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Decoding Soil Health : A Comparative Analysis of Chemical and Biological Properties in Rural Land Use Systems of Northern Transect of Bengaluru

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Abstract

The study 'Decoding soil health : a comparative analysis of chemical and biological properties in rural land use systems of northern Bangalore' was conducted at the Department of Soil Science and Agriculture Chemistry, UAS, Bengaluru to investigate the influence of different land use systems on soil chemical and biological properties in the rural area of the northern transect of Bengaluru during the year 2021 to 2023. Three land use systems, namely agriculture, forest and barren land, were selected for the study. Twenty soil samples were collected from each land use system at a depth of 0-15 cm and analyzed for various chemical and biological properties. The pH levels were slightly acidic and significantly lower in cultivated agricultural land (5.55b) followed by uncultivated forest land (5.99ab), while the electrical conductivity (EC) values recorded were slightly higher in agricultural land (0.45 dSm^{-1}) compared to forest (0.28 dSm^{-1}) and barren (0.30 dSm^{-1}) land use system. Acidic pH and increase in EC may be attributed to the application of inorganic fertilizers in cultivated agricultural land use systems. Available nitrogen, phosphorus and potassium contents recorded were also found to be higher in agricultural land use systems (N- 329.66 kg ha^{-1}, P- 35.29 kg ha^{-1}, K- 265.82 kg ha^{-1}) compared to forest (N- 218.85 kg ha^{-1}, P- 20.39 kg ha^{-1}, K- 235.53 kg ha^{-1}) and barren (N- 164.33 kg ha^{-1}, P- 13.88 kg ha^{-1}, K- 159.84 kg ha^{-1}) land use systems. Organic carbon content was found to be higher in natural forest systems (1.06%) compared to agriculture (0.67%) and barren (0.11%) land-use systems. Biological properties like dehydrogenase and urease activity recorded were found to be highest in forest land use system. The study clearly indicates that land use systems significantly influences the chemical and biological properties of the soil.

Keywords : Chemical properties, Biological properties, Enzyme activities, Dehydrogenase activities, Urease activities, Land use systems

Soil health is a critical element of agricultural productivity and ecosystem sustainability, making important subject in the context of global food security and environmental conservation. Soil health encompasses the capacity of soil to operate as a living system within the boundaries of ecosystems and land use. It involves the ability to support plant and animal productivity, uphold water and air quality, and foster the well-being of plants and animals (Karlen *et al.,* 1997; Arshad & Martin 2002 and Doran & Zeiss, 2000). Soil health is a measure of the soil's ability to carry out functions that support life, such as nutrient cycling, water filtration and retention, carbon sequestration, and supporting plant growth (Tahat *et al.,* 2020). It is a fundamental component of ecosystem health and plays a vital role in sustaining agricultural productivity, promoting biodiversity, maintaining water quality and mitigating climate change (Lal, 2011). Soil, a complex and living ecosystem serves as the foundation for terrestrial life. It's health is determined by physical, chemical and biological factors, including soil texture, organic matter content, nutrient availability, pH and the diversity and activity of soil microorganisms. These intricate components interact in a delicate balance, influencing soil functions such as nutrient cycling, water retention, carbon sequestration and support of biodiversity. By ensuring soil health, we can raise the long-term sustainability of ecosystems and optimize land use systems for the benefit of both present and future generations (Tahat *et al.,* 2020). Soil health, the fundamental aspect of ecosystem functioning and agricultural productivity, directly influences the sustainability of land use systems. The dynamic relationship between soil health and different land use systems plays a pivotal role in determining the long-term viability and resilience of both natural and managed landscapes (Lobmann *et al*., 2022).

