Original Research Article

Assessment of Physico- Chemical Properties of Soil from Various Regions ofDifferent Taluk of Pathanamthitta District in the State of Kerala

ABSTRACT

The assessment of Physico-Chemical Properties of Soil from Various Regions of Different Taluk of Pathanamthitta District of Kerala in 2023-24 was a valuable endeavour. A total of 27 samples were collected at profile depths of 0-15, 15-30, and 30-45.It is interesting to note the variations in soil colour between dry and wet conditions, ranging from light brown to dark reddish brown.The soil textural class was identified as Sandy clay Loam, and the sand, silt and clay percentage varied from45.18% to 50.64%, 17.21% to 20.70%, 30.91% to 34.61%. Bulk Density was varied from 1.08 Mg m^{-3} to 1.28 Mg m^{-3}. The Particle Density varied from 2.02 Mg m^{-3} to 2.55 Mg m^{-3}. The Pore Space (%) ranged from 40.18 % to 50.62 %. The Water Retaining Capacity (%) ranged from 39.19 to 48.98 %. The pH value ranged from 4.9 to 6.9. The Electrical Conductivity ranged from 0.03 to 0.30 dS m^{-1}. The value of total Organic Carbon (%) varied from 0.16 to 1.68 %. The available Nitrogen content of soil ranged from 119.45 to 286.07 kg ha^{-1}. The available Phosphorus content of soil ranged from 13.23 to 64.20 kg ha^{-1}. Available Potassium content of soil ranged from 100.80 to 382.40 kg ha^{-1}. Exchangeable Calcium content of soil ranged from 1.7(meq $100g^{-1}$) to 9.1(meq $100g^{-1}$). Exchangeable Magnesium content of soil ranged from 0.23 (meq $100g^{-1}$) to 0.74(meq $100g^{-1}$). The Sulphur content of soil ranged from 0.03 to 0.44 $kgha^{-1}$.The findings revealed minor increases in bulk and particle density with depth, yet the overall physical condition of the soil seems favourable for plant growth. It is evident that the soils are slightly acidic but meet the acceptable EC limit. The high levels of Organic Carbon are promising, while Nitrogen is lower and Phosphorus and Potassium levels are moderate to high. However, secondary nutrients like Calcium, Magnesium, and Sulphur are relatively low. Nutrient levels appear to be influenced by soil depth, with leaching due to higher precipitation levels in the area contributing to nutrient deficiencies. The results suggest that improvements can be made by implementing strategies such as cover crops, green manure, legume cultivation, mulching, and specific cropping systems to address leaching concerns.

Key words: Pathanamthitta District, Physico- Chemical Properties Kerala *etc*.

1. INTRODUCTION

Soil is a natural body developed by natural forces acting on natural materials. It is usually differentiated into horizons from mineral and organic constituents of variable depth which differ from the parental material below in morphology, physical properties and constitutions, chemical properties and composition and biological characteristics (Joffe and Marbut, 1965)[1].Soil (Sustainable Organic Integrated Livelihoods)Soil[23] is the loose surface material that covers the earth surface. It consists both organic matter and inorganic particles. Soil provides the structural support to plants used in agriculture and is also their source of water and nutrients. Soils vary in their chemical and physical properties.Characteristics of the soil vary from place to place. The soil on steep slopes is generally not as deep and productive as soil on gentle slopes. Soil that has developed from sandstone is more sandy and less inherently productive than soil formed from rocks such as limestone. The properties of a soil that has developed in tropical climates are different from those of a soil found in temperate areas.The uppermost layers or horizons of a soil profile are darker in color than the lower horizons. This difference is due to the accumulation of organic matter that results from the decay of plant roots and of other organic residues incorporated into the upper soil layers. Also weathering tends to be more intense in the upper horizon than in the lower layers.

Physico-chemical study of soil is based on various parameters like pH, electrical conductivity, texture, soil organic matter, bulk density, particle density, porosity, nitrogen, phosphorus and potassium etc. This knowledge will help to the people who are interested to work in agricultural field and it will also help to provide adequate amount of nutrients and increase the yield the need of soil testing is very important for getting overall physical, chemical and biological behavior of soil[24]. When we see the soils are not responding after sowing of crop and applied fertilizers, definitely soil and crop are suffering from deficiency of nutrients. Therefore, we cannot achieve optimum growth of crop, productivity and soil health. Ultimately soil and crop nutrient balance is negative. Almost, farmers are giving straight fertilizer and other nutrients will be completely mined. On the basis of soil test values can be achieved crop and soil health. Therefore, the soil testing is a future need for improvement of soil fertility, deficiency of nutrients and crop productivity.

2. MATERIALS AND METHODS

Kerala is located on the south western tip of India. The total area of Kerala covers approximately 38,863 km^2, which represents 1.18% of India's landmass. It is beautifully positioned between the Arabian Sea to the west and the Western Ghats to the east. The district of Pathanamthitta is situated at 9.2601° N, 76.9643° E, with an average elevation of 18 meters (62 ft) above sea level. Pathanamthitta district is nestled in the Central Travancore region within the state of Kerala, India, spanning an area of 23.50 km^2. This town is renowned as the "Pilgrim Capital of Kerala". Pathanamthitta enjoys a tropical monsoon climate bordering on a tropical rainforest climate, much like the rest of Kerala and is illustrated in figure 1. The annual temperatures typically vary from 20 °C to 39 °C. The district encounters three distinct seasons: winter, summer, and the monsoon, with an average annual rainfall of 3134 mm. The primary soil type in the district is mainly composed of laterite and its variations. Additionally, other soil types like river bank alluvium and peaty soil can also be found in certain parts of the district.

2.1Sampling and Analysis

Soil samples from nine villages in three different taluks of Pathanamthitta district, Kerala were carefully collected. These villages include Kozhencherry, Konni, and Adoor. The collection of soil samples involved the use of khurpi, spade, and meter scale. Prior to collecting the samples, the sampling spot was cleared to ensure accurate results. A 'v' shaped cut, 15 cm deep, was made in the sample spot with a spade. In each taluk, three sampling sites were chosen, with samples taken at depths of 0–15 cm, 15–30 cm, and 30-45 cm. The soil samples collected were thoroughly mixed to ensure homogeneity and to remove any foreign objects like gravel, stones, pebbles, and roots. The mixed samples were then quartered to divide them in half for further analysis of their physico-chemical properties represented in table 1 and table 2. The data gathered during the investigation was carefully recorded and later analysed using statistical methods such as Completely Randomized Design (CRD) through the technique of "Analysis of Variance" (ANOVA).

