Global Scientific JOURNALS

GSJ: Volume 8, Issue 4, April 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Salinity level Analysis of Coastal Soil at Satkhira District in Bangladesh

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ABSTRACT

This study tries to trace out salinity level and pH level in coastal soil. The research was performed around Jabakhali mauza under Shyamnagar Upazila, Satkhira district in Bangladesh. Salinity increase has been one of the major problems for traditional agricultural practices in coastal Bangladesh for several decades, but very few studies have been conducted on impact of salinity on agriculture in this area. This area was selected because it is one of the most vulnerable areas for high exposure to salinity intrusion and widespread many problems. The study was collected primary and secondary data different methods had been adopted which were soil sample collection, water and soil test in field, field observation and survey, FGD, questioner survey, mauza map, satellite image, other secondary sources and 100 personal interviews. In the case of data analysis; Parameter, Geo-spatial analysis, Salinity Metter, Microsoft tools, Geo-spatial analysis in Arc GIS systems have been used. Parameter ECe with HANNA Model HI 933100 have been used for salinity measuring. The findings of the research show that the severity of salinity problem in study areas increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth.

Key words

Soil, Salinity, Analysis, Geo- analysis (ECe, pH), HANNA Model HI 933100, GIS, Coastal area, Bangladesh.

Introduction

Bangladesh is a riverine country. It has coastal belt also and salinity incursion is a common phenomenon to the hostile condition in agricultural crop land. Salinity incursion is the faction of saline water into freshwater aquifers which can prime to pollution of feasting water sources and other consequence [1]. Due to the hydraulic assembly between groundwater and salt water this incursion occurs naturally to some degree in most coastal aquifers [3]. It is deeper and has a higher water pressure because saline water has a higher mineral pleased than freshwater [6]. As a result salinity can thrust interior beneath the freshwater. Many

coastal areas human activities especially groundwater inflating from coastal freshwater wells have amplified saltwater obligation [17]. Water mining drops the strength of fresh groundwater plummeting its water force and letting saline water to run extra inland. The coast of Bangladesh entails of 19 districts cover 32% of the country and lodges more than 35 million people [2]. Snowballing salinity is a decisive issue to the people of the coastal region of Bangladesh. Due to intensifying salinity in the water and soil the people of the region are misery from insufficiency of safe drinking water, irrigation, agriculture and other uses. A recent study directs that the salinity affected area has increased from 8330 km2 in 1973 to 10560 km2 in 2009 [15]. But it has been empirical that all the coastal cultivable domains are not being exploited for crop production mostly due to soil salinity. Augmented soil salinity precincts growth of upright crops and distresses overall crops. Soil salinity has been leisurely a major limitation to food grain brainchild in coastal areas of the country. Saline water incursioncomprise agricultural and drainage channels which offerditches for salinity to move domestic and it can also make sea level upsurge [10] . In coastal edge fresh groundwater bent from inland areas happenstances with saline groundwater from the deep-sea. Groundwater streams from inland areas near the coast where elevation and groundwater levels are inferior [14]. As salinity has a higher gratified of thawed salts and minerals causing it to have higher hydraulic head thicker than freshwater. The higher density and density of saltwater causes to interchange into coastal aquifers in a pack shape under the freshwater. Saltwater and freshwater meet in a conversion zone where absorptionarises during smattering and circulation [12]. Salinity in rivers, lakes, and the sea is ideally simple but severely difficult to define and measure specifically. Theoretically the salinity is the volume of liquefied saline pleased of the water which is composites like sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate that melt into ions [8]. The absorption of liquefied chloride ions is occasionallydenoted to as chlorinate. Dissolved substance is distinct as that which can pass concluded a very fine strainer, a mesh with a pore size of 0.2 µm [3]. Salinity can be uttered in the form of an addition portion the mass of the dissolved ingredient in an element mass of enlightenment. Salt water unsurprisingly has a mass salinity of around 35 g/kg though inferior values are habitual near coasts where rivers enter the ocean [19]. Rivers and lakes can have a wide range of salinities from less than 0.01 g/kg to a few g/kg even nevertheless there are many spaces where sophisticated salinities are originated [18]. Salinity is usually connected to the sum of masses of a subset of these melted chemical constituents relatively than to the unknown mass of salts that gave rise to this structure for practical reasons. Eight main ions in traditional waters for many purposes this sum can be incomplete although for seawater at highest exactness a supplementary seven minor ions are also unified. The major ions lead the lifeless masterpiece of most natural waters and hydrothermal springs include some Incomparable pit lakes and waters. Oxygen and nitrogen are not usually included in descriptions of salinity for the concentrations of dissolved gases [17]. Though carbon dioxide gas which when dissolved is moderately transformed into carbonates and bicarbonates is often integral. Silicon in the diversity of silicic acid which frequently appears as an impartial grain in the pH range of most likely waters may also be combined for some resolves [9]. Salinity is for oceanographers mostlyassociated with one of a set of obvious dimension methods. As the main techniques growth so do unusual allegories of salinity. Before the 1980s Salinities were essentially precise using titration-based methods [8]. Titration with silver nitrate could be castoff to decide the focus of halide ions primarily chlorine and bromine to stretch chlorinate. In 1978 salinity scale used of electrical conductivity dimensions to estimate the ionic content of salt water lead to the development of scale [12]. Salinities intended using PSS-78 does not have unit but the suffix PSU that means signifying practical salinity unit is sometimes added to PSS-78 volume standards [18]. A new usual for the properties of seawater called the thermodynamic equation of seawater 2010 (TEOS-10) was presentedencouragingultimate salinity as a surrogate for practical salinity and conformist temperature as anancillary for possible temperature [13]. This standard comprises a new scale called the reference arrangement salinity scale in 2010. On this scale absolute salinities are voiced as a mass fraction in grams per kilogram of solution and Salinities are strong-minded by combining electrical conductivity scopes with other information on this scale that can explanation for local changes in the masterwork of salt water. So here is an example of salt water from maximum locations with a chlorinate of 19.37 ppt will have salinity of 35.00 ppt, a PSS-78 practical salinity of about 35.0, and a TEOS-10

