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Assessment of soil properties of a lentic ecosystem in semiarid region: Nakki Lake, Mount Abu, India

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ABSTRACT

Soil parameter balances the ecological symmetry in a lake-ecosystem. It determines the portability of water through its inter-relationship among phytoplanktons and zooplanktons. The purpose of the study is to identify the status of soil parameters in different seasons across the surrounding area of Nakki Lake, Mount Abu (2017-19). The soil parameters were analyzed and based on the results of the physico-chemical parameters of the soil; it confirms that the soil in the surrounding area of Nakki Lake in winter season can be classified as moderately alkaline soil. The soil analysis shows a linear positive correlation found with undeviating pattern (r = 1.000) of Clay with Bulk density and nitrogen; chloride with sulphur. Permeability is showing strong negative correlation with most of the soil parameters and shows linear trend in negative correlation (r = -1.000) with potassium

***Keywords*:** Lentic ecosystem, alkaline, semiarid region, Nakki Lake, Mount Abu, physico-chemical parameters, phytoplanktons, zooplanktons

1. INTRODUCTION

Soil is an indispensable life sustaining element of biosphere, it is an essential medium to provide nutrients and materials, which forms the life layer of plants and also animals. Soil parameter plays a key factor in planktonic and botanical diversity, which maintains the

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portability of water and zooplanktons in a waterbody; together they constitute a balance in the equilibrium of the aquatic environment. The study of physico-chemical parameters of soil in different seasons is important to understand the growth of an aquatic ecosystem. Joffee (1949) reported, soil is a natural body composed of minerals and organic materials differentiated into horizons. Nature and type of top soil plays an important role in determining the growth of vegetation. Soil holds the plants and absorbs minerals for their normal growth and development.

The type of soil is determined by the original parent rock from which the soil is formed by the action of different agents. Mount Abu is a hill station, located at 24.596140°N, 72.703066°E in the Aravali mountain range of Rajasthan. It is a major tourist centre of the state, and has been notified as a Wildlife Sanctuary and Eco-Sensitive Zone (ESZ) or Ecologically Fragile Area (EFA) by the Ministry of Environment, Forests and Climate change (MoEFCC), Government of India.

As soil plays an important role in conserving the aquatic ecosystem, the objective of the research is to identify the status of physico-chemical parameters of the soil in rainy season at the surrounding area of Nakki Lake, Mount Abu.

2. STUDY AREA AND COLLECTION OF SAMPLES

Nakki Lake (Figure 1) has enormous importance for the residents of the town, the specific status of soil parameters in Nakki Lake have been studied through different weather cycles (2017-19) across three regions based on the geography and contact with human population over the top bank area. The area surrounding Nakki Lake can be categorised into three regions as Populated, Non-Populated and Mountain region (Gothwal and Gupta; 2019).

