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Chemical Characteristics of Native Soil in Shrimp Gher and Agricultural Land

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Abstract. This study was conducted to characterize the native soil at shrimp Gher and agricultural land in Khulna, Bangladesh, because at present this is a growing concern that the salinity is increasing at an alarming rate. Eight locations were selected and among them five Ghers from south part of Dumuria which is about 60 km away from KUET campus, Khulna, Bangladesh. In the laboratory, various parameters such as salinity, organic content, chloride, pH, alkalinity, conductivity and moisture content were determined by following standard methods. The chloride and alkalinity were determined manually and pH, conductivity and salinity were determined by digital meter. The organic and moisture content both were highest at 30 cm depth for both the cases of shrimp Gher and agricultural land. Chloride was highest at 15 cm depth for both the cases shrimp Gher and agricultural land. Alkalinity was highest at 30 cm depth for shrimp Gher, however, the lowest was for agricultural land. It is concluded that the salinity and organic content vary with depth, age and soil condition.

Keywords: Native soil, salinity, organic content, shrimp gher, Bangladesh.

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1. Introduction

The world largest mangrove forest, Sundarbans is situated at the south-western coastal zone of Bangladesh that covers about 40% of the total forest and gives good feedback to the national economy. From last few years, it has been said that salinity is increasing drastically in this particular region of Bangladesh due to sea water intrusion, reduction of fresh water flow and human activities like shrimp farming. Details of shrimp farming in southwest (Khulna division) Bangladesh are reported [1–4]. Effects of shrimp aquaculture industry (in coastal Bangladesh) on ecology and economic development are studied [5–9]. Salinity, sanitary hygiene and organic contents may affect the shrimp production [10–12]. Management of shrimp aquaculture and coastal/nearshore fisheries are investigated [13–15]. Gher is a coastal shrimp aquaculture in a field or pond situated by the side of a river. People cultivate rice in winter at Gher and shrimp in summer [14]. An integrated management approach for shrimp culture development is proposed [16]. Standard seawater comparisons are updated [17]. Socio-economic impacts of shrimp and crab aquaculture are reported [18–21].

This study is carried out to determine the present condition about salinity and organic content of west part of Khulna, Bangladesh. Soil salinity is the salt content in the soil. Salt is a natural element of soils and water. The ions responsible for salinization are: Na^+, K^+, Ca^{2+}, Mg+ and Cl^-. About 10.2 lakh hectare of land is now salinity contaminated in 19 districts according to a study by the Bangladesh Soil Resources Development Institute. It has caused crisis of drinking water [10].

When plant/debris is added to soil, it is broken down by microbes. The American Society for Testing and Materials (ASTM) stated an approach for classifying soils having organic contents. Electrical conductivity (EC) is a measure of soil conductance where a current travels.

Alkaline soil defined as the soils with pH greater than 7.3. Soil alkalinity is a naturally occurring phenomenon that can be escalated by human activity. Water content is the quantity of water contained in a mineral on a volumetric basis. The ideal range of pH in soil is 6.0 to 6.5 because most of the plants' nutrients are available in this stage [22]. The total organic carbon (TOC) is the amount of organic matter in soils. This variation occurs due to soil formation and geologic condition of that particular area. During the soil formation, heavy metals moves downwards and the organic matter moves up due to their light weight and composition of organic soils.

Both saline and fresh water can be used for this cultivation [5]. Currently, Bangladesh produces more than 2.5% of the global production of shrimp and becomes the 7th largest exporter of shrimp [2]. Fisheries sector contributes 4.57% to the Gross Domestic Product (GDP) in Bangladesh and shrimp alone contributes about 0.07% of total export income [6]. In 2009-2010, Bangladesh earned about Taka 45000 million by exporting shrimp [21]. Rearing of fish along with paddy is an age-old practice in Bengal. Use of pesticide in recent years, however, has greatly impeded fish culture in paddy fields [3].

Apart from the overall contribution of shrimp cultivation to the national economy of Bangladesh, it has been causing severe threats to local ecological systems, such as deterioration of soil and water quality, depletion of mangrove forest, decrease of local variety of rice and fish, saline water intrusion in ground water, local water pollution and change of local hydrology [9]. The Environmental Justice Foundation (EJF) documented the case of women who walk further and long distances to carry drinking water due to increase of salinity in nearer water sources (e.g. tube well and well) as a result of shrimp culture [23]. Water quality and partial mass budget in extensive shrimp ponds are studied [24].

In this study, the native soil is characterized in terms of organic content and salinity collected. Eight locations were selected and among them five Ghers from south part of Dumuria which is about 60 km away from KUET campus and another three from west part of Teligati (near Khulna bypass road) which is about 4 km away from KUET campus (Khulna, Bangladesh). In each Gher, three points were selected and from each point, two soil samples were collected at the depth of 15 and 30cm from the existing ground surface. In the laboratory, through standard methods various parameters such as salinity, organic content, chloride, pH, alkalinity, conductivity and moisture content were determined.

2. Methodology

It is very essential to determine the amount of salinity and organic content in shrimp Gher and Agricultural Land. Because due to sea water intrusion, reduction of fresh water flow and human activities like shrimp farming, salinity is increasing in south part of Khulna day by day. In the laboratory, the salinity test was performed on the collected soil sample to determine the amount salinity.

Laboratory Investigation: In 2013, the soil samples were collected from eight places among them four were shrimp Gher, two were combined of shrimp Gher and Agricultural land and another two were Agricultural land. The five soil samples were collected from Dumuria and three from Teligati. After the collection of soil samples from the selected locations, the samples were prepared for the desired test in the laboratory. According to standard methods, various parameters were tested and hence discussed in the following sections.

Sample Preparation: First the beaker was cleaned properly and dried. 100 gm soil was taken in the beaker. 100 ml water was added to the soil sample. Then soil and water were mixed properly with glass rod. After that the mixture was kept in static condition about half an hour. The funnel was placed with stand rod. The filter paper was folded and made cone shaped then placed into funnel. The mixture was slightly added into funnels and observed that the filtration rate was initially high. Finally filtered water for respective sample was obtained.

pH, Conductivity and Salinity: Apparatus were Hack meter and graduated cylinder. The filter water was placed into the graduated cylinders. The pH meter was immersed into the graduated cylinders such that at least 2 inch of pH tube was dipped. After that the reading was taken.

Alkalinity: 100 ml graduated cylinder was taken. 90 ml distilled water was mixed with 10 ml of 0.02 normality H_2SO_4 and the overall system is shown in Fig. 1.

Calculation of Alkalinity:

Alkalinity= [{(FR-IR)-0.3} × 500 × Dilution Factor]/Sample used

Dilution Factor= (Sample used + Distilled water)/Sample used

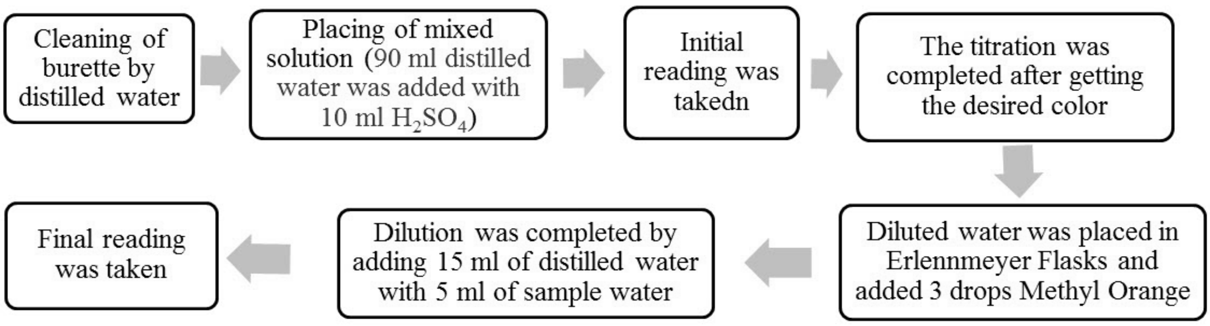

Fig. 1. Schematic diagram on the method of determining alkalinity in different places.