absolute salinity of about 35.2 g/kg. The electrical conductivity of this water at a temperature of 15 °C is 42.9 mS/cm. Chemists and Limnologists frequently define salinity in terms of mass of salt per unit volume uttered in units of mg per liter or g per liter. It is indirect that though often not stated but value applies exactly only at some reference warmth. Values accessible in this way are usually exact to the order of 1 percent and limnologists also use electrical conductivity that means reference conductivity as a delegation for salinity. So the dimension may be corrected for heat belongings and is generally uttered in units of µS/cm. Lake or river water with a salinity of unevenly 70 mg/L will usually have a precise conductivity at 25 °C of between 80 and 130 µS/cm but the real ratio be contingent on the ions present [13]. Through thickness measurements are also used to approximation salinities mostly in highly saline lakes infrequently solidity at anaccurate heat is used as an alternate for salinity [6]. An empirical salinity relationship developed for an exacting body of water is used to guess the salinity of samples from a thoughtful solidity. Salinity is an environmental factor of widespread importance swaying the types of organisms that live in a body of water [5]. Salinity influences the kinds of plants that will yield either in a water body or on land fed by water or by a groundwater. A plant altered to saline conditions is called a halophyte and a halophyte which is charitable to residual sodium carbonate salinity is termed glasswort or saltwort or barilla plants [4]. Organisms usually microbes that can live in very salty conditions are classified as extremophiles or halophiles specifically that can undergo a wide range of salinities. Salt is luxurious to abolish from water and salt content is a main factor in water custom such as transportability. The amount of salinity in oceans is a driver of the world's ocean movement where density changes due to both salinity changes and temperature changes at the superficial of the ocean construct changes in sanguinity which cause the plummeting and rising of water masses [16]. Changes in the salinity of the oceans are likeness to give to global changes in carbon dioxide as more saline waters are less soluble to carbon dioxide [7]. Water moves into plant roots by anexpansion known as osmosis which is proscribed by the equal of salts in the soil water and in the water surrounded in the plant. Water may gush from the plant inheritance back into the soil if the equal of salts in the soil water is too high. Results in dehydration of the plant instigatingharvesttrash or even death of the plant [11].

Study area

Jabakhali mauza is located on the South-west region at Satkhira district in Bangladesh (Figure 1). The Gorai River distributary from the Ganges is the solitaryimportant upstream fresh water foundation in the western portion of the region. As anupshot, salinity levels in the region reduction from west to east as well as from south.

