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MONITORING OF SURFACE SOIL QUALITY PARAMETERS OF THE SITALAKSHYA RIVER, BANGLADESH

Md. Simul Bhuyan[1]
Md. Rashed-Un-Nabi[2]
Md. Enamul Hoque[3]
Abu Sayeed Muhammad Sharif[4]
Md. Shafiqul Islam[5]

[1,2,3,5]*Faculty of Marine Sciences and Fisheries, University of Chittagong, Chittagong, Bangladesh*
[1]*Email: simulbhuyan@gmail.com Tel: +88-01849752555*
[2]*Email: mrnimscu@yahoo.com Tel: +88-01712210776*
[3]*Email: enamul_imsf@cu.ac.bd Tel: +88-01733-817080*
[5]*Email: prof.shafiqimsf@cu.ac.bd Tel: +88-01712062651*
[4]*Bangladesh Oceanographic Research Institute, Cox's Bazar, Bangladesh*
[4]*Email: sharifimscu@gmail.com Tel: +88-01812093122*

(+ Corresponding author)

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ABSTRACT

The present study was carried out to monitor and assess the surface soil quality parameters of the Sitalakshya River, Bangladesh. The soil samples were collected from Kanchpur Bridge and Atlapur during rainy and winter season. Soil texture is an important tool that aids in organic matter retention, minerals dispersal, microbial biomass, and other soil properties. The soil of the study area was recorded sandy loam and loam. The concentrations of soil parameters ranged for EC: 65.7 µS/cm-99.83 µS/cm; pH: 6.67-6.97; organic matter: 0.43%-0.66%; and organic carbon: 0.23%-0.35% in the soil of the Sitalakshya River. Most of the parameters showed no substantial variations in respect of sites and seasons ($p>0.05$) except electrical conductivity and pH ($p<0.05$). Statistical analysis like correlation matrix exposed the close relationship between organic matter and organic carbon. The soil of the Sitalakshya River has low nutrient contents that are not enough for the plants and organisms. Rapid industrialization and the huge establishment of brickfields are the major factors behind this less productive ecosystem. The river must be protected from further deterioration by taking fruitful management plan. This preliminary study will be a useful tool in the conservation plan. This will also help the future researchers who want to work on the river.

Contribution/Originality: The paper contributes the first logical analysis of the soil quality parameters of the Sitalakshya River. The study demonstrated the preliminary ecosystem condition of the river. This will provide baseline information for researchers and policymaker in the conservation issue.

1. INTRODUCTION

The soil is a natural component of the environment that constitutes of mineral matter, water, air, organic matter and living community that varies according to place and time [1, 2]. Climate affects the type of rock weathering, removal and the redeposition of materials by wind, water, and glaciers that regarded as a crucial factor for soil formation [3]. It forms a natural buffer and filter system in water and offers a wide range of ecosystem services (e.g. food, fiber, water, and timber) [4, 5]. Soil exert great influence on the environmental quality and have an impact on the climatic conditions; water quality; nutrient cycling; and cultural services (e.g. aesthetic, spiritual, and recreational purposes) [6-8].

Soil analysis is very essential to evaluate the quality of the water of a particular ecosystem [9-11]. The Surface-bottom soil is a source of nutrients as well as various pollutants [12]. The soil quality indicators can be biotic and abiotic that vary spatially and temporally [13, 14]. Abiotic factors like total ion content acidity, carbon, total nitrogen, and total phosphorous found to be varied according to sites [15, 16]. While biotic factors like precipitation, temperature, landform, topography, physicochemical, and biological processes have an impact on the soil properties [17]. Soil with high quality required for enhanced food and fiber manufacture [18].

A huge number of sediment properties are used for the assessment of sediment quality [19]. The physicochemical factors of soils are important for minimum soil degradation and increasing soil fertility [20]. Physical properties e.g. (texture, structure, and porosity) affect the chemical behavior of soil. Whereas chemical properties like nutrient availability and soil pH affect the growth of plants. In basic soil solution plants unable to uptake nitrogen, phosphorus, potassium, and other nutrients required for their growth. Some plants eventually die of toxicity in acidic soils condition as plants take up toxic metals [21].

