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Nutrient Index-based Soil Fertility Assessment along the Thonnur Kere Distributary of Mandya District, Karnataka

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ABSTRACT

The present study investigates soil fertility status using nutrient index-based assessment across irrigated agroecosystems of the Thonnur Kere distributary, located in the Southern Dry Zone of Karnataka. Composite soil samples were collected from three distinct regions: upper, middle and tail-end at two depths (0-20 cm and 20-40 cm) to evaluate key soil physico-chemical properties and nutrient availability. The results revealed a progressive increase in soil pH and electrical conductivity toward the tail-end, indicating enhanced alkalinity likely caused by prolonged irrigation and solute accumulation. Available macronutrients such as nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) exhibited higher concentrations in tail-end soils, suggesting downstream nutrient accumulation via irrigation return flows and fertilizer movement. Exchangeable calcium and magnesium also increased gradually from upper to tail-end regions, reflecting increased base saturation. Sulphur availability remained relatively uniform across sites, while micronutrients like iron and manganese declined downstream, correlating negatively with rising pH. Conversely, zinc and copper levels were higher in tail-end soils, potentially due to limited mobility in alkaline conditions. The nutrient index analysis categorized most regions under medium to high fertility status for major nutrients, emphasizing the need for site-specific nutrient management strategies to optimize input use and sustain productivity. This spatial assessment provides a foundation for improving soil health and guiding sustainable land management practices in irrigated command areas.

Keywords : Soil fertility, Nutrient index, Irrigated agroecosystem, Macronutrients, Micronutrients, Sustainable land management

SOIL fertility is a critical component of agricultural sustainability and productivity, especially in regions reliant on intensive cropping under irrigation. In India, irrigated ecosystems, particularly those in canal command areas, play a central role in ensuring food security by supporting high-value crops such as paddy and sugarcane. However, this intensive land use often leads to degradation of soil quality and nutrient imbalances, especially when fertilization is not aligned with actual soil nutrient status (Tandon, 2005; Prasad and Power, 1997). The Thonnur Kere distributary in Mandya district, situated in the Southern Dry Zone (SDZ) of Karnataka, is one such irrigated region that has witnessed a shift in soil health due to persistent monocropping, Continuous irrigation and imbalanced nutrient application.

The Mandya district falls under Southern Dry Zone, characterized by semi-arid climatic conditions, red loamy soils (*Alfisols*) and a reliance on canal water from the Cauvery river system. Although irrigation has enabled the cultivation of multiple crops per year, it has also led to unintended consequences such as nutrient leaching, reduced microbial activity and soil structural degradation (Aulakh and Malhi, 2005). In such agroecosystems, there is a growing need for site-specific soil fertility evaluation that takes into account both macro and micronutrients across different soil depths and cropping systems. Soil nutrient indexing offers a comprehensive yet simplified framework to assess and categorize soil fertility levels, helping farmers and planners take timely corrective measures (Piper, 1966; Rama moorthy *et al.,* 1967).

Nutrient indexing involves aggregating the available nutrient concentrations across samples and categorizing them into fertility classes: low, medium and high based on threshold values. This method has been widely used in India and other parts of the world as a practical approach to manage soil fertility across varied agro-climatic zones (Subba Rao and Srivastava, 1998). In irrigated regions such as the Thonnur Kere command area, where spatial variability in nutrient distribution is influenced by water availability, cropping intensity and land management practices, nutrient indexing helps pinpoint areas with potential nutrient deficiencies or surpluses.

The role of nutrient index-based assessments becomes even more critical in view of the declining use efficiency of fertilizers and the increasing cost of agricultural inputs. Over-reliance on chemical fertilizers without adequate organic matter addition or nutrient balancing leads to soil fatigue and environmental degradation (FAO, 2006). Furthermore, indiscriminate application of nutrients such as nitrogen and phosphorus often results in nutrient lock-up or antagonistic interactions, reducing their availability to crops. Recent research emphasizes the need for integrated nutrient management strategies for land suitability (Harsha *et al.,* 2020), guided by robust soil fertility data, to sustain yields and maintain long-term soil health (Sharma *et al.,* 2010).

In the Thonnur Kere distributary region, existing data on soil nutrient status are sparse and scattered. Therefore, a systematic assessment of soil fertility using nutrient indices is essential to understand the status and distribution of key nutrients such as nitrogen (N), phosphorus (P), potassium (K), secondary and micronutrients. This study aims to bridge that gap by evaluating the soil fertility status of irrigated agroecosystems in the region through a nutrient index-based approach. The outcomes of the study are expected to guide site-specific nutrient management plans, support sustainable intensification of agriculture and contribute to improved productivity and environmental stewardship.

Material and Methods

Experimental Site : This study was conducted in the irrigated agroecosystems of the Thonnur Kere distributary region (Fig. 1), a part of the Cauvery command area in Mandya district, Karnataka, which falls under the agro-climatic classification of the Southern Dry Zone (Zone 6). The region has a semi-arid climate, with an average annual rainfall ranging from 600 mm to 800 mm, primarily received during the southwest monsoon (June to September). The average temperatures range between 18°C in winter to 35°C in summer, supporting a tropical