Chloride: 100 ml graduated cylinder was taken. 15 ml distilled water was mixed with 5 ml sample water and the overall system is shown in Fig. 2.

Calculation of Chloride:

Chloride = [{(FR-IR)-0.3} × 500 × Dilution Factor]/Sample used

Dilution Factor= (Sample used + Distilled water)/Sample used

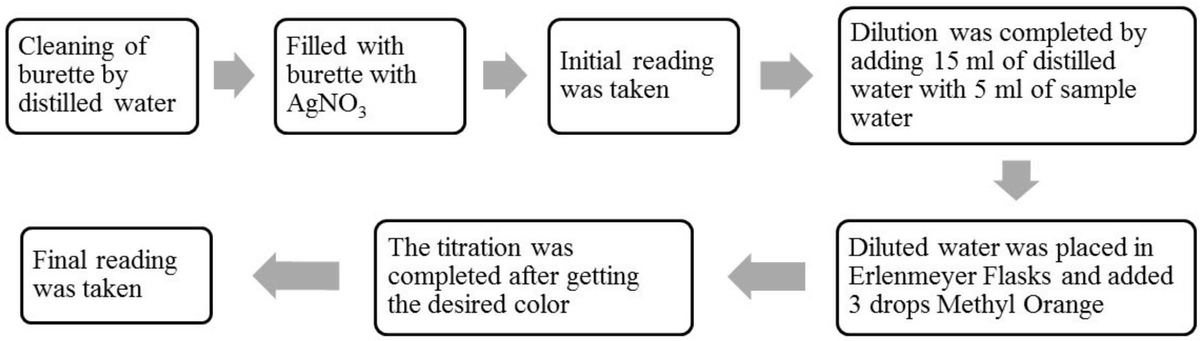

Fig. 2. Schematic diagrams on the method of determining organic content in different places.

Moisture Content: Some amount of soil sample was measured. Then the sample was kept in oven at 105°C. Duration of heating was 24 hours.

Calculation of moisture content:

$$MC\ (\%) = \{(W_w - W_d)/W_w\} \times 100$$

where W_w= Total wet weight of the soil sample, and W_d= Weight after burning at 105°C.

Organic Content: Three techniques exist to determine organic content, such as loss on ignition, oxidation with H_2O_2, and dichromate oxidation. In this study, loss on ignition method was used. The oven dried sample was crumbled into powder. Some amount of powdered sample was weighted and kept in muffle furnace at 550°C temperature for 4.5 hours. Then the sample was released from muffle furnace and weighted again. The amount of organic content was determined by following formula.

$$OC\ (\%) = \{(W_t - W_b)/W_t\} \times 100$$

where W_t= Total dry weight of the soil sample, and W_b= Weight after burning at 550°C.

3. Results and Discussion

Important chemical parameters of soil samples collected from the different locations are monitored to achieve the desired goal and are shown in Tables 1-4. It is compared between Gher A and Gher B to show the soil properties of Gher with and without agricultural uses.

Table 1. Chemical parameters of native soil in Gher A and Combined Agricultural Land and Shrimp Gher-B.

Parameters	**Gher-A**						
	AX1	**AY1**	**AX2**	**AY2**	**AX3**	**AY3**	**Avg.**
E. Conductivity (ms/cm)	41.5	26	35.5	44	90.5	33.9	45.23
Salinity (gm/L)	26.6	15.9	22.1	28.4	31.8	21.3	24.35
Chloride (mg/L)	430	360	460	610	400	490	458.33
Alkalinity as $MgCO_3$ (mg/L)	260	360	160	380	320	420	316.67
Organic Content (%)	2.97	4.4	4.14	6.36	4.03	4.98	4.48
Moisture Content (%)	40.5	38.7	50.10	61.77	30.2	35.37	42.77
pH	7.99	8.08	7.84	7.02	7.94	8.18	7.84
Chloride (mg/gm)	1.02	0.81	1.38	2.58	0.75	1.03	1.26
Parameters	**Combined Agricultural Land and Shrimp Gher-B**						
	BX1	**BY1**	**BX2**	**BY2**	**BX3**	**BY3**	**Avg.**
E. Conductivity (ms/cm)	20	21.6	25	24.7	25	77.7	32.33
Salinity (gm/L)	11.9	12.9	15.6	14.8	15.2	11.4	13.63
Chloride (mg/L)	300	330	330	410	380	420	361.67
Alkalinity as $MgCO_3$ (mg/L)	380	340	420	320	400	520	396.67
Organic Content (%)	4.04	5.99	3.97	4.5	4.11	5.44	4.68
Moisture Content (%)	34.7	44.8	45.66	47.02	48.48	38.2	43.14
pH	8.17	7.82	8.05	7.33	7.95	8.27	7.93
Chloride (mg/gm)	0.62	0.87	0.88	1.14	1.1	0.94	0.93

Gher-A is 20 years old Shrimp Gher, Combined Agricultural land and Shrimp Gher-B is 8 years old; X=Sample at 15 cm depth; Y=Sample at 30 cm depth; Avg.=Average.

Table 2. Chemical parameters of native soil in Gher C and Gher D.

Parameters	**Gher-C**						
	CX1	**CY1**	**CX2**	**CY2**	**CX3**	**CY3**	**Avg.**
E. Conductivity (ms/cm)	22.3	34.9	19.78	19.03	21.7	22.9	23.44
Salinity (gm/L)	13.4	22	11.8	11.3	13	13.8	14.22
Chloride (mg/L)	420	590	360	310	330	340	391.67
Alkalinity as $MgCO_3$ (mg/L)	240	200	240	420	540	240	313.33
Organic Content (%)	4.91	5.34	4.73	4.02	5.02	3	4.50
Moisture Content (%)	31.2	30.17	33.56	30.77	29.52	27.47	30.45
pH	7.7	7.95	7.85	7.92	7.69	8.4	7.92
Chloride (mg/gm)	0.8	1.01	0.72	0.59	0.61	0.60	0.72

Parameters	Gher-D						
	DX1	DY1	DX2	DY2	DX3	DY3	Avg.
E. Conductivity (ms/cm)	22.4	43.8	25.6	38.7	21.9	40.5	32.15
Salinity (gm/L)	13.5	28.3	15.6	24.6	13.7	25.9	20.27
Chloride (mg/L)	320	750	460	580	350	680	523.33
Alkalinity as $MgCO_3$ (mg/L)	200	220	200	220	200	240	213.33
Organic Content (%)	6.4	5.64	5.31	5.47	6.59	6.13	5.92
Moisture Content (%)	36.2	29.72	37.29	31.66	37.35	30.17	33.73
pH	8.36	8.41	7.9	8.17	8.45	8.47	8.29
Chloride (mg/gm)	0.68	1.38	1.00	1.12	0.77	1.27	1.04

Shrimp Gher-C is 5 years old at Dumuria, Shrimp Gher-D is 13 years old at Dumuria; X=Sample at 15 cm depth; Y=Sample at 30 cm depth; Avg.=Average.

Table 3. Chemical parameters of native soil in Agricultural Land E and Combined Agricultural Land and Shrimp Gher-F.

Parameters	Agricultural Land -E						
	EX1	EY1	EX2	EY2	EX3	EY3	Avg.
E. Conductivity (ms/cm)	17.16	36.7	25.3	41.4	17.24	38	29.30
Salinity (gm/L)	10.1	22.8	15.4	26.5	10.7	24.1	18.27
Chloride (mg/L)	310	620	430	810	630	730	588.33
Alkalinity as $MgCO_3$ (mg/L)	180	220	140	120	160	160	163.33
Organic Content (%)	5.0	3.89	5.2	4.74	5.15	3.29	4.55
Moisture Content (%)	33.29	24.4	37.78	30.72	38.51	24.19	31.48
pH	8.16	8.63	8.12	8.16	8.29	8.65	8.34
Chloride (mg/gm)	0.62	1.02	0.95	1.53	1.42	1.20	1.12
Parameters	**Combined Agricultural Land and Shrimp Gher-F**						
	FX1	**FY1**	**FX2**	**FY2**	**FX3**	**FY3**	**Avg.**
E. Conductivity (ms/cm)	6.62	6.88	6.13	6.02	8.90	11.23	7.63
Salinity (gm/L)	3.60	3.80	3.30	3.30	5.0	6.40	4.23
Chloride (mg/L)	420	590	360	310	330	340	391.67
Alkalinity as $MgCO_3$ (mg/L)	240	200	240	420	540	240	313.33
Organic Content (%)	6.51	7.51	7.08	7.50	6.70	6.45	6.96
Moisture Content (%)	29.20	33.47	32.15	30.70	36.40	28.75	31.78
pH	7.94	7.83	7.68	7.90	7.25	7.83	7.74
Chloride (mg/gm)	0.77	1.18	0.70	0.58	0.71	0.61	0.76

Agricultural Land -E is at Dumuria, Combined Agricultural Land and Shrimp Gher-F is 10 years old at Teligati; X=Sample at 15 cm depth; Y=Sample at 30 cm depth; Avg.=Average.