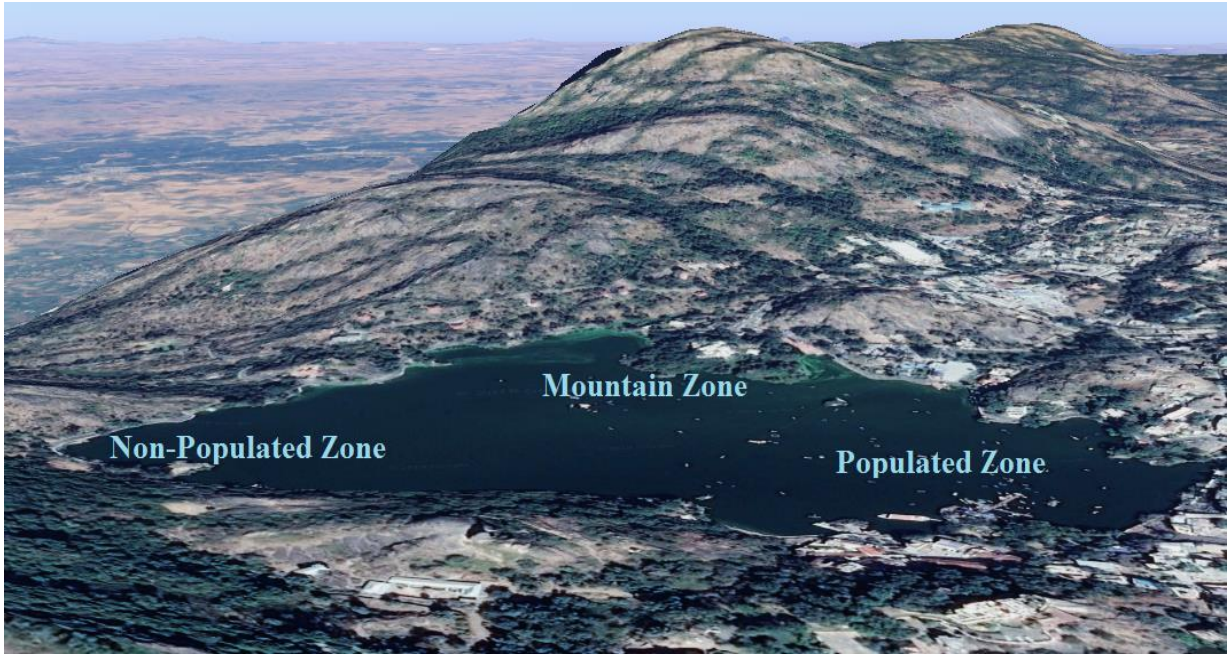

Figure 1. GIS view of Nakki Lake, Mount Abu (Rajasthan), India
(Source: *World Scientific News,* Vol. 115, pp. 118)

The present study primarily focuses on the physico-chemical analysis of soil samples collected from three pre-selected sites covering the total area of Nakki Lake in the period of 2017-2019. Soil samples were collected from three respective sites (Figure 1) using surgical suites by making a 'V' shaped cut to a depth of 25-30 cm in the sampling spot, uniform thick chunks of soil up to 3cm were collected in a plastic bucket. These soil lumps were broken into small pieces through a wooden pestle and dried. The air-dried soil samples were stored in glass bottles and labelled for various laboratory analyses by the methods given by Black C.A. (1965), Jackson, M. L (1958).

3. RESULT AND DISCUSSION

The result of soil analysis from respective samples confirms that, the texture of soil across surrounding area of Nakki Lake shows lofty amount of sand content compared to silt and clay content. The percentage of sand, silt and clay content observed in analysis of soil across populated, non-populated and mountain region of Nakki Lake shows tiny variations with the seasonal survey (Table 1). The mean value of soil texture in all three regions of Nakki Lake, Mount Abu (Figure 2) shows statics of Sand content 75.12%, Silt content 11.23%, and Clay content 6.51% in summer season, whereas in rainy season it deflects to Sand Content 78.18%, Silt Content 11.79%, Clay Content 7.21% while the observed value in winter season appears to be Sand Content 76.93%, Silt Content 11.06%, Clay Content 6.51%. The soil texture allows the root systems to spread well in dense areas and allow water and nutrients to leach too rapidly. It plays a key role in the growth of immense vegetation of terrestrial, emerged, floating and submerged plants across the lake boundaries throughout the littoral zone (Maji et al. 2005). The runoff from mountains into the lake during the rainy season elevates in the value of soil texture.

Table 1. Comparative study of soil parameters in summer, Rainy & Winter seasons (2017-19): Nakki Lake, Mount Abu

S. No	Parameters	Summer				Rainy				Winter			
		Populated	Non-Populated	Mountain	Mean Summer	Populated	Non-Populated	Mountain	Mean Rainy	Populated	Non-Populated	Mountain	Mean Winter
1	Sand Content (%)	75.44	73.6	76.32	75.12	78.64	76.34	79.56	78.18	76.38	75.87	78.54	76.93
2	Silt Content (%)	11.28	10.76	11.65	11.23	12.34	11.28	11.76	11.79	11.58	10.38	11.21	11.06
3	Clay Content (%)	5.94	6.3	7.3	6.51	6.48	7.27	7.89	7.21	5.94	6.3	7.3	6.51

