Available Online at http://www.journalajst.com

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 11, Issue, 05, pp.10978-10984, May, 2020

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCHARTICLE

ANALYSIS OF SALINITY LEVEL IN COASTAL SOIL: A CASE STUDY ON KALINCHI MAUZA AT SATKHIRA DISTRICT OF BANGLADESH

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ARTICLE INFO

Article History:
Received 07th February, 2020
Received in revised form
19th March, 2020
Accepted 14th April, 2020
Published online 30th May, 2020

Key words:

Salinity; Soil;Analysis; GIS; Coastal area; Bangladesh.

ABSTRACT

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 study tries to trace out salinity level and causes in coastal soil. The research was performed around Kalinchi mauza under Shyamnagar Upazila, Satkhira district in Bangladesh. 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 conductivity Meter and pH with HANNA HI 9210N pH Meter 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.

Citation: ***Dr. Shamalesh Biswas, Towfiqul Islam Khan and Dr. Md. Nurul Islam.* 2020.** "Analysis of salinity level in coastal soil: a case study on kalinchi mauza at Satkhira District of Bangladesh", *Asian Journal of Science and Technology*, 11, (05), 10978-10984.

INTRODUCTION

Bangladesh glowers various types of usual disaster every year. Saline water intrusion is a major problem and differing issue in south-west coastal region of Bangladesh. The southwest coastal region of Bangladesh has a very dense situation concerning fresh water and saline water interaction. Alterations in tide and fresh-water flow result in the progress and retreat of the salinity limit (Gain, *et al*, 2008). So, one of the key problems in the coastal zone of Bangladesh is Salinity intrusion. It is increasing alarmingly due to natural and anthropogenic causes. About 53% of the coastal areas are pretentious by salinity. Salinity is causing waning in soil productivity and crop yield which results in severe squalor of bio-environment and ecology (Haque, *et al*, 2013). Bangladesh is an agrarian country having 80% of its people fully reliant on agriculture. It is estimated that more than 30% people live in this area and their employment is totally needy on nature. However, more than 50% of coastal land previously goes under salinity. Salinity has degraded the quality of land and limited the diversity of cultivable crops. Due to sea level rise along with flood or land erosion the quality of land and fresh water has extinct (Mustari and Karim, 2014).

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"Sea level rise affects coastal agriculture, especially rice production in two ways. Salinity intrusion degrades soil quality which in turn decreases rice production. When the rice fields are converted into shrimp ponds, total rice production falls (Sarwar and Khan, 2007). The coast of Bangladesh consists of 19 districts shelters 32% of the country and lodges more than 35 million people (Huq and Rabbani, 2011). This zone is highly probable with diverse natural resources. The Sundarbans largest mangrove delta in the world sited in this coastal belt affords potential and inventive for the livelihoods of the local communities and tourism sectors. The coastal zone is highly susceptible because of a number of reasons including variations in temperature, erratic behavior of rainfall, cyclonic events and famine and salinity intrusion. The potential sea level increase may exacerbate the exposure of the local communities. Currently, the cyclones convoyed by storm surges and the rise of salinity intrusion in the water and soil are the key catastrophic phenomena for the coastal people (Rabbani, *et al*, 2013). Saline water which can be enabled by usual conditions, human actions and climate change is a huge intimidation to mankind from social, environmental, economic, and ecological lookout. Agriculture the largest consumer of water is recognized as both provider and most visible sector to saltwater intrusion especially in low lying coastal areas like Kalinchi mauza of Shyamnagar Upazilla in Satkhira. Bangladesh with the escalating stress and antagonism of water unsettled to economic population progress, flourish, and climate fluctuations. Through punitive attrition and passionate saline water intrusion the preponderance of the plants and trees are departed and their natural and healing plants, gardens, agricultural land and trapping grounds along with the animals are away (Ahsan and Sattar, 2010). Sustainable water resource supervision is straight away anticipated remaining to its necessary in solving this issue. Salinity is one of the most severe environmental issues limiting the efficiency of agricultural yields. Most crops are sensitive to salinity caused by high concentration of salts in the soil (Anati, 1999). As yield of crop production had been abridged due to salinity, the cost of production had gradually enlarged. In addition to this enormous financial cost of production there are other serious effects of salinity on infrastructure, water supplies, on soil structure and immovability of communities. The total quantity of dissolved salts in the irrigation water and their composition stimulus the soil salinity. Therefore, some parameters such as source water EC and its minerals content should be verified. The type and amount of fertilizers applied to soil distress its salinity. Some fertilizers contain high levels of possibly damaging salts such as potassium chloride or ammonium sulphate (Bhuiyan and Dutta, 2011). Overuse and misuse of fertilizers clues to salinity buildup and should be evaded. The higher the water magnitude useful the closer soil salinity is to irrigation water salts absorption. When the soil dries the concentration of salts in the soil solution is enlarged. Since salts move with the wetting front the salts accumulate in exact profiles according to the irrigation regimen and the type of irrigation reused.

