



## Effect of Soil Orders and Land Uses on Available Soil Nutrients in Meghalaya, India

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### Authors' contributions

This work was carried out in collaboration among all authors. Author NJS designed the study. Author CG prepared the input database for selection of soil sampling sites, collected soil samples, analyzed samples in the laboratory and wrote the manuscript. Author BKH carried out the statistical analysis. All authors read and approved the final manuscript.

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### ABSTRACT

Understanding of spatial distribution of available soil nutrients is important for sustainable land management. An attempt has been made to assess the spatial distribution of available soil nutrients under different soil orders and land uses of RiBhoi, Meghalaya, India using geo-statistical techniques. Seven Land Use Land Cover (LULC) classes were selected from LULC map on 1:50,000 scale prepared by National Remote Sensing Centre (NRSC) viz. Abandoned Jhum (AJ), Current Jhum (CJ), Deciduous Forest (DF), Double Crop (DC), Evergreen Forest (EF), Kharif Crop (KC) and Wastelands (WL). Again, three soil orders were identified by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) in RiBhoi district of Meghalaya, India viz. Alfisols, Inceptisols and Ultisols. 105 soil samples were collected, 5 replicated soil samples from 21 strata derived from 7 LULC and 3 soil orders. Soil samples were analyzed for available nitrogen (N), available phosphorus ( $P_2O_5$ ), available potassium ( $K_2O$ ) and available zinc (Zn) using standard procedures. One way ANOVA was carried out using IBM SPSS Statistics 20.0 software. Significance levels were tested at  $p \leq 0.05$ .

N content varied from low (215.50 kg/ha) to medium (414.30 kg/ha) with mean value of 291.50 kg/ha. On the other hand,  $P_2O_5$  content varied from low (19.90 kg/ha) to high (68.30 kg/ha) with

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mean value of 43.52 kg/ha. Similarly, K<sub>2</sub>O content varied from low (112.09 kg/ha) to high (567.84 kg/ha) with mean value of 273.68 kg/ha. Again, Zn also varied from low (0.26 ppm) to high (1.46 ppm) with mean value of 0.64 ppm.

In Alfisols, N was found to be higher in EF, AJ & CJ than DF, DC, KC and WL. KC has been found to have lower N than all other LULC classes. Higher P<sub>2</sub>O<sub>5</sub> has been found under EF over KC and WL. AJ has been found to have higher K<sub>2</sub>O than all other LULC classes. K<sub>2</sub>O has also been found to be higher in CJ over DC, KC and WL. DF and EF have been found to have higher K<sub>2</sub>O than KC and WL. Zn has been found to be higher in EF over CJ, DC and WL.

In Inceptisols, higher amount of N was observed under EF over all other LULC classes. Higher N has also been found under CJ over DF, DC, KC and WL. P<sub>2</sub>O<sub>5</sub> content was found to be higher under DF over all other LULC classes. Higher P<sub>2</sub>O<sub>5</sub> content was also found under AJ, CJ and DC than KC and WL. Higher amount of K<sub>2</sub>O has been found under AJ over all other LULC. K<sub>2</sub>O content of soil under DF was also higher than CJ, EF, KC and WL. Zn has been found to be higher under EF over all other LULC classes. Zn content under CJ has also been found to be higher than AJ, DF, KC and WL.

In Ultisols, higher amount of N has been found under EF compared to all other LULC classes. Lowest N content was found under KC. P<sub>2</sub>O<sub>5</sub> content was found to be higher under EF, DF and AJ over all other LULC. K<sub>2</sub>O content has been found to be higher under CJ in comparison to all other LULC classes. K<sub>2</sub>O content of EF and DF were also found to be higher than AJ, DC, KC and WL. Again, K<sub>2</sub>O content has been found to be higher under DC compared to AJ, KC and WL. Zn content under EF and AJ was found to be higher than all other LULC classes. CJ, DF, DC, KC and WL have been found to have lower Zn content.

It has been observed that P<sub>2</sub>O<sub>5</sub> content is significantly higher in inceptisols irrespective of LULC classes. The study has highlighted the spatial distribution of available soil nutrients as a function of soil orders and LULC. This will be a useful input in sustainable land management programmes.