4	pH Value	7.04	7.12	7.16	7.11	7.46	7.23	7.67	7.45	7.13	7.37	7.24	7.25
5	Permeability (mm/hr)	28	26	29	27.67	24	23	27	24.67	26	24	28	26
6	Air Filled Porosity (%)	15	13	15	14.33	17	14	16	15.67	14	12	16	14
7	Bulk Density (kg/m^3)	1458	1436	1465	1453	1467	1442	1478	1462.33	1455	1442	1461	1452.67
8	Calcium Carbonate (%)	1.44	1.56	1.43	1.48	1.56	1.78	1.69	1.68	1.49	1.58	1.52	1.53
9	Organic Matter (%)	3.55	3.1	3.43	3.36	3.78	3.62	3.96	3.79	3.57	3.24	3.88	3.56
10	Nitrogen Content (%)	0.22	0.26	0.22	0.23	0.25	0.27	0.23	0.25	0.23	0.25	0.22	0.23
11	Chloride (Cl) (mg/L)	4032	4125	4168	4108.33	4047	4183	4174	4134.67	4039	4168	4159	4122
12	Sulphur Content (mg/L)	223	265	245	244.33	232	270	263	255	227	268	254	249.67
13	Phosphorus Content (mg/L)	53	48	56	52.33	56	51	59	55.33	56	51	53	53.33
14	Potassium Content (mg/L)	749	720	729	732.67	758	727	740	741.67	754	723	736	737.67
15	Magnesium Content (mg/L)	158	153	150	153.67	164	159	154	159	162	156	153	157
16	Electrical Conductivity (µS/cm)	2411	2450	2480	2447	2415	2463	2494	2457.33	2421	2448	2476	2448.33

The mean pH value of soil (Figure 3) in adjoining areas of the waterbody shows slight difference of 7.11 in summer, 7.45 in rainy and 7.25 in winter season. The result in range of pH shows that the soil can be classified as slightly alkaline in summer and winter, however with rainy season; it seems to be moderately alkaline. Soil permeability refers to the association of air and water throughout the soil; it supplies the available nutrients and moisture for plant uptake. It is an important property of the soil to transmit water and air for the growth of producers in the food chain. It is one of the most important qualities to reflect fish ethnicity in

an aquatic ecosystem. The seasonal mean permeable value in soil of Nakki Lake shows 27.67 mm/hr in summer, 24.67 mm/hr in rainy and 26 mm/hr in winter season. Air-filled porosity is the vacate pores in soil which is not filled with water and varies with soil moisture content.

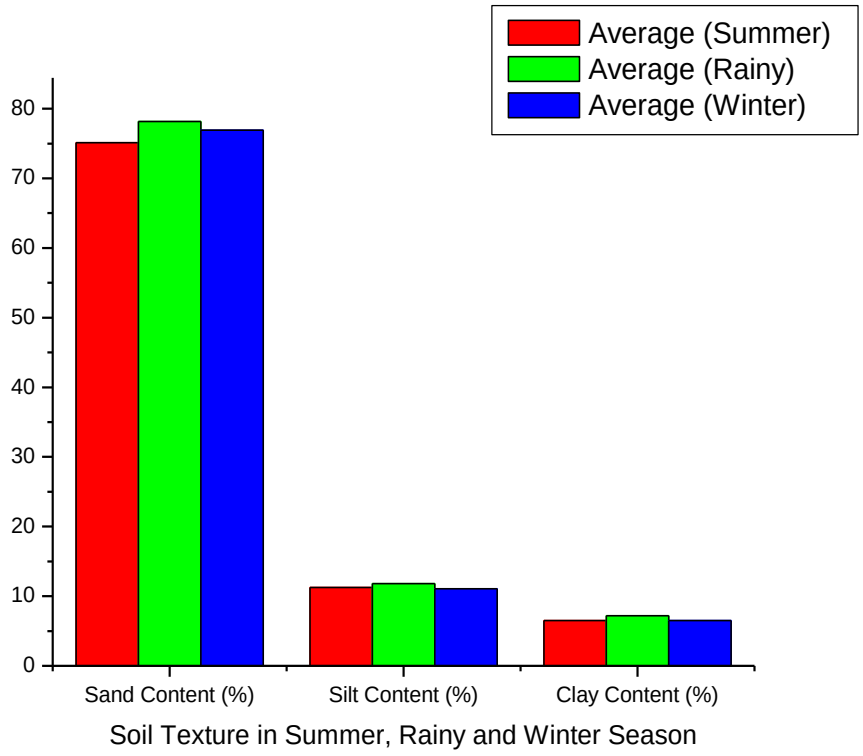

Figure 2. Comparative Analysis of Soil Texture in Summer, Rainy and Winter seasons (2017-2019) Nakki Lake, Mount Abu

The average value of air filled porosity analyzed under the research study is 14.33% in summer, 15.67% in rainy and 14% in winter season. Bulk density is defined as the dry weight of soil per unit volume; it considers both the solids and the pore space. In the present research study the mean bulk density (kg/m^3) in the soil of Nakki Lake over summer, rainy and winter season shows value of 1453 kg/m^3, 1462.33 kg/m^3 and 1452.67 kg/m^3. The experiential value of bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration in all the seasons.

