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Mapping of soil Macro-nutrients in the Kathua District of Jammu Region using GIS approach

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Abstract
Macro-nutrients play an important role in plant growth and sustaining productivity. A study was carried out to evaluate and map the spatial distribution of soil macro-nutrients in plains and hilly areas of Kathua district. The study area lies in between 32°17`N to 32°55`N of latitude and 75°70`E to 76°46` E of longitude and experiences wide range of climatic variations from sub-tropical to temperate areas and even alpine in higher regions. The available N content distribution was high in hilly areas of ranging between 160 kg/ha to 564.5 kg/ha. The areas having high organic carbon were found to have high available nitrogen content. The lower areas or areas which are highly cultivated i.e. - areas adjoining Ravi River were found to have low nitrogen content. More than 50 percent of the total area had available P in the range between 3.00 kg/ha to 76.00 kg/ha. A large patch of study area was having Available P content in the medium range. However some hilly parts of hilly areas depicted very high available P content. The value seemed to be very low in some patches of plain areas usually varying in between 3.2 kg/ha to 9.4 kg/ha. Available K in the soil was mainly in the range of 71.00 kg/ha to 791.00 kg/ha. In some portion of hilly terrains showed medium potassium content. In plains where cultivated area is more, the potassium is low due to many cropping patterns and higher yields. Soils of hilly terrains are high in organic matter and therefore are higher in nitrogen. So, there is a problem of Nitrate leaching by heavy rain, resulting in soil acidification. In order to reduce leaching and soil acidification, there is a need to apply nitrogen through organic manures in small amounts often so that plants use all of it, or in organic form such as composted manure. In areas where Phosphorus is in sufficient range doesn't require any introduction of manures of fertilizers, however where the portion is deficient, manures which contain phosphorus or preferably manure from grain-fed animals which are particularly rich source of Phosphorus should be applied. The Potassium deficient areas can be dealt with supplying Muriate of potash or sulfate of potash which are the most common sources of potassium.

Keywords: GIS, Soil mappings, available nitrogen, available phosphorus, available potassium

Introduction
In India, where the population is increasing at a rapid rate, land and water resources for agriculture are diminishing continuously. The rainfed regions are on verge of degradation and has low cropping intensity, low organic matter status, low microbial activity, low fertility and poor soil physical health (GOI, 2009). In 21st century where industrialization and urbanization are on their peak, the faster consumption rate and large scale exploitation of land resources has resulted in faster rate of depletion of nutrients. Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have a high degree of spatial variability. However, major constraints impede wide scale adoption of soil testing inmost developing countries. In India, these include the prevalence of small holding systems of farming as well as lack of infrastructural facilities for extensive soil testing (Sen et al., 2008).

Along with soil testing, mapping of soil nutrients provides a lot help in initiating proactive measures that would ameliorate the constraints for plant growth, mitigate soil degradation and preserve soil quality for future. Use of GIS (Geographical Information System) has emerged as a unique tool in recent years for analysis of natural resources and their management. It is an effective and versatile tool to automate the transformation of soil nutrient data into soil/ natural resource information system. These tools can be effectively used to prepare soil fertility maps. The GIS soil fertility maps provide clear information on the patterns and trend with respect to individual soil properties. Soil fertility maps along with a ready database of soil information at district level will benefit the farmers and planners alike and will help in taking location specific dimensions on nutrient management as well as finalizing measures specific to that area for future capacity building programmes.

Use of such maps as a decision support tool for nutrient management will not only be helpful for adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization, but will also reduce the necessity for elaborate plot-by-plot soil testing activities. However, information pertaining to such use of GIS-based fertility maps has been meager in India (Sen and Majumdar, 2006; Sen et al., 2008). The current study was aimed to evaluate and map the spatial distribution of soil nutrients in plains and hilly areas of Kathua district of Jammu and Kashmir.