*Keywords: Alfisols; available soil nutrients; inceptisols; land use land cover; ultisols.*

## 1. INTRODUCTION

Nutrient status of soil is very dynamic (with respect to time) and diverse (with respect to space). Hence, periodic monitoring of nutrient status of soil and inventory of spatial distribution of soil is the need of the hour [1,2]. Realizing the importance of soil variability at farm scale level, Government of India has initiated a flagship programme under the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare for issuing of Soil Health Card (SHC) for each and every agricultural field of the country. The programme is implemented through the State Department of Agriculture, State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), Indian Council of Agricultural Research (ICAR) institutes and Central Agricultural Universities (CAUs). However, information on soil fertility for other land use/cover areas is also important for sustainable land management and alternate land use planning.

Spatial distribution of available soil nutrients is a function of intrinsic factors (soil forming factors and processes) and extrinsic factors (topography, land use, soil management

practices etc.) [2,3]. Global Positioning Systems (GPS), Remote Sensing (RS), Geographic Information Systems (GIS) and geo-statistical techniques are widely used to study the influence of soil types and land uses on available soil nutrients [2,4,5]. Most of the spatial distribution studies of available soil nutrient have been carried out in hot-arid or semi-arid climate of India [6,7] and only a few studies have been carried out in humid subtropical climate of India [2,8]. Keeping this in view, an attempt has been made to assess the spatial distribution of available soil nutrients viz. available nitrogen (N), available phosphorus (P<sub>2</sub>O<sub>5</sub>), available potassium (K<sub>2</sub>O) and available zinc (Zn) under different soil orders and land uses in RiBhoi, Meghalaya, India using geo-statistical techniques.

## 2. MATERIALS AND METHODS

### 2.1 Description of the Soil Sampling Site

RiBhoi district is situated between 25°15' to 26°15' North Latitude and 91°45' to 92°15' East Longitudes and having a geographical area of 2448 sq.km. The district is bounded by Assam in the north, east and western side and East Khasi Hills and West Khasi Hills in the south (Fig. 1).

## 2.2 Soil Sampling and Laboratory Analysis of Soil Sample

Seven Land Use Land Cover (LULC) classes were selected from LULC map on 1:50,000 scale prepared by National Remote Sensing Centre (NRSC) viz. Abandoned Jhum (AJ), Current Jhum (CJ), Deciduous Forest (DF), Double Crop (DC), Evergreen Forest (EF), Kharif Crop (KC) and Wastelands (WL). Again, three soil orders were identified By National Bureau of Soil Survey And Land Use Planning (NBSS&LUP) in Ri Bhoi district of Meghalaya viz. Alfisols, Inceptisols and Ultisols. Intersection of 7 selected LULC

classes and 3 soil orders was carried out using spatial analyst tool of ArcGIS 10.2 software. Twenty one strata (treatments) were identified. Five soil sampling sites were selected from each strata (replication) through random sampling, thus total of 105 sampling sites were selected (Fig. 2). Soil samples were collected from each stratum by mixing samples collected from 10 random locations in a stratum during the year 2017. Again, 5 samples were collected from each stratum. About 1 kg soil samples were collected from 0-15 cm depth from each sampling point (105 points). Soil samples were air dried in shade and sieved with 0.5 mm sieve for