Table 4. Chemical parameters of native soil in Gher G and Agricultural Land H.

Parameters	Gher-G						
	GX1	GY1	GX2	GY2	GX3	GY3	Avg.
E. Conductivity (ms/cm)	7.23	7.51	7.02	7.19	7.65	8.05	7.44
Salinity (gm/L)	4.2	4.35	3.90	4.09	5.05	5.45	4.51
Chloride (mg/L)	390	450	420	390	435	500	430.83
Alkalinity as $MgCO_3$ (mg/L)	412	320	230	215	490	320	331.17
Organic Content (%)	7.67	8.86	6.77	7.85	7.89	8.85	7.98
Moisture Content (%)	33.83	37.7	35.2	25.67	39.65	39.2	35.21
pH	7.82	8.06	7.59	7.95	7.89	8.12	7.91
Chloride (mg/gm)	0.79	0.99	0.88	0.66	1.01	1.14	0.91
Parameters	**Agricultural Land-H**						
	HX1	**HY1**	**HX2**	**HY2**	**HX3**	**HY3**	**Avg.**
E. Conductivity (ms/cm)	7.66	0.024	6.11	5.07	0.0185	0.0175	3.15
Salinity (gm/L)	4.20	0	3.3	2.7	0	0	1.70
Chloride (mg/L)	140	120	210	140	180	190	163.33
Alkalinity as $MgCO_3$ (mg/L)	755	4000	2420	2500	1940	1640	2209.17
Organic Content (%)	12.73	12.73	12.92	12.40	13	12.94	12.79
Moisture Content (%)	42.69	36.89	40.96	36.45	50.73	43.56	41.88
pH	7.94	7.83	7.68	7.9	7.25	7.83	7.74
Chloride (mg/gm)	0.35	0.26	0.50	0.30	0.55	0.48	0.407

Shrimp Gher-G is 8 years old at Teligati, Agricultural Land-H is at Teligati; X=Sample at 15 cm depth; Y=Sample at 30 cm depth; Avg.=Average.

Since salinity and organic content are the basic and most important parameters of soil, so these are discussed in details here. Figure 3 shows the salinity is higher at 15 cm depth than 30 cm depth. Similarly in Fig. 4, the value of salinity is higher at 30 cm depth than 15 cm depth. The variation of organic content of the collected soil samples with the increase of depth as shown in Figs. 5 and 6. Figure 5 depicts that the organic content in case of old Gher was found higher at 30 cm depth than as that of 15 cm depth. Similarly in Fig. 6, the value of Organic content is also higher at 30 cm depth than 15 cm depth. Gher-A is 20 years old and B is combined agricultural land and Shrimp Gher.

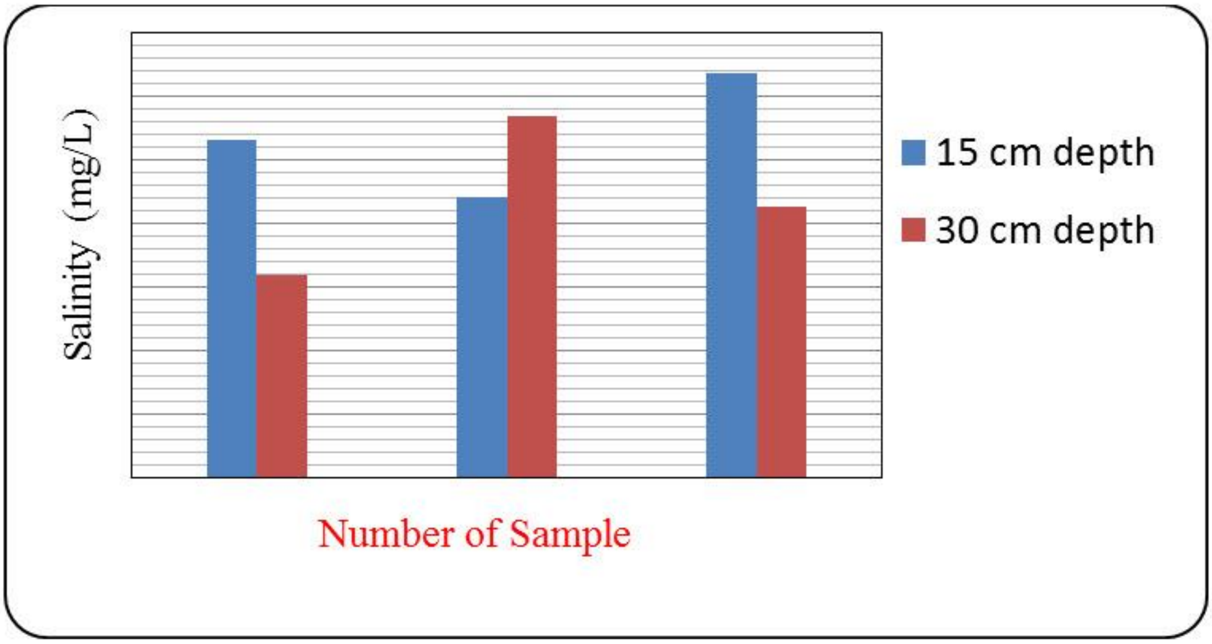

Fig. 3. Variation of Salinity with depth of soil for Gher-A.

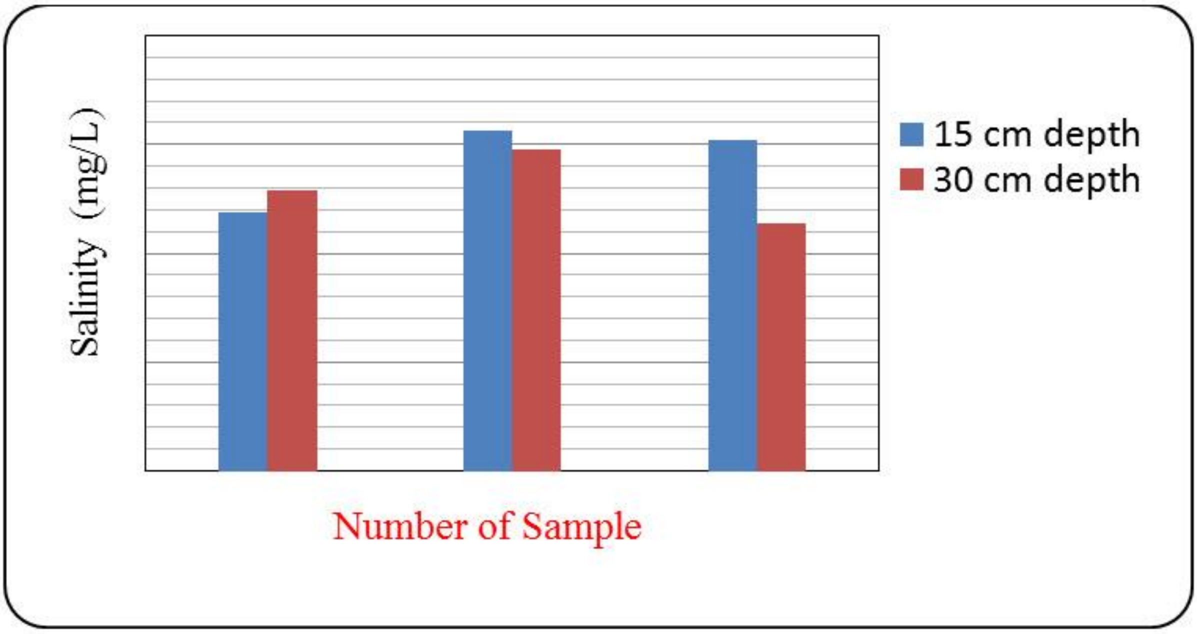

Fig. 4. Variation of Salinity with depth of soil for Gher-B.