When irrigating using sprayers water and salts move deeper according to the soil's penetration capacity and the water quantity until they stop at a certain intricacy. When using drip irrigation there is also a lateral effort of water and salts. A poorly drained soil might reach salinity level that is injurious to the plants and to the whole crop. A soil that was not blushing after a previous growing cycle might contain high level of amassed salts (Culkin and Smith, 1980).

Study Area: Kalinchi mauza is situated on the South West region remains higher than the eastern part at Satkhira district in Bangladesh (Figure 1). The Gorai River distributary from the Ganges is the only important upstream fresh water cradle in the western part of the region. As a result, salinity levels in the region reduction from west to east as well as from south.

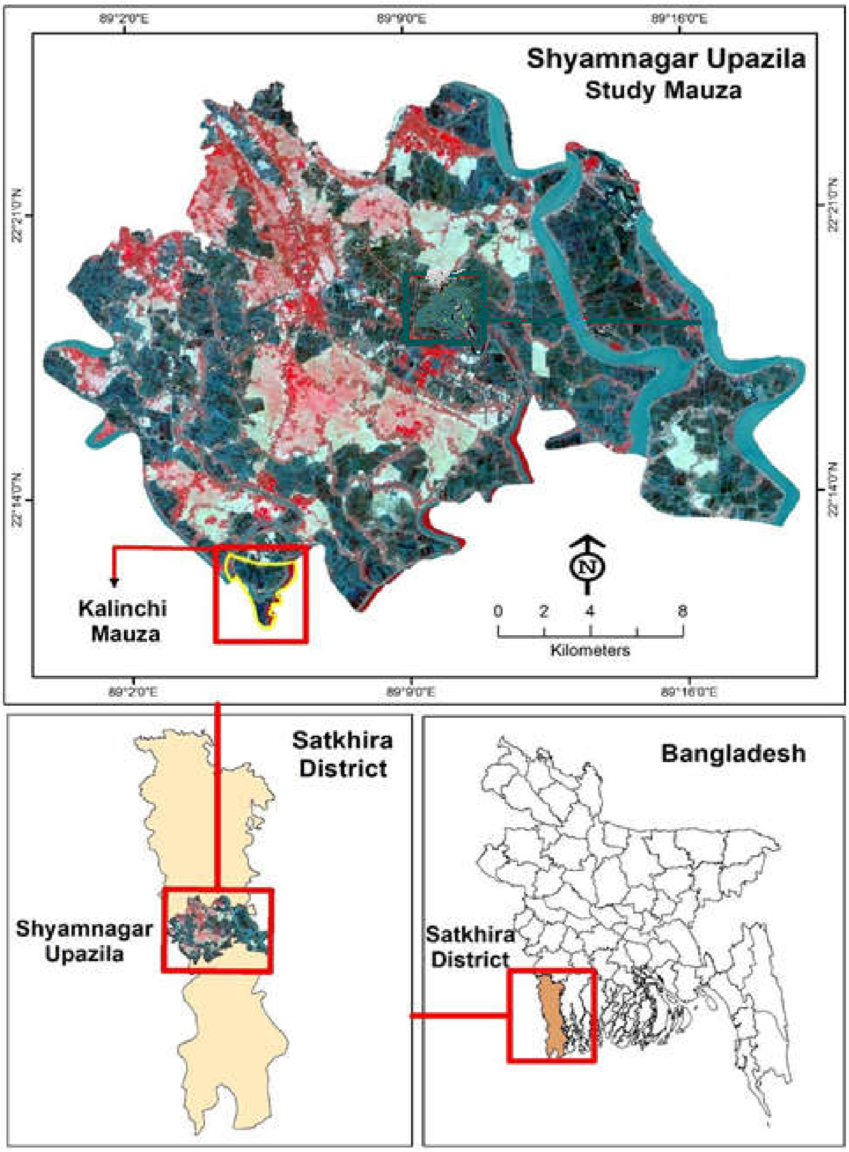

Figure 1. Study area

Data and Methods

Sample has been collected from the field in 6 inch depth. Salinity level analysis into the coastal area and its impacts on agriculture crops using ECe with HANNA Model HI 933100 conductivity Meter and pH with HANNA HI 9210N pH Meter, 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.

***Interpretation of Salinity Data*:** There are various tools have been used to interpret the saline data such as Microsoft Excel, SPSS, ArcGIS etc. The collecting saline data from field survey that has been analyzed by Excel and SPSS software and then data are presented by table and graph.

