Chloride Concentration Test etc. Among these, EC Test & TDS test are more reliable. Theory and procedure of TDS and EC tests are discussed in detail in the following articles.

### 3.1.1 Total Dissolved Solid Test

Total Dissolved Solids is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size or smaller) pores. Total dissolved solids are normally discussed only for freshwater systems, as salinity comprises some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects). It is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. Primary sources for TDS in water are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants. The most common constituents are calcium, phosphates, nitrates, sodium, potassium and chloride, which are found in nutrient runoff, general storm water runoff and runoff from snowy climates where road de-icing salts are applied. The chemicals may be in the form of cations, anions, molecules or agglomerations. More exotic and harmful elements of TDS are pesticides arising from surface runoff. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils.

Gravimetry method is the most accurate and involves evaporating the liquid solvent and measuring the mass of residues left. This method is generally the best, although it is time consuming. If inorganic salts comprise the great majority of TDS, gravimetric methods are appropriate. During sample test, a clear dry glass beaker (which was kept at 103°C for 1 hour) of 150ml capacity was identified & weighted, thereafter noted. 100 ml of sample was taken in it & filtered through a double layered filter paper. The filtrate is then collected. The beaker was then placed in an oven maintained at 103°C for 24 hours and then cooled. After that, the beaker was weighted. The weight of the beaker found in step 1 was subtracted to find the weight of total dissolved solids.

*TDS (mg/l) = (milligram of solids in the beaker × 1000) / (Volume of sample)*

The allowable limit for TDS is 1000 mg/l (Bangladesh drinking water standard, 1997).

### 3.1.2 Electrical Conductivity Test

Salinity is often measured by measuring how well electricity travels through the water. This property of water is called conductivity. Water that has dissolved salt in it will conduct electricity better than water with no dissolved salt. The more salt that is dissolved in the water, the better the water conducts electricity. The salt content of the water can be measured very precisely using the conductivity method. Electrical conductivity of water is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids in water create the ability for that water to conduct an electrical current, which can be measured using a conventional conductivity meter or TDS meter. When co-related with laboratory TDS measurements, conductivity provides an approximate value for the TDS concentration, usually to within ten-percent accuracy. The relationship between TDS and specific conductance of groundwater can be approximated by the following equation:

$TDS = k_e \, X \, EC$

Where, TDS is expressed in mg/l and EC is the electrical conductivity in micro Siemens per centimeter at 25°C. Value of $k_e$ is 0.64. This formula doesn't give exact value rather gives a general idea which may vary up to 10% from exact value. Based on EC value water can be classified into 4 categories. They are C1 (100-250 µs/cm) Water, C2 (100-250 µs/cm) Water, C3 (750-2250 µs/cm) Water, C4 (>2250µs/cm) Water (Garg, 1976).

## 4. RESULTS

TDS and EC test results for collected samples from the study area were shown in figure 4 and figure 5 with coordinates. Results were expressed in TDS to represent drinking water quality standard and EC for irrigation standard. The allowable limit of TDS in drinking water is shown in Figure 4 as well as C3 & C4 ranges have been shown in figure 5. Figure 6 consists of distance vs. salinity graphs which show the change in salinity of the samples collected at a depth of 30-45 feet from existing ground level. Two types of graphs have been made showing the salinity change of the study area. They are TDS (mg/l) vs. distance (meter) graph (Figure 6(a) and 6(c)) and EC (µs/cm) vs. distance (meter) graph (Figure 6(b) and 6(d)). The distance vs. salinity graph for Fulsoripara & Nazirapara shows a sudden decrease in salinity due to the probable presence of perched aquifer at the beginning & a sudden increase in salinity due to greater depths at further. The decrease in salinity in the

West Muslimabad & Kathgar is almost uniform. Nevertheless there is also sudden fluctuation in salinity due to variation in depths of collected samples.