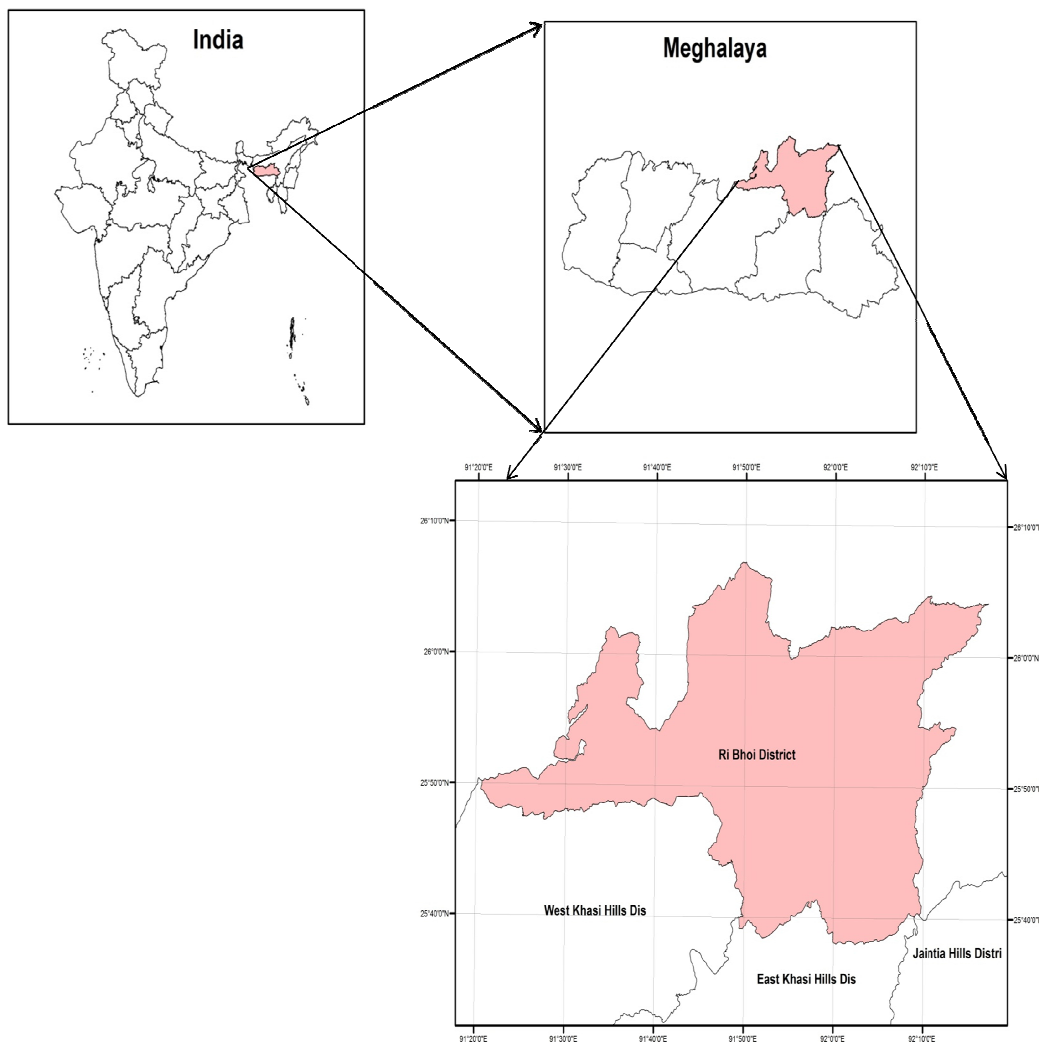
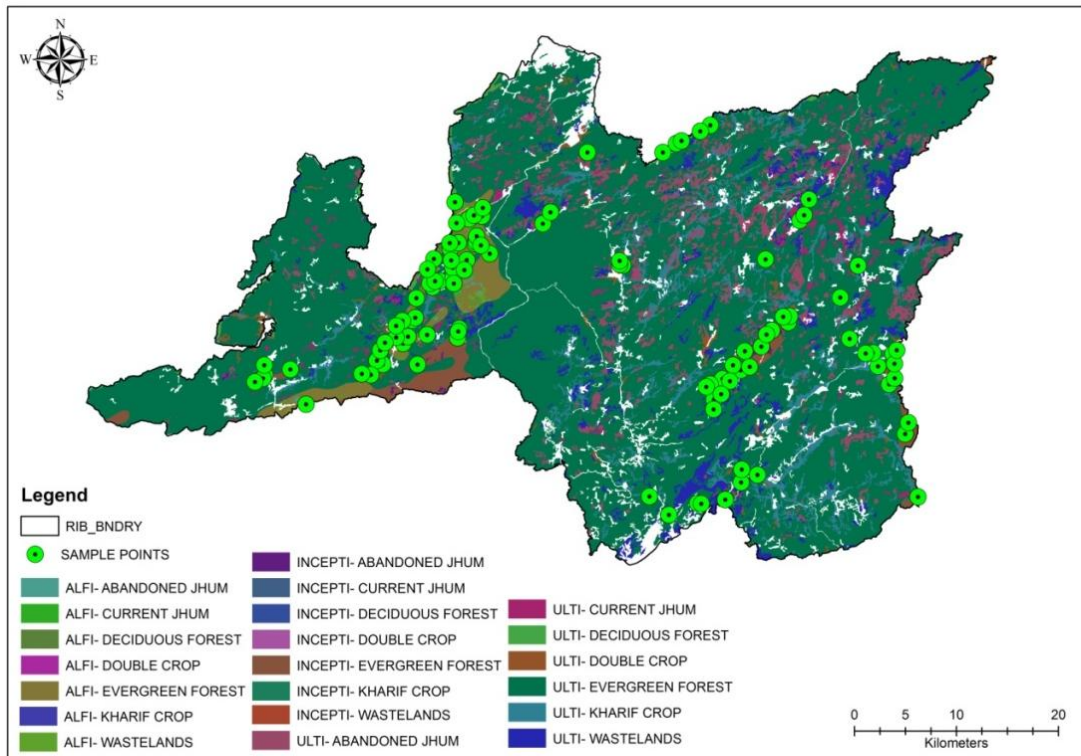