Soil organic matter is the most important determinants of soil quality that have interlinked with Soil color, pH, and electric conductivity (EC) [22]. It determines the soil productivity and fertility of a particular ecosystem since a massive amount of carbon (58 % of organic carbon) amass in organic matter. Hence soil is regarded as the largest reservoir that contains at least 1500 gigaton (Gt) of organic carbon [23, 24]. Being characterized with different kinds of organic compounds soil organic matter subjected to change in temporal and spatial basis [25]. Old and new land use types, the soil type, management, and climate are the key factors that change the organic matter [26, 27]. Organic matter stores energy for plants and helps to improve soil fertility by increasing the amount of available nutrients like nitrogen, phosphorous, and sulfur [28]. Soil quality assessment is very important to determine the fertility of the soil and help farmers. This type of information indicator of productivity that ensures the health of plants and animals [5].

A huge amount of untreated effluents enter into Sitalakshya River from various industries such as cement industries, textile crafts, brickfields, dying industries, spinning mills, cotton, steel mills, municipal or domestic sewerage and oil from steamers. Excessive use of fertilizer, eutrophication, soil loss, and soil pollution exert adversarial effects on the soil quality [29, 30]. This negative consequences resulted in low food production in various countries like Africa [31, 32]. Therefore, the present study is undertaken with aim; (1) to assess soil quality parameters of the Sitalakshya River; (2) to see the seasonal and spatial variations of the parameters; (3) to find out the significant difference in the concentrations of soil parameters; and (4) to examine the correlation among the soil parameters using Pearson correlation method.

2. MATERIALS AND METHODS

2.1. Sampling Sites

The present study was conducted in Sitalakshya River. The samples were collected from Kanchpur Bridge (23°42'11.17"N and 90°31'01.92"E) and Atlapur (23°87'58.98"N and 90°57'91.90"E) of the Sitalakshya River (Fig. 1). The Kanchpur is located beside the Kanchpur Bridge that connects the busiest road of Chittagong and Dhaka city. The ship breaking machines and the effluents from the Sinha Textile Ltd. are continuously being discharged into the upstream of this location. In Khanpur some sand loaded launch/steamer are loaded and unloaded there. Water vehicles like launch or steamer carry goods via this river and dumped oil into the river. The municipal or domestic sewerage is also discharged there. There are many cement factories at the bank of the river. Different types of chemical industries also located and discharged their untreated effluents. In Atlapur, there are also industries, brickfields, the mobility of water vehicles. Domestic sewage also contributes effluents in the river. Steamers and transport boats are also found here.

Sampling procedures were performed in two phases: firstly, in July 2017 (monsoon-rainy season); secondly, in January 2018 (post-monsoon-winter season).