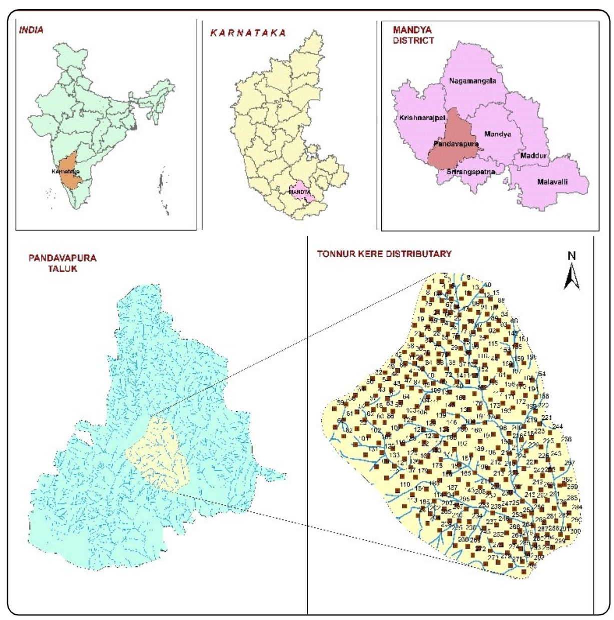


Fig. 1 : Location map of Study area

cropping system

The soils of the area are predominantly red sandy loams (*Alfisols*), with low to moderate inherent fertility, low organic carbon content and moderate water-holding capacity. Paddy and sugarcane are the dominant irrigated crops cultivated in this region, supported by canal irrigation from Thonnur Lake, making it an ideal agroecosystem for assessing nutrient status and formulating location-specific management strategies.

Soil Survey and Sampling : To capture soil fertility with the spatial variation across the command area, a random survey approach was employed. The study area was stratified based on dominant cropping systems (paddy and sugarcane) and physiographic features. A total of 300 geo-referenced sampling sites were selected randomly using Global Positioning System (GPS) coordinates to ensure spatial uniformity and eliminate bias. At each selected site, composite soil samples were collected from two depths: surface (0-15 cm) and subsurface (15-30 cm).

Each composite sample was derived from five sub-samples taken diagonally across area in a zigzag pattern to ensure uniformity and representativeness of soil conditions within each plot. These sub-samples were thoroughly mixed in a clean plastic sheet and approximately 1 kg of the homogenized soil was retained in labelled polythene bags for laboratory analysis.

Soil Sample Preparation : Upon arrival at the laboratory, all collected soil samples were air-dried in shade at room temperature to prevent microbial activity that could alter the nutrient composition. Once dry, the samples were gently crushed using a wooden mallet and passed through a 2 mm sieve for routine chemical analysis. A portion of each sample was further used estimation of micronutrients, as per the standard protocols outlined by Jackson (1973). Laboratory Analysis of Soil Fertility Parameters: Soil samples were analyzed for primary (N, P, K), secondary (S, Ca, Mg) and micronutrients (Fe, Mn, Zn, Cu, B) using established and validated analytical procedures adopted from standard soil testing manuals and scientific literature.

Primary Nutrients

Available nitrogen (N) was estimated using the alkaline potassium permanganate method as described by Subbiah and Asija (1956). This method involves distillation of soil with alkaline $KMnO_4$ solution, during which ammoniacal nitrogen is released and absorbed in boric acid, followed by titration with standard sulfuric acid. This is a widely accepted and reliable method for estimating mineralizable nitrogen in Indian soils. Available Phosphorus (P) was determined using the Olsen's method (Olsen *et al.*, 1954), suitable for neutral to alkaline soils. The method involves extraction of phosphorus using 0.5 M sodium bicarbonate solution at pH 8.5, followed by the development of a blue-coloured complex with ammonium molybdate and ascorbic acid, which is measured spectrophotometrically at 660 nm. Available Potassium (K) was extracted using 1N ammonium acetate (NH_4OAc) at pH 7.0 and measured using a flame photometer (Jackson, 1973). This method estimates the exchangeable and water-soluble potassium, which together represent the readily available K pool in the soil.

Secondary Nutrients

Available sulphur (S) was determined by the turbidimetric method after extraction with 0.15 per cent calcium chloride ($CaCl_2$) solution. The procedure, outlined by Chesnin and Yien (1950), is based on the formation of a barium sulphate ($BaSO_4$) precipitate, the turbidity of which is measured at 420 nm in a spectrophotometer. Exchangeable Calcium (Ca) and Magnesium (Mg) were extracted using 1N NH_4OAc solution buffered at pH 7.0 and concentrations were measured using an atomic absorption spectrophoto meter (AAS) following the protocols described by Jackson (1973). These methods ensure accurate quantification of divalent cations in soil exchange complexes.

Micronutrients

The availability of iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) was assessed by the DTPA extraction method standardized by Lindsay and Norvell (1978). The extraction solution (DTPA-$CaCl_2$-TEA, pH 7.3) simulates the root environment and extracts the bioavailable forms of these micronutrients. The concentrations were then quantified using AAS for precision. Available boron (B) was determined by hot water extraction, followed by colorimetric estimation using azomethine-H reagent, as described by Berger and Truog (1939). The absorbance of the yellow-coloured complex formed was measured at 420 nm, which reflects the concentration of plant-available boron in soil.

Nutrient Index Calculation

To evaluate the overall soil fertility status of the region, the Nutrient Index (NI) was computed for each nutrient following the method proposed by Ramamoorthy *et al*., (1967). The index was calculated using the formula:

$$NI = \frac{(NL \times 1) + (NM \times 2) + (NH \times 3)}{NT}$$

Where NL, NM and NH are the number of samples falling under low, medium and high categories respectively and NT is the total number of samples analyzed. Based on the index value, soil fertility was categorized as: Low (NI < 1.67), Medium (1.67 ≤ NI ≤ 2.33) and High (NI > 2.33). Critical limits for classification were adopted from regional soil fertility guidelines developed by ICAR and relevant literature (Tandon, 2005).