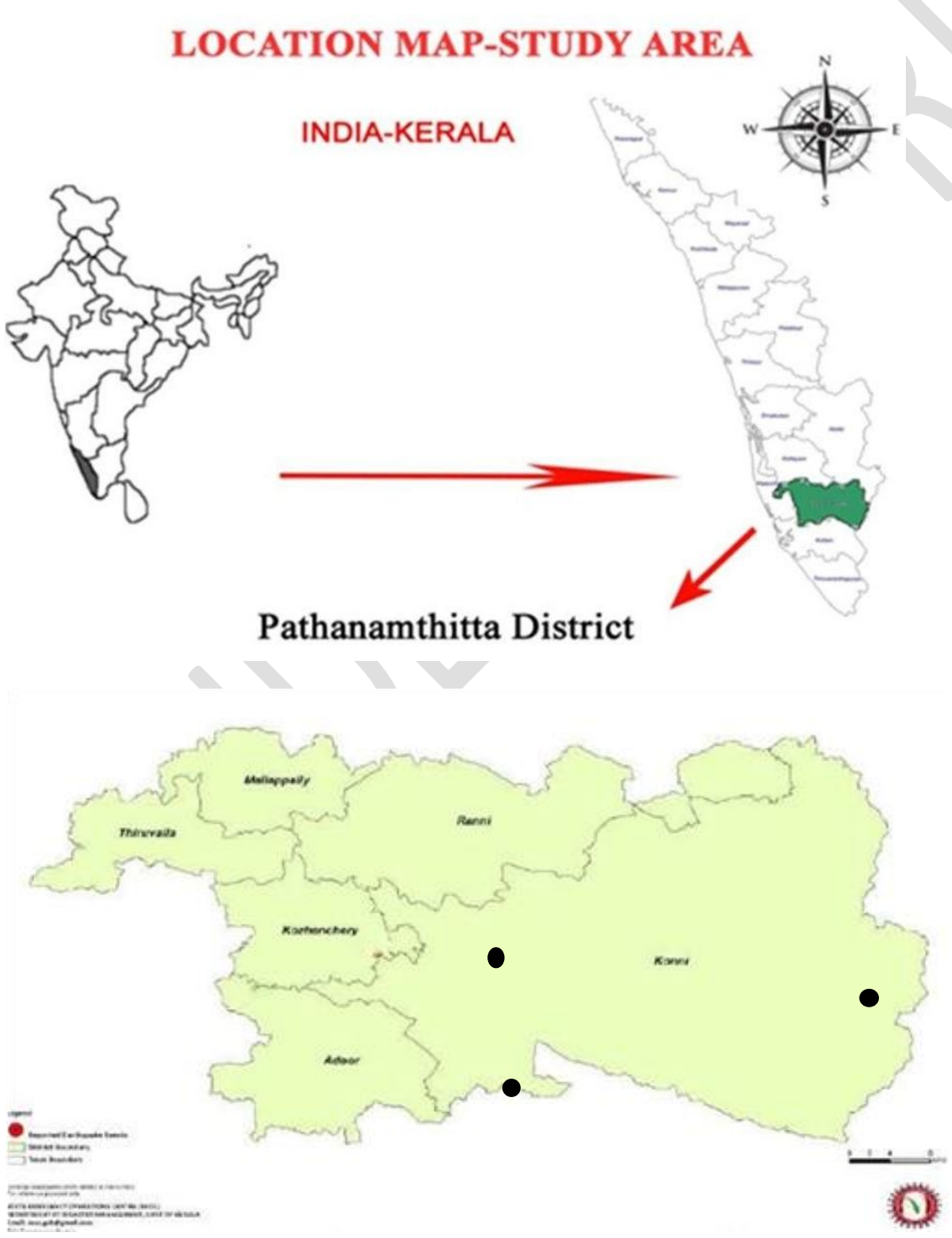

Fig.1: Geographical Map of Study Area

Table 1: Physical analysis of soil

S. No.	PARTICULARS	SCIENTIST(YEAR)
1	Soil Colour	Albert Henry Munsell, (1971)
2	Soil Texture	Bouyoucos, (1927) [2]
3	Bulk Density (Mg m^{-3})	(Muthuvel *et al.*,1992) [3]
4	Particle Density (Mg m^{-3})	
5	Pore space (%)	
6	Water Retaining Capacity (%)	

Table 2: Chemical analysis of soil

S. No.	PARTICULARS	SCIENTIST(YEAR)
1	Soil pH (1:2.5)	(Jackson, 1958) [4]
2	Electrical Conductivity (ds m^{-1})	(Wilcox, 1950) [5]
3	Organic Carbon (%)	(Walkley and Black, 1947) [6]
4	Available Nitrogen (kg ha^{-1})	(Subbiah and Asija, 1956) [7]
5	Available Phosphorus (kg ha^{-1})	(Olsen *et al.*, 1954) [8] ,(Bray and Kurtz,1945) [9]
6	Available Potassium (kg ha^{-1})	(Toth and Prince, 1949) [10]
7	Available Sulphur (kg ha^{-1})	(Chesnin & Yien, 1950) [11]
8	Calcium and Magnesium (meq $100g^{-1}$)	(Jackson, 1973) [12]

3. RESULTS AND DISCUSSION

3.1 Physical properties

3.1.1 Soil Colour

The findings show that the soil samples obtained from Kozhencherry, Konni, Adoor Taluk of Pathanamthitta district exhibit a range of colors, from light brown to dark brown to reddish yellow in dry conditions, and from reddish brown to dark reddish brown to strong brown in wet conditions. The presence of high organic matter content is typically indicated by dark brown colour. Wet soils tend to be darker compared to dry soils.similar outcomes were discovered by Nair*et al.*, (2022). [14]

3.1.2Soil Texture

The outcome clearly shows that the soil samples taken from Kozhencherry, Konni, and Adoor Taluk in Pathanamthitta district have a texture classified as sandy clay loam, with percentages of sand, silt, and clay ranging from 45.18% to 50.64%, 17.21% to 20.70%, and 30.91% to 34.61%, respectively and illustrated in figure 2. similar outcomes were discovered by Gopan *et al*., (2022). [15]