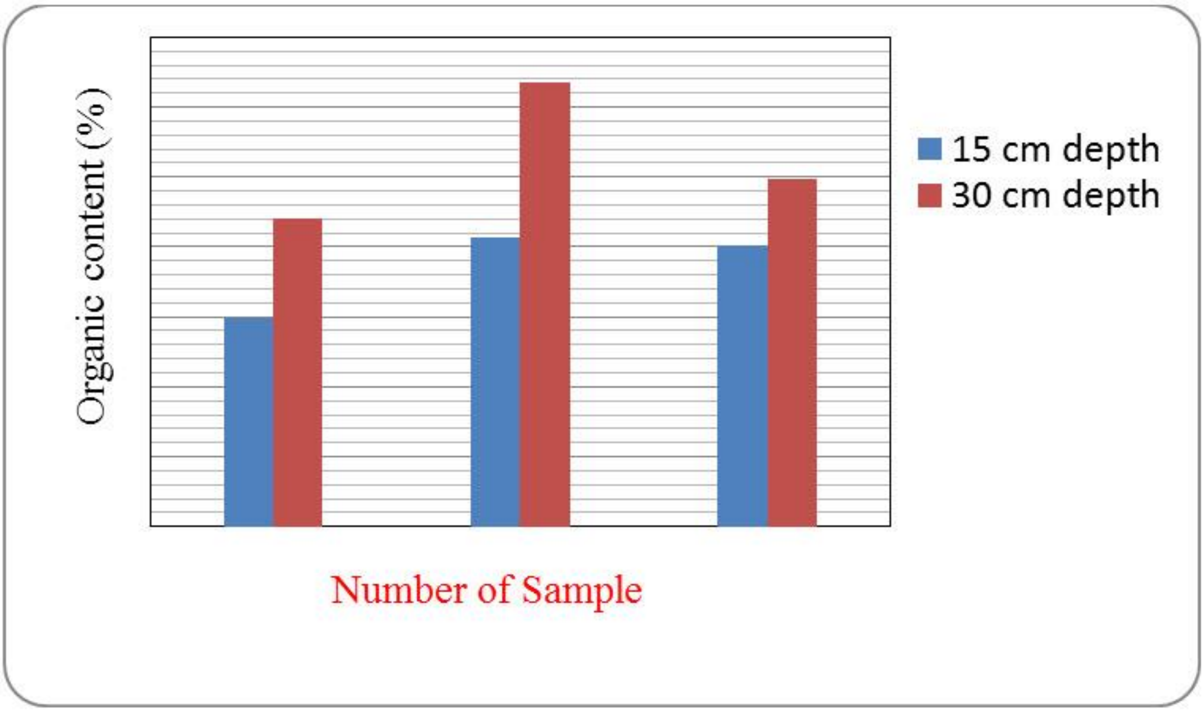

Fig. 5. Variation of Organic content with depth of soil for Gher-A.

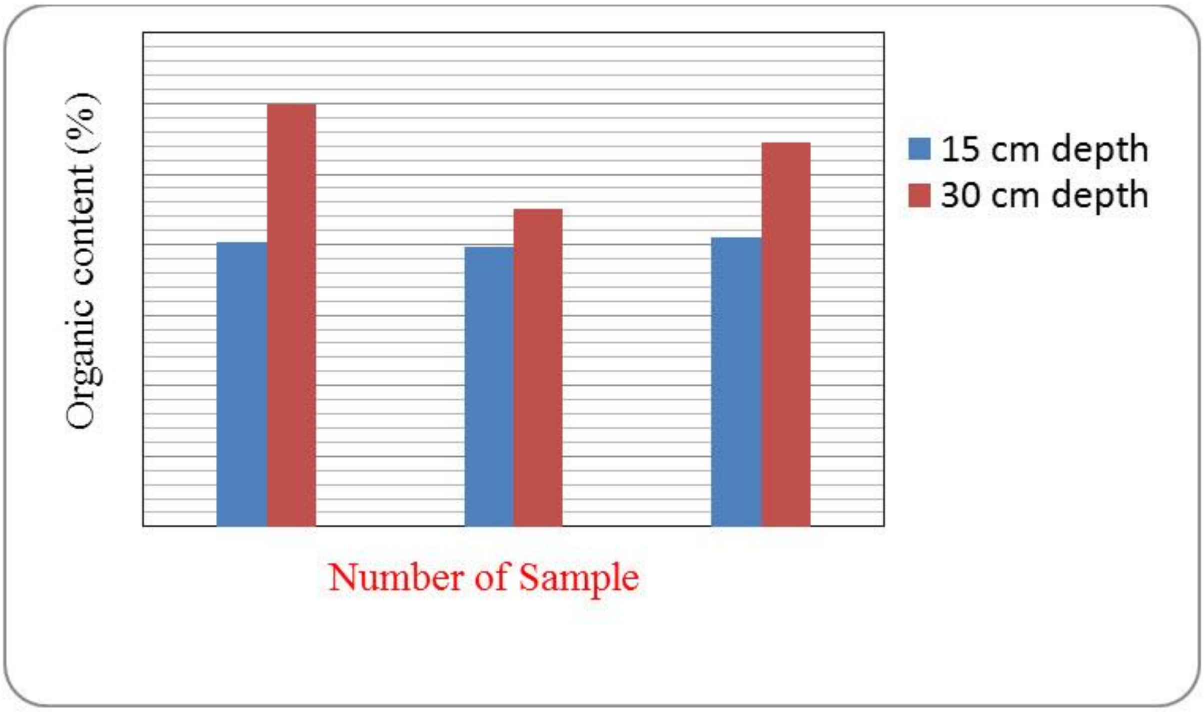

Fig. 6. Variation of Organic content with depth of soil for Gher-B.

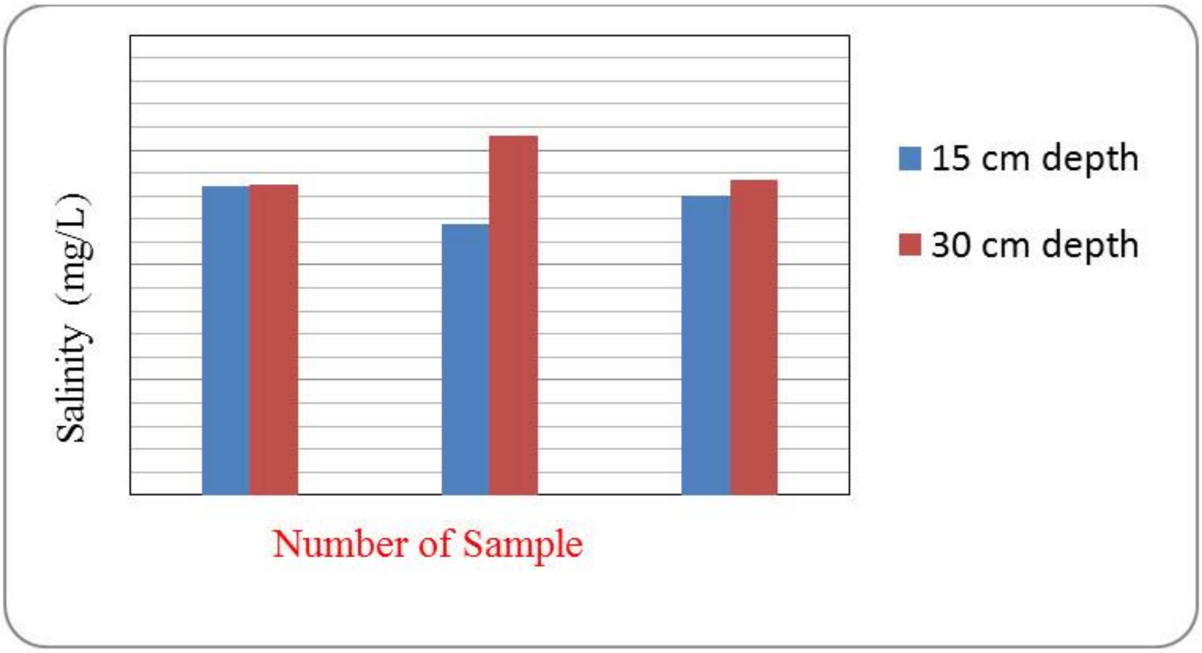

Fig. 7. Variation of Salinity with depth of soil for Gher-C.