Statistical and Spatial Analysis

Descriptive statistics, including mean, standard deviation and coefficient of variation, were computed using Microsoft Excel to assess the distribution and variability of nutrient content across the study area.

Results and Discussion

Descriptive Statistics

Soil properties and nutrient availability of Thonnur Kere Distributary have shown differential distribution pattern across upper (Table 1), middle (Table 2) and tail-end (Table 3) regions under irrigated conditions. The soil pH ranged from slightly acidic to alkaline, showing a clear increasing trend from the upper to the tail-end region. Surface soils in the upper region exhibited pH values between 6.12 and 7.98, while the

Table 1

Descriptive statistics of soil properties in upper surface and subsurface region of Thonnur Kere Distributary, Mandya District

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
pH	0-20	6.12	7.98	7.02	0.46	6.55
	20-40	6.87	8.67	7.94	0.43	5.42
EC (dS m^{-1})	0-20	0.13	0.87	0.55	0.2	36.36
	20-40	0.75	1.62	1.29	0.21	16.28
Avail. N (kg ha^{-1})	0-20	82.31	113.25	97.21	9.61	9.89
	20-40	75.31	103.62	88.95	8.79	9.88
Avail. P_2O_5 (kg ha^{-1})	0-20	15.25	31.21	23.41	4.93	21.06
	20-40	13.74	28.12	21.09	4.44	21.05
Avail. K_2O (kg ha^{-1})	0-20	230.36	248.63	239.52	5.48	2.29
	20-40	208.24	224.76	216.53	4.95	2.29

Continued....

TABLE 1 CONTINUED....

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
Exch. Ca (c mol (P+) kg^{-1})	0-20	7.14	10.41	8.85	0.88	9.94
	20-40	7.41	10.81	9.20	0.92	10.00
Exch. Mg (c mol (P+) kg^{-1})	0-20	1.72	2.79	2.19	0.33	15.07
	20-40	1.84	2.99	2.35	0.36	15.32
Avail. S (mg kg^{-1})	0-20	10.62	12.65	11.55	0.60	5.19
	20-40	9.81	11.68	10.67	0.55	5.16
Fe (mg kg^{-1})	0-20	21.74	44.53	32.21	6.92	21.48
	20-40	14.56	29.83	21.58	4.64	21.50
Mn (mg kg^{-1})	0-20	4.27	8.19	6.25	1.12	17.92
	20-40	2.48	4.76	3.63	0.68	18.73
Cu (mg kg^{-1})	0-20	0.51	2.35	1.40	0.53	37.86
	20-40	0.32	1.50	0.90	0.34	37.78
Zn (mg kg^{-1})	0-20	0.25	1.19	0.69	0.28	40.58
	20-40	0.26	1.23	0.71	0.27	38.03
B (mg kg^{-1})	0-20	0.18	0.32	0.25	0.04	16.00
	20-40	0.86	1.19	1.05	0.09	8.57

TABLE 2

Descriptive statistics of soil properties in middle surface and subsurface region of Thonnur Kere Distributary, Mandya District

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
pH	0-20	7.15	8.97	8.02	0.41	5.11
	20-40	8.65	9.43	7.63	0.34	4.46
EC (dS m^{-1})	0-20	0.21	1.18	0.76	0.27	35.53
	20-40	1.51	1.93	0.93	0.27	29.03
Avail. N (kg ha^{-1})	0-20	131.28	180.63	155.06	15.33	9.89
	20-40	144.67	168.53	122.49	4.31	3.52
Avail. P_2O_5 (kg ha^{-1})	0-20	16.05	32.86	24.65	5.19	21.05
	20-40	22.71	30.27	14.79	4.78	32.32
Avail. K_2O (kg ha^{-1})	0-20	250.17	270.01	260.12	5.95	2.29
	20-40	240.36	249.49	231.16	5.50	2.38
Exch. Ca (c mol (P+) kg^{-1})	0-20	7.27	10.60	9.02	0.90	9.98
	20-40	7.99	11.65	9.92	0.99	9.98
Exch. Mg (c mol (P+) kg^{-1})	0-20	1.97	2.90	2.28	0.35	15.35
	20-40	1.94	3.14	2.47	0.38	15.38
Avail. S (kg ha^{-1})	0-20	10.60	12.62	11.53	0.59	5.12
	20-40	10.60	12.63	11.53	0.60	5.20

Continued....

TABLE 2 CONTINUED....

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
Fe (mg kg^{-1})	0-20	10.65	21.81	15.78	3.39	21.48
	20-40	9.76	19.99	14.46	3.11	21.51
Mn (mg kg^{-1})	0-20	2.74	5.24	4.00	0.75	18.75
	20-40	3.55	6.81	5.20	0.98	18.85
Cu (mg kg^{-1})	0-20	2.45	3.98	3.13	0.48	15.34
	20-40	1.87	3.03	2.38	0.37	15.55
Zn (mg kg^{-1})	0-20	0.16	0.76	0.44	0.18	40.91
	20-40	0.14	0.69	0.40	0.16	40.00
B (mg kg^{-1})	0-20	0.19	0.35	0.27	0.04	14.81
	20-40	0.16	0.29	0.22	0.04	18.18

TABLE 3

Descriptive statistics of soil properties in tail end surface and subsurface region of Thonnur Kere Distributary, Mandya District

