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Macronutrient status of low land soil profiles (Kole, Kaipad and Mangroves) of North Kerala, India

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Abstract
The present investigation was carried out in lowland soil profiles (Kole, Kaipad and Mangroves) in north Kerala. In this study, we excavated three soil profiles in the selected lowlands to assess the macronutrient status. To study the soil macronutrient status, three pedons from (Kole, Kaipad and Mangroves) of AEU 6 and AEU 7 of north Kerala were determined. The soils were extremely acidic to strongly alkaline in reaction with pH ranging from 3.94 to 5.55 and surface horizons of Kaipad lowlands (13 dS m^{-1}) have noticed high EC values. The organic carbon content of soils varied from 2.78 to 3.77per cent. The clay distribution, cation exchange capacity and base saturation of the soils ranged from 35.79 to 47.04 per cent, 15.81 to21.22 cmol (p+) kg^{-1} and 93 to 100 per cent respectively. Calcium and Magnesium ranging 487.00 to 1329.00 cmol (p+) kg^{-1}, 237.00 to 925.00 cmol (p+) kg^{-1} and 189.16 to 821.35 ppm of S respectively. The macronutrient status of the soil samples indicated that the available nitrogen content was high in all the pedons and also high in available phosphorus, and available potassium, Ex. Calcium and Ex. Magnesium and sufficient with respect to sulphur.

Keywords: Kole, Kaipad and mangroves, macronutrients, lowlands, north Kerala

Introduction
Soil is the soul of infinite life, a medium for the growth of land plants, and is generally referred to as the loose material composed of weathered rock and other material including partly decayed organic matter. It is a reservoir of nutrients and plays a pivotal role in supporting the growth of crops and other vegetation maintaining the earth's environment clean. It also acts as a source as well as a sink for atmospheric gases. To improve the productivity of the soil, we need to utilize it scientifically. Healthy soil provides pure water and air for living organisms including plants, humans, and animals. It is a reservoir of nutrients and balances the gaseous exchanges by maintaining the earth's surface clean. To increase the productivity of soil, we need to manage soil fertility. Nitrogen, phosphorus and potassium as primary nutrients are the main sources of sustainable agriculture production that have the ability to control the yield of crops. Calcium, magnesium, and sulphur as secondary nutrients increase root absorption and their translocation in plants. The absence of any essential nutrients renders a decline in crop production and yields. Nitrogen plays a role to optimize yield by ensuring energy and helps to regulate water and nutrient uptake. Phosphorus is showing a primary role in storing and transferring energy for growth and reproductive process and promotes root growth, hastens maturity enhances winter hardiness and stimulates tillering. Potassium keeps a major role in increasing disease resistance, drought tolerance, and upright growth in plants. Calcium is contributing to the fertility of the soil by clay flocculation and ensure maximum aeration in the soil. Magnesium act as the core central part of the chlorophyll molecule and stunted growth occurs in plants when it is deficient. Sulphur is required to make proteins for plants and its deficiency may lead to poor yield in crops. Kerala is divided into three geographical regions; Highlands, Midlands, and Lowlands. This study aims at lowland soils (Kole, Kaipad and Mangroves) of North Kerala. Kole wetlands are one of the largest and the most important wetlands of Kerala. The name 'Kole 'refers to the particular type of cultivation practices carried out from December to May and is a Malayalam word that indicates 'bumper yield 'or high returns in case floods did not damage the crop. It spreads over Thrissur and Malappuram districts, extend from the northern bank of the Chalakudy river in the south to the southern bank of the Bharathapuzha river in the north. Kaipad is a salinity/alkalinity-prone natural organic rice production tract of North Kerala, like the Pokkali tract of South Kerala. The Kaipad system of rice cultivation is an integrated organic farming system, in which rice cultivation and aquaculture are practiced together in coastal brackish-

water marshes, which are rich in organic matter. The soil type is saline hydromorphic. The network of backwaters and estuaries serves as an inlet of sea water and causes salinity in the area. Mangrove forests are considered some of the world's most productive ecosystems. Mangrove ecosystems are coastal wetlands comprised of woody vegetation that is found in intertidal marine and brackish environments (Lugo and Snedaker, 1974; Friess, 2016a) [6, 3]. Mangroves of India are unique in several aspects viz. rich biodiversity and spatial distribution. Overall, the mangrove area in India has been estimated as 4740 sq km, which accounts for nearly 3 percent of the world's area covered by vegetation (FSI, 2019) [4]. The objective of this investigation was to assess the macronutrient status of low land soil profiles (Typical Kole lands, Kaipad lands and mangroves) of north Kerala.