Electrical conductivity (EC) in soil measures the salinity of soil, in other words it identifies the amount of salts in soil. It is a vital gauge of soil health (Meena et. al. 2017). The Electrical Conductivity (µS/cm) in soil of Nakki Lake shows statics of 2447 in summer, 2457.33 in rainy and 2448.33 in winter season. The soil across the adjoining areas of Nakki Lake exhibit an intemperance in salts that occurs naturally in arid and semiarid climates, these salt levels results to an increment in diversity of the vegetation.

Calcium Carbonate raise the pH of soil, the experiential value of Calcium Carbonate (%) in different seasons across soil of adjoining areas of Nakki Lake is 1.48 % in summer, 1.68 % in rainy and 1.53 % in winter season. Organic Matter serves as a pool of nutrients in the soil; it

increases infiltration of water and surface crusting by reducing compaction along with binding of soil particles, which improves the water holding capacity of soil. The value of Organic Matter (%) is 3.36 in summer season, 3.79 in rainy season and 3.56 in winter season. Soil contains more than 20% of organic matter refers to as organic soil and less than 20% considered as mineral soil.The main soil nutrients analysed under the research study are Nitrogen (N), Chloride (Cl), Sulphur (S), Phosphorus (P), Potassium (K) and Magnesium (Mg). According to the soil analysis of nutrient parameters over populated, non-populated and mountain regions, the mean seasonal value of soil nutrients across the adjoining areas of Nakki Lake shows variations in their percentage with different seasons.

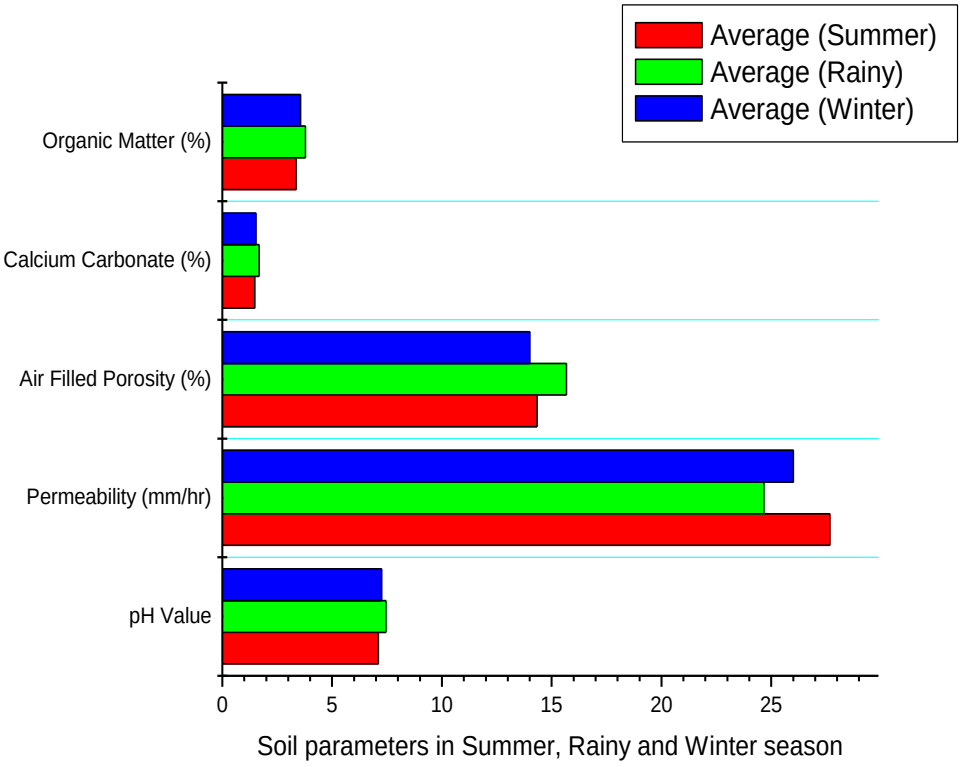

Figure 3. Comparative Analysis of Soil parameters in Summer, Rainy and Winter seasons (2017-2019) Nakki Lake, Mount Abu