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
pH	0-20	8.12	8.97	8.64	0.15	1.74
	20-40	8.46	9.49	9.24	0.25	2.71
EC (dS m^{-1})	0-20	0.21	1.99	1.12	0.51	45.54
	20-40	2.09	4.99	3.57	0.81	22.69
Avail. N (kg ha^{-1})	0-20	170.28	234.28	201.28	19.89	9.88
	20-40	155.46	213.89	183.61	18.16	9.89
Avail. P_2O_5 (kg ha^{-1})	0-20	21.74	44.50	33.38	7.04	21.09
	20-40	19.87	40.67	30.51	6.43	21.08
Avail. K_2O (kg ha^{-1})	0-20	269.93	291.34	280.68	6.42	2.29
	20-40	244.05	263.37	253.73	5.81	2.29
Exch. Ca (c mol (P+) kg^{-1})	0-20	7.83	11.41	9.71	0.97	9.99
	20-40	8.78	12.81	10.90	1.09	10.00
Exch. Mg (c mol (P+) kg^{-1})	0-20	1.93	3.14	2.46	0.38	15.45
	20-40	2.12	3.45	2.71	0.41	15.13
Avail. S (kg ha^{-1})	0-20	11.29	13.45	12.28	0.64	5.21
	20-40	11.29	13.45	12.28	0.63	5.13
Fe (mg kg^{-1})	0-20	8.91	18.26	13.21	2.84	21.50
	20-40	7.28	14.91	10.79	2.32	21.50
Mn (mg kg^{-1})	0-20	2.77	5.25	4.00	0.76	19.00
	20-40	1.74	3.33	2.54	0.48	18.90
Cu (mg kg^{-1})	0-20	0.65	3.00	1.79	0.68	37.99
	20-40	0.21	1.00	0.59	0.22	37.29

Continued....

Table 3 Continued....

Soil Properties	Depth (cm)	Min	Max	Mean	SD	CV (%)
Zn (mg kg^{-1})	0-20	0.35	1.65	0.97	0.39	40.21
	20-40	0.27	1.30	0.76	0.30	39.47
B (mg kg^{-1})	0-20	0.19	0.34	0.27	0.04	14.81
	20-40	0.14	0.28	0.22	0.04	18.18

tail-end recorded higher alkalinity with pH values reaching up to 8.97. This trend extended into the subsurface layers, where the pH reached 9.49 in the tail-end, suggesting potential buildup of alkaline salts due to prolonged irrigation and evapotranspiration effects (Reddy *et al*., 2014 and Kavitha & Prathap, 2020). Similar trend was followed in case of electrical conductivity (0.13-0.21 dS m^{-1} in surface, 0.75-2.09 dS m^{-1} in subsurface) complementing to the soil reaction, indicating sedimentation of bases in tail end which might be transported from upper to tail end reach through irrigation water (Fig. 2).

Available nitrogen (N) content (Fig. 3) increased progressively from upper to tail-end regions, with maximum values observed in the surface soils of the tail-end (234.28 kg ha^{-1}), indicating nutrient accumulation due to runoff and irrigation return flow (Subba Rao *et al*., 2017). A similar increasing trend was observed for available phosphorus (P_2O_5) and potassium (K_2O). Notably, P_2O_5 (Fig. 3) content in surface soils ranged from 15.25 kg ha^{-1} in the upper to 44.50 kg ha^{-1} in the tail-end region, while K_2O (Fig. 3) ranged from 230.36 to 291.34 kg ha^{-1} across the same gradient. These elevated values at the tail-end may be attributed to nutrient enrichment through irrigation water and possible over-application of fertilizers (Patil *et al.,* 2019). Available sulphur (S) remained relatively stable across all regions (Fig. 3) and depths, showing slight increases in the tail-end surface soils (13.45 kg ha^{-1}), consistent with irrigation-induced redistribution of soluble nutrients (Bhattacharyya *et al.,* 2013),