Material and Methods

Study Area

The present study area lies in between 32°17`N to 32°55`N of latitude and 75°70`E to 76°46` E of longitude and experiences wide range of climatic variations from sub-tropical to temperate areas and even alpine in higher regions of Bani and Lohai-Malhar blocks. Kathua district has five tehsils viz. Basohli, Bani, Billawar, Hiranagar and Kathua. Basohli is located at 32.50°N, 75.82°E. It has an average elevation of 460 meters above mean sea level and is situated in the uneven hills of shivaliks. It is situated in the right bank of Ravi River. Bani is a small glaciated valley located at a height of 1280 meters from mean sea level in the lap of lofty mountains. It experiences temperate and polar type of climate. Severe winters and moist summer are main climatic phenomenon of this valley. Billawar is located at 32.62°N 75.62°E with an average elevation of 844 m above mean sea level and is situated in the lap of Shivaliks between the banks of Naj and Bhini Rivers. Kathua is located at Jammu to the Northwest, the Doda and Udhampur districts to the north and Pakistan working boundary to the west. Hiranagar is located at 32.45° N, 75.27°E and an average elevation of 308 meters. Main crops of the area are Paddy and Wheat. The annual rainfall in the area is about 1300 mm approximately. The area is mostly irrigated and productive.

Soil sampling

Composite surface soil samples from two hundred and six (206) locations distributed randomly across the whole of the area were collected at the depth of 0-15cms (Fig. 1). The exact sample location was recorded using a handheld GPS receiver and then were analyzed as per the standard procedure in the laboratory. ArcGIS 10.3 was used to digitize the nutrient maps of the area. Available N was determined using alkaline permanganate method (Subbiah & Asija, 1956). The available phosphorus was determined by the method suggested by Jackson (1973). 1 N NH_4OAc was used as extractant and the available potassium content was determined by feeding the extract to flame photometer (Jackson, 1973). Fertility status of N, P and K was interpreted as low, medium and high by the following criteria as given below.

Macro nutrients	Low	Medium	High
Nitrogen (Kg/ha)	<280	280-560	>560
Phosphorus (Kg/ha)	<10	10-24	>24
Potassium (Kg/ha)	<110	110-280	>280

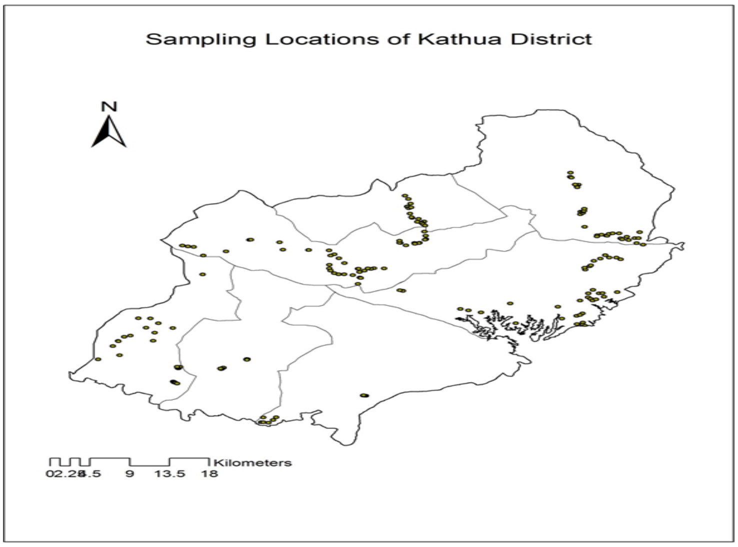

Fig 1: Map of Kathua district of Jammu with sampling locations.

Statistical Analysis and Mapping

Descriptive Statistical analysis of the data which included mean values, Coefficient of variation, Minimum and Maximum Values, standard deviation, standard error of mean, Skewness and Kurtosis was carried out using SPSS.

Inverse distance weighting (IDW) technique was adopted to generate prediction maps of the soil properties. The choice of either technique to prepare filled contour maps of soil properties was based upon error analysis (Robinson & Metternicht, 2006). The process of digitization and generation of maps was carried out with ArcGIS 10.3.

Result & Discussion

Hilly Areas

The available Nitrogen content in the soil of hilly areas varies from 160.31 to 564.5 kg/ha with a mean value of 228.6 kg/ha. The descriptive statistics of the available nitrogen content in hilly areas is presented in Table 1. From above statements it can be concluded that the available nitrogen content ranges between low to high. In the hilly areas where 95% of the area is expressing high nitrogen content is being positively correlated to high organic matter content in the soils. In an experiment conducted by Jatav et.al (2011) in hills majority of samples were high in nitrogen which was expected in view of high organic matter content of the soils as most of the soil Nitrogen is in organic form. Sud and Sharma (1982) obtained a linear relationship between soil organic carbon and N availability in soils of mid and high hills of Shimla region. Moreover, low crop intensity in the region and less mineralization rate owing to low temperatures during most part of the year may be another reason for buildup of soil Nitrogen content.