***Geo-statistical Analysis*:** Geo-statistical analysis affords a widespread set of tools for creating surfaces that can be used to visualize, analyze, and understand spatial phenomena. Here geo-statistical analysis are used to show the distribution of salinity rate of soil (Figure 2).

***Process*:** ArcGIS 10.2, Add Data, Geo-statistical Analysis, Geo-statistical Wizard, Kriging/ CoKriging Method.

Soil Salinity Field-test: By digging hole with a shovel and take samples in a plastic bag from study area. These samples took from a depth of 10 to 30cm and near trees or in a deep-rooted pasture sample had been taken from below 30cm due to salinity increase with depth as surface salts are flushed down by rainfall or irrigation. It is very important that soil salinity will be highest before a rain break or before irrigating.

Procedure of Soil Analysis:

- Take a soil sample and consent it to dry as long as possible, leave the sample bag open to let moisture leakage.
- Infatuation the air dried sample so there are no large aggregates. Necessity to crush these aggregates with a rolling pin or mallet. Soil particles should be no larger than 2 mm. Remove as much distant matter, plant material and stones from the sample.
- The test contains adding one part soil for every five parts water. So put 50g of soil (weighed on scales) into the container then essential to add 250ml of the rainwater or purified water.
- Shake the container energetically for three minutes to make sure the salts dissolve. More shaking will bring more salts into the solution and rise the accuracy of the test.