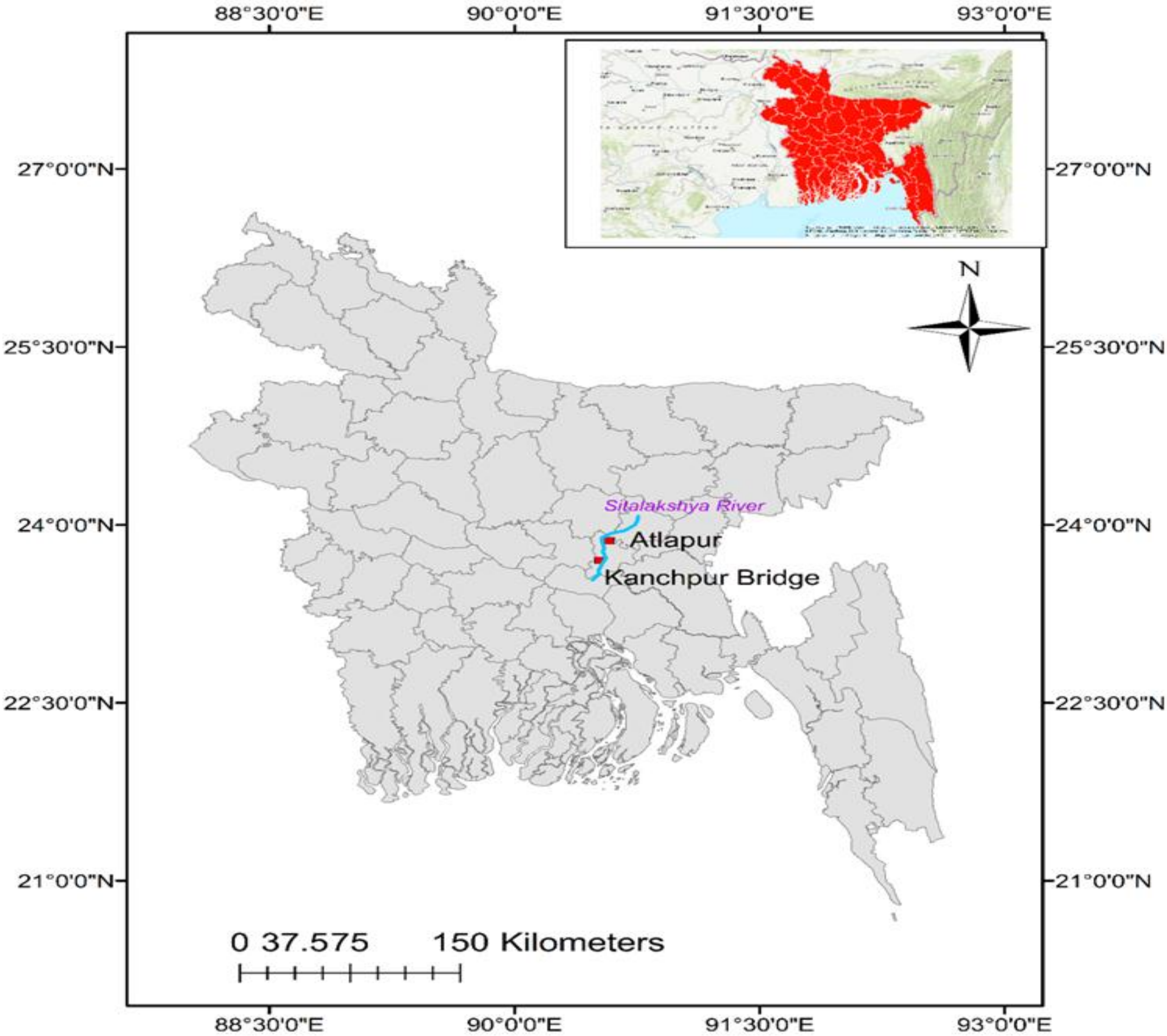

Fig-1. Map showing the sampling sites of the Sitalakshya River (Map created by ArcGIS v.10.3)

2.2. Sample Collection and Preservation

A total of 8 surface sediment samples were collected at 2 selected sites (Kanchpur Bridge and Atlapur) in July 2017 (Rainy season) and January 2018 (Winter season). Kanchpur Bridge is the polluted site and Atlapur is selected as the reference site. Samples were collected by Eckman Grab Sampler from a hired boat. Then the samples were labeled polythene bag and transferred to the laboratory of the Department of Soil Science, University of Chittagong. Then the samples were dried under sunlight for several days to evaporate the moisture. The samples were also air dried at room temperature for further removal of moisture. After that, samples were grinded with a hand operated grinder (Haman dista) and passed through a 2mm sieve mesh size. After sieving, the samples were kept in a plastic container for further analysis in the laboratory.

2.3. Sample Analysis

Soil pH was measured at sampling sites (in situ) using a soil pH meter. Soil texture analysis was executed following the Hydrometer method (% of sand, silt, and clay) {Described by Huq and Alam [33] modified from Bouyoucos [34]}. This method quantitatively determines the physical proportions of three sizes of primary soil particles as determined by their settling rates in an aqueous solution using a hydrometer. Following stated formula was used for texture analysis:

The corrected hydrometer reading is given by:

$$Rc = (R-RL) + (t-20.0) * 0.3$$

Where,

R= hydrometer reading at a different time (40 sec and 2 hours)

Rc = corrected hydrometer reading.

RL= blank

t = temperature.