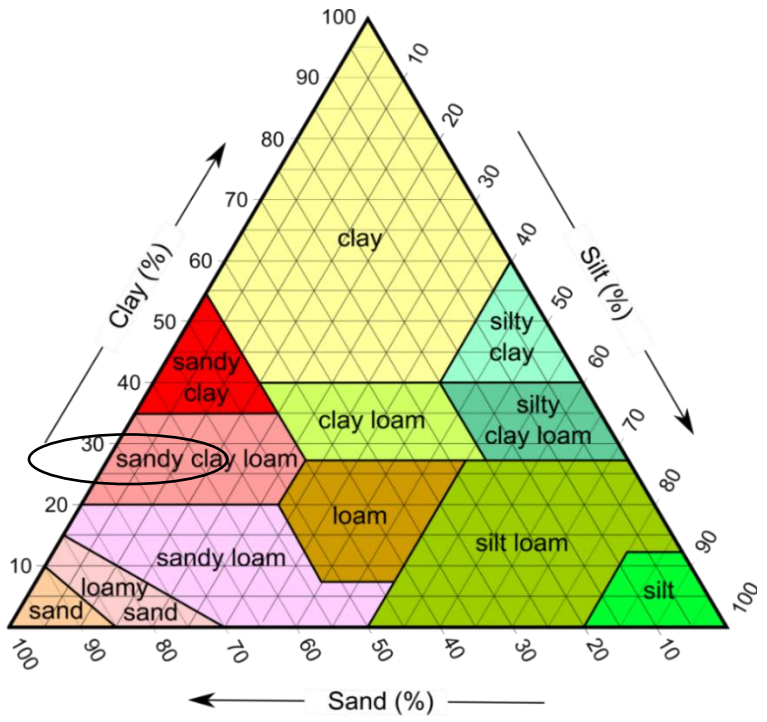

Fig.2: Soil Textural Triangle (Sand, silt and clay %) by USDA

3.1.3 Bulk Density (Mg m^{-3})

As the result illustrates that the bulk density of soil samples collected from Kozhencherry, Konni, Adoor Taluk of Pathanamthitta district, ranging from 1.08 Mg m^{-3} to 1.28 Mg m^{-3}.It is evident that the bulk density slightly increases with depth as a result of the more compacted subsurface layers.Similar outcomes were discovered by Amjad *et al.*, (2021). [16]

3.1.4 Particle Density (Mg m^{-3})

The Particle Density also shows variation from 2.02 Mg m^{-3} to 2.55 Mg m^{-3}, with an upward trend observed with increasing soil depth, attributed to soil compaction and is represented in table 3 and is shown in figure 3. Similar outcomes were discovered by Amjad *et al.*, (2021). [16]

Table 3: Bulk density and Particle density (Mg m^{-3}) of soil at various regions of different taluk of Pathanamthitta district

Taluk	Village	BulkDensity(Mgm^{-3})		ParticleDensity(Mgm^{-3})	
		Range	Mean	Range	Mean
Kozhencherry	Omalloor (V_1)	1.11 – 1.14	1.12	2.46 – 2.49	2.47
	Kulanada (V_2)	1.25 – 1.28	1.26	2.50 – 2.53	2.51
	Aranmula (V_3)	1.25 – 1.25	1.25	2.53 – 2.55	2.53
Konni	Konni (V_4)	1.08 – 1.10	1.09	2.06 – 2.10	2.08
	Thannithodu (V_5)	1.10 – 1.17	1.13	2.02 – 2.08	2.05
	Vallikkodu (V_6)	1.16 – 1.18	1.16	2.35 – 2.38	2.36
Adoor	Enathu (V_7)	1.10 – 1.20	1.15	2.15 – 2.18	2.16
	Pandalam (V_8)	1.11 – 1.18	1.14	2.24 – 2.29	2.26
	Peringanad (V_9)	1.17 – 1.22	1.19	2.22 – 2.25	2.23

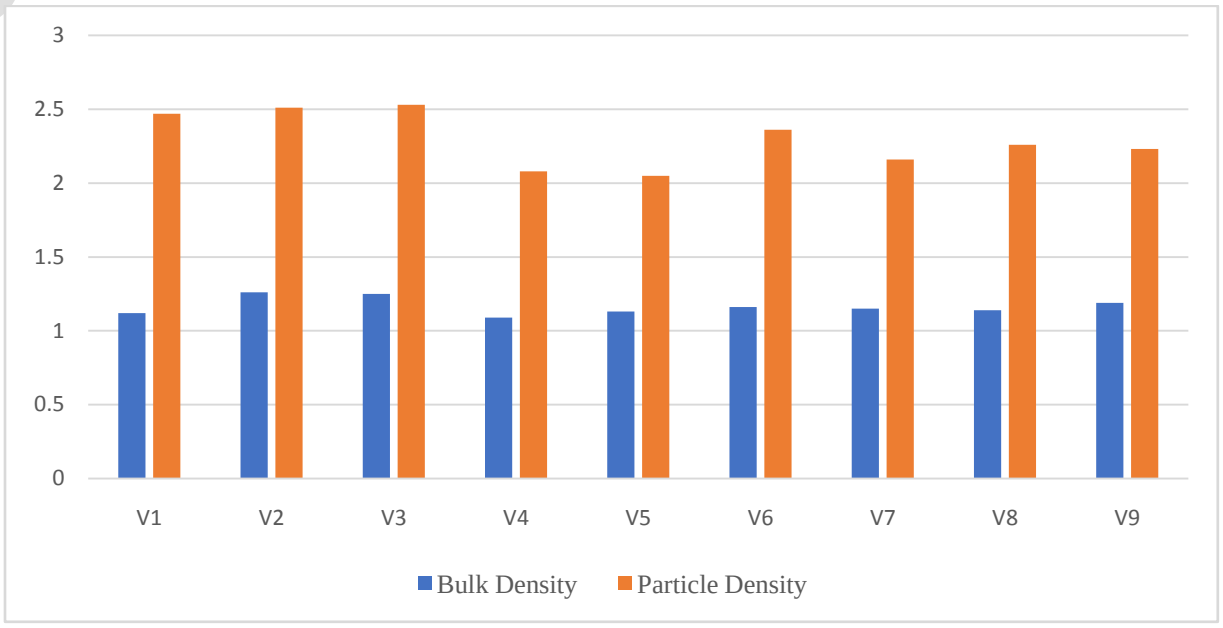

Fig.3: Bulk Density and Particle Density (Mg m^{-3}) of soil samples at 0- 15, 15–30, and 30-45 cm depth in various regions of different Taluk of Pathanamthitta district