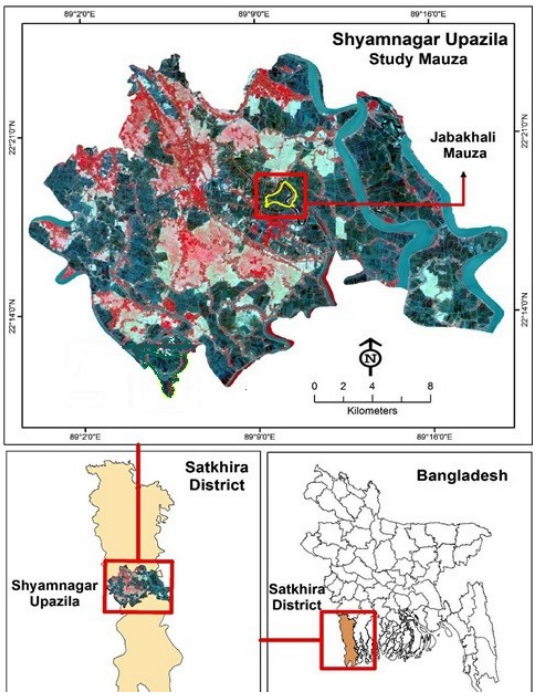


Figure 1. Study Area

Data and Methods

Sample has been composed from the field in 6 inch depth. Salinity level investigation into the coastal area and its impressions on agriculture crops using ECe with HANNA Model HI 933100, Geo analysis (ECe, pH), temperature, Moisture, Soil & Water test of study area have been used for salinity measuring by salinity Metter and pH Metter. Geographical Information System (GIS) and Remote Sensing (RS) are used to visualize various phenomenon related with this study.

Measurement of Electric Conductivity with HANNA Model HI 933100 Conductivity Meter

Conductivity Calibration

Make sure that the probe is completely dry also inside the PVC sleeve. Turn the instrument on by pressing ON/OFF. Press CAL. The display will show '0.0 µS1, 'CAL1 and a 'BUF' symbol. After a short time 'CON1 will start blinking then press CFM.

Immerse the probe in a 0.01 M KC1 solution. The display will show '1413 µS', 'CAL1 and a 'BUF' symbol. After a short time 'CON ' will start blinking on the display. Press CFM (confirm). Press ON/OFF. The instrument is now ready for use. The conductivity calibration must carry out daily.

Measurement of Electric Conductivity of Soil Extracts and Water

1. Go the instrument on by pressing ON/OFF.
2. Sparkling the probe with water and, if possible, with acetone. Let it dry and submerge it in the soil excerpt or water.
3. Change the probe slowly up and down until the reading becomes stable. Read the EC at 25°C from the display.
4. Eliminate the probe from the soil suspension, clean the probe with water and, if possible, acetone, let it dry and submerge it in the next soil suspension to be measured.
5. Once all measurements have been completed, turn the instrument off by pressing ON/OFF. The probe is cleaned and kept in distilled water orin dry condition.

Soil Salinity and pH Measurement of Jabakhali mauza

Saline Soil encompasses an excess of soluble salts, especially sodium chloride. In other words, soils that develops under the influence of the electrolyte of sodium salts, with a nearly neutral reaction. The estimates indicate that Bangladesh has about 1.06 million ha of land affected by salinity in 2019. Soil test result of Jabakhali mauza is showing in Table 1. The total area of Jabakhali mauza includes deltaic floodplains and offshore islands andlies around the northern apex of the Bay of Bengal.

Table 1. Soil Salinity and pH measurement (In Lab) of Jabakhali mauza

Plot No	EC	pH	Plot No	EC	pH
01 (Road)	4.1	5.9	40	7.5	6.2
2	3.8	8.1	43	4.3	6.8
3	4.9	7.3	52	2.3	7.6
4	3.9	6.7	55	4.8	6.5
5	6.2	6.4	57	1.5	8.3
6	2.9	7.9	58 (Paddy land)	5.5	6.5
7	5.3	6.9	59 (Paddy land)	9.1	7.1
8	4.1	6.9	61	2.1	8.1
9	2.3	7.8	62	5.9	6.8
12	4.2	6.5	73	3.7	6.5
16	3.7	6.7	82	4.6	5.9
18	4.3	7.2	83	4.7	6.9
22	6.1	7.1	86	6.1	6.9
29	5.5	6.3	89	4.1	7.1
30	5.5	6.5	91	2.3	7.2
34	2.4	8	96 (Pond)	2.6	6.8
37	4.8	6.1	103	2.9	7.4
39 (Pond)	3.6	8.2	-	-	-