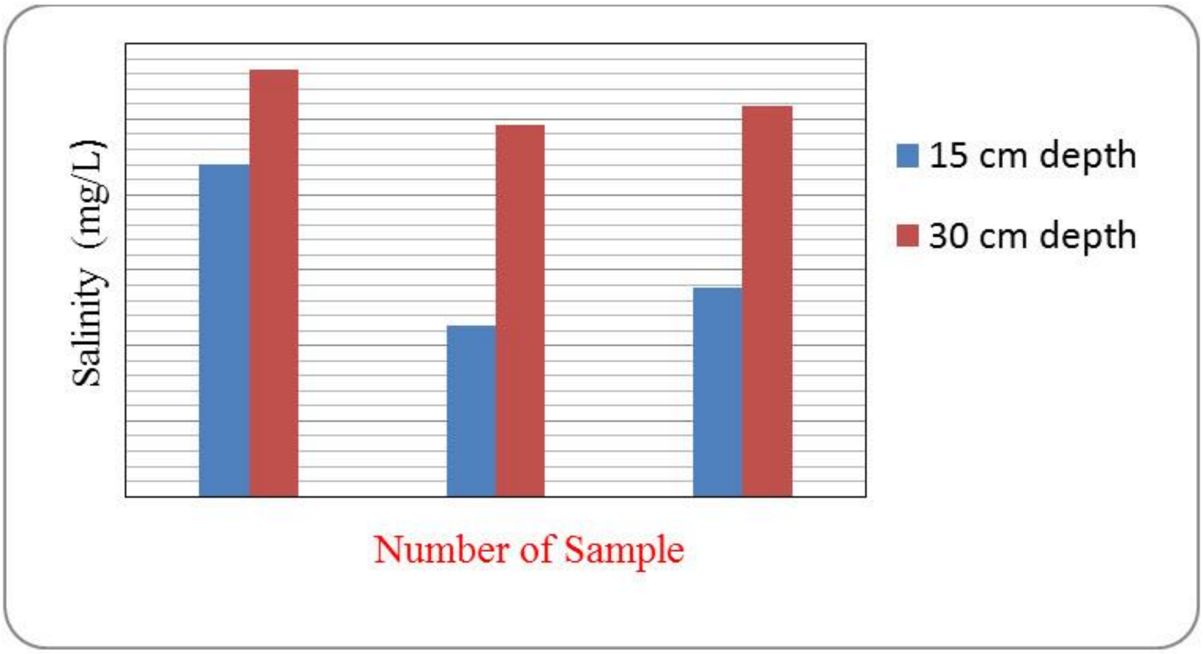

Fig. 8. Variation of Salinity with depth of soil for Gher-D.

Figure 7 shows the salinity is higher at 30 cm depth than 15 cm depth for Gher C. Similarly for Gher D in Fig. 8, the value of salinity is higher at 30 cm depth than 15 cm depth. Figure 9 depicts that the organic content in case of shrimp Gher was found higher at 15 cm depth than as that of 30 cm depth. Similarly in Fig. 10, the value of organic content is also higher at 15 cm depth than 30 cm depth. Gher-C is 5 years old and Gher D is 13 years old Shrimp Gher.

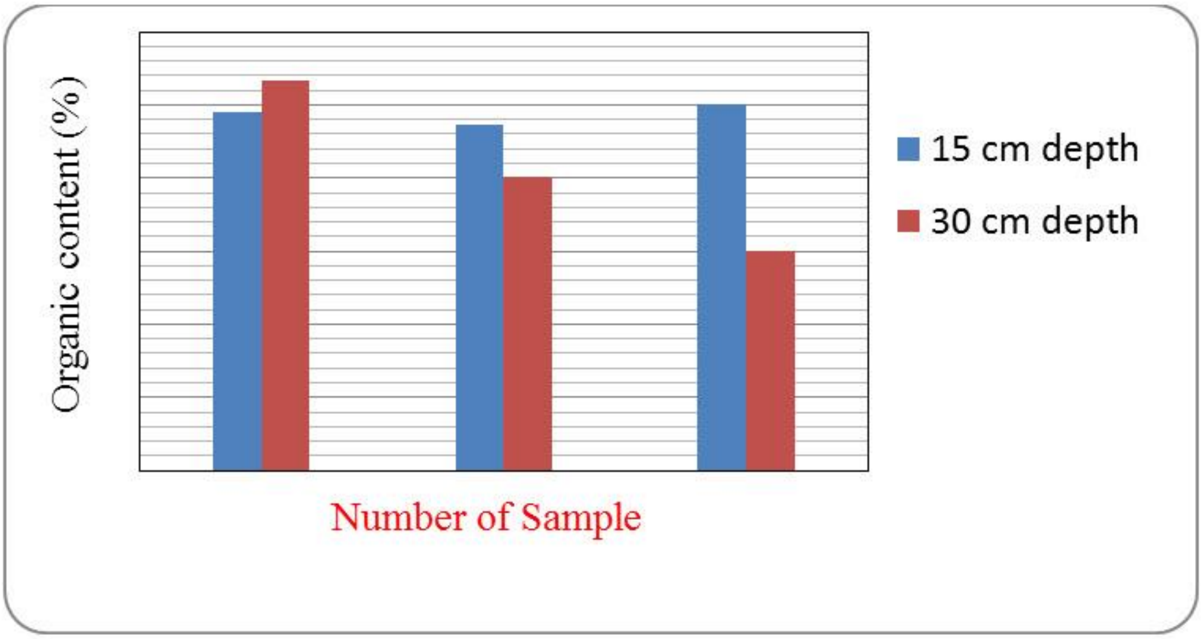

Fig. 9. Variation of Organic content with depth of soil for Gher-C.

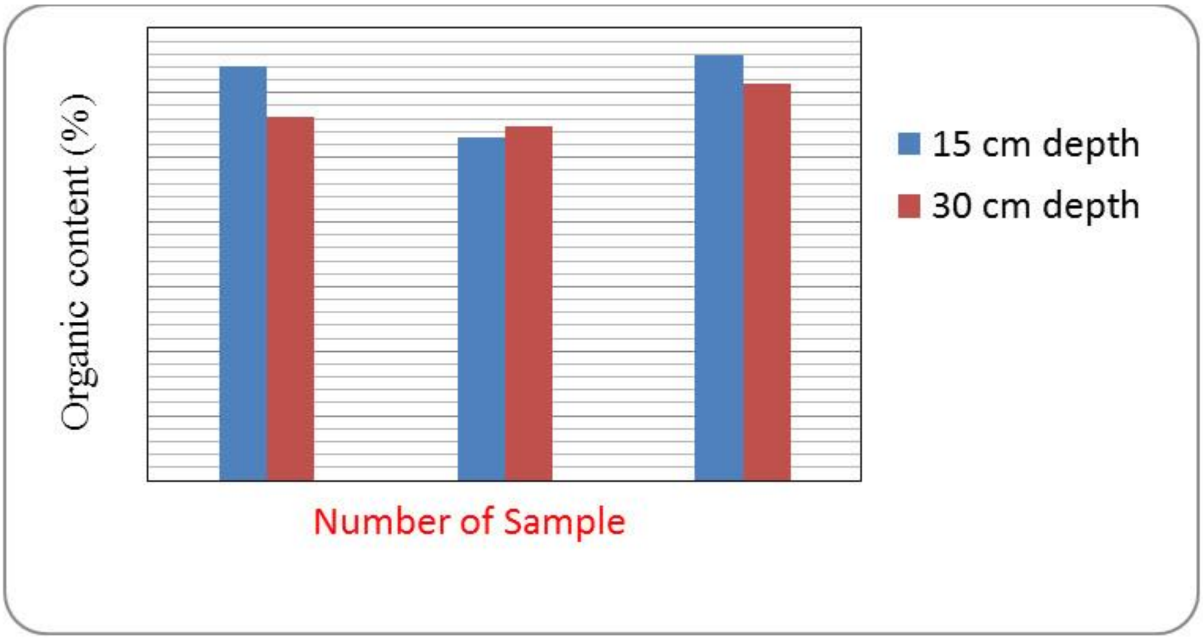

Fig. 10. Variation of Organic content with depth of soil for Gher-D.