3.1.5 Pore space (%)

The Pore Space (%) ranged from 40.18 % to 50.62 % as shown by the results in Table 4. It is important to note that the variation in percentage of pore space is influenced by factors such as soil compaction and cementation. Similar outcomes were discovered by Johnson *et al*., (2023). [17]

3.1.6Water Retaining Capacity (%)

The Water Retaining Capacity (%) ranged from 39.19 to 48.98 % according to the results in table 4 and shown in figure 4. It is evident that along with soil depth, the Water Retaining Capacity (%) decreases as Subsurface layers are more compacted and have less pore space compared to surface layers, thus containing less water retaining Capacity. Similar outcomes were discovered by Johnson *et al*., (2023).[17]

Table 4: Pore space (%) and Water Retaining Capacity (%)of soil at various regions of different taluk of Pathanamthitta district

Taluk	Village	Pore space (%)		Water Retaining Capacity(%)	
		Range	Mean	Range	Mean
Kozhencherry	Omalloor (V_1)	44.86 – 47.64	46.15	39.47 – 45.69	42.80
	Kulanada (V_2)	45.11 – 48.44	46.95	40.18 – 44.44	42.60
	Aranmula (V_3)	49.30 – 50.62	50.01	41.01 – 48.64	45.34
Konni	Konni (V_4)	44.51 – 47.28	45.79	41.38 – 46.99	43.85
	Thannithodu (V_5)	42.12 – 45.30	43.97	40.08 – 43.95	41.87
	Vallikkodu (V_6)	48.10 – 50.29	49.40	42.61 – 48.98	45.57
Adoor	Enathu (V_7)	44.07 – 48.61	45.97	40.06 – 46.70	42.98
	Pandalam (V_8)	45.94 – 50.55	48.20	41.78 – 48.02	44.90
	Peringanad (V_9)	40.18 – 47.05	43.49	39.19 – 45.94	41.73

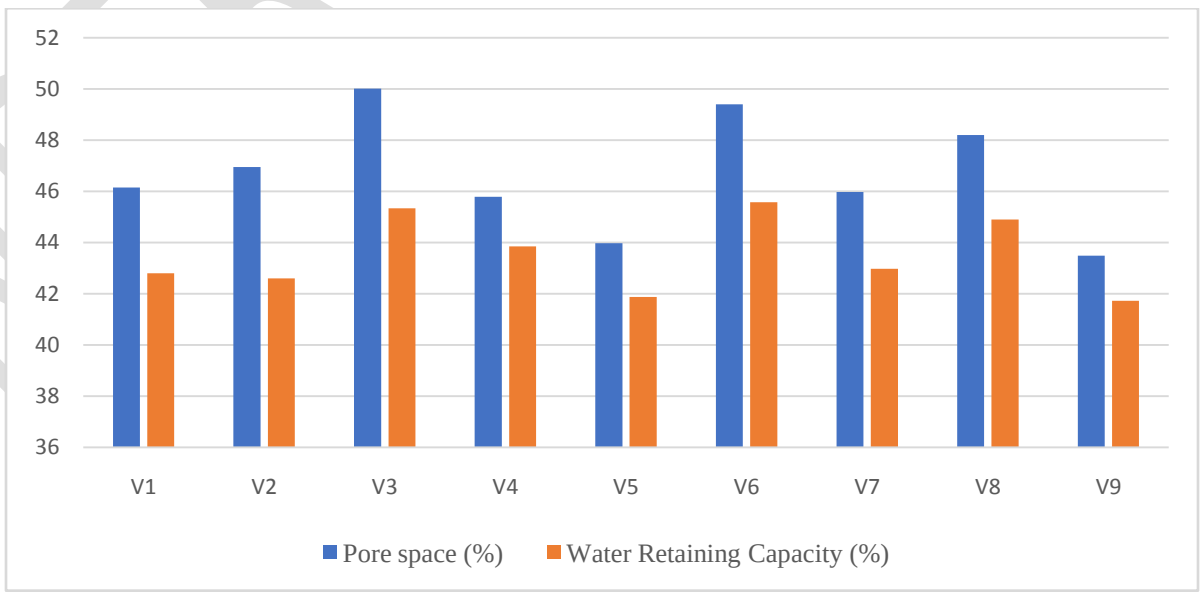

Fig.4:Pore space (%) and Water Retaining Capacity (%) of soil samplesat 0- 15, 15–30, and 30-45cm depthin variousregions of different Taluk ofPathanamthitta district

3.2 Chemical properties

3.2.1 Soil pH

The results show that the pH value was found to range from 4.9 to 6.9 and is represented in table 5and is shown in figure 5. It is worth mentioning that soils of selected villages in Pathanamthitta district tend to be acidic in nature, primarily due to heavy rainfall. The leaching of basic cations during heavy rainfall leads to soil acidity.Similar outcomes were discovered by Swathi *et al*., (2020). [18]

Table 5: Soil pH (%) of soil at variousregionsof different taluk of Pathanamthitta

district

Taluk	Village	Soil pH	
		Range	Mean
Kozhencherry	Omalloor (V_1)	6.1 – 6.6	6.36
	Kulanada (V_2)	6.4 – 6.5	6.43
	Aranmula (V_3)	6.6 – 6.9	6.76
Konni	Konni (V_4)	5.1 – 5.4	5.30
	Thannithodu (V_5)	4.9 – 5.8	5.23
	Vallikkodu (V_6)	5.5 – 5.6	5.53
Adoor	Enathu (V_7)	6.4 – 6.7	6.56
	Pandalam (V_8)	5.7 – 5.7	5.70
	Peringanad (V_9)	6.1 – 6.6	6.30