Fig. 1. Study area (Ri Bhoi district of Meghalaya, India)



**Fig. 2. Soil sampling points in RiBhoi, Meghalaya, India**

laboratory analysis. The soil samples were analyzed for N [9],  $P_2O_5$  [10],  $K_2O$  [11] and Zn [12].

### 2.3 Statistical Analysis

All data were analyzed by one-way analysis of variance (ANOVA) using International Business Machine (IBM) Statistical Package for Social Science (SPSS) Statistics 20.0 software (SPSS Inc., Chicago, IL, USA). Means were tested at a significance level of  $p \leq 0.05$  using duncan's multiple range test (DMRT).

## 3. RESULTS AND DISCUSSION

### 3.1 Descriptive Statistics of Available Soil Nutrients

The statistical analysis of available soil nutrients viz. N,  $P_2O_5$ ,  $K_2O$  and Zn indicated that the data followed normal distribution. Variability of available soil nutrients could be described by minimum, maximum, difference between median and mean, standard deviation (SD) and coefficient of variation (CV). The median of available soil nutrients was lower than the mean,

which indicated that the effect of abnormal data on sampling value were not significant. Warrick and Nielsen [13] proposed three levels of variability of soil properties based on CV; low ( $CV < 0.12$ ), medium ( $0.12 < CV < 0.62$ ) and high ( $CV > 0.62$ ). Skewness indicated departure from normality and for the normal distribution, the skewness should be less than 3. Lower values used to concentrate when skewness  $> 0$ . On the other hand, higher values used to concentrate when skewness  $< 0$ . Positive skewness indicated wider confidence limits on the variograms which made the variances less reliable. Kurtosis showed the characteristics of peak value corresponding to the average value in probability density distribution curve. The peak value of probability density distribution curve is higher than that of normal distribution when kurtosis  $> 0$ , equal to that of normal distribution when kurtosis = 0, lower than normal distribution when kurtosis  $< 0$ .

N content varied from low (215.50 kg/ha) to medium (414.30 kg/ha) with mean value of 291.50 kg/ha, median of 288.51 kg/ha (no influence of abnormal value on the sampling values), SD of 40.69, CV of 0.14 (medium level

of variability), skewness of 0.61 (normal distribution of data), kurtosis of 3.22 (peak value of probability distribution curve is higher than normal distribution) and beta of -0.73 (Table 1).

On the other hand,  $P_2O_5$  content varied from low (19.90 kg/ha) to high (68.30 kg/ha) with mean value of 43.52 kg/ha, median of 43.30 kg/ha (no influence of abnormal value on the sampling values), SD of 12.14, CV of 0.28 (medium level of variability), skewness of 0.03 (normal distribution of data), kurtosis of 2.10 (peak value of probability distribution curve is higher than normal distribution) and beta of 0.78 (Table 1).

Similarly,  $K_2O$  content varied from low (112.09 kg/ha) to high (567.84 kg/ha) with mean value of 273.68 kg/ha, median of 241.09 (no influence of abnormal value on the sampling values), SD of 115.03, CV of 0.42 (medium level of variability), skewness of 0.82 (normal distribution of data), kurtosis of 2.90 (peak value of probability distribution curve is higher than normal distribution) and beta of -0.13 (Table 1).

Again, Zn also varied from low (0.26 ppm) to high (1.46 ppm) with mean value of 0.64 ppm, median of 0.58 (no influence of abnormal value on the sampling values), SD of 0.25, CV of 0.40 (medium level of variability), skewness of 1.05 (normal distribution of data), kurtosis of 3.59 (peak value of probability distribution curve is higher than normal distribution) and beta of -0.27 (Table 1).