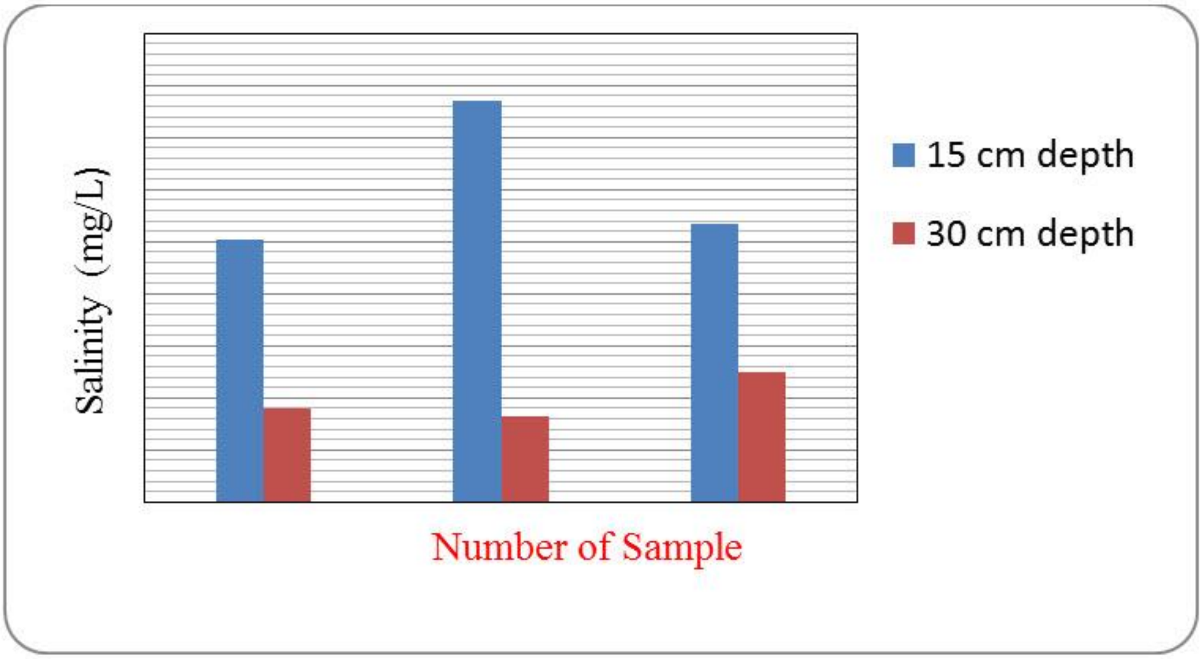

Fig. 11. Variation of Salinity with depth of soil for Gher-E.

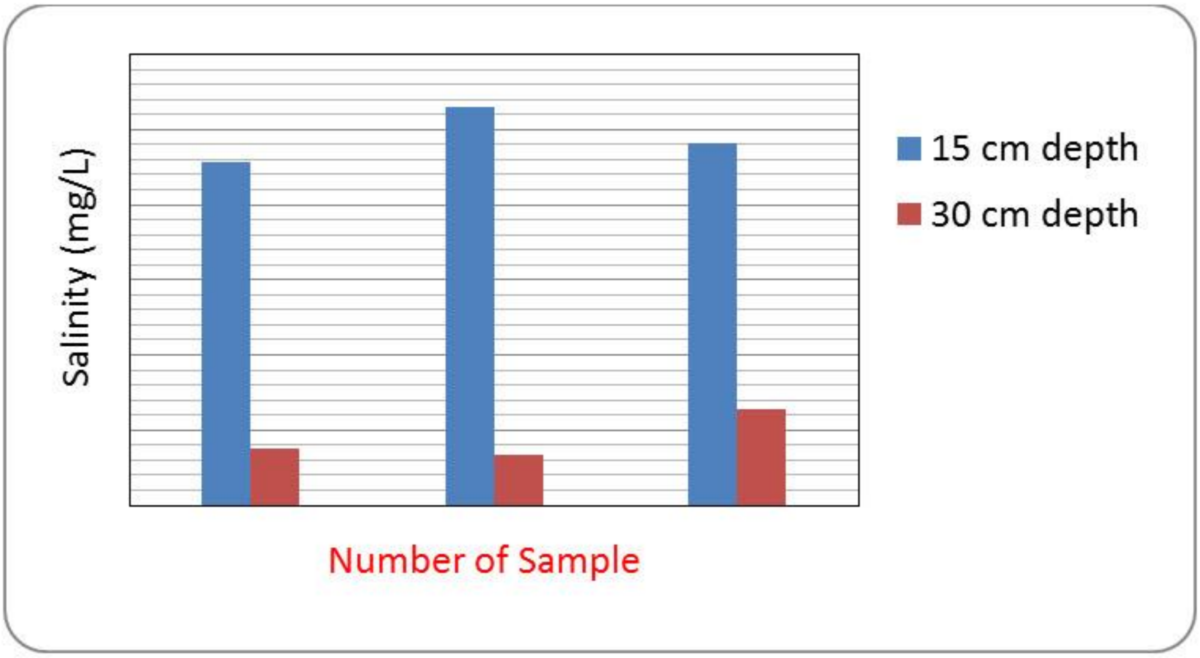

Fig. 12. Variation of Salinity with depth of soil for Gher-F.

Figure 11 shows the salinity is higher at 30 cm depth than 15 cm depth for Gher E. Similarly for Gher D in Fig. 12, salinity is higher at 30 cm depth than 15 cm depth at point 1 and 3 for Gher F. Figure 13 depicts that the organic content is higher at 15 cm depth than as that of 30 cm depth. However, in Fig. 14, the value of organic content is higher at 30 cm depth than 15 cm depth. Gher-E is Agricultural land and F is combined Agricultural land and Shrimp Gher.