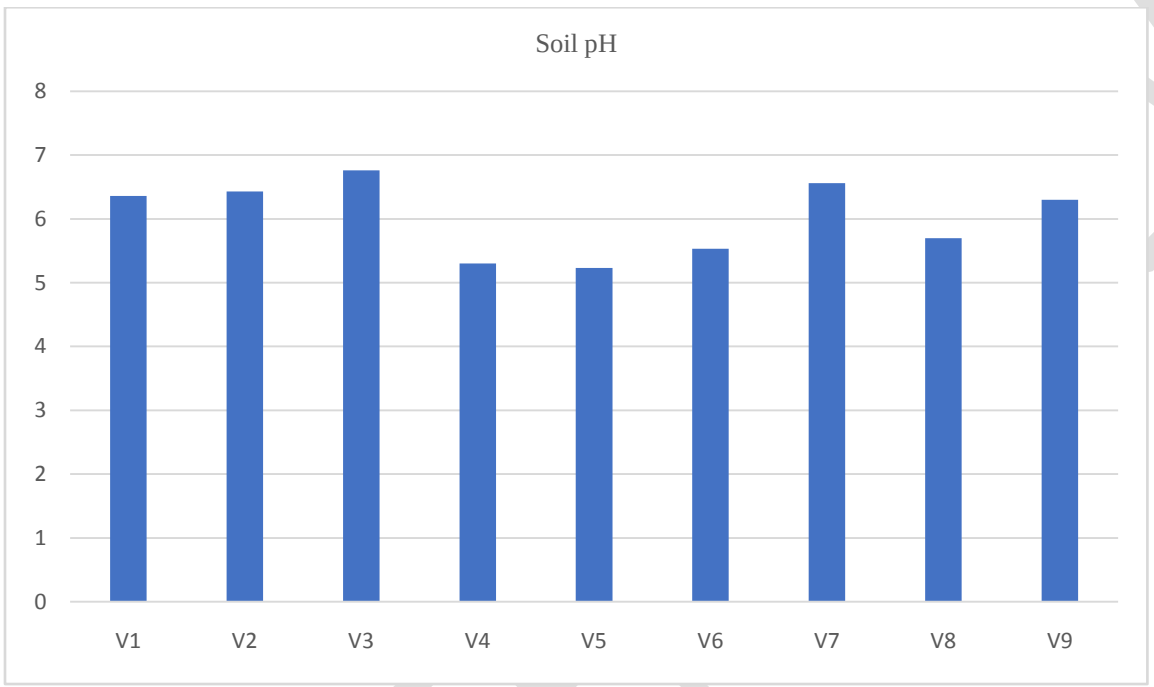

Fig.5: pH of soil samplesat 0- 15, 15–30, and 30-45 cm depth in various regions of different Taluk of Pathanamthitta district

3.2.2 EC of soil water suspension (dS m^{-1})

The Electrical Conductivity of soil samples collected from Kozhencherry, Konni, Adoor Taluk of Pathanamthitta district ranged from 0.03 to 0.30 dS m^{-1}, as indicated by the results. It is evident that the soil samples meet the allowable EC limit and are considered ideal for most crops. Similar outcomes were discovered by Mili (2020). [19]

3.2.3 Organic Carbon (%)

The Organic Carbon (%) of soil samples collected from the same locations varied from 0.16 to 1.68 % according to the results and represented in table 6 and illustrated in figure 6. The high percentage of organic carbon content is attributed to factors such as high microbial activity, plant residue deposition, rainfall, and temperature.Similar outcomes were discovered by Nair*et al.*, (2022). [14]

Table 6: EC of soil water suspension (dS m^{-1})andOrganic Carbon (%) of soil at various regions ofdifferent taluk of Pathanamthitta district

Taluk	Village	EC of soil water suspension (dS m^{-1})		Organic Carbon (%)	
		Range	Mean	Range	Mean
Kozhencherry	Omalloor (V_1)	0.06 – 0.12	0.09	0.83 – 1.37	1.10
	Kulanada (V_2)	0.05 – 0.07	0.05	0.78 – 0.96	0.85
	Aranmula (V_3)	0.08 – 0.14	0.10	0.51 – 0.77	0.64
Konni	Konni (V_4)	0.04 – 0.06	0.05	0.66 – 1.58	1.18
	Thannithodu (V_5)	0.03 – 0.05	0.04	1.12 – 1.68	1.41
	Vallikkodu (V_6)	0.16 – 0.29	0.24	0.76 – 1.39	1.13

Adoor	**Enathu (V_7)**	0.03 – 0.09	0.05	1.19 – 1.42	1.32
	Pandalam (V_8)	0.04 – 0.04	0.04	1.12 – 1.26	1.17
	Peringanad (V_9)	0.15 – 0.30	0.22	0.16 – 0.69	0.40

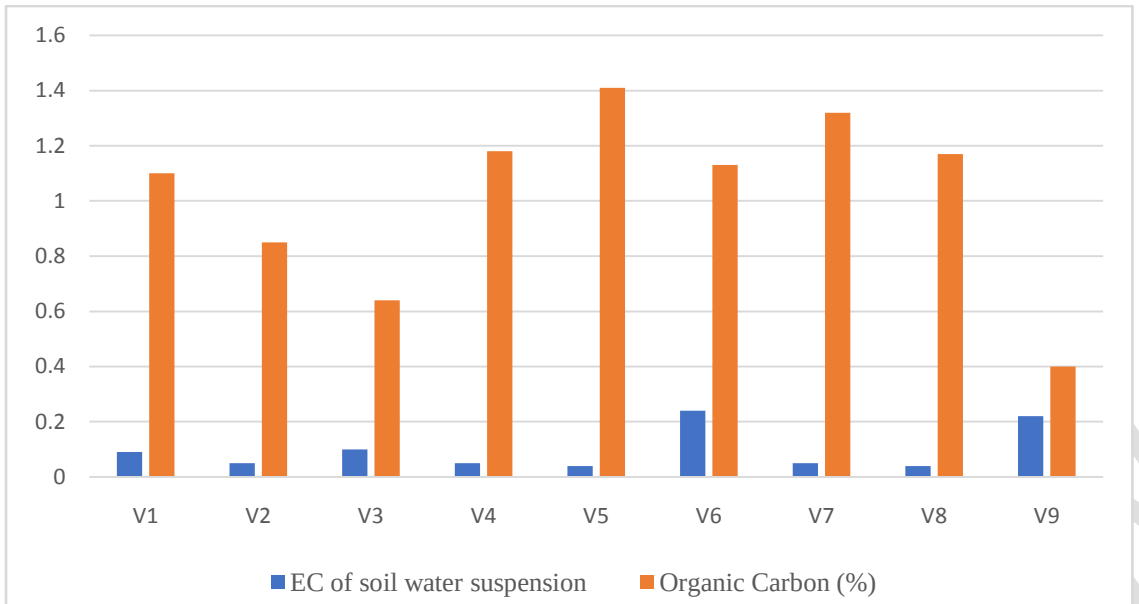

Fig.6: Electrical Conductivity(dS m^{-1}) andOrganic Carbon (%)of soil samplesat 0-15, 15–30, and 30-45 cm depth in various regions of different Taluk of Pathanamthitta district