Therefore, from the corrected hydrometer reading, percentage of sand, silt and clay can be calculated as follows:

$$\% \text{ silt + clay} = \frac{\text{Rc at 40 sec}}{\text{Oven dry wt}} * 100$$

$$\% \text{ clay} = \frac{\text{Rc at 2 hours}}{\text{Oven dry wt}} * 100$$

% silt = (% silt + clay) - % clay.

% sand = 100 - (% silt + clay).

Sediment organic matter was determined by following the method stated by Boyd [35]. About 20 g of oven dried and sieved sediment was placed in porcelain crucibles and labeled. The crucibles were placed in a muffle furnace at a temperature of 450°c for 6 hours. Crucible was removed from furnace carefully using the tongs. Then, the sample was kept in the desiccator for cooling. After cooling the weight of the samples was taken. The following formula was used to find out soil organic matter

$$\% \text{ organic matter} = \frac{(B-C)}{B} * 100$$

Where,

B= weight of the sample in oven dried

C= Weight of burning samples in a muffle furnace.

Sediment organic carbon was calculated dividing the organic matter by a factor of 1.9 [36, 37].

$$\text{Organic carbon} = \frac{\text{Organic matter}}{1.9}$$

2.4. Statistical Analysis

One Way Analysis of Variance (ANOVA) of the data showed the variations in the concentration of soil parameters in terms of seasons and seasons. The graph was used for graphical presentation of soil parameters against seasons and sites. Correlation Matrix was executed to find out the interrelationship among the parameters (SPSS v.22).

3. RESULTS AND DISCUSSION

Soil quality is only one constituent of land quality that integrates characteristics of the soil, water, climate, topography, and vegetation [38, 39]. The dynamic soil properties can be strongly impacted by management and are mainly observed in the top 20-30 cm of the soil [40]. Soil quality influences the health of animals and humans via the quality of an organism or a community [41-43].

Soil texture is an important factor that helps in organic matter retention in soil, dispersal of minerals, microbial biomass, and other soil properties [44, 45]. In the present study, the soil of the Sitalakshya River was recorded Sandy Loam at Kanchpur and Atlapur during the rainy season. In winter season the soil was found mainly loam at Kanchpur and Atlapur (Table 1). A similar result was reported by Firdous, et al. [5] in the Rawal Lake watershed, Islamabad, Pakistan. Gupte and Shaikh [46] found soil texture class clay loam at Shelar Lake, Maharashtra. Kakavipure [47] detected clayed loam soil at Khativli Lake while BPDB [48] recorded clay to medium sand in Kaptai Lake. Similar textural classes of the soil of a particular area designate the same soil formation processes [49].

Table-1. Soil quality parameters of the Sitalakshya River.

Stations	Seasons		Textural Class	EC (µs/cm)	pH	%O.M	%O.C	EC mean	pH mean	%O.M mean	%O.C mean
Kanchpur	Rainy season	ST-1a	Sandy Loam	93.6	7.05	0.61	0.32	95.23	6.97	0.54	0.28
		ST-1b	Sandy Loam	97.7	6.92	0.65	0.34				
		ST-1c	Sandy Loam	94.4	6.93	0.37	0.19				
Atlapur	Rainy season	ST-2a	Sandy Loam	102	6.91	0.41	0.22	99.83	6.90	0.43	0.23
		ST-2b	Sandy Loam	94.6	6.89	0.41	0.22				
		ST-2c	Sandy Loam	102.9	6.89	0.48	0.25				
Kanchpur	Winter season	ST-1a	Loam	102.1	6.69	0.54	0.29	96.03	6.70	0.55	0.30
		ST-1b	Loam	98	6.68	0.54	0.29				
		ST-1c	Loam	88	6.72	0.58	0.31				
Atlapur	Winter season	ST-2a	Loam	70.5	6.79	0.58	0.31	67.97	6.67	0.66	0.35
		ST-2b	Loam	67.7	6.62	0.61	0.32				
		ST-2c	Loam	65.7	6.61	0.78	0.41				