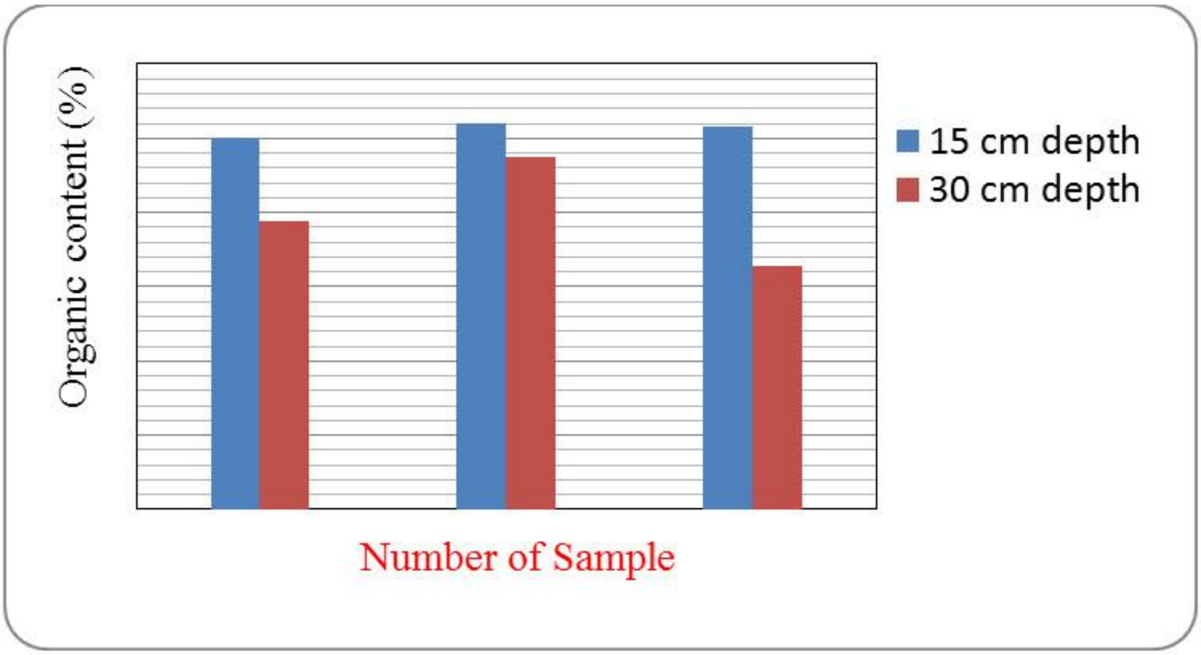

Fig. 13. Variation of Organic content with depth of soil for Gher-E.

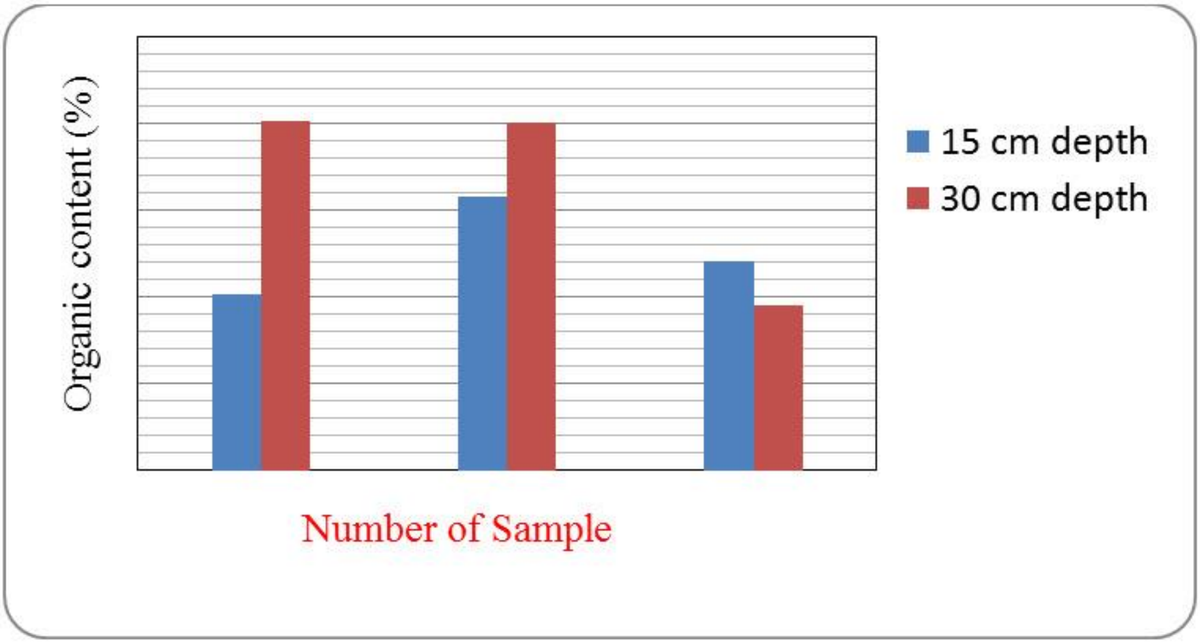

Fig. 14. Variation of Organic content with depth of soil for Gher-F.

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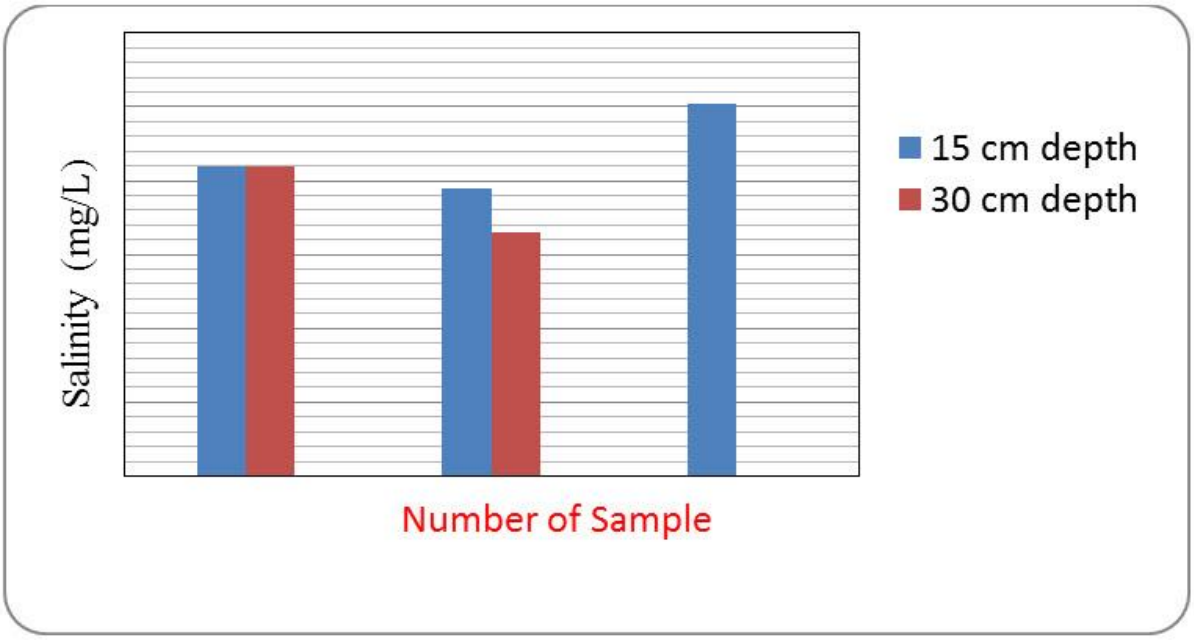

Fig. 15. Variation of Salinity with depth of soil for Gher-G.

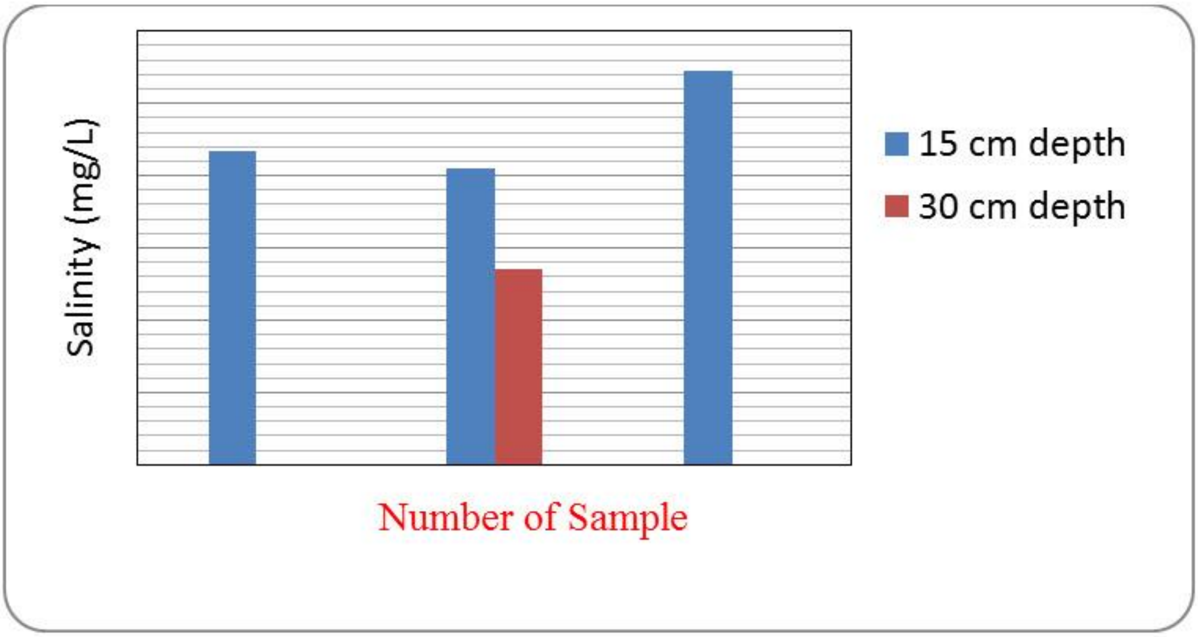

Fig. 16. Variation of Salinity with depth of soil for Gher-H.