Land use systems refer to the ways in which land is utilized and managed for various purposes. It involves the classification and categorization of land based on its primary use or activity. Land use systems can vary widely depending on factors such as geographical location, climate, soil conditions and human activities (Lagro, 2005). Different land use systems, ranging from natural ecosystems to intensive agricultural practices and urban developments, impose distinct pressures on soil health. Natural ecosystems, with their complex web of interactions and limited human intervention, often exhibit higher levels of soil biodiversity and healthy nutrient cycling processes. In contrast, conventional intensive agricultural systems, driven by the need to maximize crop yields, may deplete soil nutrients, degrade soil structure and reduce microbial diversity, leading to soil degradation over time (Correia & Lopes, 2023 and Rayne & Aula, 2020). Soil degradation and loss of soil fertility can result in reduced crop yields, increased vulnerability to erosion and flooding and diminished water quality due to nutrient runoff. Moreover, altered soil ecosystems can disrupt the balance of greenhouse gas emissions, potentially exacerbating climate change. Agricultural intensification and urban expansion are significant drivers of land use change on a global scale (Lambin and Meyfroidt, 2011). The continuous increase in population and economic growth increased the demand for various resources, including food, fiber and infrastructure. So to meet these growing demands of the population, natural habitats such as forests, grasslands and wetlands have been converted into agricultural fields and urban landscapes (Bengtsson *et al.,* 2019; Pilgrim *et al.,* 2010; Bullock *et al*., 2011; Lemaire *et al.,* 2011 and Lavorel *et al.,* 2013). Intensive agricultural practices, such as heavy ploughing, monoculture cropping, and excessive use of chemical fertilizers and pesticides, lead to soil degradation, loss of soil organic matter and a decline in soil biodiversity (Francaviglia *et al.,* 2023). As a result, soil health is compromised and affects the ability of the soil to sustainably support plant growth and provide essential ecosystem services.

To address the challenges posed by different land use systems on soil health, in northern transect of Bengaluru, scientific research was conducted at the Department of Soil Science and Agricultural Chemistry during the years 2021-2023 to analyze the effects of various management practices on chemical and biological properties. And also to explore the interconnections between soil health and different land use systems, encompassing natural ecosystems, and traditional agricultural practicing systems.

Material and Methods

Site Description

In the background of a larger study that investigates social-ecological conversion processes in the rural-urban interface of the South Indian Metropolis, Bengaluru, two transects (Northern and Southern) were demarcated as a common space for inter disciplinary research (Fig. 1). The Northern transect is a rectangular stripe of 5 km in width and 50 km in length (Fig. 2 and 3). The below part of this transect is urban and the upper part is rural villages (Hoffmann *et al.,* 2017). The corner coordinates of the northern transect of Bengaluru (Hoffmann *et al.,* 2017) are presented in Table 1.

Site Selection and Soil Sampling

After a preliminary survey, land use systems from different villages were identified along the northern transect of Bengaluru and soil samples were collected