Source: Field data

The ***electrical conductivity*** of soil is the amount of ion (e.g. Ca^{+2}, Na^{+1}, Mg^{+2}, K^{+1}, Cl^{-1}, SO_4^{-2}, and HCO_3^{-1}) concentration exist in soil [50]. In the present study, soil EC varied between 65.7 µS/cm to 99.83 µS/cm (Table 1). The highest amount of EC (99.83 µS/cm) was recorded at Atlapur during the rainy season which had a medium range of pH (6.9) (Table 1). Firdous, et al. [5] found similar kind of EC at Bari Imam located in Rawal Lake watershed, Islamabad, Pakistan. This result is also agreed with the findings of Shabbir, et al. [51] who reported the negative relation between pH and EC in soil samples of Rawalpindi. Ouhadi and Goodarzi [52] mentioned that pH has effects on the electrical conductivity of the soil. The general guideline for good soil is that it should have EC concentration between 200 and 1400 µS/cm. Soil having EC below 200 µS/cm regarded as the low nutrients available to the plants. The concentration of EC above 1400 µS/cm may direct too much high salt fertilizer or possibly a salinity problem [53]. In the present study, the amount of EC was found far below from the recommended value that means the nutrient concentration is not enough at all the sampling sites during all seasons (Table 1). The concentrations of soil quality parameters at different sampling sites was depicted in Figure 2.

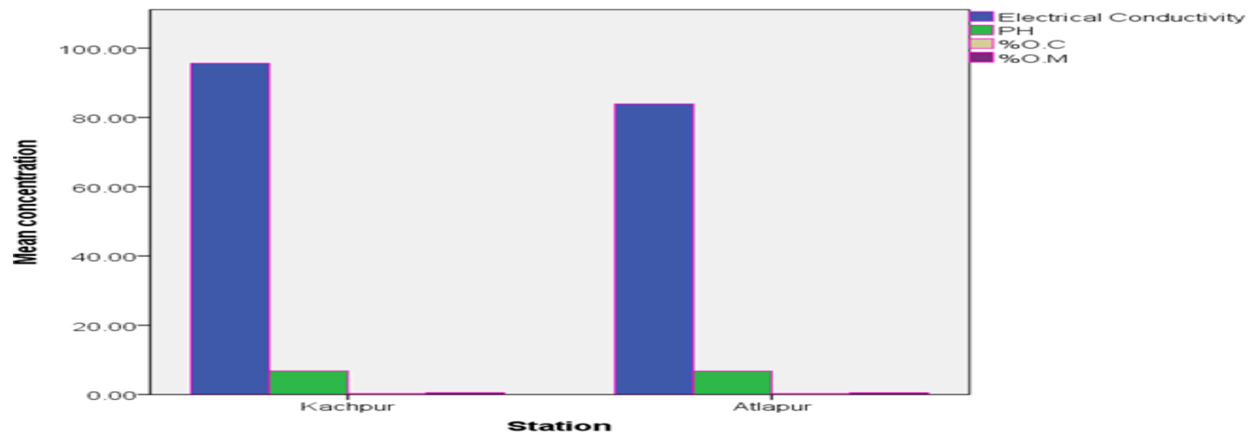

Fig-2. Concentrations of soil quality parameters at different sites

Source: Figure created by SPSS v.22

The ***pH*** of soil determines the chemical nature of soil either the soil is neutral, alkaline or acidic. Soil pH plays a vital role in maintaining optimum nutrients in the soil that render natural healthy environment for living organisms [54]. In the present study, pH was ranged between 6.67-6.97. These present results indicate that the soil of the study area is slightly acidic in nature and very close to the neutral condition. The highest pH was 6.97 recorded at Kanchpur during rainy season while lowest pH 6.67 was found at Atlapur during the winter season (Table 1). Firdous, et al. [5] reported soil pH of the Rawal Lake watershed ranged between 7.1 and 8.7. Upadhyaya and Bajpai [55] stated that the pH of soil was found between 6.3 to 7.9 at Shahpura Lake of Bhopal (M.P). Usha, et al. [56] recorded pH (8.0 to 8.4) at Perumal Lake, Tamilnadu while Gupte and Shaikh [46] found pH range 7.8 to 8.91 in bottom soil at Shelar Lake, Maharashtra. Saravanakumar, et al. [57] documented the pH in soil ranged between and 6.29 and 8.45 in mangroves of Kachchh-Gujarat. The soil pH can be ranged from less than 4 to more than 9 but the optimum pH level for soils is considered to be about neutral pH 7 [35]. Maximum soil phosphorus is locked by forming complexes with calcium at about pH between 6 and 7.5 [58]. Most of the microorganisms (e.g. soil bacteria) function best at pH 7 to 8 [35]. The concentrations of soil quality parameters at different seasons were shown in Figure 2.