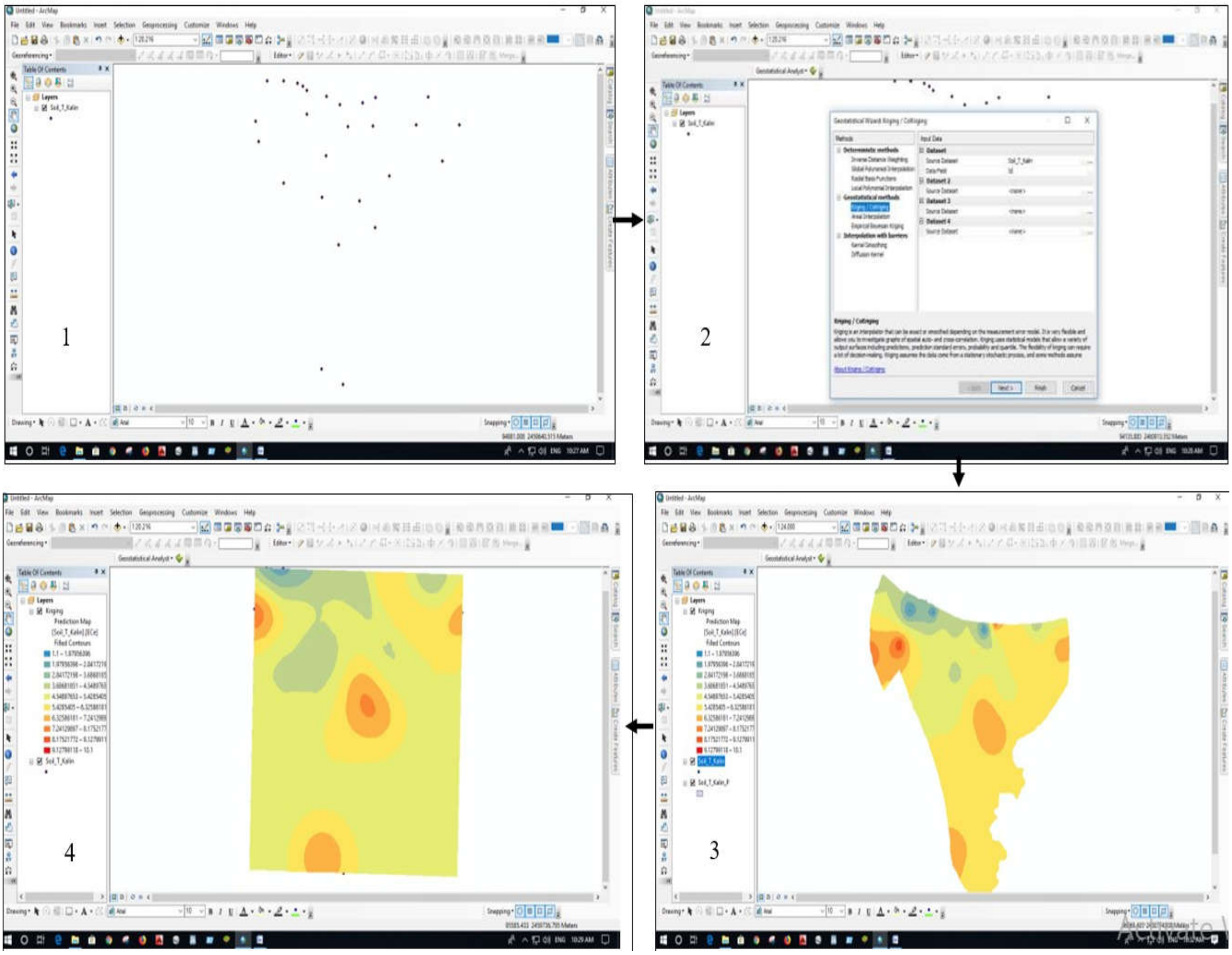

Figure 2. Geo-statistical Analysis process

- Consent the solution to settle for at least one minute before testing.
- Domicile the salinity meter in the solution but not in the soil at the bottom of the jar and read the show once it has steadied.
- Wash the meter conductors and sample jar with purified or rainwater and dry.
- Change salinity meter readings to soil salinity (ECe) by multiplying the value by the Conversion Issue constructed on the texture of the soil sample.
- .

Water and soil salinity are dignified by passing an electric current between the two conductors of a salinity meter in a sample of soil or water. The electrical conductivity or EC of sailor water sample is prejudiced by the absorption and composition of dissolved salts. Salts rise the aptitude of a solution to conduct an electrical current, so a high EC value designates a high salinity level. Salinity capacities are often testified with subscript abbreviations to indicate the origin of the sample tested and the method used to regulate the salinity measurement. The method used will affect the accuracy of the results and sureness in interpretation. Common ellipses and their descriptions are explained below.

explanation is verified. An EC1:5 can be achieved in the field or a workroom.

ECeis the assessed amount of salt in the soil. It is estimated by swelling the EC1:5 value by a suitable factor connected to the soil texture of the sample. This can be resolute in the field or laboratory.

ECse is the electrical conductivity of a saturated soil excerpt which should be steered by a National Association of Testing Authorities.

ECa is the seeming electrical conductivity. It is a quantity of bulk electrical conductivity of uninterrupted soil in the field. It is measured with an electromagnetic tool in a soil survey.