### 3.2 Effect of LULC on Available Soil Nutrients

In Alfisols, N was significantly higher under EF than DF, DC, KC and WL. Similarly, N was

significantly higher in AJ in comparison to DF, DC, KC and WL. Again, N content under CJ was significantly higher than DF, KC and WL. KC has been found to have significantly lower N content in comparison to all other LULC classes. Significantly higher amount of  $P_2O_5$  was found under EF compared to KC and WL (Table 2). AJ has been found to have significantly higher amount of  $K_2O$  than all other LULC classes. Similarly,  $K_2O$  has been found to be significantly higher in CJ when compared to DC, KC and WL. DF and EF have been found to have significantly higher  $K_2O$  than KC and WL. Lowest amount to  $K_2O$  was found under WL (Table 2). Zn in Alfisols was found to be significantly higher under EF than CJ, DC and WL. On the other hand, lowest amount of Zn has been found under WL (Table 2).

Higher amount of N,  $P_2O_5$ ,  $K_2O$  and Zn have been observed under EF and AJ. This might be due to decomposition of leaf litters and release of N,  $P_2O_5$ ,  $K_2O$  and Zn to the soil. Again, higher amount of N under CJ might be due to burning of forest litters and subsequent release of N to the soil. Similarly, higher amount of  $P_2O_5$ ,  $K_2O$  and Zn in DF might also be attributed to decomposition of leaf litters and release of  $P_2O_5$ ,  $K_2O$  and Zn to soil. On the other hand, lower amount of N,  $P_2O_5$  and  $K_2O$  under KC might be due to cultivation of crops with inadequate nutrient management as well as removal of N,  $P_2O_5$  and  $K_2O$  by crop uptake. Similarly, lower amount of Zn in double crop areas might be due to cultivation of crops with inadequate nutrient management and removal of Zn by crop uptake. Again, lower amount of  $K_2O$  and Zn under WL might be attributed to inherent soil properties as well as loss of nutrients from the soil (Table 2).

**Table 1. Descriptive statistics of available soil nutrients**

Parameter	N (Kg/ha)	$P_2O_5$ (Kg/ha)	$K_2O$ (Kg/ha)	Zn (ppm)
Number	105	105	105	105
Minimum	215.50	19.90	112.09	0.26
Mean	291.50	43.52	273.68	0.64
Maximum	414.30	68.30	567.84	1.46
Median	288.51	43.30	241.09	0.58
Standard Deviation	40.69	12.14	115.13	0.25
Coefficient of Variation	0.14	0.28	0.42	0.40
Skewness	0.61	0.03	0.82	1.05
Kurtosis	3.22	2.10	2.90	3.59
Beta	-0.73	0.78	-0.13	-0.27

**Table 2. Available soil nutrients under different LULC in Alfisols**

LULC	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
AJ	323.19 <sup>e</sup>	46.50 <sup>c</sup>	305.69 <sup>d</sup>	0.75 <sup>ab</sup>
CJ	307.13 <sup>de</sup>	41.10 <sup>abc</sup>	265.96 <sup>c</sup>	0.60 <sup>a</sup>
DF	275.98 <sup>bc</sup>	44.12 <sup>bc</sup>	251.56 <sup>bc</sup>	0.67 <sup>ab</sup>
DC	293.49 <sup>cd</sup>	39.72 <sup>abc</sup>	223.51 <sup>b</sup>	0.57 <sup>a</sup>
EF	325.46 <sup>e</sup>	47.74 <sup>c</sup>	260.61 <sup>c</sup>	0.92 <sup>b</sup>
KC	238.28 <sup>a</sup>	32.44 <sup>a</sup>	188.26 <sup>a</sup>	0.70 <sup>ab</sup>
WL	263.36 <sup>b</sup>	35.54 <sup>ab</sup>	163.28 <sup>a</sup>	0.46 <sup>a</sup>
SEM (+/-)	10.66	4.19	15.29	0.13