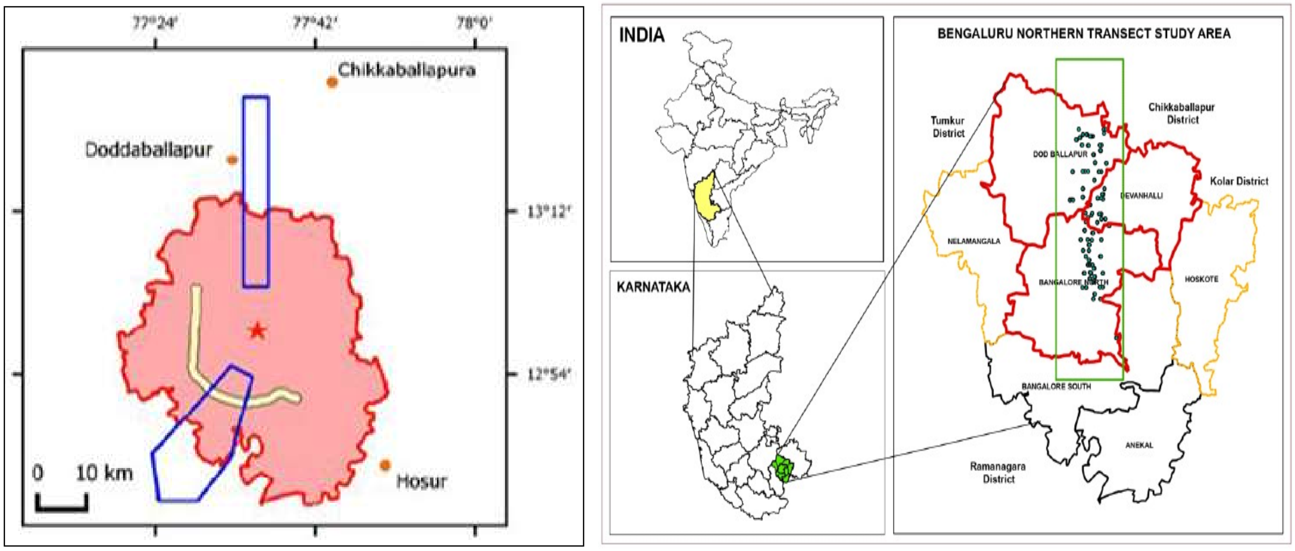

Fig. 1 : Rural-urban interface of Bengaluru

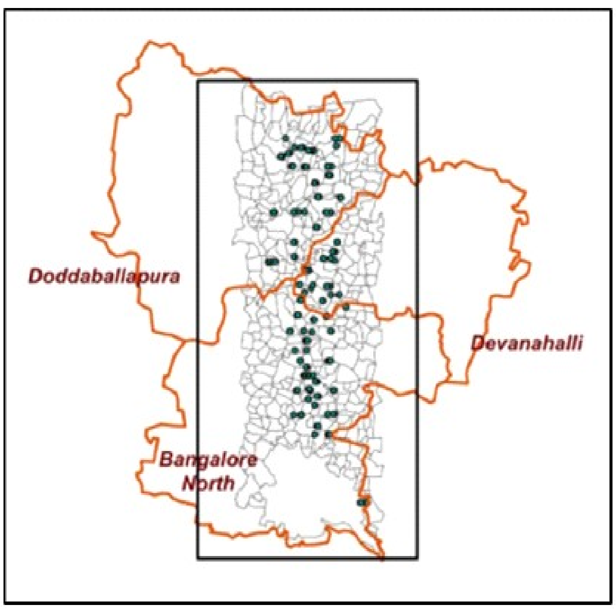

Fig. 2 : Study area village layers of the Northern transect of Bengaluru

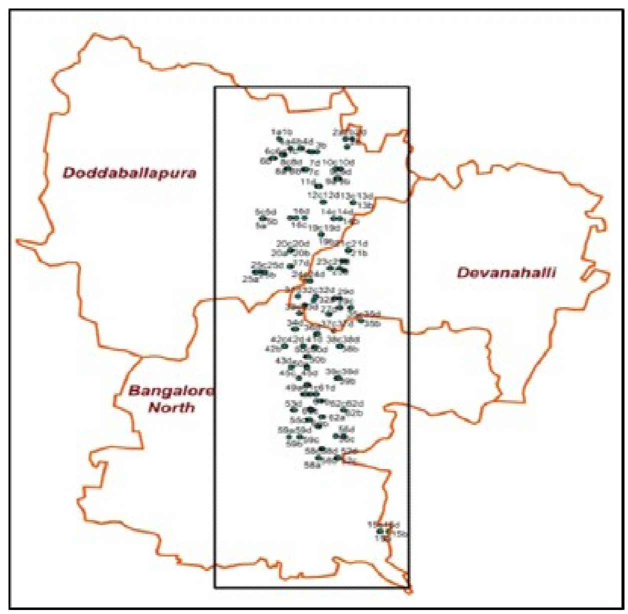

Fig. 3 : Grid points of study area

TABLE 1
Corner coordinates of the northern transect

N-Transect	
77.56452° E	13.06168° N
77.61002° E	13.06139° N
77.61119° E	13.40723° N
77.56321° E	13.40669° N

from various sites. From the Northern transect of Bangalore, three land use systems were selected. They were agriculture land use systems, forest land use systems and barren land use systems. From each land use system, 20 (from twenty selected villages) surface samples were collected at a depth of 0-20 cm. Sixty representative surface soil samples were collected which were geo-referenced and placed in polythene cover with proper labelling. Collected soil samples were air-dried and then ground to a fine texture using a wooden pestle and mortar. Subsequently, the processed samples were sieved through a 2 mm sieve. Chemical and biological parameters of soil samples were determined using standard analytical procedures (Table 2).