Electrical Conductivity (ECe) Procedures the aptitude of the soil solution to conduct electricity and is ex-pressed per meter (dS/m, which is equivalent to mmhos/cm). As pure water is a poor conductor of electricity increases in resolvable salts result in proportional increases in the solution EC. The standard process for salinity testing is to measure EC of a solution mined from a soil wetted to a “satu-ration paste.” According to U.S. Salinity Laboratory Staff (1954), a saline soil has an EC of the soaked paste excerpt of more than 4 dS/m a value that agrees to approximately 40 mm salts per liter.

Table 1. Salinity class

Class	ECe (mmhos/cm)
Normal	Below 4.0
Saline	Above 4.0
Sodic	Below 4.0
Saline-Sodic	Above 4.0

Source: NRCS, 2019

Table 2. Salinity Classification, Range and Reaction

Soil Salinity Class	*ECe (dS/m)	Crop Reaction
Non Saline	0-2	Salinity effects are mostly negligible.
Slightly Saline	2-4	Salinity effects are mostly negligible except for themost sensitive plants.
Moderately Saline	4-8	Yields of many crops restricted.
Strongly Saline	8-16	Only tolerant crops yield satisfactorily.
Very Strongly Saline	16-42	Only a few very tolerant crops yield satisfactorily.
Brine	>42	Only tolerant Sea Plant and Mangrove plants.

Source: SRDI, 2019
* ECe (ElectricalConductivity)
* dS/m = deciSiemens permetre

Table 3. Soil extracts Interpreting ECe

Electrical Conductivity (mmhos/cm)	Rating	Interpretation
0 - 0.15	Very Low	Plants may be starved of nutrients.
0.15 - 0.50	Low	If soil lacks organic matter.
		Satisfactory if soil is high in organic matter.
0.51 - 1.25	High Medium	Okay range for established plants.
1.26 - 1.75	High	Okay for most established plants.
		Too high for seedlings or cuttings.
1.76 - 2.00	Very High	Plants usually stunted or chlorate.
	Excessively	Plants severely dwarfed; seedlings and rooted
>2.00	High	Cuttings frequently killed.

Source: NRCS, 2019

ECw is the salinity of water. This can be dignified in the field or a laboratory.

EC1:5is the first of three steps to approximation soil salinity (ECe). It is determined by intercourse 1 part soil with 5 parts purified or deionized water. After mixing the sample and letting the sediment to settle, the electrical conductivity of the

Crops vary in their lenience to salinity and some may be badly pretentious at ECs less than 4 dS/m. Salt acceptances are known for common crops. For example, peach is subtle whereas cotton is more salt tolerant (Corwin and Lesch, 2005). Beets and asparagus are actual accepting of salinity. The Natural Resources Conservation Service (NRCS) delivers (Table 1) the following classification of salt-affected soils using the saturated paste extraction. The general interpretation of data on electrical conductivity and exchangeable sodium percentage (Table 2) from saturated paste extracts and Interpreting ECe data from soil extracts Interpreting ECe data from soil extracts (Table 3) are given. When a soil has an SAR value of above 13 (or ESP greater than 15), it contains excess sodium that makes it a sodic soil. Excess sodium can cause soil dispersion, which prevents the formation of soil aggregates, resulting in surface sealing or crusting. Dispersion of the soil by excess sodium reduces water infiltration and movement through the soil, and also causes poor aeration. Good aeration and water movement are both essential to unrestricted growth of plant roots. To eliminate surface sealing, the soil should be treated with calcium to remove sodium. One of the most commonly used calcium sources for correcting sodium- contaminated soil is gypsum (calcium sulfate, CaSO4.2H2O). Gypsum is incorporated into the soil, followed by application of salt-free irrigation water. The amount of calcium to apply depends on the quantity of sodium in the soil. Road de-icing salt or calcium chloride (CaCl2) is also an option to provide calcium to soil, but it is more expensive than gypsum.

Lab Test Procedure: pH and ECe are measurement by the HANNA HI meter in the laboratory. Measurement of pH with HANNA HI 9210N ATC pH Meter is showing below (Figure3).