3..2.4 Available Nitrogen (kg ha^{-1})

The available Nitrogen (kg ha^{-1}) in the soil samples varied from 119.45 to 286.07 kg ha^{-1}, as shown by the results. Nitrogen levels were generally low across all locations except for one. Similar outcomes were discovered by Johnson *et al*., (2023). [17]

3.2.5 Available Phosphorus (kg ha^{-1})

The available Phosphorus (kg ha^{-1}) in the soil samples ranged from 13.23 to 64.20 kg ha^{-1}, as illustrated by the results. The phosphorus content was considered to be at a medium to high level, influenced by soil acidity. In acidic conditions, phosphorus combines with iron and aluminum to form compounds that are not readily available to plants.Similar outcomes were discovered by Thomas*et al*., (2017).[20]

3.2.6 Available Potassium (kg ha^{-1})

The available Potassium (kg ha^{-1}) in the soil samples ranged from 100.80 to 382.40 kg ha^{-1}, based on the results and is shown in table 7 and illustrated in figure 7. The Potassium content was observed to be at a medium to high level. Similar outcomes were discovered by Yadav *et al*., (2023). [21]

Table 7: Available Nitrogen (kg ha^{-1})Phosphorus (kg ha^{-1})Potassium (kg ha^{-1}) of soil at various regions of different taluk of Pathanamthitta district

Taluk	Village	Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean
Kozhencherry	**Omalloor (V_1)**	159.64 – 194.90	176.86	27.64 – 36.08	31.27	313.6 – 369.6	343.4
	Kulanada (V_2)	124.18 – 154.03	137.79	17.85 – 31.71	23.03	100.8 – 179.2	141.8
	Aranmula (V_3)	188.08 – 220.05	206.44	27.54 – 57.54	42.72	179.2 – 235.2	212.8
Konni	**Konni (V_4)**	173.08 – 201.19	185.53	48.63 – 64.20	55.51	238.5 – 324.8	277.3
	Thannithodu (V_5)	164.82 – 198.04	180.68	18.90 – 21.84	20.34	112.0 – 145.6	130.6
	Vallikkodu (V_6)	253.83 – 286.07	269.03	24.51 – 31.80	27.63	354.2 – 382.4	361.8
Adoor	**Enathu (V_7)**	179.58 – 210.62	193.98	13.23 – 22.23	17.55	239.0 – 280.0	261.0
	Pandalam (V_8)	184.02 – 213.76	197.56	13.59 – 18.06	15.83	145.6 – 165.0	155.8
	Peringanad (V_9)	119.45 – 138.32	129.55	14.25 – 19.60	17.10	112.6 – 190.4	154.0

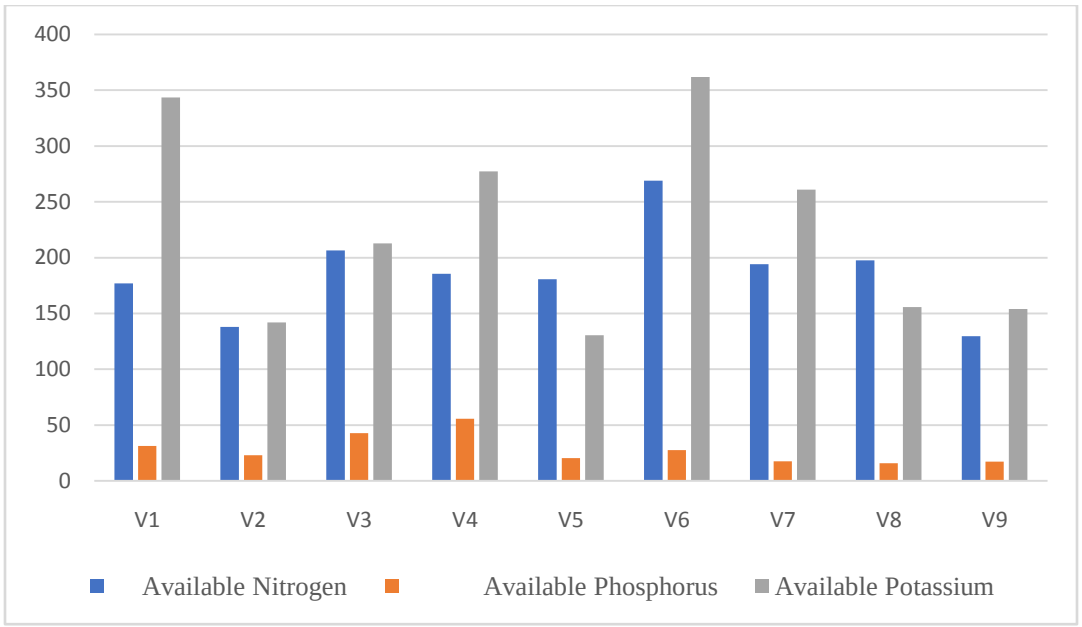

Fig.7: Available Nitrogen (kg ha^{-1}) Phosphorus (kg ha^{-1}) Potassium (kg ha^{-1}) of soil samples at 0- 15, 15–30, and 30-45 cm depth invarious regions of different Taluk of Pathanamthitta district

3.2.7Exchangeable Calcium andMagnesium(meq 100g^{-1})

The Exchangeable Calcium content of soil ranged from 1.7 (meq 100g^{-1}) to 9.1 (meq 100g^{-1}), while the Exchangeable Magnesium content ranged from 0.23 (meq 100g^{-1}) to 0.74 (meq 100g^{-1}) and represented in table 8 and illustrated in figure 8. It was found that the Calcium content was sufficient, but Magnesium was deficient in all soil samples. Similar outcomes were discovered by Gopan *et al*., (2022). [15]

Table 8: Exchangeable Calcium and Magnesium (meq 100g^{-1})of soil at various regions of different taluk of Pathanamthitta district