Available Phosphorus content ranged from 3.90 to 76.70 kg/ha respectively. Similar status of available phosphorus was obtained by Jatav *et.al* (2011) and was due to the lesser use of super phosphate by the upland farmers who prefer FYM at a rate depending upon its availability at the site.

The available potassium content of the surface soils varied from 95 kg/ha to 791 kg/ha with a mean value of 351 kg/ha. The available K was high. Jatav *et.al* (2011) explained that the presence of illite, a potassium mineral may be a key factor responsible for high K supply capacity of these soils having clay loam texture. The application of FYM, low crop intensity and lower yield may be the other factors responsible for less removal of K by crops in the hilly region. High variability was observed in the N, P and K.

Table 1:- Characterstics of calculated semi-variograms for Available Nitrogen, Available Phosphorus & Available Potassium in study area.

Soil Nutrients	Residual SS	R^2	Proportion (C/ [Co + C])	Model	Nugget Variance	Sill (Co+C)	Range (A)
Available N	0.0503	0.299	0.509	Exponential	3220.00	8050.00	25380
Available P	0.0214	0.317	0.855	Exponential	30.100	167.700	2820.00
Available K	0.0103	0.428	1.000	Exponential	10.00	22490.00	2220.00

Table 2. Statistical Parameters of Macronutrients in Soils of Hilly Areas of North Western Shivaliks of Jammu region

Column Statistics	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potassium (Kg/ha)
Minimum	160.31	3.90	95.0
Maximum	564.5	76.70	791.0
Mean	228.6	21.96	351.0
Standard Deviation	90.21	13.80	157.6
Standard Error	7.736	1.18	13.52
Coefficient of Variation (%)	39.45	62.86	44.92
Skewness	0.94	1.28	0.48
Kurtosis	2.28	2.05	-0.49

Table 3. Statistical Parameters of Macronutrients in Soils of Plain Areas of North western Shivaliks of Jammu region

Column Statistics	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potassium (Kg/ha)
Minimum	45.26	45.16	71.00
Maximum	296.0	51.90	678.4
Mean	123.3	17.44	222.0
Standard Deviation	55.00	9.59	133.0
Standard Error	6.62	1.15	16.01
Coefficient of Variation (%)	44.60	55.04	59.91
Skewness	1.01	1.29	1.43
Kurtosis	0.96	2.03	2.31