Source: Field survey, 2019

Salinity Level Distribution of Jabakhali mauza

Jabakhali mauza is thought to be one of the most vulnerable mauza in Bangladesh to Climate Change and Sea Level Rise. There are a number of environmental issues and problems that are encumbering the development of Bangladesh. Salinity is such an environmental problem which is probable to exacerbate by climate change and sea level rise in the future. The higher salinity levels have opposing impacts on agriculture, aquaculture, and domestic and industrial water use and so. The present temporal and spatial variation of salinity is expected to depreciate further as a consequence of the external drivers of change. Table 2 represents the Salinity area distribution of Jabakhali mauza.

Table 2. Salinity area distribution of Jabakhali mauza

Salinity Class (Ece (dS/m))	Area (Hector)	Percentage (%)
>2	0	0
2-3	14.8	6.7
3-4	49.43	22.5
4-5	128.6	58.4
5-6	24.58	11.2
6-7	1.5	0.7
7-8	0.77	0.4
< 8	0.46	0.2

Source: Field survey, 2019

Figure 2 shows Salinity level distribution of Jabakhali mauza where most of the saline impact land is 5 to 6 ECe (ds/m). The highest salinity of Jabakhali mauza 8 ECe (ds/m) above that is too much dangerous for any kind of agricultural production. The less salinity level of Jabakhali mauza is about 2 ECe (ds/m).

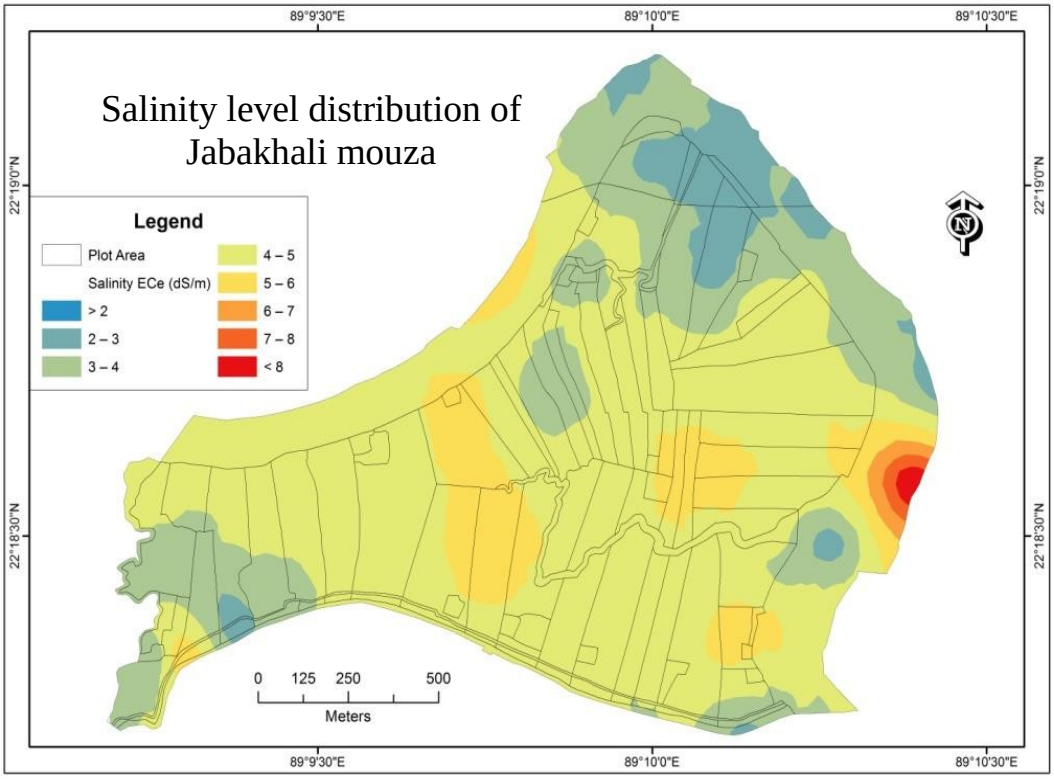


Figure 2. Salinity level distribution of Jabakhali mouza

Average salinity concentrations at the Jabakhali mauza are higher in the dry season than in the monsoon, due to lack of freshwater flows from upstream. The salinity normally builds up from October to the late May, and it remains higher during the dry season, usually from February to May. At the end of May, salinity level drops sharply due to upstream flows and rainfall.