Taluk	Village	Exchangeable Calcium (meq 100g^{-1})		ExchangeableMagnesium (meq 100g^{-1})		
		Range	Mean	Range	Mean	
Kozhencherry	Omalloor (V_1)	3.6 – 4.7	4.1	0.55 – 0.62	0.58	
	Kulanada (V_2)	3.4 – 3.8	3.5	0.23 – 0.33	0.28	
	Aranmula (V_3)	5.3 – 8.4	6.9	0.36 – 0.42	0.40	
Konni	Konni (V_4)	3.4 – 4.5	3.9	0.66 – 0.72	0.70	
	Thannithodu (V_5)	1.9 – 2.1	2.0	0.46 – 0.53	0.49	
	Vallikkodu (V_6)	5.0 – 9.1	6.9	0.51 – 0.69	0.61	
Adoor	Enathu (V_7)	1.8 – 1.9	1.8	0.64 – 0.74	0.70	
	Pandalam (V_8)	1.7 – 2.7	2.2	0.37 – 0.46	0.42	
	Peringanad (V_9)	2.4 – 3.9	2.9	0.39 – 0.55	0.47	

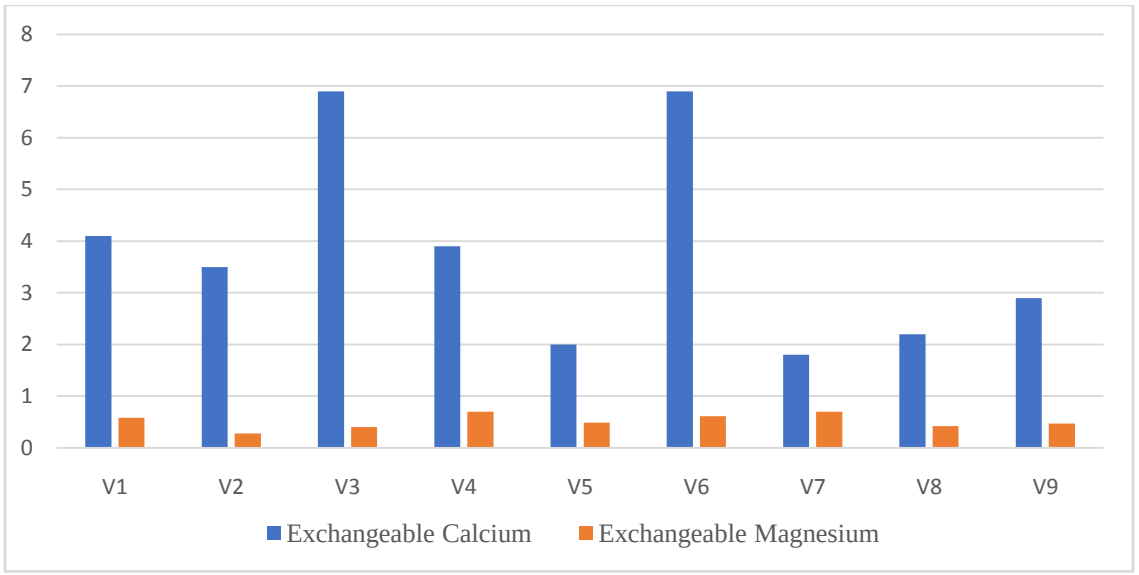

Fig.8:Exchangeable Calcium and Magnesium (meq $100g^{-1}$) of soil samplesat 0- 15, 15–30, and 30-45cm depth in various regions of different Taluk of Pathanamthittadistrict

3.2.8 Available Sulphur (kg ha^{-1})

The Available Sulphur (kg ha^{-1}) in the soil samples collected from the same locations varied from 0.03 to 0.44 kg ha^{-1}, according to the results in table 9 and illustrated in figure 9. The low Sulphur content observed at all locations was attributed to leaching. Similar outcomes were discovered by Mini and Raj (2024). [22]

Table 9: Available Sulphur (kg ha^{-1}) of soil at various regions of different taluk of Pathanamthitta district

Taluk	Village	Available Sulphur (kg ha^{-1})	
		Range	Mean
Kozhencherry	Omalloor (V_1)	0.13 – 0.40	0.28
	Kulanada (V_2)	0.11 – 0.38	0.25
	Aranmula (V_3)	0.18 – 0.44	0.32
Konni	Konni (V_4)	0.03 – 0.23	0.14
	Thannithodu (V_5)	0.04 – 0.28	0.14
	Vallikkodu (V_6)	0.06 – 0.20	0.14
Adoor	Enathu (V_7)	0.07 – 0.25	0.17
	Pandalam (V_8)	0.08 – 0.30	0.19
	Peringanad (V_9)	0.09 – 0.34	0.23

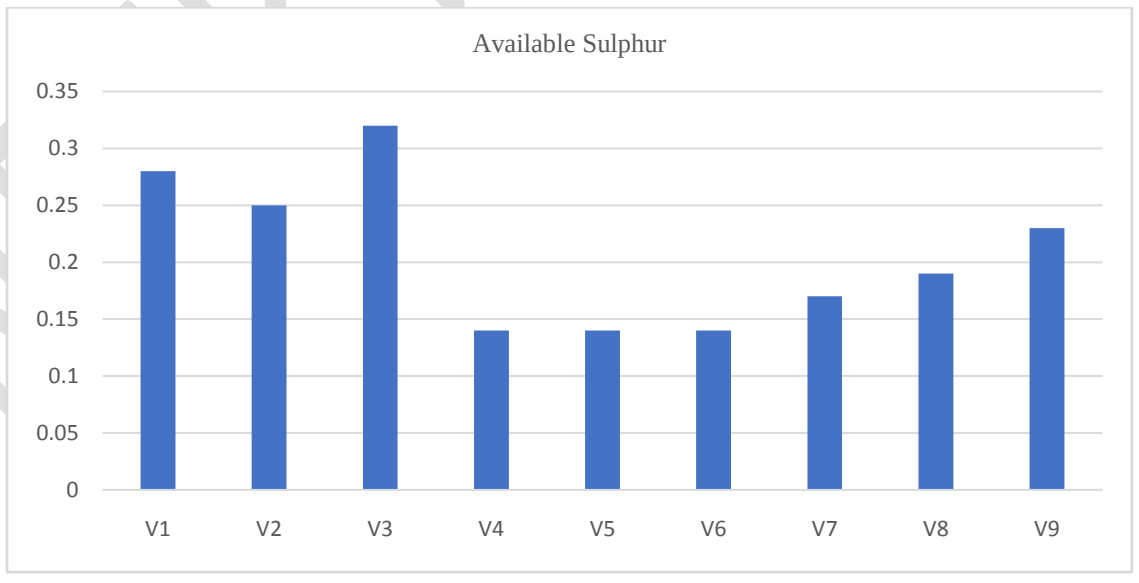

Fig.9:Available Sulphur (kg ha^{-1}) of soil samplesat 0- 15, 15–30, and 30-45 cm depth in various regions of different Taluk of Pathanamthitta district