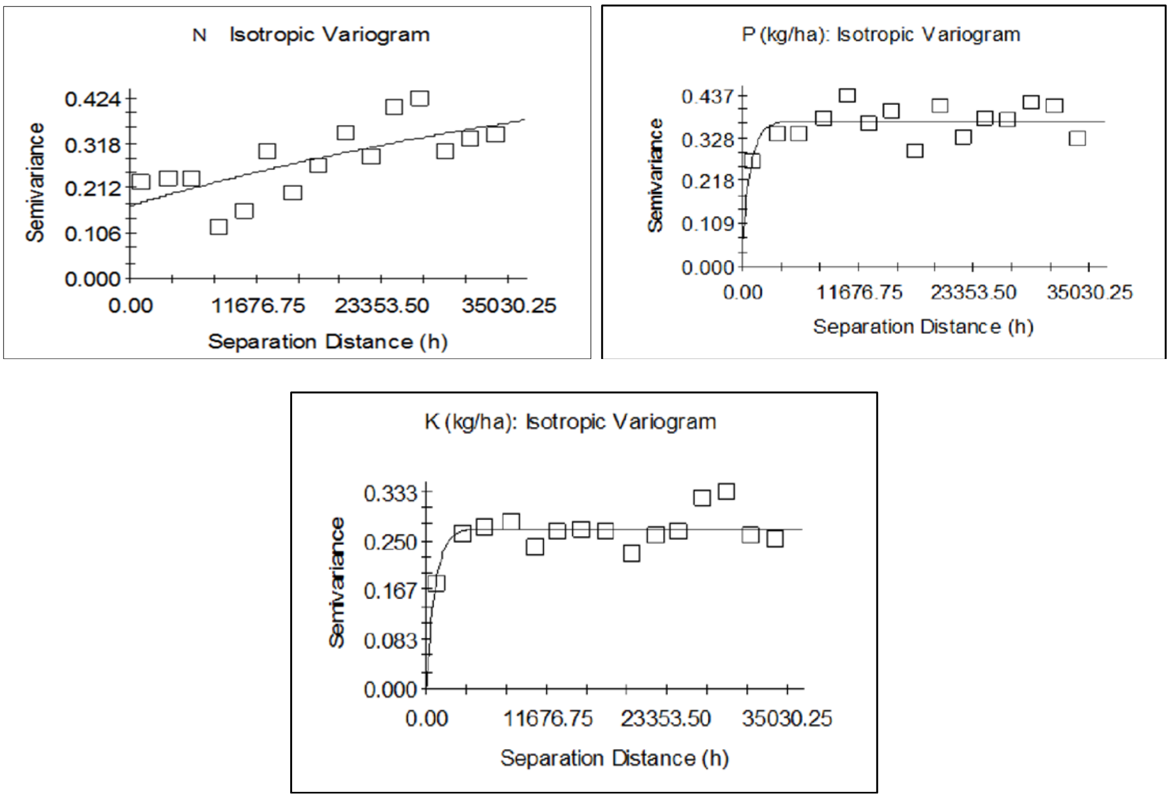

Fig 2: Experimental and fitted Semivariogram model for macronutrients

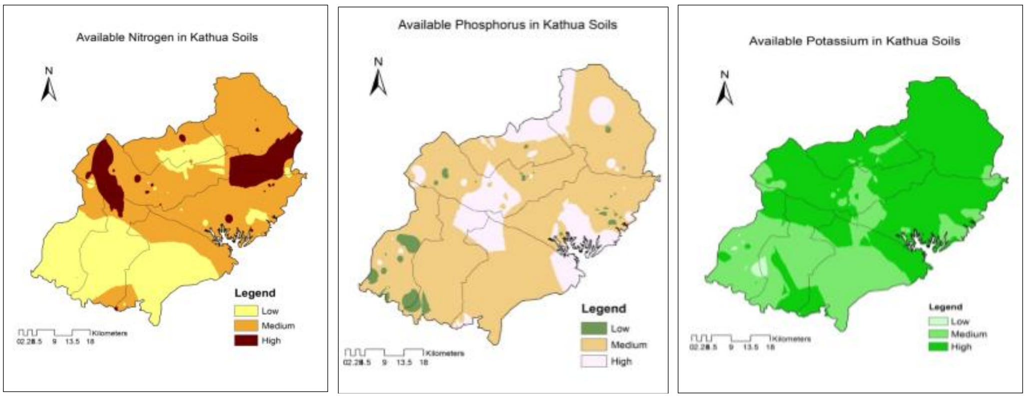

Fig 3:- Spatial distribution maps of macro-nutrients interpolated by ordinary Kriging