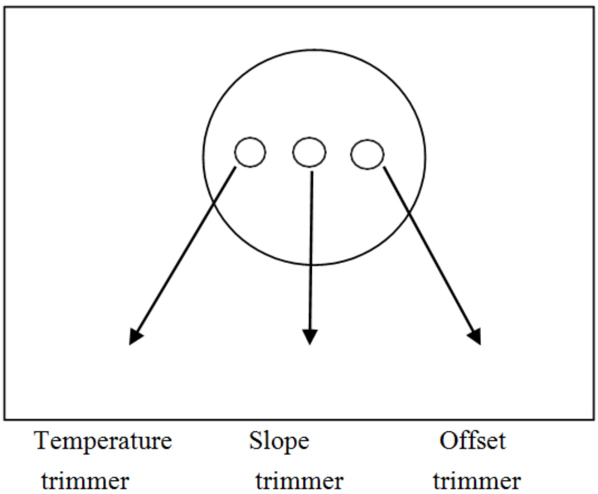

Figure 3. pH measuring Trimmer

pH Calibration Procedures

- Remove the trimmer cover by hand with a coin or a screwdriver.
- Turn the pH meter on by pressing the ON/OFF key.
- Bleach the electrode with water and wipe it dry with tissue paper. Submerge the electrode in the buffer solution with pH 6.87.
- Select the pH range by pressing the RANGE key.
- Using the small screwdriver abounding with the instrument, regulate the offset trimmer until the display shows 6.87.
- Eliminate the electrode from the buffer solution, bleach it with purified water and wipe it dry with tissue paper. Submerge the electrode in the buffer solution with pH 4.01.
- Using the small screwdriver provided with the instrument adjust the slope trimmer until the show shows 4.01.
- The adjustment made under 7 has possibly affected the adjustment made under 5.
- Therefore, recurrence step 5, 6 and 7 until the appropriate reading are shown in both buffer solutions.
- Close the trimmer cover.
- Check of the pH meter: Rinse the electrode with water and wipe it dry with tissue paper. Submerge the electrode in the buffer solution with pH 9.18. The display should show a value close to 9.18. If so, the pH meter is ready for use.

Note: The buffer solution used for calibration and checks of the instrument must be discarded after use. They must not be returned to the supply bottle.

If the soil samples to be measured usually have pH values above 7 the buffer with pH 9.18 should be used for alteration of the slope trimmer (steps 6-10 above). In this case the slope trimmer is adjusted until the display shows 9.18. The check (step 12 above) is then made with the buffer with pH 4.01 and the reading should be close to this value.

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. Press CFM (confirm). Submerge 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

- Turn the instrument on by pressing ON/OFF.
- Clean the probe with water and if possible with acetone. Let it dry and immerse it in the soil excerpt or water.
- Move the probe gradually up and down until the reading develops stable. Read the EC at 25°C from the display.
- Eliminate the probe from the soil deferralclean the probe with water and if possible acetone let it dry and plunge it in the next soil holdup to be leisurely.
- When all dimensions have been accomplished turn the instrument off by pressing ON/OFF. The probe is prepared and kept in purified water orin dry complaint.

Soil Salinity and pH Measurement of Kalinchimauza

The soil salinity intensity and extent, constraints as well as possible soil management practices to be followed in Kalinchi mauza. Soil salinity measurement and ph are the vital responsible thing for the development of production, especially in shrimp cultivation. Table 4 in the below shows that the highest soil pH is plot no 61, 17, 14, and 21. Soil Salinity high in plot 60, 33 and 5. Most of the plots are equal to soil ph of Kalinchi mauza.