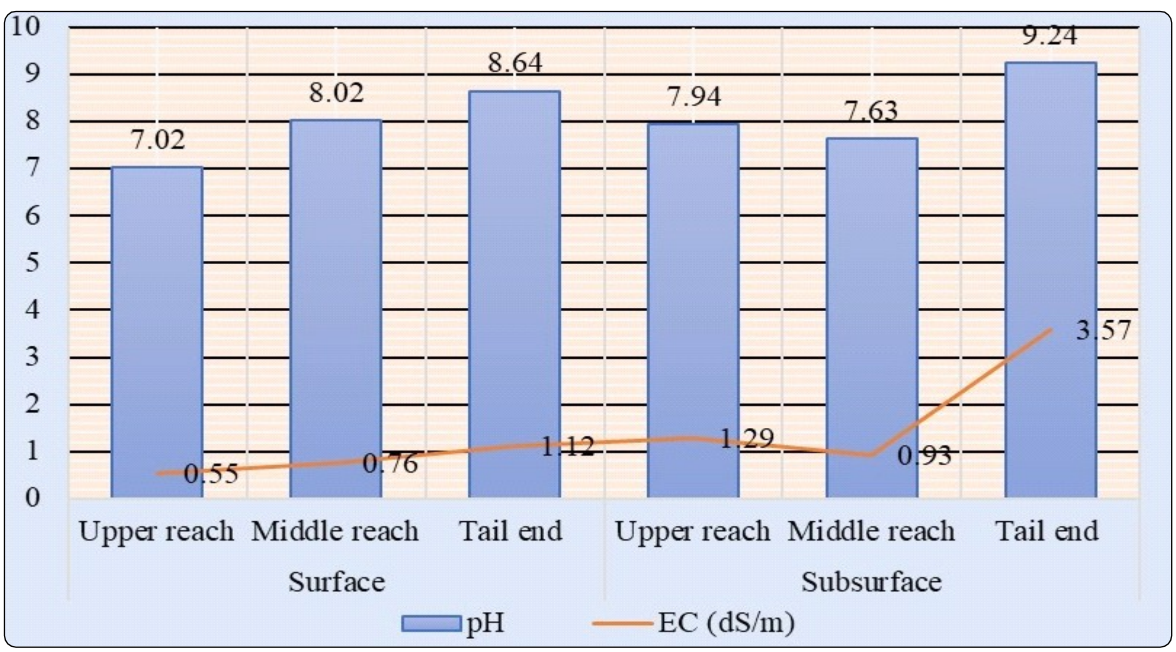


Fig. 2 : Variability of Soil Reaction (pH) and Electrical Conductivity (EC)

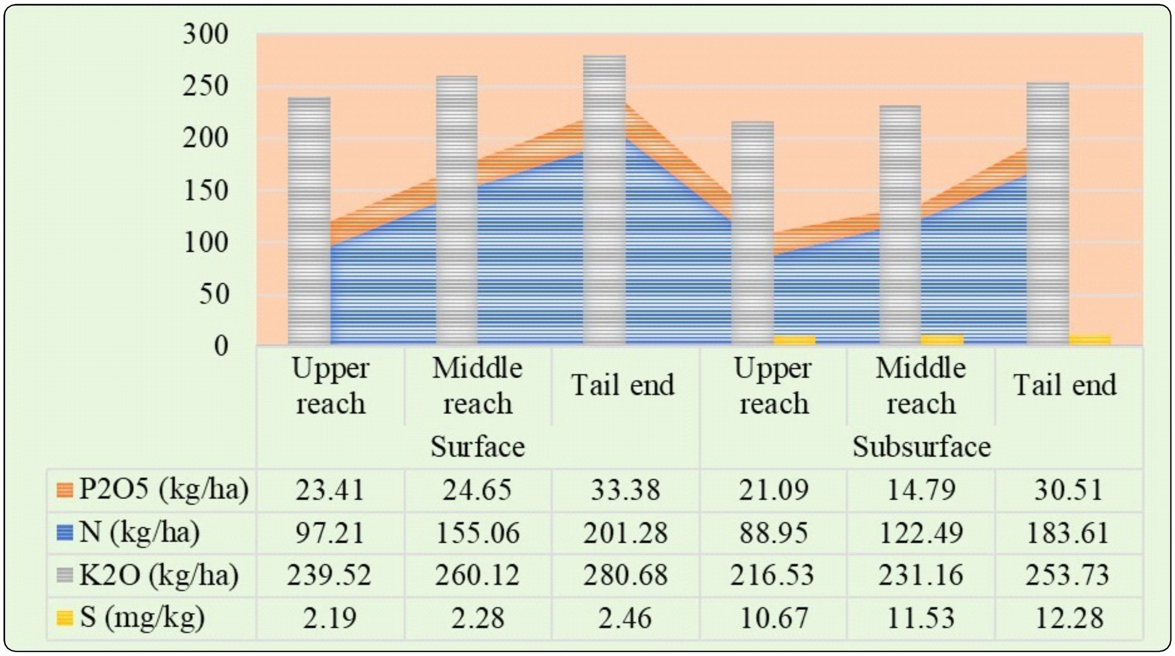


Fig. 3 : Averaged variability of Soil chemical properties (Available nitrogen, phosphorus, potassium and sulphur)

which might be transported from upper to tail end reach through irrigation water (Fig. 2).

Exchangeable calcium (Ca) and magnesium (Mg) followed a similar spatial trend (Fig. 4), with both nutrients increasing from upper to tail-end regions in both soil depths. For instance, exchangeable Ca in the subsurface layer reached 12.81 c mol (P^{+}) kg^{-1} in the tail-end region, while Mg values peaked at 3.45 c mol (P^{+}) kg^{-1}, suggesting enhanced base saturation