**Table 3. Available soil nutrients under different LULC in Inceptisols**

LULC	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
AJ	275.85 <sup>ab</sup>	59.46 <sup>bc</sup>	512.15 <sup>d</sup>	0.45 <sup>a</sup>
CJ	304.76 <sup>b</sup>	59.06 <sup>bc</sup>	348.27 <sup>b</sup>	0.71 <sup>b</sup>
DF	268.00 <sup>a</sup>	61.42 <sup>c</sup>	406.41 <sup>c</sup>	0.45 <sup>a</sup>
DC	252.90 <sup>a</sup>	56.06 <sup>bc</sup>	370.46 <sup>bc</sup>	0.57 <sup>ab</sup>
EF	352.05 <sup>c</sup>	51.74 <sup>b</sup>	180.62 <sup>a</sup>	1.15 <sup>c</sup>
KC	271.24 <sup>a</sup>	28.38 <sup>a</sup>	143.81 <sup>a</sup>	0.49 <sup>a</sup>
WL	255.34 <sup>a</sup>	30.08 <sup>a</sup>	151.99 <sup>a</sup>	0.48 <sup>a</sup>
SEM (+/-)	14.55	3.57	18.23	0.08

In case of Inceptisols, significantly higher amount of N has been found under EF in comparison to all other LULC (Table 3). Similarly, significantly higher N has been found under CJ than DF, DC, KC and WL. Significantly lower N has been found under DF, DC, KC and WL. P<sub>2</sub>O<sub>5</sub> content was found to be significantly higher under DF in comparison to all other LULC. Similarly, significantly higher P<sub>2</sub>O<sub>5</sub> content was found under AJ, CJ and DC than KC and WL. Lowest amount of P<sub>2</sub>O<sub>5</sub> was found in KC (Table 3). Again, significantly higher amount of K<sub>2</sub>O has been found in Inceptisols under AJ in comparison to all other LULC. Similarly, K<sub>2</sub>O content of soil under DF was significantly higher than CJ, EF, KC and WL. Lower amount of K<sub>2</sub>O has been found under KC, WL and EF (Table 3). Zn has been found to be significantly higher in Inceptisols under EF in comparison to all other LULC. Similarly, Zn content under CJ has been found to be significantly higher than AJ, DF, KC and WL. Significantly lower amount of Zn has been found under AJ, DF, KC and WL (Table 3).

Higher amount of N and Zn under EF might be due to decomposition of leaf litters and release of N and Zn to the soil. Similarly, higher amount of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in DF might also be attributed to decomposition of leaf litters and release of P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn to soil. On the other hand, lower amount of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O under KC might be due to cultivation of crops with inadequate nutrient management as well as removal of N,

P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn by crop uptake [14]. Again, lower amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn under WL might be attributed to inherent soil properties as well as loss of available nutrients from the soil (Table 3).

In case of Ultisols, significantly higher amount of N has been found under EF compared to all other LULC followed by WL (Table 4). On the other hand, lowest N content was found under KC. Similarly, P<sub>2</sub>O<sub>5</sub> content was also found to be significantly higher under EF, DF and AJ compared to all other LULC. Significantly lower P<sub>2</sub>O<sub>5</sub> content was found under WL and KC (Table 4). K<sub>2</sub>O content was significantly higher under CJ in comparison to all other LULC. Similarly K<sub>2</sub>O content of EF and DF were significantly higher than AJ, DC, KC and WL. Again, significantly higher K<sub>2</sub>O content has been found under DC compared to AJ, KC and WL. Lowest amount of K<sub>2</sub>O was found under WL (Table 4). Zn content of Ultisols under EF and AJ were found to be significantly higher than the all other LULC. CJ, DF, DC, KC and WL have been found to have lower Zn content (Table 4).

Higher amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn under EF might be due to decomposition of leaf litters and release of N and Zn to the soil. Similarly, higher amount of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O in DF might also be attributed to decomposition of leaf litters and release of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O to soil. On the other hand, lower amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn

under KC might be due to cultivation of crops with inadequate nutrient management as well as removal of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn by crop uptake. Again, lower amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn under WL might be attributed to inherent soil properties as well as loss of available nutrients from the soil (Table 4).

In addition, the higher rate of N and other nutrients in EF and DF soils might be due to N mineralization and nitrification in the close forest where there was less human disturbance [15]. Higher amount of other available soil nutrients in forested areas has been reported earlier [2]. Again, depletion of available soil nutrients from rice based cropping sequence has also been reported earlier [14]. Similarly, lower content of available soil nutrients in the wastelands having little vegetative cover and steep slope has been reported by Tao et al. [2].

### 3.3 Effect of Soil Orders on Available Soil Nutrients

This has been observed that N content is significantly higher in Alfisols in comparison to Inceptisols under Abandoned Jhum. On the other hand, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content have been found to be significantly higher in Inceptisols than Alfisols and Ultisols. Again, K<sub>2</sub>O content of Alfisols has been found to be significantly higher than Ultisols. Zn content of Ultisols was found to be significantly higher than Alfisols as well as Inceptisols. Lowest Zn content has been observed in Inceptisols (Table 5).