Statistical Analysis and Data Interpretation

One-way statistical analysis was used (Gopinath *et al.,* 2020) for comparing soil properties among different land use systems. Level of significance used for determining the significant difference in the chemical and biological properties of different land use systems was $p<0.05$. Post-hoc tests were performed to identify specific differences between land use systems by using least significant difference.

Results and Discussion

Soil Physico-chemical Properties

Soil pH : In the observation area, soil pH was found to be slightly acidic regardless of the various land use systems. The reason for the acidic pH may be attributed to the prevalence of red soil due to the presence of granite parent material along the northern transect of Bangalore. Similar findings were reported by Shen *et al.* (2021).

Data depicked in Table 3 revealed, that the pH ranged between 4.48-6.94. The lowest soil pH (5.5^{b}) was found in the agriculture land use systems compared to pH recorded in the forest land use systems (5.59^{ab}). The pH values in forest land use systems were on par with the pH values of barren land (6.33^{a}). Low pH in agriculture land use systems can be attributed to the extensive use of nitrogen fertilizers like DAP (Diammonium Phosphate), urea, etc. According to Smith *et al.* (2018), these nitrogen fertilizers release H^+ ions into the soil solution during chemical processes, leading to a decrease in soil pH in agricultural land use systems.

Following agriculture land use systems, lowest level of soil pH was recorded in the forest land use systems, with a mean pH value of 5.99. The dominant species in the forest land use systems were eucalyptus trees. According to Soumare *et al.* (2015), eucalyptus litter has a high polyphenol content hence when the litter

TABLE 2

Soil properties and methods adopted for analysis

Soil properties	Methods of analysis
pH	Potentiometric method (Jackson1973)
EC (dS/m)	Conductivity (Jackson1973)
SOC (g/kg)	Wet digestion method (Jackson1973)
Available N (kg/ha)	Alkaline $KMnO_4$ method (Jackson1973)
Available P_2O_5	Colorimetric method (Jackson1973)
Available K_2O	Flame photometry (Jackson1973)
Exchangeable Ca [cmol (p+) kg^{-1}]	Versenate titration method (Jackson1973)
Exchangeable Mg [cmol (p+) kg^{-1}]	Versenate titration method (Jackson1973)
Available S (mg/kg)	Turbidimetry (Black 1965)
Available Zn (ppm)	DTPA extraction and observation in AAS (Lindsay and Norwell1978)
Available Cu (ppm)	DTPA extraction and observation in AAS (Lindsay and Norwell1978)
Available Mn (ppm)	DTPA extraction and observation in AAS (Lindsay and Norwell1978)
Available Fe (ppm)	DTPA extraction and observation in AAS (Lindsay and Norwell (1978)
Urease (µg NH^+_4 g^{-1} soil hr^{-1})	Spectrophotometric (Tabatabai and Bremner, 1970).
Dehdrogesease (µg TPF g^{-1} of soil day)	Spectrophotometric (Casida *et al.* (1964)
Soil microbial biomass carbon and nitrogen	Chloroform fumigation and incubation method (Carter, 1991)

TABLE 3

One-way analysis of soil pH, soil EC and SOC in different land use systems

Soil parameters	Agriculture land use systems ± SD (n=20)	Forest land use systems± SD (n=20)	Barrenland use systems ± SD (n=20)	Between land use systems	
				S.Em.	LSD*(p=0.05)
pH (1:2.5)	$5.55^{b} \pm 0.78$	$5.99^{ab} \pm 0.75$	$6.33^{a} \pm 0.96$	0.18	0.51
EC (1:2.5) (dSm^{-1})	$0.45^{a} \pm 0.09$	$0.28^{b} \pm 0.13$	$0.30^{b} \pm 0.11$	0.0	0.11
OC (%)	$0.67^{b} \pm 0.08$	$2.01^{a} \pm 0.87$	$0.11^{c} \pm 0.06$	0.09	0.25

breaks down, it releases certain chemicals into the soil solution, which potentially contributing to increase in soil acidity.

Soil EC : Among different land use systems, the EC values recorded in agriculture land use systems were found to be significantly higher (0.45 dSm^{-1}) compared to all other land use systems under the study. The reason for the higher level of soil EC may be due to the use of inorganic fertilizers in agriculture land use systems. Sahrawat *et al.* (2014) also recorded a higher level of soil EC in inorganic nutrient management systems compared to uncultivated areas like forest land use systems.