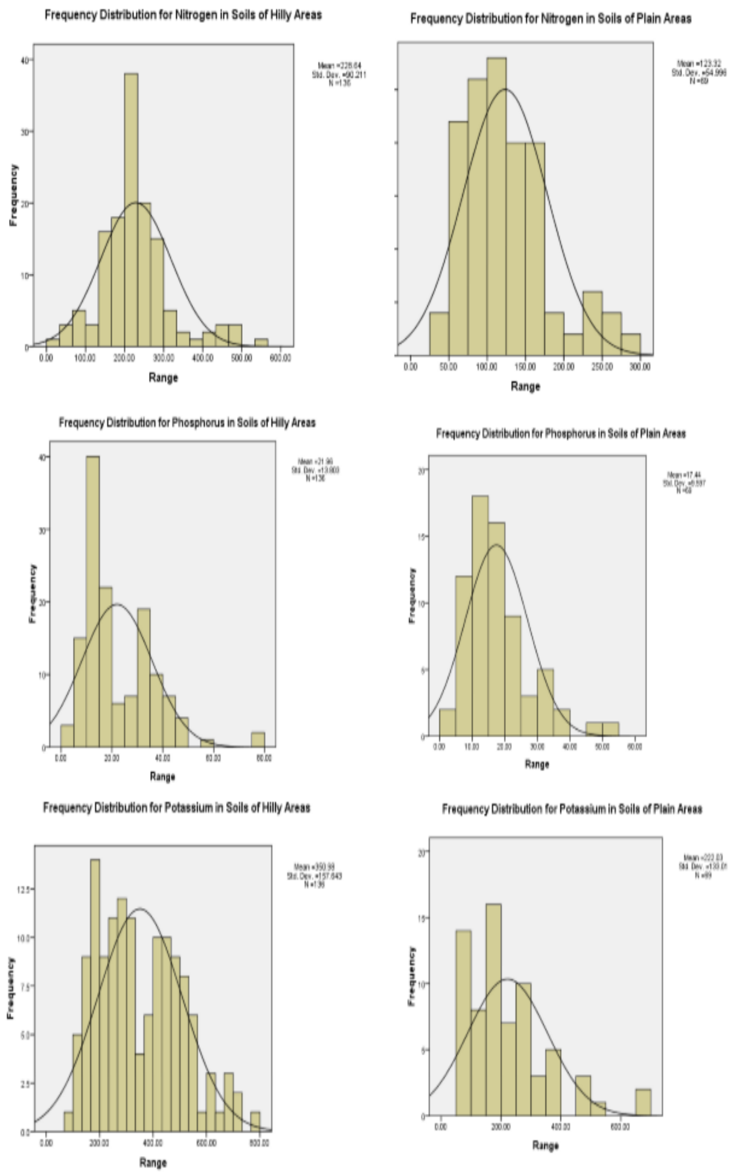

Fig 4: Comparison of Frequency distribution of macronutrients in soils of hilly and plain areas

Plain Areas

The available Nitrogen content in the soil of plain areas varies from 45.16 to 296.0 kg/ha with a mean value of 123.3 kg/ha. The available nitrogen content was low in major portion of the plains which might be due to low organic matter content in these soils. Higher vegetation content in the area favors higher degradation rate and removal of organic matter leading to nitrogen deficiency. The variation in N content may be related to soil management practices, application of FYM and fertilizer to previous crops. Ashok Kumar (2000) and Nagaraj (2001) observed a similar trend of nutrient status in black soils of North Karnataka.

Available P content ranged from 45.16 to 51.90 kg/ha respectively and average was in medium range and not too high which may be due to low CEC, low clay content and acidic soil reaction of <7.0 (Anon., 2003).

The available potassium content of the surface soils varied from 71 kg/ha to 678 kg/ha with a mean value of 222 kg/ha.

Hilly soils were higher in available potassium status than plain soils which may be as described already due to predominance of potassium rich micaceous and feldspars minerals in parent material. Similar results were observed by Ravikumar *et al.* (2007a). Major portion of area was under medium and low category of available potassium status in plain soils, because these soils are coarser in texture.

Spatial Variability

Geo-statistical methods were used to analyze the spatial correlation structures of the available contents of Nitrogen, Phosphorus and Potassium in soil and spatially estimate their values at unsampled locations jointly in both hilly and plain areas. Because Kriging assumes the normal distribution for each estimated variable, it is necessary to check whether the available contents of N, P and K in soil samples are approximately normally distributed or not. The first step in using of Kriging methods is to check the presence of spatial structure among data by variogram analysis. The distribution of data should be normal for the parameter estimation, and the KS test was used to examine the distribution of the data. It can be noticed that the skewness and kurtosis indices of all the macronutrients are close to the standard value of 0 and tend to be normally distributed. The information generated with variogram was used to calculate sample weighing factors for spatial interpolation by ordinary Kriging procedures. Ordinary Kriging was chosen to create the spatial distribution maps of soil N, P, and K contents, with the maximum search radius being set to the autocorrelation range of the corresponding variable. The exponential model was suitable for estimation of soil properties. The ratio of nugget variance to sill expressed in percentages (C0/C+C0) can be regarded as a criterion for classifying the spatial dependence of the soil parameters. If this ratio is less than 25%, then the variable has strong spatial dependence (Shi *et al.*, 2005). The AP, AN and AK showed weak spatial dependence as the ratio of nugget variance exceeded 75% and have moderate spatial structure. Usually, a strong spatial dependence of soil properties can be attributed to intrinsic factors, and a weak spatial dependence can be attributed to extrinsic factors (Cambardella *et al.*, 1994). So, all experimental variograms were in anisotropic form and were fitted using basic math models, such as Exponential. A filled contour map (prediction map) and a relevant prediction standard error map were created for soil properties using the ArcGIS Geo-statistics tool. The correlation range measures the spatial separate distances within which data are auto correlated (Cahn *et al.*, 1994). The approximate correlation ranges for AN, AP and AK are 2.538 km, 2.820 and 2.220 km, respectively. This may imply that AN, AP, and AK contents are more sensitive to extrinsic factors such as fertilization. To map the spatial distributions of AN, AP and AK, ordinary Kriging was used to interpolate their respective sample data.