pH level distribution of Jabakhali mouza

Soil pH is the negative logarithm of hydrogen ion absorption in soil solution. To measure the degree of soil acidity and alkalinity, soil pH is a very imperative variable and it helps to know soil properties chemical, biological and indirectly physical environment comprising both nutrients and toxins. The activity of micro-organisms, plant growing, biochemical breakdown, solubility and absorption of colloids etc. are known through soil pH. The pH of a solution is a ration of the molar absorption of hydrogen ions in the solution and as such is a measure of the acidity or basicity of the elucidation. Table 3 shows pH area distribution of Jabakhali mauza. Figure 4.5 presents the pH level dispersal of Jabakhali mauza. The ideal range of pH in soil is 6.0 to 6.5 because most of the plant nutrients are available in this stage. In most cases, a pH range of 6.0-7.5 is optimum for the passableobtainability of nutrients in the soils of Bangladesh. The highest pH value was 8.0 and the lowest pH value was 5.85. The average value is 7.06. In the current study area, most of the soil was alkaline (pH > 7.5). This pH is not appropriate for farmingmanufacture.

Table 3. pH area distribution of Jabakhali mauza

pH Range	Area (Hector)	Percentage
5.9 – 6.2	0.9	0.41
6.2 – 6.5	4.58	2.1
6.5 – 6.8	49.85	22.64
6.8 – 7.1	108.7	49.38
7.1 – 7.4	40.45	18.37
7.4 – 7.7	11.29	5.12
7.7 – 8.0	3.75	1.7
8.0 – 8.3	0.62	0.28

Source: Field survey, 2019

The pH below 8.5 indicates saline soil, which is also testified by Brady and Weil. The highest pH value in the study area was 6.85 and the lowest pH value was 5.3. The highest pH value in the study area was 7.90 and the lowest pH value was 5.2. The average pH value of soil samples in the study area was 7.06. The average pH value is increased over time. The pH value has increased day by day due to natural disasters. These natural disasters cause flood which is the reason of saline water intrusion. Another important cause for increasing pH is shrimp culture which affects pedological and environmental change in soil. Figure 3 shows pH level distribution of Jabakhali mauza.