Soil Organic Carbon (SOC) : Forest land use systems recorded significantly higher SOC content (2.0%) compared to the other land use systems. The higher SOC content in the forest land use systems may be attributed to the continuous deposition of litterfall, leading to increased organic matter accumulation in the soil. Due to limited disturbances through tillage operations and other human activities, organic matter in the forest soil decomposes at a slower rate, resulting in a higher content of soil organic carbon. Similar findings were also reported by Abbasi *et al.* (2007) and Amanuel *et al.* (2018). Agriculture land use systems recorded organic carbon content of 0.67 per cent. The soil organic carbon content in agriculture land use systems was in the range of 0.58-0.85 per cent and it was found to be lower than forest land use systems (range is 1.06-4.04%). The higher frequency of tillage practices in agricultural land use systems may lead to rapid oxidation of organic matter, as a result, the soil organic carbon content in the agricultural land use systems decreases. The same trend was recorded by Ayoubi *et al*. (2011) and Awotoye *et al*. (2013). In comparison to agriculture and forest land use systems, barren land use systems exhibited significantly lower organic carbon concentration (0.11%). This can be attributed to the absence of organic matter addition naturally or through management practices in barren land use systems (Gupta *et al*., 2012).

Soil Macronutrients (N. P. K. and S.)

Nitrogen (kg ha^{-1}) : There was a significant difference in the available nitrogen content among different land use systems. Agriculture land use systems recorded higher available nitrogen content of 329.66 kg ha^{-1} with a range of 200.70-481.46 kg ha^{-1} (Table 5).

TABLE 4

The range and mean value of Soil pH, soil EC and SOC in different land use systems

Soil parameters	Agriculture land use systems (n=20)		Forest land use systems (n=20)		Barrenland use systems (n=20)	
	Range	Mean	Range	Mean	Range	Mean
pH (1:2.5)	4.48-6.94	5.50	3.77-7.00	5.99	4.35-7.72	6.33
EC (1:2.5) (dSm^{-1})	0.16-1.26	0.45	0.12-0.60	0.28	0.19-0.60	0.30
OC (g/kg)	0.58-0.85	0.67	1.06-4.04	2.01	0.03-0.36	0.11

TABLE 5

The range and mean value of soil available macronutrients (N, P, K. and S.)

Soil parameters	Agriculture land use systems (n=20)		Forest land use systems (n=20)		Barrenland use systems (n=20)	
	Range	Mean	Range	Mean	Range	Mean
Available N (kg ha^{-1})	200.70 - 481.46	329.66	163.07 - 288.16	218.85	75.26 - 275.97	164.33
Available P_2O_5 (kg ha^{-1})	19.49 - 52.07	35.29	07.44 - 62.58	20.39	5.64 - 27.44	13.88
Available K_2O (kg ha^{-1})	98.38 - 565.02	265.82	148.65 - 383.58	235.53	51.72-365-57	159.84
Available S (mg kg^{-1})	6.16 - 34.17	15.29	00.18 - 17.93	6.75	0.18 - 10.69	2.16

Increase in nitrogen availability in agriculture land use system can be attributed to the predominant use of inorganic fertilizers such as DAP and urea. These fertilizers contain easily available nitrogen like nitrate (NO_3^-) and ammonium (NH_4^+), which efficiently contribute to the soil available nitrogen content (Shivakumar *et al.,* 2020).

In the forest land use systems, the available nitrogen content (218.85 kg ha^{-1}) was lower when compared to agriculture land use systems. This might be due to the absence of nitrogen-fixing bacteria associated with eucalyptus tree species and the lack of external fertilizer applications in forest land use systems. Band *et al.* (2001) also reported a similar trend, indicating higher available nitrogen content in agricultural land use systems compared to forest land use systems.

Lowest content of available nitrogen (164.33 kg ha^{-1}) was recorded in the barren land use systems, this may be due to the lack of application of organic matter and inorganic fertilizers in barren land use systems, leading to a reduction in available nitrogen (Mandal *et al*., 2018).