Frequency Distribution

The frequency distribution of Nitrogen in hilly areas is mostly represented by long peaks favoring N content ranging between 200-300 kg/ha which is usually medium and same in case of plain areas lies in low range usually between 100-200 kg/ha. The frequency distribution of Phosphorus in hilly areas mostly covered under 10-24 kg/ha i.e. again in the medium range and in plain areas is between low to medium range. In case of Potassium the peak lies in medium range whereas in plain areas it ranges in low to medium range.

Conclusion

The results of this study refer to the effective role that can be played by GIS, especially in the spatial distribution mapping using IDW interpolation technique for producing maps of macronutrients in the soils of transition zone of north western shivaliks of himalayas. Spatial distribution maps generated under the study will be useful for guiding the farmers to decide the amount and kind of nutrients to be applied for economic returns based on site specific nutrient management.
It also prioritizes the tehsils of district which need immediate attention for achieving the optimum crop yields. Geo-statistical analysis estimates an average status of macronutrients in the soil of study area. Both the spatial distribution maps and geo-statistical analysis reflect on spatial variability of macronutrients in the soils of transition zone of north western shivaliks of Himalayas of Jammu region. This study also brings out the recommendations of macronutrients based on the status of deficiency or based on the requirements of the crops which is ultimately based on the soil characteristics.

References

1. Anon. Ebrary announces institutional repository program. Advanced Technology Libraries. 2003; 32, 3
2. Ashok Kumar S. Studies on soil aggregation in Vertisols of North Karnataka. M. Sc. (Agri.) Thesis, Univ. Agril. Sci., Dharwad (India), 2000.
3. Cahn MD, Hummel JW. Brouer BH. Spatial analysis of soil fertility for site-specific crop management. Soil Science Society of America Journal. 1994; 58:(4):1240–1248.
4. Cambardella CA, Moorman TB, Novak JM, Parkin TB, Karlen DL, Turco RF, Konopka AE. Field scale variability of soil properties in Central Iowa soils. Soil Science Society of America Journal. 1994; 58:1501-1511.
5. Iqbal JJ, Thomasson A, Jenkins JN, Owens PR, Whisler FD. Soil Sci. Soc. Am. J. 2005; 69:1338-1350.
6. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1967.
7. Jackson ML. Soil Chemical Analysis. New Delhi: Oxford & IBH Publications.Sen, P. and K. Majumdar. 2006. In Proceedings of the Fifth International Conference of the Asian Federation for Information Technology in Agriculture, Macmillan (India), Bangalore, India: 1973, 653-660.
8. Jatav V, Mishra P, Kashaw S, Stables JP. CNS depressant and anticonvulsant activities of some novel 3-[5-substituted 1, 3, 4-thiadiazole-2-yl]-2-styryl quinazoline-4(3H)- ones. European Journal of Medicinal Chemistry. 2008; 43(9):1945-1954.
9. McBratney AB, Webster R. Soil Sci. 1983; 135:177-183.
10. Mueller TG, Pierce FJ, Schabenberger O, Warncke DD. Soil Sci. Soc. Am. J. 2001; 65:1547-1558
11. Nagaraj K. Studies on soils and their interpretative grouping under Distributary No. 18 in Malaprabha Command Area. M. Sc. (Agri.) Thesis, Univ. Agril. Sci., Dharwad (India), 2001.
12. Ravikumar R, Saravanan R, Vasanthi NS, Swetha J, Akshaya N, Rajthilak M, Kannan KP. Biodegradation and decolourization of biomethanated distillery spent wash. Indian Journal of Science and Technology http://www.indjst.org. 2007a, 2007; 1(2).
13. Sen P, Majumdar K, Sulewski GD. Indian J. Fert. 2008; 4(11):43-50.

14. Sen P, Majumdar K. In Proceedings of the Fifth International Conference of the Asian Federation for Information Technology in Agriculture, Macmillan (India), Bangalore, India: 2006, 653-660.
15. Subbaiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 1956; 25:259.
16. Sud KC, Sharma RC. Organic carbon and nitrogen status of brown hill soils of Shimla district. Journal of Indian Society of Soil Science, 1982; 30:216-18.
17. Robinson TP, Metternicht G. Testing the performance of spatial interpolation techniques for mapping soil properties. Computers and Electronics in Agriculture. 2006; 50:97-108.
18. VEIRA, Dalila Andrade (Org.). Gestão democrática da educação: desafios contemporâneos. 4. ed. Petrópolis: Vozes. 2002, 105-140.
19. Webster R, Oliver MA. Statistical Methods in Soil and Land Resource Survey. New York, NY. Oxford University Press, 1990.