Materials and Methods

The study was undertaken in three different types of low lands of north Kerala representing (AEU 6 & AEU 7) agroecological units of North Kerala (Table 1).

Kole lands overview

Kole lands soil profile

The soil samples were collected horizon-wise, air-dried, powdered, and sieved using a 2 mm sieve. Particle-size analysis of the samples was carried out by the international pipette method. Electrical conductivity, pH, organic carbon, cation exchange capacity and base saturation were determined by standard methods (Jackson, 1973) [5]. Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956) [8]. For available phosphorus determination, extraction was done using Bray's extractant and then subsequent estimation by Jackson (1973) [5] method. Available potassium was extracted using neutral normal ammonium acetate and measured with flame photometer (Jackson, 1973) [5]. Sulphur was extracted using 0.15 percent $CaCl_2$ solution and was made to react with $BaCl_2$ to form turbid solution of $BaSO_4$. The intensity of turbidity was measured using spectrophotometer at a wavelength of 420 nm (Jackson, 1973) [5]. Exchangeable calcium and magnesium were determined by using neutral normal ammonium acetate (CH_3COONH_4) with the help of atomic absorption spectrometry.

Kaipad lands overview

Kaipad soil Profile

Mangroves land overview

Mangroves soil profile

Results and Discussion

The range and mean of physical, chemical, and physico-chemical properties of different pedons are given in Table 2. The soils were extremely acid to strongly alkaline in reaction with pH ranging from 3.94 to 5.55 and surface horizons of Kaipad low lands have noticed high EC values (high in soluble salts). The acidic pH of the soil might have been attributed mainly to the leaching of the bases due to the existing high rainfall conditions and to some extent due to the acidic parent materials and these pH values indicate a slightly acidic to slightly basic soil tendency, with values near neutral, which can be considered a standard feature of mangrove soils not subject to disturbance, which tend toward a pH balance promoted by oxidation-reduction reactions (Souza-Júnior *et al.*, 2008) [7]. The EC values ranging from 1.18 to 13.00 dsm^{-1}. The high EC values with respect to surface horizons of Kaipad soil profiles may be due to tidal sea water inundations and salt accumulations in the upper horizons. The organic carbon content of soils varied from 2.78 to 3.77 per cent. This high organic matter content in the soil can be explained by the frequent deposits of litter (Fernandes *et al.*, 2007) [2] and plant debris from water courses, associated with a low decomposition rate of this material, due to a lack of oxygen in the highly saturated soil. The clay distribution of all the three pedons varied from 35.79 to 47.04 percent. The CEC in all the pedons estimated varied from 15.81 to 21.22 cmol (p+) kg^{-1}soil, which corresponds to clay content in the horizons, active presence of exchangeable ions and also a type of clay mineral present in the soil. According to (Brady and Weil, 1996) [1], CEC determines the ability of the soil to bind or hold nutrients against leaching and it is usually influenced by clay mineral and organic matter components. Base saturation values varied from 93.00 to100.00 per cent in all selected profiles. High base saturation might be attributed to high deposition after leaching below sea level combined with heavy rainfall in the study area.

Available macronutrients

Available macronutrient contents of soils of different pedons are given in Table 3. The available nitrogen content was from 790.27 to 1317.12 kg ha^{-1} throughout the depth in all the pedons and was rated high. However, available N content was found to be high in most of the surface horizons due to the accumulation of plant residues and rhizosphere activity. The available phosphorus content in the pedons varied from 9.04 to 28.85 kg ha^{-1} and was rated as Low to high in the profiles. Available potassium ranged from 174.00 to 879.00 kg ha^{-1} and all the pedons showed high available potassium. The available sulphur in the soils varied from 189.16 to 21.35 mg kg^{-1}. Exchangeable calcium and magnesium in all the profiles ranged from 487.00 to 1329.00 cmol (p+) kg^{-1} and 237.00 to 925.00 cmol (p+) kg^{-1} respectively.