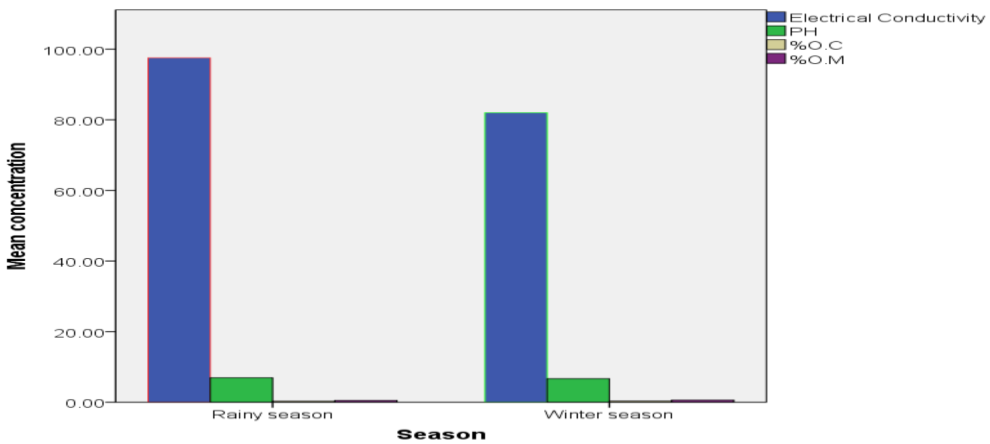

Fig-3. Concentrations of soil quality parameters during rainy and winter season

Source: Figure created by SPSS v.22

Soil organic matter usually ranged from 4-7% of the total soil mass Wagai, et al. [59]; Mallick, et al. [60]. Akram, et al. [61] reported that organic matter was found to be lower than the satisfactory level (>1.29). Moreover, Low organic matter in soil indicates low total nitrogen in the soil [62]. SOM have great impacts on the chemical, biological, and physical properties of the soil that are used for crop production [63]. In the present study, the concentrations of organic matter in the soil of the Sitalakshya River varied between 0.43%-0.66% during all seasons. The highest amount of organic matter was 0.66% recorded at Atlapur during the winter season. The lowest value 0.43% was also recorded from Atlapur during the rainy season (Table 1). Islam, et al. [10] found the concentration of SOM 4.81- 6.59% in the coastal shrimp culture pond at Chakaria, Cox's Bazar. Higher organic matter content is contained in loamy soils while sandy soils are lacking organic matter [64-66]. Variation in soil organic matter largely relies on rainfall pattern, moisture content, and temperature. Organic matter content was higher in the winter season while the minimum was in the rainy season. Since slow microbial decomposition increases the organic matter in the soil [67]. Organic matter in soil generated in huge amount when there is more vegetation growth [68]. Organic matter increase cation exchange capacity that supports the decomposition of dead plants and organisms in pond bottom, consume oxygen and release toxic gas. Organic matter is the key determinants of soil quality for fish production in the lake [35, 69].

Soil organic carbon plays a significant role in cation exchange capacity, nutrient retaining, water holding capacity and biological activity [70]. In the present study, the concentrations of organic carbon ranged between 0.23%-0.35% in the soil of the Sitalakshya River. Minimum concentration 0.23% was found at Atlapur during rainy season while maximum concentration 0.35% was recorded at the same site during winter (Table 1). Talukder, et al. [70] mentioned that organic carbon varied on the spatiotemporal basis from 0.6-4.4% at Chittagong Coast, Bangladesh. Saravanakumar, et al. [57] reported total organic carbon ranged between 0.29% to 2.56% in mangroves of Kachchh, Gujarat [46] found 0.59 % to 1.02 % organic carbon in the Shelar Lake. Soil having 1.5 to 2.5 % or above organic carbon content is considered productive in nature [71]. Organic carbon production has good relation with mud, organic carbon increased with the increasing of mud content [72].