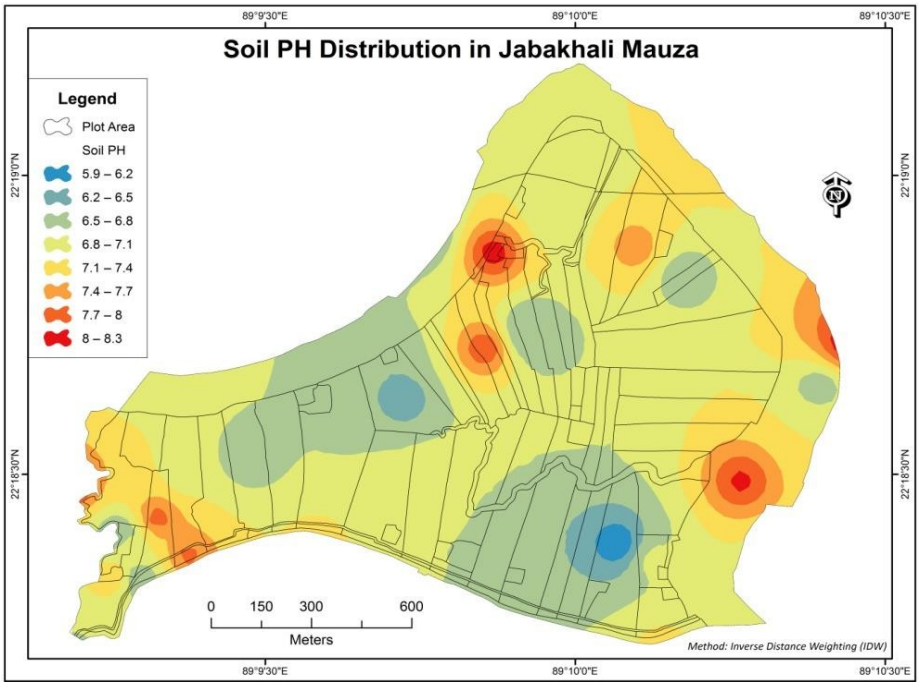


Figure 3. pH level distribution of Jabakhali mauza

Water salinity and pH measurement in field

Salinity and pH are two chemical factors that should be assumed consideration when growing plants. They are complicated in plant nutrition and soil lushness and can be manipulated to ensure that their effects do not limit plant growth. Salinity can occur unsurprisingly where drainage is poor, in inland areas that were once swamped by coastal area of Bangladesh. Salts are chemical compounds composed of two parts (ions) that have a positive or negative charge and so will carry an electrical current. Therefore salt absorptions can be determined by measuring the electrical conductivity of a solution. As the salt concentration increases, so does the electrical conductivity.pH technically denotes to the concentration of hydrogen ions in a medium. In practical terms it is a portion of the acidity or alkalinity of the growing medium and as such indicates the accessibility of nutrients to plants.

Maximum plants produce best in soils or soil-based media with pH values between pH 5.5 and 6.5. Artificial mixes typicallynecessitate a slightly more acid pH of 5.0 to 6.5. Within these ranges all nutrients are eagerly available. At low pH in soil-based media, aluminum and manganese can become toxic. Although hydrangeas need high levels of aluminum to produce blue flowers and calcium, magnesium and molybdenum may be preventive. As the pH rises to pH 7.0 and above, manganese, boron and particularly iron may developscarce. Where nutrients are continually abounding either through the irrigation water or slow-release enrichers, the pH value is of lesser prominence.

Water salinity and pH of Jabakhali mauza

Water Salinity of Jabakhali mauza is showing in Table 4. Most of the plots have moderate salinity levels of the Jabakhali mauza. Here the amount of salinity is between 0.1% to 0.5%. 3% to 4% salinity is present in the peak amount of water of Jabakhali mauza. As a result of shrimp cultivation in this mauza for the last 7 years, the amount of salinity has not yet been increased. Water pH level of Jabakhali mauza is showing in (Table 4). The value of pH is between 4.1 to 6.2 in Jabakhali mauza. Average water pH value 5.55 in this mauza. Which indicates low level of acidic in water. So this water is less affected by the growth of plants.

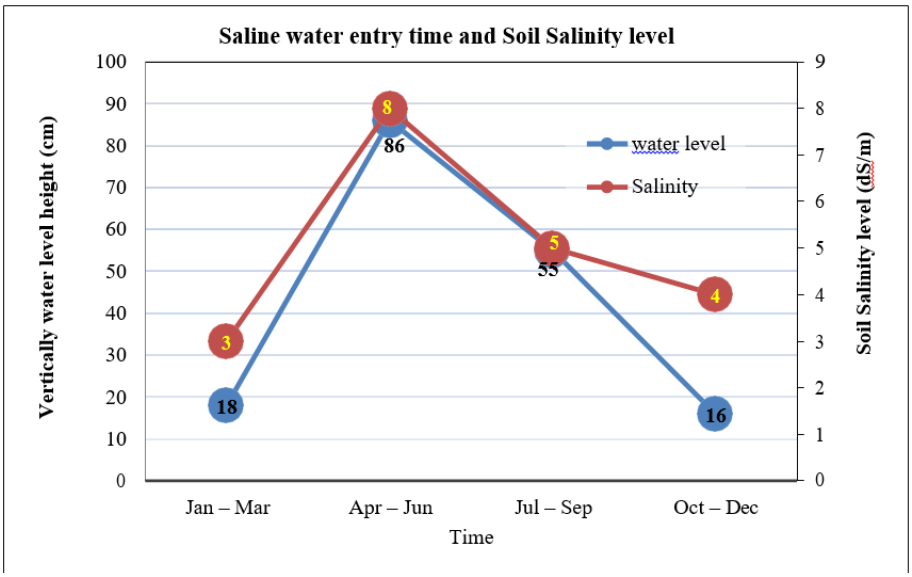
Table 4. Water Salinity and pH of Jabakhali mauza (field test)