Phosphorus (kg ha^{-1}) : The mean value and range of phosphorus content in soils of different land use systems are given in Table 5. The mean value of the phosphorus in different land use systems was 35.29 kg ha^{-1} in agriculture land use systems, 20.39 kg ha^{-1} in forest land use systems, and 13.88 kg ha^{-1} in the barren land use system. A significant difference was observed in the soil phosphorus content of the different land use systems (Table 6). The study revealed that agriculture land use systems recorded higher status of available phosphorus compared to non-cultivated fields like forests and barren land use systems. This difference can be attributed to the direct application of easily available phosphate nutrient-containing fertilizers (such as DAP, SSP, etc.) in cultivated land use systems, which enhances the availability of phosphorus in the soil.

The forest soil contains more carbon and less phosphorus, which slows down the mineralization rate (Kaiser *et al.,* 2012). Since phosphorus is relatively immobile in forest systems, it is not as readily available to plants as in cultivated fields. As a result, available phosphorus levels in soil are lower in forest

TABLE 6

One-way analysis of soil available macronutrients (N. P. K. and S.)

Soil parameters	Agriculture land use systems ± SD (n=20)	Forest land use systems ± SD (n=20)	Barrenland use systems ± SD (n=20)	Between land use systems	
				S.Em.	LSD*
Available N (kg ha^{-1})	329.66^{a} ± 81.62	218.85^{b} ± 33.25	164.33^{c} ± 65.99	17.90	47.93
Available P_2O_5 (kg ha^{-1})	35.29^{a} ± 7.78	20.39^{bc} ± 12.89	13.88^{c} ± 6.24	2.36	6.64
Available K_2O (kg ha^{-1})	265.82^{a} ± 136.53	235.53^{a} ± 80.90	159.84^{b} ± 69.22	26.04	72.95
Available S (mg kg^{-1})	15.29^{a} ± 7.77	6.75^{bc} ± 5.25	2.16^{c} ± 2.40	2.05	5.75

land use systems compared to agriculture land use systems. Bolan *et al.* (2012), Kaiser *et al.* (2012) and Liang *et al.* (2018) also reported similar findings of higher C/P ratios in forest land compared to cultivated land.

Potassium (kg ha^{-1}) : The barren land use system recorded a significantly lower content of available potassium in soil when compared to other land use systems (Table 6). The lower content of available potassium in barren land use system (159.84 kg ha^{-1}) may be due to the well-drained nature of the red soil (Baligar *et al.,* 2004). Limited organic matter in barren land use systems results in reduced soil ability to retain positively charged potassium ions. Similar findings were reported by Agrawal *et al*. (2017); Vanitha *et al.* (2022), found that erosion can remove potassium-rich topsoil and leaching can transport potassium away from the surface soil of the barren land use systems. These trends were also observed by Khan *et al.* (2012), Duhan *et al.* (2014) and Pal *et al.* (2016).

Soil Exchangeable Nutrients (Ca, Mg and Na)

Calcium (cmoli (p+) kg^{-1}) : Barren land use system recorded 2.9 cmoli (p+)kg^{-1} exchangeable calcium content. Low exchangeable calcium content in barren land use systems might be due to loss of calcium through surface runoff and leaching processes (Luo *et al.,* 2023). The lack of vegetation and inadequate soil cover in these regions exacerbates erosion, leading to the removal of calcium-rich topsoil through surface runoff. Additionally, leaching further contributes to the depletion of calcium from the soil. Similar findings were reported by Palaniswami *et al.* (2023); Donnell *et al.* (2016) and Brown *et al.* (2015), affirming that barren land use systems generally significantly lower exchangeable calcium levels compared to other land-use systems.

The concentrations of exchangeable calcium in the agriculture (4.4 meq/100 mg soil), and forest (4.8 meq/ 100 mg soil) land use systems did not show any significant differences. One possible reason for this similarity is that farmers in agricultural land use systems might not frequently apply lime this may be the reason for the reduced level of exchangeable calcium in the agriculture land use systems (Mahmud and Chong, 2022).