3.1. Correlation Matrix (CM)

The correlation matrix is commonly used to find out the interrelationship among soil variables at different significant level [73, 74]. Two-tailed Pearson product correlation was executed in the present study. The very strong positive correlation was recorded between %O.M vs %O.C (0.998) at the significance level 0.01 (Table 2). Moderate negative relation was found between %O.M vs Electrical Conductivity (-0.612), %O.C vs Electrical Conductivity (-0.596), %O.C vs pH (-0.493) and %O.M vs pH (-0.469) at the alpha level 0.05 (Table 2).

Table-2. Correlation among the soil quality parameters.

Correlations					
		Electrical Conductivity	**pH**	**%O.C**	**%O.M**
Electrical Conductivity	Pearson Correlation	1	0.555	-0.596*	-0.612*
	Sig. (2-tailed)		0.061	0.041	0.035
	N	12	12	12	12
pH	Pearson Correlation	0.555	1	-0.493*	-0.469*
	Sig. (2-tailed)	0.061		0.103	0.124
	N	12	12	12	12
%O.C	Pearson Correlation	-0.596*	-0.493*	1	0.998**
	Sig. (2-tailed)	0.041	0.103		0.000
	N	12	12	12	12
%O.M	Pearson Correlation	-0.612*	-0.469*	0.998**	1
	Sig. (2-tailed)	0.035	0.124	0.000	
	N	12	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Source: Table produced by SPSS V.22

3.2. Analysis of Variance (ANOVA) in Respect of Sites

Electrical Conductivity, pH, %O.C and %O.M showed no significant variations in terms of sampling sites at the significance level (p>0.05). There are the variations in the concentrations of soil parameters but not substantial variations (Table 3).

3.3. Analysis of Variance (ANOVA) in Respect of Seasons

Significant variations in the concentrations of Electrical Conductivity and pH was found in respect of seasons (Rainy season and winter season) at the alpha level ($p<0.05$). Nevertheless, no substantial variations ($p>0.05$) was recorded in %O.C and %O.M concentrations in terms of the season (Table 4).

Table-3. One Way Analysis of Variance (ANOVA) in terms of sites.

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Electrical Conductivity	Between Groups	413.013	1	413.013	2.441	0.149
	Within Groups	1691.953	10	169.195		
	Total	2104.967	11			
pH	Between Groups	0.007	1	0.007	0.302	0.595
	Within Groups	0.216	10	0.022		
	Total	0.223	11			
%O.C	Between Groups	0.000	1	0.000	0.007	0.934
	Within Groups	0.046	10	0.005		
	Total	0.046	11			
%O.M	Between Groups	0.000	1	0.000	0.002	0.963
	Within Groups	0.148	10	0.015		
	Total	0.148	11			

Source: Table produced by SPSS V.22

Table-4. One Way Analysis of Variance (ANOVA) in terms of seasons.

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Electrical Conductivity	Between Groups	723.853	1	723.853	5.241	0.045
	Within Groups	1381.113	10	138.111		
	Total	2104.967	11			
PH	Between Groups	0.183	1	0.183	45.369	0.000
	Within Groups	0.040	10	0.004		
	Total	0.223	11			
%O.C	Between Groups	0.013	1	0.013	4.124	0.070
	Within Groups	0.032	10	0.003		
	Total	0.046	11			
%O.M	Between Groups	0.041	1	0.041	3.794	0.080
	Within Groups	0.108	10	0.011		
	Total	0.148	11			

Source: Table produced by SPSS V.22

4. CONCLUSION

This study was conducted to assess the soil quality parameters of the Sitalakshya River, Bangladesh. Electrical Conductivity and pH showed temporal variation among the studied parameters. Studied parameters showed no significant variation in respect of sites. Correlation analysis revealed the close relationship between organic matter and organic carbon. The present study indicates that there are not enough nutrients in the soil for the optimum growth of species (both plant and fish). This scenario occurs may be due to the heavy industrialization and brickfields in the study area. The river ecosystem should be protected for our forthcoming future by implementing some good management practices. This is a baseline study and it will be a supportive resource for researchers and policymakers that will help in the holistic watershed managing plan.

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