The concentration of Nitrogen (N) in the soil of Nakki Lake is 0.23(%) in summer season, 0.25(%) in rainy season and 0.23(%) in winter season, whereas Sulphur (S) deflects with change in season, 244.33 mg/L in summer season, 255 mg/L in rainy season and 249.67 mg/L in winter season. According to Thoni et al. (1996), the excess burning up of fuels with influx of tourist in the town can be the reason for increase in Sulphur content throughout the year near densely populated areas. Saxena et al. (2010) indentifies smallest amount of Sulphur concentration revealed in rainy season which could be due to deviation of tourism in the monsoon season and dispersal of pollutants along with the intense growth in biomass takes place more quickly, as a result, it decreases the Sulphur fraction in undergrowth in proportion to biomass. Poikolainen et al. (2004) indicates supplement of metals in soil and surrounded area is associated with the

automobile generated contamination and appears as absurd enrichment in utmost Sulphur content during winter season due to high traffic movement. Similarly, concentration of Phosphorus and Magnesium has been noted 52.33 mg/L and 153.67 mg/L in summer season, 55.33 mg/L and 159 mg/L in rainy season, and 53.33 mg/L and 157 mg/L in winter season. Elser et al. (2007) expressed that application of phosphorus is necessary for maintaining a balance with other plant nutrients and act as a co-limiting factor of ensuring the normal growth of the vegetation and ecosystem productivity. Wang et al. (2007), Vitousek et al. (2010) state low Phosphorus availability can constrain N_2 fixation.

Table 2. Correlation coefficient analysis in variables of soil samples across all sites of Nakki Lake in Summer, Rainy & Winter seasons (2017-2019)

Parameters	Sand Content (%)	Silt Content (%)	Clay Content (%)	pH Value	Permeability (mm/hr)	Air Filled Porosity (%)	Bulk Density (kg/m3)	Calcium Carbonate (%)	Organic Matter (%)	Nitrogen Content (%)	Chloride (Cl) (mg/L)	Sulphur Content (mg/L)	Phosphorus Content (mg/L)	Potassium Content (mg/L)	Magnesium Content (mg/L)
Sand Content (%)	1														
Silt Content (%)	0.658	1													
Clay Content (%)	0.809	0.975	1												
pH Value	0.979	0.798	0.912	1											
Permeability (mm/hr)	-0.999	-0.687	-0.832	-0.986	1										
Air Filled Porosity (%)	0.685	0.999	0.982	0.820	-0.713	1									
Bulk Density (kg/m3)	0.791	0.981	1.000	0.900	-0.814	0.988	1								
Calcium Carbonate (%)	0.926	0.893	0.971	0.984	-0.941	0.909	0.963	1							
Organic Matter (%)	0.989	0.760	0.885	0.998	-0.994	0.783	0.871	0.971	1						
Nitrogen Content (%)	0.809	0.975	1.000	0.912	-0.832	0.982	1.000	0.971	0.885	1					

Chloride (Cl) (mg/L)	0.997	0.718	0.855	0.992	-0.999	0.743	0.839	0.954	0.998	0.855	1				
Sulphur Content (mg/L)	0.995	0.733	0.866	0.995	-0.998	0.757	0.850	0.961	0.999	0.866	1.000	1			
Phosphorus Content (mg/L)	0.957	0.848	0.945	0.996	-0.968	0.867	0.935	0.996	0.989	0.945	0.978	0.982	1		
Potassium Content (mg/L)	0.999	0.688	0.832	0.986	-1.000	0.714	0.815	0.941	0.995	0.832	0.999	0.998	0.968	1	
Magnesium Content (mg/L)	0.999	0.629	0.786	0.970	-0.997	0.657	0.767	0.911	0.983	0.786	0.993	0.990	0.945	0.997	1

The value of Potassium shows the mean value of 732.67 mg/L in summer season, 741.67 mg/L in rainy season and 737.67 mg/L in winter season, while significance of Chloride (Cl) (mg/L) in the soil of Nakki Lake ranges 4108.33 in summer season 4134.67 in rainy season and 4122 in winter season. Saxena and Saxena (2000) reveal that the town in winter season is more crowded with tourists than in summer and monsoon season. Hence the increase in load of metallic values is directly proportional to the traffic density that can be identified by their high value in soil and plants growing at the side of Nakki Lake, Mount Abu.