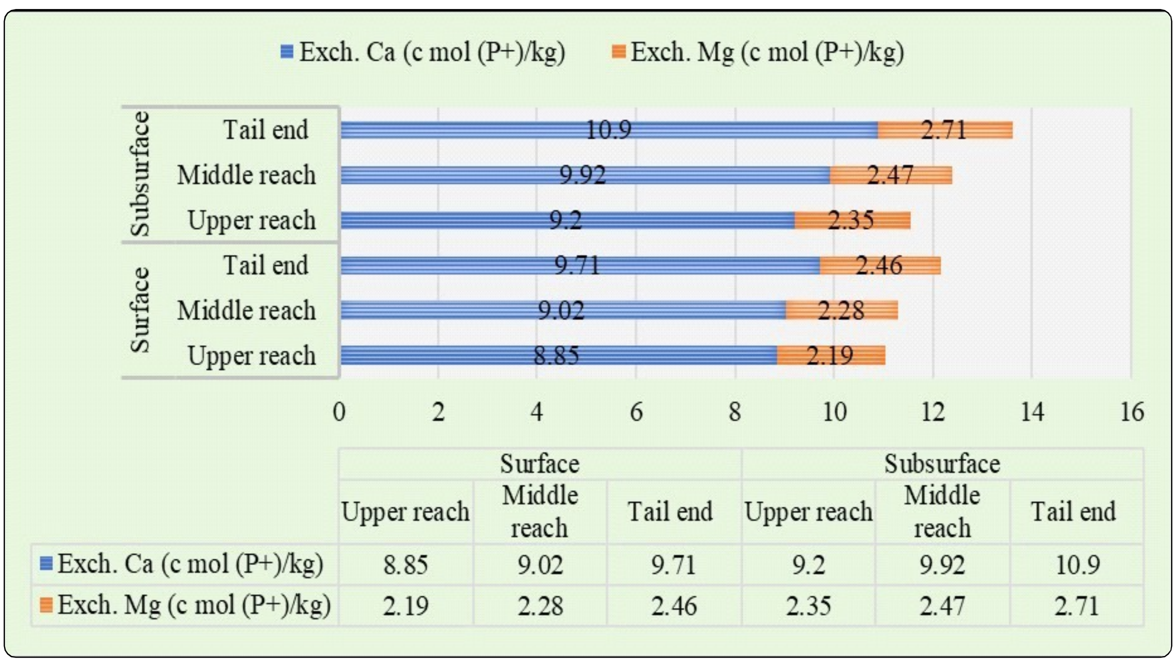
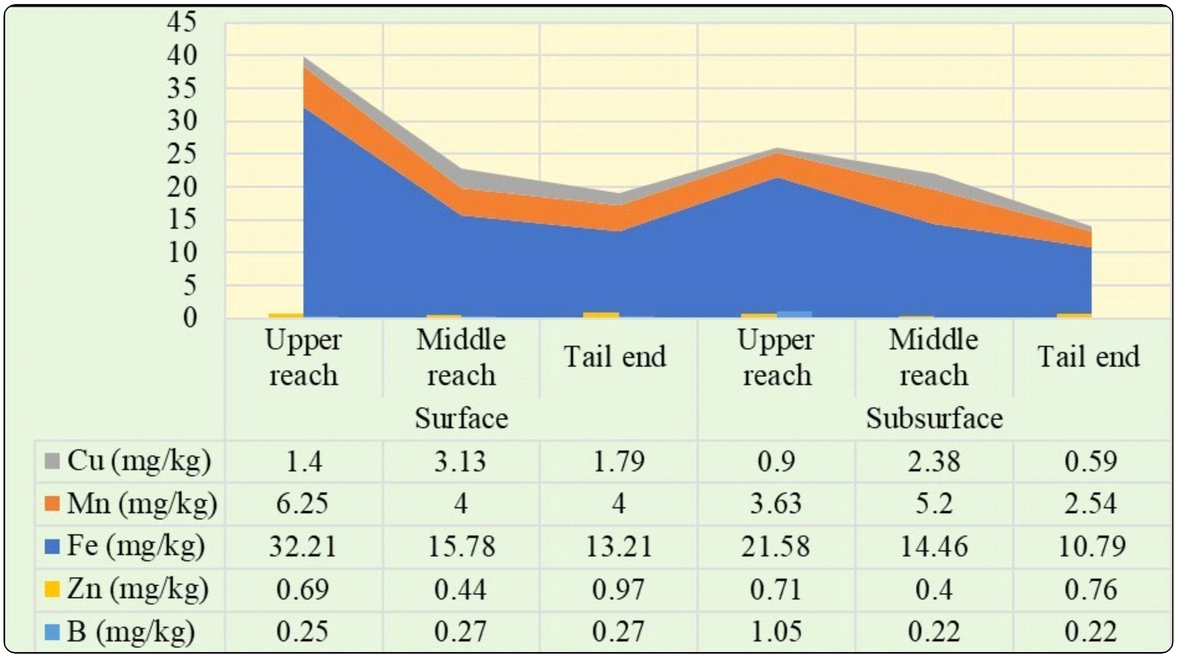


Fig. 4 : Variability of Soil chemical properties (Exchangeable calcium and magnesium)



	Surface: Upper reach	Surface: Middle reach	Surface: Tail end	Subsurface: Upper reach	Subsurface: Middle reach	Subsurface: Tail end
Cu (mg/kg)	1.4	3.13	1.79	0.9	2.38	0.59
Mn (mg/kg)	6.25	4	4	3.63	5.2	2.54
Fe (mg/kg)	32.21	15.78	13.21	21.58	14.46	10.79
Zn (mg/kg)	0.69	0.44	0.97	0.71	0.4	0.76
B (mg/kg)	0.25	0.27	0.27	1.05	0.22	0.22

Fig. 5 : Variability of Soil chemical properties (micronutrients: iron, manganese, copper, zinc and boron)

downstream (Sharma & Swarup, 2006). Micronutrient availability exhibited contrasting patterns (Fig. 5). Iron (Fe) and manganese (Mn) were highest in the upper region (32.21 mg kg^{-1} and 6.25 mg kg^{-1} respectively in surface soils) and declined progressively toward the tail-end, likely due to leaching or reduced mobility in alkaline conditions (Tandon, 2013).