PL No	Salinity Rate (%)	PH	Remarks
2	0.4	6	-
3	0.3	5.7	-
4	0.1	5.2	-
5	0.1	5.1	-
7	0.3	5.2	-
9	0.1	5.8	-
18	0.3	5	-
39	0.4	6.2	-
42	0.4	5.8	-
43	0.5	5.4	-
54	0.4	5.9	-
55	0.4	5.4	-
57	0.4	5.8	-
58	0.2	5.3	Paddy Cultivation
59	0.4	4.1	Paddy Cultivation
61	0.1	6	Fresh water Dighi
83	0.3	6	-
86	0.3	5.6	-
90	0.3	5.5	-
96	0.1	5.7	Pond
103	0.2	5.4	-

Source: Field survey, 2019

Saline water entry time and soil salinity level

Shrimp cultivation is a long-term cultivation method. For the use of prawn, this fish is to be experiential for 9 to 10 months. Direct observations have exposed that shrimp farms store the salt water throughout the year. During of the winter season (January) water is dehydrated in the shrimp farm for 1 month. At this time the farm is prepared and stock the salt water from the beginning of February. This activity reached the water level and soil salinity highest from April to June (water level 86 cm and salinity 8 dS/m). So, from April to June, there is the highest amount of salt water and soil salinity in the Gher (Figure 4). Since July, the water gradually decreases.



Source: Field survey, 2019

Figure 4. Arrival time of saline water in agriculture field.

Discussion and conclusion

The water of Jabakhali mauza is not functional for domestic purposes if salinity is higher than 1ppt, though it is still promising for crop and livestock agriculture unless salinity exceeds 2ppt. Some freshwater aquaculture is still possible when the salinity is below 4ppt. However, in the south and western part of the study region salinity is higher than 4ppt during the dry season which has fascinated brackish water shrimp farming in Satkhira district. About more than 80% of study area are precious by salinity. Agricultural land use in these areas is very poor, which is much lower than country's usual cropping strength. Salinity causes disapproving environment and hydrological situation that restrict the normal crop production throughout the year. The factors which contribute pointedly to the development of saline soil are, tidal flooding throughout wet season, straight inundation by saline water and upward or lateral drive of saline ground water during dry season. The harshness of salinity problem in Bangladesh upsurges with the desiccation of the soil. It disturbs crops depending on degree of salinity at the precarious stages of growth, which reduces yield and in severe cases total yield is lost. The salinity problem conventional very little attention in the past. It has become authoritative to explore the possibilities of increasing potential of saline lands for amplified production of crops. Thus it is essential to have an appraisal of the present state of land areas pretentious by salinity.

The pH of a natural soil be contingent on the mineral composition of the parent material of the soil and the weathering responses undergone by that parent material. Soil acidification occurs over time as the products of weathering are leached by water moving downwards in warm and humid environments through the soil in the study area. Soil weathering and leaching are less intense and soil pH is often neutral or alkaline in dry climates. Stalwartly alkaline soils are sodic and dispersive with slow penetration, low hydraulic conductivity and poor available water aptitude. Plant growth is harshlyconstrained because aeration is poor when the soil is wet in dry conditions.Plant-available water is rapidly exhausted and the soils become hard and cloddy. On the other hand manymuscularly acidic soils have strong aggregation, good internal drainage, and good water-holding characteristics. However, for many plant species, aluminum toxicity severely limits root growth and moisture stress can occur even when the soil is relatively moist. Yet, a plant may be prejudiced of a particular pH in some soils as a result of a particular mechanism and that mechanism may not apply in other soils. For example, a soil low in molybdenum may not be suitable for soybean plants at pH 5.5, but soils with sufficient molybdenum allow optimal growth at that pH. Likewise, some calcifuges can tolerate calcareous soils if sufficient phosphorus is supplied. Another confounding factor is that different varieties of the same species

often have different suitable soil pH ranges. Plant breeders can use this to breed varieties that can tolerate conditions that are otherwise considered inappropriate for that species examples are projects to breed aluminum-tolerant and manganese-tolerant diversities of cereal crops for food production in strongly acidic soils. Excellently ground agricultural lime is often practical to acid soils to increase soil pH. The amount of limestone or chalk desirable to change pH is determined by the mesh size of the lime and the cushioning capacity of the soil. The cushioning capacity of a soil depends on the clay content of the soil, type of clay, amount of organic matter present and may be related to the soil caution altercationaptitude. Soils with high clay content will have a higher buffering capacity.Soils with little clay and soils with high organic matter will have a higher buffering capacity, those with low organic matter. Soils with higher buffering capacity require a greater amount of lime to achieve an equivalent change in pH. So, the findings of the research show that the severity of salinity problem in study areas increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth.

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