As shown in Table 2, Statistical analysis of Correlation coefficients in the soil samples variables across all sites of Nakki Lake were analyzed to obtain relations between them. The analysis shows that there is a positive correlation (r = 1.000) with undeviating pattern in Clay content with Bulk density and nitrogen. Chloride and Sulphur shows linear positive correlation (r = 1.000) whereas, Bulk density shows positive correlation with nitrogen (r = 1.000) in a linear trend. Sand content, silt content and clay content shows strongly positive correlation with pH Value (r = 0.979, 0.798, 0.912), Bulk Density (r = 0.791, 0.981,1.000), Calcium Carbonate (r = 0.926, 0.893, 0.971), Organic Matter(r = 0.989, 0.760, 0.885), Nitrogen (r = 0.809, 0.975, 1.000), Chloride (r = 0.997, 0.718, 0.855), Sulphur (r = 0.995, 0.733, 0.866) and Phosphorus (r = 0.957, 0.848, 0.945) while permeability is showing strong negative correlation with most of the soil parameters and shows linear trend in negative correlation with potassium (r= -1.000). In Table 3, the test of Analysis of Variance (ANOVA; except mean values of summer, rainy and winter season in Table 1), the result of ANOVA shows that the calculated F-value 1.75 is smaller than F-critical value 2.02 with 5% level of significance. Hence the test of ANOVA accepts the null hypothesis (H_o).

In the given parameters of soil samples from Table 1:

Table 3. Two-way ANOVA in variables of soil samples in Summer, Rainy & Winter season (2017-19)

Null hypothesis (H_0): there is no significant variation between the parameter means of the Sampling sites

Alternative hypothesis (H_A): there is significant variation between the parameter means of the Sampling sites

Parameters	Count	Sum	Average	Variance
Sand Content (%)	9	690.69	76.74	3.45
Silt Content (%)	9	102.24	11.36	0.33
Clay Content (%)	9	60.72	6.75	0.50
pH Value	9	65.42	7.27	0.04
Permeability (mm/hr)	9	235.00	26.11	4.36
Air Filled Porosity (%)	9	132.00	14.67	2.50
Bulk Density (kg/m^3)	9	13104.00	1456.00	188.50
Calcium Carbonate (%)	9	14.05	1.56	0.01
Organic Matter (%)	9	32.13	3.57	0.08
Nitrogen Content (%)	9	2.15	0.24	0.00
Chloride (Cl) (mg/L)	9	37095.00	4121.67	4081.00
Sulphur Content (mg/L)	9	2247.00	249.67	342.50
Phosphorus Content (mg/L)	9	483.00	53.67	11.50
Potassium Content (mg/L)	9	6636.00	737.33	191.50
Magnesium Content (mg/L)	9	1409.00	156.56	21.03
Electrical Conductivity (µS/cm)	9	22058.00	2450.89	908.11

*Variance value (Nitrogen- 0.00036)

Parameters	Count	Sum	Average	Variance
Populated_Summer	16	9231.91	576.99	1300958.59
Non-Populated_Summer	16	9338.70	583.67	1350022.13
Mountain__Summer	16	9444.51	590.28	1381211.52
Populated_Rainy	16	9290.51	580.66	1308910.70
Non-Populated_Rainy	16	9439.79	589.99	1380665.49
Mountain_Rainy	16	9517.76	594.86	1387774.67
Populated_Winter	16	9260.32	578.77	1305903.85
Non-Populated_Winter	16	9396.99	587.31	1370233.95
Mountain_Winter	16	9445.91	590.37	1375045.96

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Rows	182369671.69	15	12157978.11	35384.99	5.08	1.75
Between Columns	4812.24	8	601.53	1.75	0.09	2.02
Residual Error	41230.97	120	343.59			
Total	182415714.90	143				

The calculated F-value 1.75 is smaller than F-critical value 2.02 with 5% level of significance. Hence the test of ANOVA accepts the null hypothesis (H_o)

4. CONCLUSION

The nature of the soil determines botanical diversity at any topography. The existence of organic matter and accessibility of minerals in the soil acts as a key role for fertility and growth of vegetation. Consequently soil creates a dynamic medium or an important substrate for the assortment of vegetation at any environment. Based on the results of physico-chemical parameters of the soil analysis, the nature of the soil in the adjacent area of Nakki Lake can be classified as moderately alkaline soil.

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