Magnesium (cmol (p+) kg^{-1}) : The magnesium (Mg) content did not differ significantly among agriculture [4.4 cmol (p+) kg^{-1}] and forest [2.3 cmol (p+) kg^{-1}] land use systems. However higher Mg content was recorded in forest land use systems compared to barren land use systems [cmol (p+) kg^{-1}], it can be attributed to the abundance of organic matter, better soil structure and higher cation exchange capacity (CEC) of the soil. As a result, forest soils have the ability to retain and hold magnesium, leading to higher concentrations of Mg when compared to barren land use systems. This phenomenon highlights the importance of organic matter in promoting nutrient retention and soil fertility (Wang *et al.,* 2020).

TABLE 7
Soil exchangeable nutrients (Ca, Mg and Na)

Soil parameters	Agriculture land use systems ± SD (n=20)	Forest land use systems ± SD (n=20)	Barren land use systems ± SD (n=20)	Between land use systems	
				S.Em.	LSD* (p=0.05)
Exchangeable Ca (cmol (p+) kg^{-1})	4.4^{a} ± 2.18	4.8^{a} ± 2.38	2.9^{b} ± 1.70	0.44	1.25
Exchangeable Mg (cmol (p+) kg^{-1})	2.1^{a} ± 1.08	2.3^{a} ± 0.93	1.5^{b} ± 0.84	0.22	0.6
Exchangeable Na (cmol (p+) kg^{-1})	3.94 ± 3.90	4.45 ± 2.26	3.25 ± 3.22	0.68	NS

TABLE 8

One-way analysis of soil available micronutrients (Zn, Fe, Mn, and Cu) (mg/kg)

Soil parameters	Agriculture land use systems ± SD (n=20)	Forest land use systems ± SD (n=20)	Barren land use systems ± SD (n=20)	Between land use systems	
				S.Em.	LSD* (p=0.05)
Available Zn (mg kg^{-1})	0.72^{a} ± 0.50	0.78^{a} ± 0.42	0.32^{b} ± 0.28	0.12	0.35
Available Fe (mg kg^{-1})	10.34^{ab} ± 2.69	07.74^{c} ± 3.13	03.71^{c} ± 1.95	0.54	1.52
Available Mn (mg kg^{-1})	6.60^{a} ± 2.00	4.28^{b} ± 1.74	1.94^{c} ± 1.14	0.42	1.20
Available Cu (mg kg^{-1})	01.66^{a} ± 0.57	01.29^{a} ± 0.75	0.87^{a} ± 0.64	0.30	0.84

Sodium (cmol(p+)kg^{-1}) : Sodium content did not differ among different land use system.

Soil Micro-nutrients

In agriculture land use systems, the recorded Zn was 0.72 mg/kg, while the Fe content was 10.34 mg/kg, Mn content was 6.60 mg/kg, and the Cu content was 1.66 mg/kg. In forest land use systems, Zn, Fe, Mn and Cu content was 0.78 mg/kg, 7.74 mg/kg, 4.28 mg/kg, 1.29 mg/kg, respectively. In barren land use systems, Zn, Fe, Mn, and Cu concentration was 0.32 mg/kg, 3.71 mg/kg, 1.94 mg/kg and 0.87 mg/kg, respectively.

There is a significant difference in the micronutrient content among the three land use systems. It is evident that the management practices employed in agriculture land use systems are markedly distinct from those in the forest and barren land. These divergent management approaches likely to account for the significant variations observed in the micronutrient levels. The agricultural practices, such as the use of fertilizers, irrigation techniques and crop selection can contribute to the variation in micronutrient content when compared to the more natural practices found in forested areas and barren land use systems (Vanitha, 2022). In a study by Cholarajan and Vijayakumar, (2017), it was reported that the micronutrient contents of soil depend on various soil parameters, such as pH, organic matter (OM), and soil moisture content.

Enzyme Activity

Dehydrogenase enzyme activity : Dehydrogenase activity is used to measure the active microbial biomass (Subhani *et al.,* 2001). Significant differences in dehydrogenase activity were observed among different land use systems. These variations can be attributed to soil-related factors, such as soil pH, temperature, soil organic matter content, microbial activity and redox potential as highlighted by Trevors (1984); Bremner and Zantua (1975) and Frakenberger & Johanson (1982). The different conditions and management practices associated with each land use systems can affect microbial activity and enzyme expression, thereby contributing to the variations in dehydrogenase activity levels.