In contrast, copper (Cu) and zinc (Zn) concentrations were elevated at the tail-end, possibly due to accumulation effects or differential mobility under alkaline soil pH. Notably, zinc content in tail-end surface soils reached 1.65 mg kg^{-1} compared to 0.69 mg kg^{-1} in the upper region. Boron (B) levels were generally low across all sites, with a surprising peak (1.05 mg kg^{-1}) observed in the subsurface soils of the upper region, which may reflect site-specific parent material or localized input (Naik *et al*., 2021). Overall, the findings reflect a spatial gradient in soil fertility across the irrigated command area of Thonnur Kere Distributary, Mandya with nutrient enrichment and alkalinity increasing toward the tail-end of the Thonnur Kere distributary. This pattern is characteristic of irrigated agro ecosystems where prolonged irrigation and nutrient in flow tend to favour downstream accumulation (Singh *et al*., 2012). Such data provide essential insight for site-specific nutrient management and sustainable land use planning to elevate nutrient use efficiency (Raghavendra & Ramakrishna, 2018).

Soil Nutrient Status Across Different Regions of the Cauvery Command Area

The soil nutrient analysis of the upper, middle and tail-end regions in the Thonnur Kere Distributary of Cauvery command area, Mandya District reveals significant regional variations, reflecting differences in soil fertility, nutrient availability and agricultural practices. The nutrient status of key macro and micronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S) and several micronutrients (*e.g*., iron, manganese, zinc, copper and boron) provides valuable insights into the soil health of these regions.

Available Nitrogen (N)

In all three regions (upper, middle and tail-end), the nitrogen content was consistently low, both in surface (0-20 cm) and subsurface (20-40 cm) layers, suggesting a relatively imbalanced supply of this crucial nutrient. Specifically, nitrogen levels were observed to be at 100 per cent low in both surface and subsurface layers across the regions.

This low nitrogen availability is indicative of poorly managed nitrogen cycling and inadequate fertilization practices. As nitrogen is a highly mobile nutrient, its availability is largely determined by the organic matter content and microbial activity, which are relatively unstable across these regions. Studies have shown that regions with higher organic matter tend to maintain better nitrogen availability. The irrigation practices in these areas might also contribute to the excess leaching of nitrogen, which is important factor for soil and nutrient erosion down the slope, particularly in paddy and sugarcane ecosystems, which require substantial nitrogen inputs for optimal productivity. For the nutrient use efficiency purpose farmers can go precision agriculture and site specific management practices (Sayantika and Chikkaramappa *et al.,* 2023)

Available Phosphorus (P_2O_5)

Phosphorus availability varied significantly across the regions. In the tail end region, phosphorus levels were shifted from low (upper and middle) to moderate (21-44 kg ha^{-1} in the surface layer and 19-40 kg ha^{-1} in the subsurface), indicating good phosphorus management and cycling. Phosphorus is crucial for root development, energy transfer and overall crop productivity and moderate levels suggest balanced fertilization practices. The relatively higher phosphorus levels in the surface layer of the middle region (16-32 kg ha^{-1}) also suggest better phosphorus cycling compared to the tail-end region. However, the upper-region showed a significant difference in phosphorus availability, with very low phosphorus content in the surface soil (15-31 kg ha^{-1}), while the subsurface soils exhibited lesser concentrations (13-28 kg ha^{-1}). This stark contrast may indicate phosphorus fixation in the tail-end region, a common problem in regions where soil pH is low or where soils are rich in iron and aluminium oxides, which can bind phosphorus and make it less available to plants. Waterlogging, common in tail-end areas due to inadequate drainage, can further exacerbate phosphorus fixation by altering soil pH and reducing the soil's ability to cycle phosphorus efficiently. Studies have highlighted that waterlogged soils often show reduced phosphorus availability, impacting crop yields.

TABLE 4

Nutrient index in upper surface and subsurface region of Thonnur Kere Distributary, Mandya District

Upper reach	Low		Medium		High		Nutrient index		Nutrient index	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Nitrogen	100	100	-	-	-	-	1	1	Low	Low
Phosphorus	47	62	53	38	-	-	1.53	1.38	Low	Low
Potassium	-	-	100	100	-	-	2	2	Medium	Medium
Calcium	-	-	-	-	100	100	3	3	High	High
Magnesium	-	-	-	-	100	100	3	3	High	High
Sulphur	16	-	84	100	-	-	1.83	2	Medium	Medium
Iron	-	-	-	-	100	100	3	3	High	High
Manganese	-	-	13	26	87	74	2.87	2.74	High	High
Zinc	100	93	-	7	-	-	1	1.07	Low	Low
Copper	-	-	18	45	82	55	2.82	2.55	High	High
Boron	100	100	-	-	-	-	1	1	Low	Low

Available Potassium (K_2O)

Potassium availability was consistent across all regions, with 100 per cent availability in both surface and subsurface soils. Potassium is a relatively mobile nutrient that is commonly replenished through irrigation and the breakdown of organic matter. The high levels of potassium in the soils of the upper, middle and tail-end regions suggest that potassium deficiency is unlikely to be a limiting factor in these areas. Efficient nutrient management practices, particularly the use of balanced fertilizers and proper irrigation scheduling, likely contribute to the high potassium levels in the soils. Potassium is crucial for regulating plant water uptake, enzyme activation and photosynthesis, making its ample availability essential for crop growth, particularly in water-intensive crops such as paddy and sugarcane.

Exchangeable Calcium (Ca) and Magnesium (Mg)

Both calcium (Ca) and magnesium (Mg) were found in high concentrations (100%) across all regions and depths, suggesting that these essential cations are not limiting factors for soil fertility. Calcium plays a key role in cell wall structure and signalling, while magnesium is central to chlorophyll production and photosynthesis. Their high availability indicates that the soils in these regions are not deficient in these elements, which is typical of well-irrigated soils in regions with adequate soil management (Subba Rao *et al*., 2017). High levels of calcium and magnesium contribute to overall soil structure and stability, making the soil more resilient to erosion and compaction, which is crucial for sustainable land management.