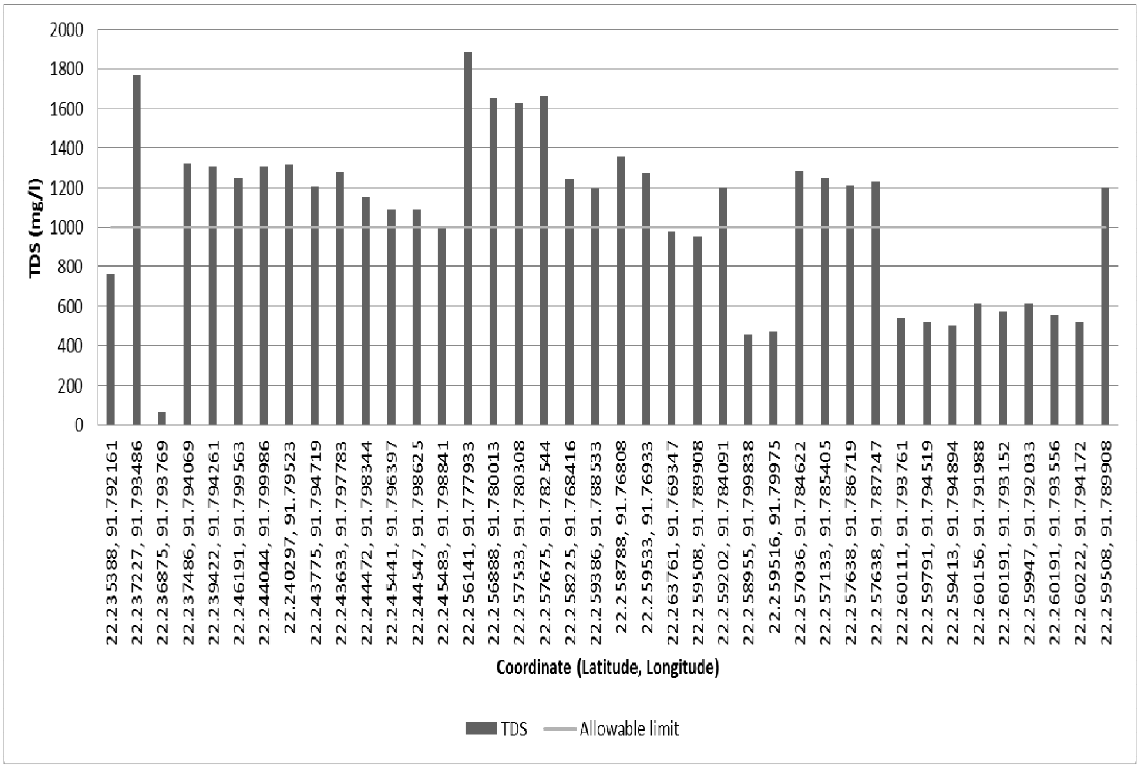


Figure 4: Salinity in TDS (mg/l) vs. Coordinate

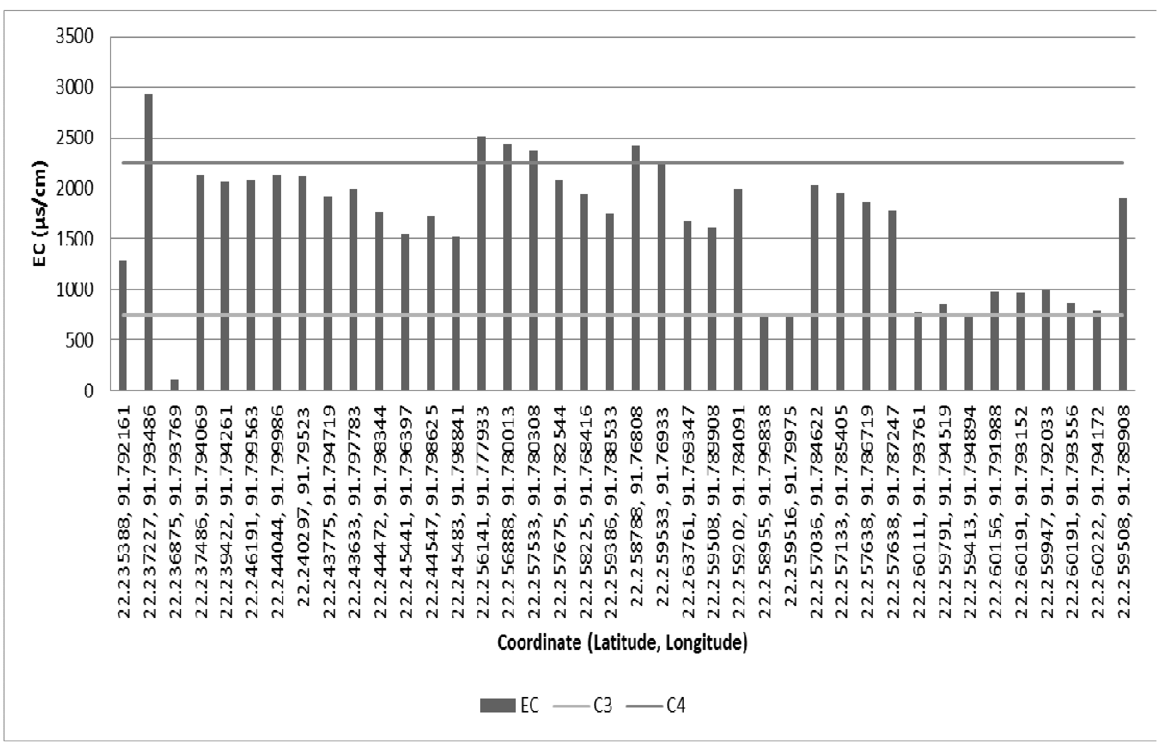


Figure 5: Salinity in EC (µs/cm) vs. owner name

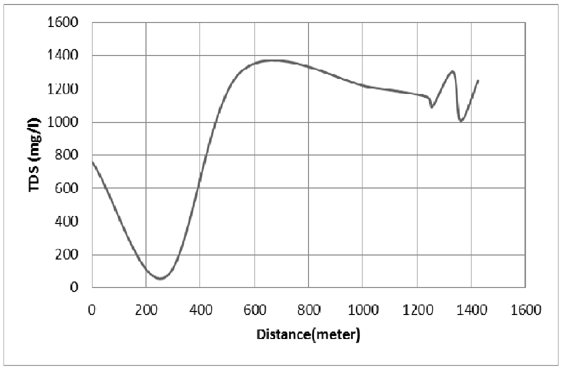


Figure 6(a): TDS (mg/l) vs. Distance (meter) graph for Fulsoripara & Nazirapara

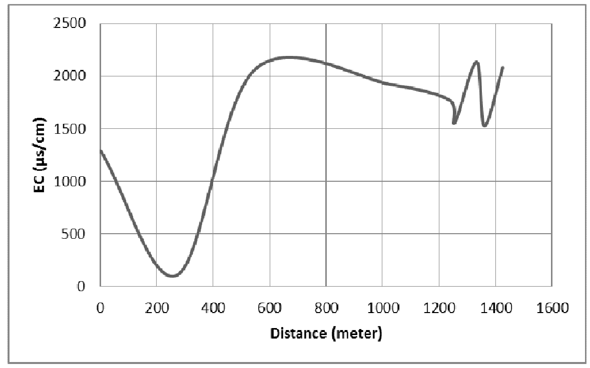


Figure 6(b): EC (µs/cm) vs. Distance (meter) graph for Fulsoripara & Nazirapara

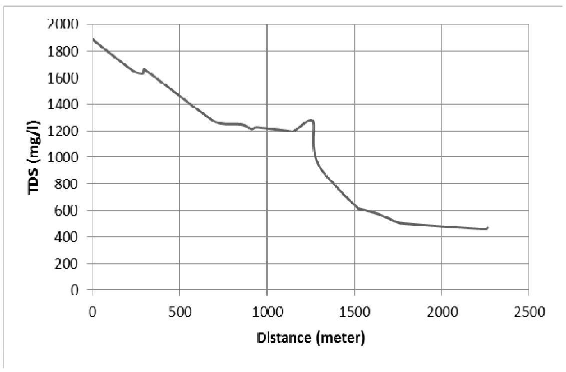


Figure 6(c): TDS (mg/l) vs. Distance (meter) graph for West Muslimabad & Kathgar

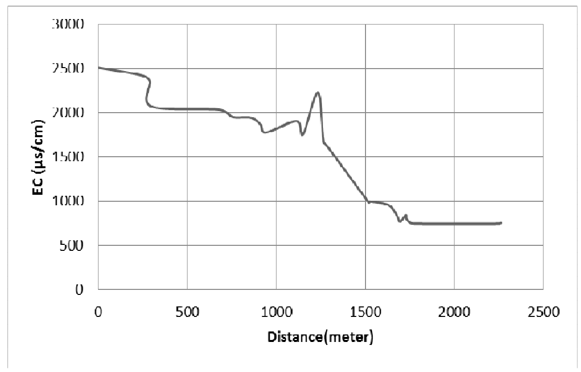


Figure 6(d): EC (µs/cm) vs. Distance (meter) graph for West Muslimabad & Kathgar

Figure 6: Salinity vs. distance graphs

## 5. MAP GENERATION

From the above investigation, it was found that salinity of Patenga Thana changes as the point of sample collection increases form sea-shore. So, it is necessary to divide the area on basis of the intensity of salinity and thereafter to make a map on Patenga Thana showing the salinity change of the study area. On this perspective, GIS map has been generated indicating different salinity zones. Therefore, two maps of Patenga Thana has been made on the basis of TDS and EC as shown in Figure 7(a) and 7(b) . Interpolation method has been used to divide the study area into several zones.