Table 1: Typifying locations of low lands of north Kerala

District	Taluk	Block	Village	Pedon number	Type of Land
Trichur	Chavakkad	Anthikad	Chazhur	1	Typical Kole lands
Kannur	Talipparamba	Payyanur	Cherukunnu	2	Kaipad lands
Kannur	Talipparamba	Talipparamba	Ezhom	3	Mangroves

Table 2: Ranges and means of physical, chemical and physicochemical properties of surface soils collected from different low lands of north Kerala

Properties	Range	Mean
pH (1:2.5)	3.94-5.55	4.85
EC (dsm^{-1})	1.18-13.00	7.16
Organic carbon (%)	2.78-3.77	3.23
Clay (%)	35.79-47.04	40.47
CEC (cmol (p+) kg^{-1})	15.81-21.22	55.65
Base saturation (%)	93.00-100.00	97.67
Available (Av.) and exchangeable (Ex.) macronutrients		
Av. Nitrogen (kg ha^{-1})	790.27-1317.12	625.60
Av. Phosphorus (kg ha^{-1})	9.04-28.85	16.70

Av. Potassium (kg ha^{-1})	174.00-879.00	622.67
Av. Sulphur (mg kg^{-1})	189.16-821.35	453.76
Ex. Calcium (cmol (p+) kg^{-1})	487.00-1329.00	795.00
Ex. Magnesium (cmol (p+) kg^{-1})	237.00-925.00	688.67

Table 3: Depth wise distribution of available macronutrients in different low lands of north Kerala

Horizon	Depth (cm)	pH	OC (%)	Available macronutrients					
				N	P	K	Ca	Mg	S
				kg ha^{-1}			(Cmol (p^+) kg^{-1})		ppm
Pedon 1-Typical Kole lands									
Ap	0-26	5.55	3.77	1266.94	9.04	174	1329	237	189.16
Bw1g	26-37	7.26	0.70	464.13	8.31	123	3664	215	51.66
Bw2g	37-57	8.55	0.66	376.32	20.05	121	4609	223	65.00
Bw3g	57-86	7.64	0.83	357.77	16.62	156	1024	309	77.50
BC1g	86-114	3.37	3.42	501.76	11	5	1354	871	755.00
BC2g	114-166+	3.31	5.19	457.12	22.25	4	1657	2051	795.83
Pedon 2-Kaipad lands									
A	0-22	3.94	3.14	1317.12	28.85	815	487	904	350.76
Bw1	22-43	5.18	1.23	752.64	69.2	1039	731	1228	217.44
Bw2g	43-74	5.58	0.64	702.64	58.93	405	294	519	159.51
Bw3g	74-100	6.23	1.11	639.74	23.72	612	516	616	239.66
BC1g	100-128	7.94	0.91	627.20	26.16	690	921	603	30.31
BC2g	128-162+	7.93	1.55	652.29	22	560	963	601	394.41
Pedon 3-Mangroves									
A	0-15	5.07	2.78	790.27	12.22	879	569	925	821.35
Bw1	15-25	6.45	0.95	564.48	13.2	545	574	733	726.12
Bw2g	25-40	7.16	0.64	552.10	29.1	802	1011	1018	392.03
Bw3g	40-68	7.37	0.56	501.76	35.94	912	1235	1093	348.38
BCg	68-100	7.55	0.60	376.32	35.7	560	1045	906	338.06
CBg	100-120	8.09	1.75	360.12	22.98	576	2895	1018	386.47
	120+	Water saturated layer							

Conclusion

Different kinds of low lands (Typical Kole lands, Kaipad lands, and mangroves) of north Kerala indicate that the soil diversity is quite large because of the variability of several factors of soil formation**.** Lowlands must be preserved since their removal adversely affects human habitation both directly and indirectly.

Despite the fact that they are known to emit greenhouse gases, they also perform extremely vital tasks including Bio-remediation, preservation of microbial diversity and water storage for both agricultural and drinking purposes and proper nutritional management is very much essential to provide better soil health conditions. Any drastic changes in these lowlands may lead to failure to provide food in the required quantity and quality with all the nutrients essential to human life. The fertility status of different lowlands of north Kerala indicated that soils are high in available N and available K and low to high in available P in surface and subsurface horizons. Available Sulphur remained sufficient in soils. Among the exchangeable bases, exchangeable calcium was found to be high in most soils, followed by magnesium. There must be proper land management to improve the lowlands' production in north Kerala.

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