Table 4. Soil Salinity and pH measurement (In Lab) of Kalinchimauza

Plot No	ECe	pH	Plot No	ECe	pH
2	7.1	8.3	14	4.1	8
5 (Starting)	3.8	8.2	15	7	8.2
5 (North West side)	10.1	6.4	17	7.7	8.5
5 (South East side)	4.9	6.5	19	4	8.1
5 (Middle of west)	3.1	7	21	8.2	8.6
5 (3)	1.2	8.3	23	4.1	7.9
6	2.6	8	29	6.2	8.1
7 (Vita)	1.5	8.3	33 (Starting)	6.2	8.1
7	3.6	8.1	33 (End)	8.3	8.2
8	4.1	8.2	38	8.1	8
10	2.9	8.1	39	2.8	8
11	4.6	8.4	60	8.7	8.3
12	6.2	8.3	61	6.1	8.5
13	1.1	8.1	-	-	-

Source: Field survey, 2019

Salinity Level Distribution of Kalinchi mauza: Saline area distribution of Kalinchi mauza is showing in (Table 5). From the table it is clear that about 6 to 7 (Ece, dS/m) captured around 215 hector agricultural land which is 43% of total land. The salinity class 4 to 8 (Ece, dS/m) is highly harmful to the irrigation system of agricultural production. Salinity level distribution of Kalinchi mauza (Figure 4) where the highest salinity is above 8 (ECe, dS/m) salinity and the lowest salinity level is under 2 (ECe, dS/m) salinity. Most of the area is surrounded by 6 to 7 (ECe, dS/m) salinity. 5 to 6 (ECe, dS/m) salinity and 4 to 5 (ECe, dS/m) salinity level are also enclosing the number of location. For the agricultural production salinity level as per 4 to 7 is much more harmful to the irrigation system. Water moves into plant roots by a process known as osmosis, which is controlled by the level of salts in the soil water and in the water contained in the plant. If the level of salts in the soil water is too high, water may flow from the plant roots back into the soil. This results in dehydration of the plant, causing yield decline or even death of the plant. Crop yield losses may occur even though the effects of salinity may not be obvious. The salt tolerance of a specific crop depends on its ability to extract water from Stalinized soils. Salinity affects production in crops, pastures and trees by interfering with nitrogen uptake, reducing growth and stopping plant reproduction. Some ions are toxic to plants and as the concentration of these ions increases, the plant is poisoned and dies Kalinchi mauza.

Table 5. Salinity area distribution of Kalinchimauza

Salinity Class (ECe (dS/m)	Area (Hector)	Percentage (%)
>2	0	0
2-3	7.15	1.4
3-4	22.96	4.6
4-5	81.39	16.3
5-6	123.67	24.8
6-7	214.9	43.1
7-8	46.75	9.4
< 8	1.78	0.4

Source: Field survey, 2019

pH Level Distribution of Kalinchi mauza: Figure 5 shows the pH level distribution of Kalinchi mauza. Soil pH is a measure of the acidity and alkalinity in soils. pH levels range from 0 to 14, with 7 being neutral, below 7 acidic and above 7 alkaline. The optimal pH range for most plants is between 5.5 and 7.0 however, many plants have adapted to thrive at pH values outside this range. The standard level of soil ph 5.5 and 7.0. The major problem when soils acidify is aluminum toxicity in the subsurface soil. Low pH in topsails primarily affects nutrient availability and decreases nodulation of legumes and nitrogen fixation in pastures. These problems are minimized if the topsoil pH is maintained above 5.5. Table 6 shows the pH area distribution of Kalinchi mauza.