TABLE 9

The range and mean of soil enzymatic activity

Soil parameters	Agriculture land use systems (n=20)		Forest land use systems (n=20)		Barrenland use systems (n=20)	
	Range	Mean	Range	Mean	Range	Mean
Urease activity (µg NH_4^+-N $g^{-1}h^{-1}$)	51.21 - 72.86	64.63	55.23 - 75.96	64.91	21.41 - 29.86	24.47
Dehydrogenase Activity (µg TPF $g^{-1}h^{-1}$)	24.19 - 30.15	27.58	32.25 - 41.04	36.65	05.63 - 15.00	11.05

TABLE 10
One-way analysis of soil enzymatic activity

Soil parameters	Agriculture land use systems ± SD (n=20)	Forest land use systems ± SD (n=20)	Barren land use systems ± SD (n=20)	Between land use systems	
				S.Em.	LSD* (p=0.05)
Urease activity (µg NH_4^+-N$g^{-1}h^{-1}$)	64.63 ^{a} ± 5.69	64.91 ^{a} ± 6.21	24.47 ^{b} ± 2.26	1.43	4.00
Dehydrogenase Activity (µg TPF $g^{-1}h^{-1}$)	27.58 ^{c} ± 1.65	36.65 ^{a} ± 2.60	11.05 ^{e} ± 2.81	0.56	1.59

Dehydrogenase activity in the forest land use system (36.65 µg TPF g^{-1} soil 24 h^{-1}) was significantly higher compared to the other two land use systems. This might be due to the increased input of organic matter, providing a rich substrate for microbial growth and activity (Wolinnska and Stępniewska, 2012). As microbial communities decompose organic matter, more carbon sources are released, facilitating microbial growth and consequently enhancing dehydrogenase activity (Sparling, 1985 and Lee & Pankhurst, 1992).

In agriculture land use systems, the recorded dehydrogenase activity was 27.58 µg TPF g^{-1} soil 24 h^{-1}, which was lower in comparison to forest land use systems. It might be due to the utilization of synthetic materials such as inorganic fertilizers, pesticides and herbicides in cultivated land use systems. The application of synthetic inputs may lead to imbalances in soil nutrients over time, which can negatively impact the microbial community's growth and activity and have toxic effects on beneficial microorganisms, thus reducing their abundance and impairing their enzymatic activities (Subhani *et al.,* 2001 and Trevors, 1984).

Enzyme Activity

Urease enzyme activity : Urease enzyme (Urea amidohydrolase) plays a significant role in nitrogen cycle (Kuscu, 2019; Srinivasa *et al*., 2017 and Tabatabai, 1994). Barren land use systems recorded lower urease activity (24.47 µg NH_4^+-N g^{-1} soil h^{-1}) compared to other two land use systems (Reynolds *et al*., 1985). The reduced organic matter content in barren land restricts the availability of organic substrates, consequently reduce the activity of urease, which relies on these substrates for its catalytic function in the nitrogen cycle. Higher level of urease activity (64.63 µg NH_4^+-N g^{-1} soil h^{-1}) was recorded from agriculture land use systems. Several studies have reported that the incorporation of materials like compost, straw mulch and urea fertilizer in cultivated lands leads to elevated levels of urea-like compounds in the soil. As a result, the release rate of the urease enzyme is improved (Crecchio *et al*., 2004; Kizilkaya and Bayrakli, 2005 and Meyer *et al.,* 2015).

The comparative analysis of chemical and biological properties in rural land use systems of Northern transect of Bengaluru provides some valuable insights into soil health dynamics. The study reveals significant variations in soil parameters, including pH, organic matter content, available nutrient levels and biological properties across different land use systems, indicating the impact of diverse land use practices on soil quality. Agriculture land use systems exhibit distinct characteristics from forest and barren land, with intensively managed agricultural areas showing altered soil properties due to synthetic fertilizer use resulting in reduced organic matter content and elevated inorganic nitrogen levels. In contrast, forested regions showcase higher organic matter content, fostering increased microbial activity as evident in the higher dehydrogenase activity. Understanding these variations is vital for implementing sustainable land management practices to enhance soil health and support the long-term productivity of rural ecosystems in Northern transect of Bengaluru.

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