4. CONCLUSION

The soils of selected villages in Kozhencherry, Konni, and Adoor Taluk of Pathanamthitta district have been identified as Sandy clay Loam, displaying sufficient bulk density, particle density, and pore space, which are all conducive to plant growth. The soil colour ranges from light brown to dark brown to reddish yellow in dry conditions, and from reddish brown to dark reddish brown to strong brown in wet conditions. These conditions indicate a favourable physical state of the soil and its ability to retain water. It is evident that the soils in these villages are acidic, with soil samples meeting the allowable EC limit, making them suitable for most crops. Organic carbon content is notably high across all locations, while nitrogen levels are generally low except in one instance. The levels

of Phosphorus and Potassium are observed to be medium to high, with sufficient Calcium but deficient Magnesium in all soil samples. Sulphur content is low in all locations, and nutrient levels vary with soil depth. The nutrient shortage is mainly attributed to leaching caused by high precipitation levels in the area. However, there is potential for improvement through the incorporation of cover crops, green manure, legume cultivation, mulching, tillage practices, and specific cropping system tools to address leaching issues.

REFERENCES

1. **Joffe, J.S. (1965).** ***The ABC of Soils*****. Oxford Book Co., Kolkata and New Delhi.**
2. **Bouyoucos, G.J. (1927).** The hydrometer as new method of mechanical analysis of soil. *Soil Science*.23:343-353.
3. **Muthuvel P, Udayasoorian C, Natesan R, Ramaswami PR. (1992.)** *Introduction to soil analysis*. Coimbatore: Tamil Nadu Agricultural University;
4. **Jackson, M. L. (1958)** The pH was determined in 1:2 soil water suspensions using digital pH meter. *Soil Chemical Analysis, Prentice Hall, Inc. Englewood. cliffe*. N.J.
5. **Wilcox *et al*., (1950)** Electrical conductivity, Amer. Water Works Assoc. J., 42: 775-776.
6. **Walkley, A., and Black (1947)** A critical examination of a Rapid method for determining organic carbon in soils: Effect of variations in digestion conditions and of Organic soil constituents. Soil Sci., 63: 251- 263.
7. **Bray, R.H. and Kurtz, L.T. (1945)** Determination of Total Organic and Available Forms of Phosphorus in Soils. Soil Science, 59, 39-45.
8. **Subbiah, B. V. And Asija, G. L. (1956).** A Rapid Procedure for The Determination of Available Nitrogen in Soils. *Current Science,* Vol.**25**: 259-260.
9. **Olsen. S.R., Cole. C.V., Watanabe. F.S. And Dean. L.A. (1954).** Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. *U. S. Department of Agriculture,* Circular No. 939
10. **Toth, S. J., and Prince, A. L. (1949)** Estimate of Cation Exchange capacity and exchangeable Ca, K, Na, Content of soil by flame photometer technique. Soil Sci., 67: 439-445.
11. **Chesnin. L. And Yien. C.H. (1950).** Turbidimetric Determination of Available Sulphur. *Proceeding of Soil Science. American,* Vol.**14**: 149-151
12. **Jackson. M. L. (1973).***Soil Chemical Analysis*. *Prentice Hall of India Pvt. Ltd.,* New Delhi
13. **P.C. Jaiswal,** Soil, plant and water analysis, Practical manual
14. **NAIR, J. M., SWAROOP, N., THOMAS, T., and BARTHWAL, A. (2022).** Assessment of soil fertility status of different villages from palakkad district, kerala.
15. **GM, V. G., Hasan, A., Thomas, T., David, A. A., and Reddy, I. S. (2022).** Correlation of Physico- chemical Parameters of Soil and Soil Nutrient Index Status of Kollam District, Kerala, India.
16. **Amjad, A., Thomas, T., Swaroop, N., Singh, A. K., Aasim, M., Reddy, I. S., and Harit, H. (2021).** Assessment of physico-chemical properties from different blocks of Malappuram district in the state of Kerala. *The Pharm Innov J*, 10(**11**), 1236-41.
17. **Johnson, N., Swaroop, N., Thomas, T., and Mohanta, S. R. (2023).** Assessment of Physical Properties of Soil from Different Villages of Devikulam Block of Idukki District of Kerala, India. *International Journal of Environment and Climate Change*, 13**(9)**, 547-551.
18. **Swathi, G., Meera, A. V., Thampatti, M. K. C., and John, J. (2020).** Physico chemical and biological properties of post flood soils in the south-central laterites of southern Kerala. *IJCS*, 8**(5)**, 1829-1835.
19. **Mili, M. (2020).** Assessment of soil quality in the post flood scenario of AEU 15 (northern high hills) in Thrissur district of Kerala and mapping using GIS techniques (Doctoral dissertation, Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara).
20. **Mini V., & Raj, A. (2024)**. Effect of Different Factors on the Soil Quality of Typic Ustipsamments of State Kerala, in India. *International Journal of Environment and Climate Change*, 14**(1)**, 712–718.
21. **Tomas, Binoy, T., Saranya Mol, S. T, Reshma Rajan, Bhagya, M. A. (2017).** Comparative Evaluation of Physico-chemical Characteristics of Laterite Soil. *IJAR*.5**(6)**, 1748- 1753.
22. **Yadav, P. I., Manu, C. R., Lekha, M., and Shilpa, P. (2023).** Assessment of soil nutrient status of coconut gardens of East Kallada Panchayath of Kollam district, Kerala under the programme 'Kalparaksha': A compact area group approach programme on integrated crop management in coconut. *The Pharma Innovation Journal*. 2023; 12(**8**): 715-720.

23. Yadav , P., Swaroop , N., David , A. A., Thomas , T., Singh, A. K., & Kaur, K. (2023). Assessment of Physico-chemical Properties of Soil and Irrigation Water Quality of Phulpur Blocks of Prayagraj District, Uttar Pradesh, India. International Journal of Environment and Climate Change, 13(11), 4046–4058. https://doi.org/10.9734/ijecc/2023/v13i113584
24. Selvi , P. K., Thomas , T., Swaroop , N., & Singh , A. K. (2023). Assessment of Physico-chemical Properties of Soil from Different Blocks of Theni District, Tamil Nadu, India. International Journal of Plant & Soil Science, 35(15), 392–406. https://doi.org/10.9734/ijpss/2023/v35i153120