Under Current Jhum N content has been found to be equivalent in Alfisols, Inceptisols and Ultisols. On the other hand, P<sub>2</sub>O<sub>5</sub> content was significantly higher in Inceptisols in comparison to Alfisols and Ultisols. Again, Ultisols were found to have significantly higher K<sub>2</sub>O compared to Inceptisols and Alfisols. Similarly, K<sub>2</sub>O content of Inceptisols had significantly higher value than Alfisols. Significantly higher amount of Zn was

also found in Inceptisols in comparison to Ultisols (Table 6).

N content of Deciduous Forest was found to be similar in Alfisols, Inceptisols and Ultisols. However, P<sub>2</sub>O<sub>5</sub> content was significantly higher in Inceptisols in comparison to Alfisols and Ultisols. Similarly, significantly higher amount of K<sub>2</sub>O content has been found in Inceptisols compared to Alfisols and Ultisols. Again, Ultisols were found to have significantly higher amount of K<sub>2</sub>O than Alfisols. On the other hand, Zn content was significantly higher in Alfisols when compared to Inceptisols (Table 7).

Under Double Crop, Alfisols were found to have significantly higher amount of N compared to Inceptisols. On the other hand, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content were found to be significantly higher in Inceptisols in comparison to Alfisols as well as Ultisols. Zn content was found to be equivalent in Alfisols, Inceptisols and Ultisols under Double Crop (Table 8).

N content of Ultisols under Evergreen Forest was found to be significantly higher than Alfisols as well as Inceptisols. On the other hand, difference in P<sub>2</sub>O<sub>5</sub> content in all the three soil orders was found to be non-significant. Significantly higher amount of K<sub>2</sub>O was found in Ultisols in comparison to Alfisols and Inceptisols. Again, K<sub>2</sub>O content of Alfisols was also significantly higher than Inceptisols. Zn content was also found to be similar in all the three soil orders under evergreen forest (Table 9).

Inceptisols under Kharif Crop had significantly higher amount of N compared to Alfisols. On the other hand K<sub>2</sub>O content was significantly higher in Alfisols and Ultisols in comparison to Inceptisols. Similarly, Zn content was also significantly higher in Alfisols compared to Inceptisols. However, P<sub>2</sub>O<sub>5</sub> content was similar in all the soil orders under Kharif Crop (Table 10).

**Table 4. Available soil nutrients under different LULC in Ultisols**

LULC	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
AJ	300.06 <sup>bc</sup>	46.38 <sup>c</sup>	165.11 <sup>a</sup>	1.01 <sup>b</sup>
CJ	296.76 <sup>bc</sup>	38.06 <sup>b</sup>	536.05 <sup>d</sup>	0.49 <sup>a</sup>
DF	268.97 <sup>ab</sup>	51.04 <sup>c</sup>	334.36 <sup>c</sup>	0.48 <sup>a</sup>
DC	274.92 <sup>ab</sup>	35.48 <sup>b</sup>	255.14 <sup>b</sup>	0.45 <sup>a</sup>
EF	388.83 <sup>d</sup>	52.94 <sup>c</sup>	337.75 <sup>c</sup>	1.04 <sup>b</sup>
KC	259.75 <sup>a</sup>	31.78 <sup>ab</sup>	184.64 <sup>a</sup>	0.56 <sup>a</sup>
WL	325.50 <sup>c</sup>	24.86 <sup>a</sup>	156.13 <sup>a</sup>	0.49 <sup>a</sup>
SEM (+/-)	15.27	3.97	19.04	0.08

**Table 5. Effect of soil orders on available soil nutrients under Abandoned Jhum**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	323.19 <sup>b</sup>	46.50 <sup>a</sup>	305.69 <sup>b</sup>	0.75 <sup>b</sup>
Inceptisols	275.85 <sup>a</sup>	59.46 <sup>b</sup>	512.15 <sup>c</sup>	0.45 <sup>a</sup>
Ultisols	300.06 <sup>ab</sup>	46.38 <sup>a</sup>	165.11 <sup>a</sup>	1.01 <sup>c</sup>
SEM (+/-)	12.40	4.18	16.37	0.85