Available Sulphur (S)

Sulphur content was also high across all regions, especially in the subsurface layers, with values reaching 100 per cent. Sulphur is a critical element for protein synthesis and enzyme function. Its high availability suggests that sulphur cycling is efficient, which can be attributed to both organic matter decomposition and sulphur-based fertilizers that are often applied in paddy and sugarcane systems. Sulphur deficiencies can lead to stunted growth and chlorosis, particularly in high-input agricultural systems like those in the upper and middle regions, where proper nutrient management ensures an adequate supply. Sulphur is often under appreciated in soil management, but its consistent availability across

TABLE 5

Nutrient index in midddle surface and subsurface region of Thonnur Kere Distributary, Mandya District

Middle reach	Low		Medium		High		Nutrient index		Nutrient index	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Nitrogen	100	100	-	-	-	-	1	1	Low	Low
Phosphorus	43	52	57	48	-	-	1.57	1.48	Low	Low
Potassium	-	-	100	100	-	-	2	2	Medium	Medium
Calcium	-	-	-	-	100	100	3	3	High	High
Magnesium	-	-	-	-	100	100	3	3	High	High
Sulphur	-	-	100	100	-	-	2	2	Medium	Medium
Iron	-	-	-	6	100	94	3	2.94	High	High
Manganese	-	-	-	-	100	100	3	3	High	High
Zinc	100	100	-	-	-	-	1	1	Low	Low
Copper	-	-	6	46	94	54	2.94	2.54	High	High
Boron	100	100	-	-	-	-	1	1	Low	Low

TABLE 6

Nutrient index in tail end surface and subsurface region of Thonnur Kere Distributary, Mandya District

Tail end	Low		Medium		High		Nutrient index		Nutrient index	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Nitrogen	100	100	-	-	-	-	1	1	Low	Low
Phosphorus	10	17	90	83	-	-	1.9	1.83	Medium	Medium
Potassium	-	-	100	100	-	-	2	2	Medium	Medium
Calcium	-	-	-	-	100	100	3	3	High	High
Magnesium	-	-	-	-	100	100	3	3	High	High
Sulphur	-	-	100	100	-	-	2	2	Medium	Medium
Iron	-	-	-	-	100	100	3	3	High	High
Manganese	-	-	33	100	77	-	2.97	2	High	Medium
Zinc	56	72	44	28	-	-	1.44	1.28	Low	Low
Copper	-	13	8	63	92	24	2.92	2.11	High	Medium
Boron	100	100	-	-	-	-	1	1	Low	Low

these regions highlights its importance in supporting overall crop productivity.

Micronutrients

Iron (Fe) : The availability of iron was highest in the upper and middle regions (100% availability in both layers), with lower levels in the tail-end region, especially in the surface soil (6%). Iron availability is influenced by soil aeration and microbial activity, with waterlogged conditions in the tail-end region likely reducing iron availability due to poor oxygen exchange and microbial reduction of ferric iron (Subba Rao *et al*., 2017). These conditions could limit iron uptake by plants and reduce crop yields in the tail-end, particularly for crops like paddy that are sensitive to iron deficiencies.

Manganese (*Mn*) : Manganese levels were significantly higher in the upper region (87% in the surface and 74% in the subsurface) compared to the middle (77% in surface) and tail-end regions (33% in surface). Manganese is crucial for photosynthesis and respiration and its higher availability in the upper and middle regions suggests that these regions benefit from better soil aeration and organic matter content. In contrast, manganese deficiency in the tail-end may result from reduced soil oxygen levels due to waterlogging, a common issue in tail-end areas.

Zinc (*Zn*) : Zinc availability was abundant in the upper and middle regions (100% availability in both surface and subsurface layers), but showed a decline in the tail-end (56% in surface). Zinc is an essential micronutrient for enzyme activation and protein synthesis. Reduced zinc levels in the tail-end could be due to high soil pH or the presence of competing cations like calcium and magnesium, which can reduce zinc availability.

Copper (*Cu*) : Copper concentrations were higher in the middle and tail-end regions, particularly in the subsurface layers, with values reaching 92 per cent. Copper is important for photosynthesis and reproductive development. The higher copper levels in the tail-end could indicate accumulation from irrigation water or a slower release from organic matter in deeper soil layers, reflecting poor soil aeration or slower organic matter decomposition.

Boron (B) : Boron levels were consistently high across all regions, with no significant differences. Boron is essential for cell wall integrity and reproductive development and its adequate availability suggests that boron is not limiting in these soils. Regular replenishment through irrigation water may contribute to maintaining stable boron levels.

The nutrient status of the soils in the upper, middle and tail-end regions of the Thonnur Kere distributary indicates significant regional differences in soil fertility. The tail end region is nutrient-rich, with balanced levels of nitrogen, phosphorus, potassium and essential micronutrients, supporting sustainable agricultural practices but faces some threats to alkalinity requiring the reclamation measures in some areas. The middle region shows moderate nutrient levels, with slightly higher phosphorus and manganese content than the upper region, but also some areas of nutrient stress due to water management challenges. The upper region faces the greatest challenges in nutrient availability due to waterlogging, poor drainage and inefficient nutrient cycling. These findings underscore the need for tailored soil and water management practices to address regional disparities in nutrient availability and ensure sustainable agriculture across the entire command area.

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