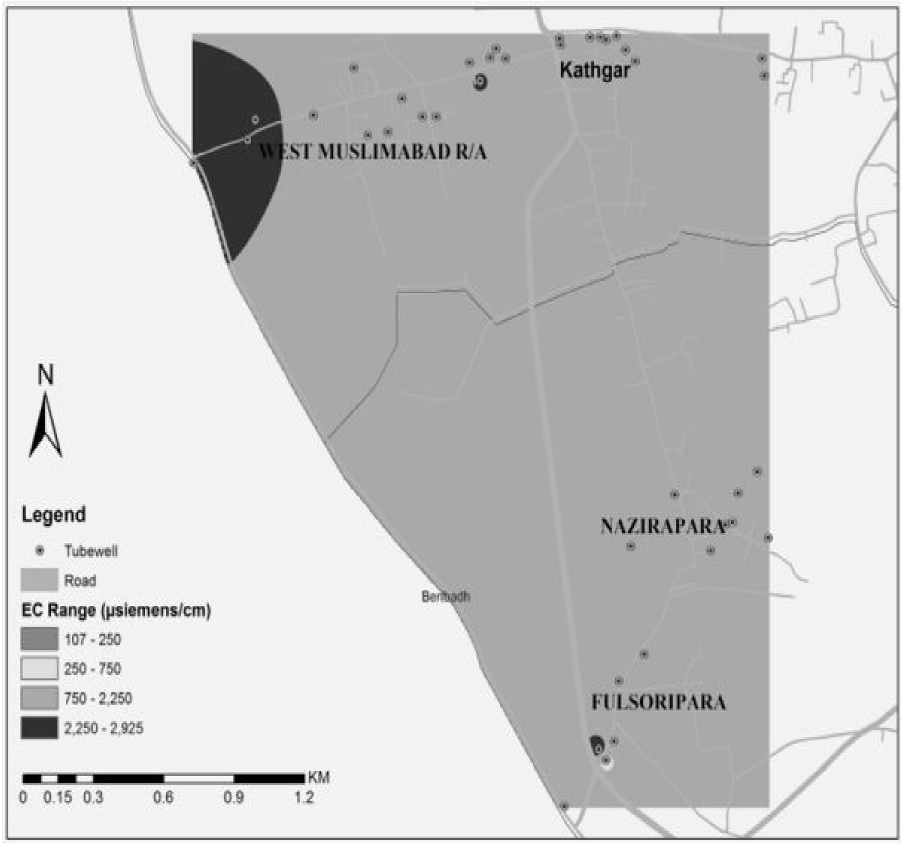


Fig. 7a: Salinity zoning of study area expressed in EC (µs/cm)

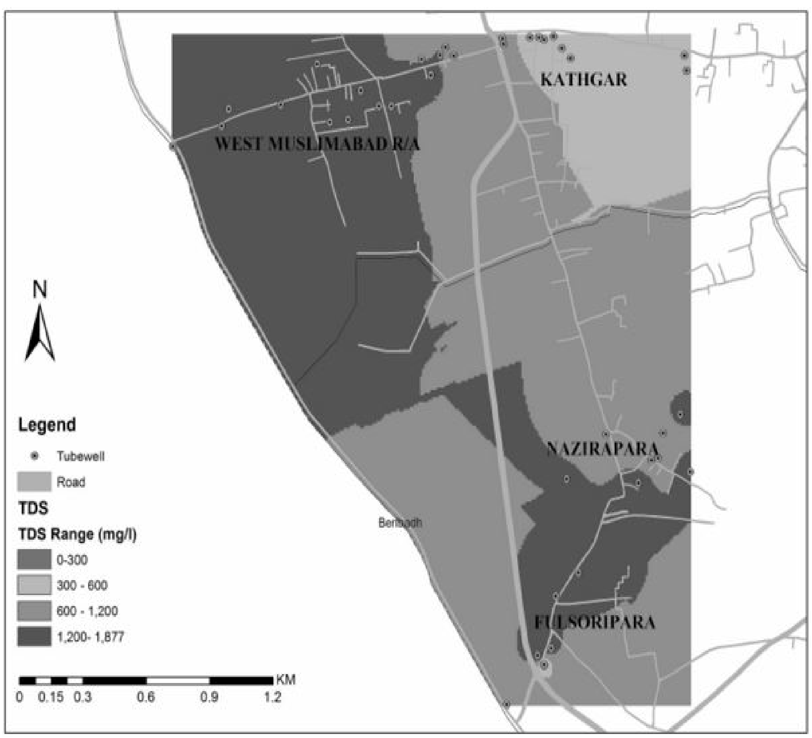


Fig. 7b: Salinity zoning of study area expressed in TDS (mg/l)

## 6. CONCLUSIONS

Salinity intrusion is an alarming problem to the coastal regions of Bangladesh. Patenga is no exception in that case. The water quality of Patenga has been decreased due to the salinity in groundwater for both drinking & irrigation purposes. The intensity of salinity of the groundwater in the inland from the sea-shore decreases with the distance from the sea-shore, excluding some places of Fulsoripara nearby the sea-shore which indicates the possibility of the perched aquifer. The area of West Muslimabad R/A nearby the sea-shore is extremely salinity prone & Kathgar is the least salinity prone area. Salinity zoning of Patenga based on TDS and EC represents the groundwater quality of the study area for drinking & irrigation purposes respectively.

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