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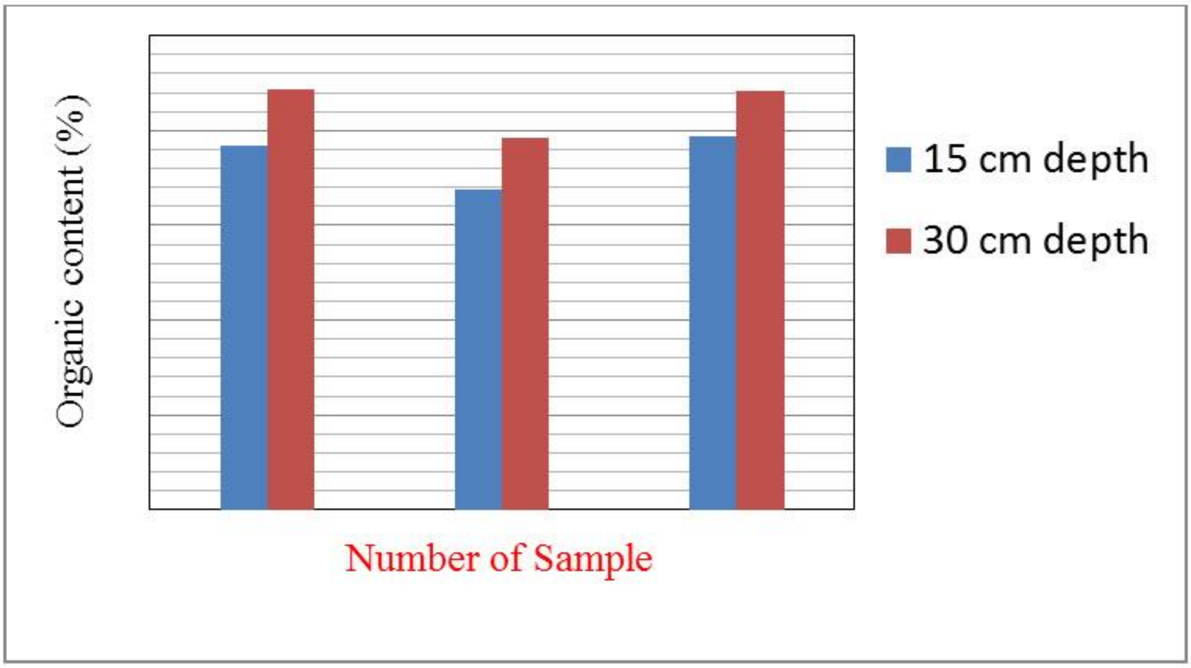

Fig. 17. Variation of Organic content with depth of soil for Gher-G.

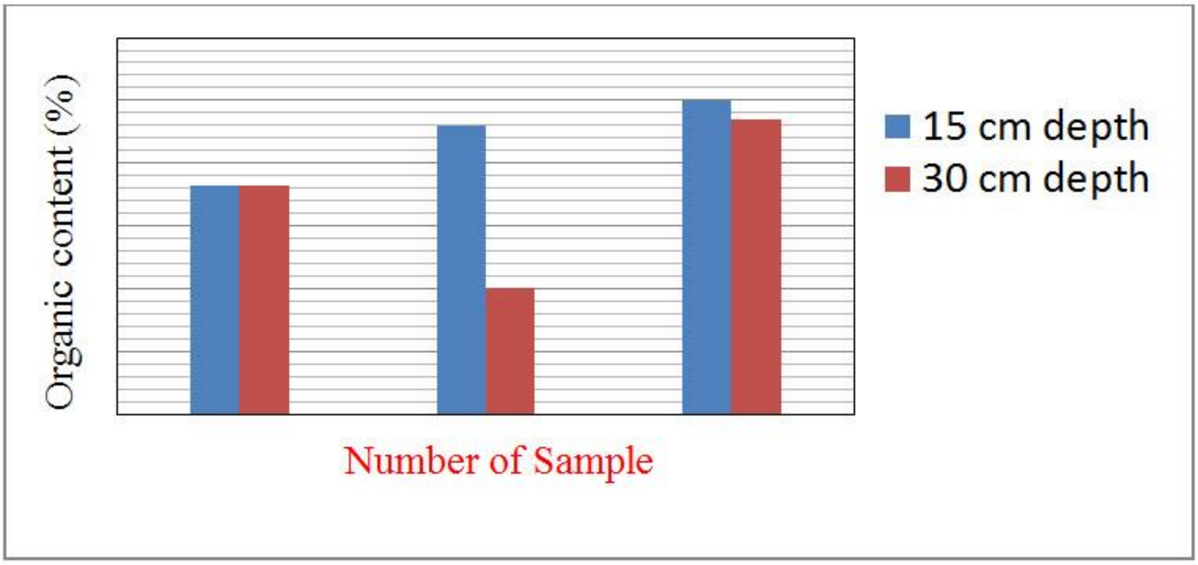

Fig. 18. Variation of Organic content with depth of soil for Gher-H.

From Fig. 15, it is revealed that there is a small difference in salinity between 15 cm and 30 cm depth. In Fig. 16, the values of salinity are nil for points 1 and 3. In Fig. 17, it is found that organic content is higher at 30 cm than 15 cm depth. However from Fig. 18, it is observed that organic content is same for point 1 in Gher H, however, at points 2 and 3, the value of organic content is higher at 15 cm depth than 30 cm depth.

4. Conclusions

This is an environmental concern that the salinity is increasing at an alarming rate in areas vicinity to shrimp Ghers. This study was conducted to observe the current status of the native soil at shrimp Gher and agricultural land by characterizing the soil properties. Organic content was found higher at the depth of 30 cm than that of 15 cm depth for Gher-A (20 years old) and agricultural land-B. Organic content was lower at the depth of 30 cm than that of 15 cm depth for Gher-C (5 years old) and Gher-D (13 years old). Organic content was lower at the depth of 30 cm than that of 15 cm depth Gher-E (plain agricultural land), located at Dumuria. Organic content was higher at the depth of 15 cm than that of 30 cm depth for combined Gher and agricultural land-F (10 years), located at west part of Teligati. Salinity was higher at 15 cm depth than 30 cm depth for Gher-A (20 years old), located at Dumuria. Organic content was higher at 30 cm depth than 15 cm depth for Gher-G (8 years old), located beside the by-pass road. Salinity was higher at 30 cm depth than 15 cm depth for Gher-C (5 years old). Salinity was higher at 30 cm depth than 15 cm depth for Gher-D (13 years old). Organic content was higher at 15 cm depth than 30 cm for combined Gher-H (5 years old), located beside the by-pass road. Salinity is higher at 15 cm depth than 30 cm depth for agricultural land-B. Salinity was higher at 30 cm depth than 15 cm depth for agricultural land-E. Chloride and conductivity were higher in old Gher and pH was higher in the new Gher. Salinity was higher at 30 cm depth than 15 cm depth for combined shrimp Gher and agricultural land-F (10 years old), located beside the by-pass road. Salinity is a crucial land degradation issue. It can be reduced by leaching soluble salts out of soil with excess irrigation water. Salt-tolerant plants can be planted in areas of high levels of soil salinity.

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