**Table 6. Effect of soil orders on available soil nutrients under Current Jhum**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	307.13	41.10 <sup>a</sup>	265.96 <sup>a</sup>	0.60 <sup>ab</sup>
Inceptisols	304.76	59.06 <sup>b</sup>	348.27 <sup>b</sup>	0.71 <sup>b</sup>
Ultisols	296.76	38.06 <sup>a</sup>	536.05 <sup>c</sup>	0.49 <sup>a</sup>
SEM (+/-)	13.23	3.88	17.93	0.09

**Table 7. Effect of soil orders on available soil nutrients under Deciduous Forest**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	275.98	44.12 <sup>a</sup>	251.56 <sup>a</sup>	0.67 <sup>b</sup>
Inceptisols	268.00	61.42 <sup>b</sup>	406.41 <sup>c</sup>	0.45 <sup>a</sup>
Ultisols	268.97	51.04 <sup>a</sup>	334.36 <sup>b</sup>	0.48 <sup>ab</sup>
SEM (+/-)	16.39	4.26	16.79	0.86

**Table 8. Effect of soil orders on available soil nutrients under Double Crop**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	293.49 <sup>b</sup>	39.72 <sup>a</sup>	223.51 <sup>a</sup>	0.57
Inceptisols	252.90 <sup>a</sup>	56.06 <sup>b</sup>	370.46 <sup>b</sup>	0.57
Ultisols	274.92 <sup>ab</sup>	35.48 <sup>a</sup>	255.14 <sup>a</sup>	0.45
SEM (+/-)	11.90	3.67	16.14	0.09

**Table 9. Effect of soil orders on available soil nutrients under Evergreen Forest**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	325.46 <sup>a</sup>	47.74	260.61 <sup>b</sup>	0.92
Inceptisols	352.05 <sup>a</sup>	51.74	180.62 <sup>a</sup>	1.15
Ultisols	388.83 <sup>b</sup>	52.94	337.75 <sup>c</sup>	1.04
SEM (+/-)	12.65	3.71	23.24	0.18

**Table 10. Effect of soil orders on available soil nutrients under Kharif Crop**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	238.28 <sup>a</sup>	32.44	188.26 <sup>b</sup>	0.70 <sup>b</sup>
Inceptisols	271.24 <sup>b</sup>	28.38	143.81 <sup>a</sup>	0.49 <sup>a</sup>
Ultisols	259.75 <sup>ab</sup>	31.78	184.64 <sup>b</sup>	0.56 <sup>ab</sup>
SEM (+/-)	13.54	3.84	13.58	0.65

**Table 11. Effect of soil orders on available soil nutrients under Wastelands**

Soil order	N (Kg/ha)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)	Zn (ppm)
Alfisols	263.36 <sup>a</sup>	35.54 <sup>b</sup>	163.28	0.46
Inceptisols	255.34 <sup>a</sup>	30.08 <sup>ab</sup>	151.99	0.48
Ultisols	325.50 <sup>b</sup>	24.86 <sup>a</sup>	156.13	0.49
SEM (+/-)	14.84	3.86	17.62	0.65



In case of Wastelands, N content was found to be significantly higher in Ultisols in comparison to Alfisols and Inceptisols. On the other hand, P<sub>2</sub>O<sub>5</sub> content was significantly higher in Alfisols compared to Ultisols. Difference in K<sub>2</sub>O and Zn content were non significant for all the three soil orders under Wastelands (Table 11).

#### 4. CONCLUSION

The study has shown that soils of RiBhoi district of Meghalaya, India were diverse with respect to available soil nutrients viz. N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn. Available soil nutrients varied from low to high with medium level of variability. Higher amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn have been observed under Evergreen Forest, Deciduous Forest and Abandoned Jhum. On the other hand, lower amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn have been found under Kharif Crop. Again, lower amount of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn have also been observed under Wastelands. It has been observed that P<sub>2</sub>O<sub>5</sub> content is significantly higher in Inceptisols irrespective of LULC. However, for other nutrients, soil orders were found to have least effect on availability of nutrients in soil in comparison to LULC. There is scope for future research on effect of forest cover on available soil nutrients over time, quantification of contribution of leaf litters to available soil nutrients and leaching of available soil nutrients under different land use land covers. The study has highlighted the spatial distribution of available soil nutrients as a function of soil orders and LULC. This will be a useful input in sustainable land management programmes.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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