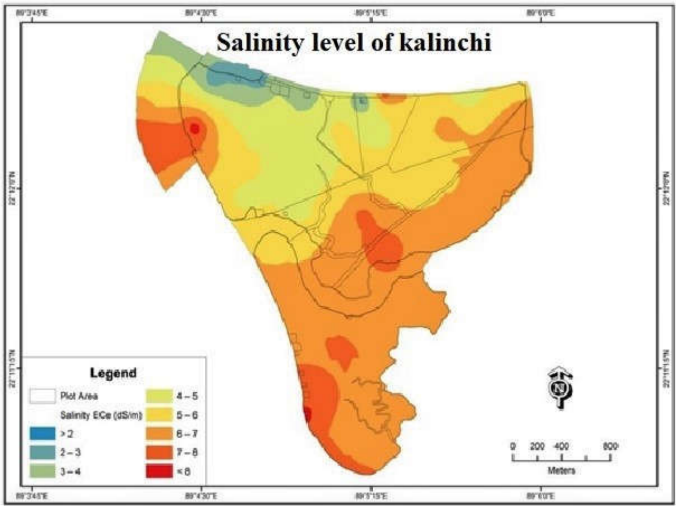

Figure 4. Salinity level distribution of Kalinchimauza

Table 6. pH area distribution of KalinchiMauza

pH Range	Area (Hector)	Percentage
6.4 – 6.68	0.31	0.06
6.68 – 6.95	3.43	0.69
6.95 – 7.22	9.2	1.85
7.22 – 7.5	18.33	3.68
7.5 – 7.78	35.64	7.15
7.78 – 8.05	95.71	19.19
8.05 – 8.32	265.28	53.21
8.32 – 8.6	70.7	14.17

Source: Field survey, 2019

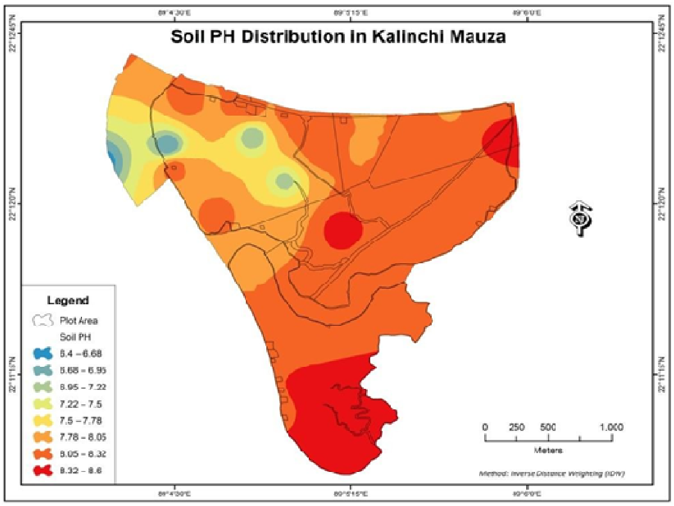

Figure 5. pH level distribution of Kalinchimauza

Water salinity and pH of kalinchi mouza: Water Salinity of Kalinchi mauza is showing in Table 7. The amount of salinity in closed water (Khal and Gher) is high. There is very few difference in the salinity of the water bodies in the area. The amount of salinity is between 0.5% to 0.8% in Kalinchi mauza. Water salinity may inhibit plant growth for two reasons. First, the presence of salt in the soil solution reduces the ability of the plant to take up water, and this leads to reductions in the growth rate is referred to as the water-deficit effect of salinity (Peverill and Lee, 1979).

Table 7. Water Salinity and pH of Kalinchimauza (field test)

Plot No	Salinity Rate(%)	pH	Remarks
2	0.6	4.8	-
5	0.6	4	-
5	0.6	5	middle of west 5 no plot
5	0.6	5	-
5	0.6	4.8	Starting corner of 5 no plot
5	0.6	4.7	South west corner of 5 no plot
6	0.5	5.2	-
7	0.5	5.2	-
7	0.1	4.6	Pond
8	0.1	5	-
11	0.6	4.6	khal
11	0.4	5.1	Fish farming by dam on Khal
12	0.6	4.8	-
14	0.4	5.2	-
15	0.8	4.2	Middle of 15 no plot
17	0.8	4.2	-
33	0.7	4.5	Middle of 33 no plot
33	0.7	4.6	End of 33 no plot
38	0.6	4.7	Khal
39	0.7	4.8	khal
61	0.7	4.7	-
60	0.8	4.6	-
Tube-well	0.1	-	-

Source: Field survey, 2019

The value of pH is between 4 to 5.2 and the average water pH value 4.74 in the study area which indicates acids. In some mineral soils aluminum can be dissolved at pH levels below 5.0 becoming toxic to plant growth. Soil pH may also affect the availability of plant nutrients. Nutrients are most available to plants in the optimum 5.5 to 7.0 range (Handreck and Black, 1984) which is inadequate in the water of the Kalinchi mauza.

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