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PRELIMINARY STUDIES ON EXISTING SCENARIO OF SELECTED SOIL PROPERTY IN CHEDDIKULAM DS DIVISION VAVUNIYA, SRI LANKA

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Abstract

This study was conducted to quantify the spatial variability of soil properties, use this information to produce accurate map by means of ordinary kriging and find the ways to reclaim the problem soil and make suggestions to cultivate the crop variety which is suitable for the existing soil property.70 sampling points were selected for that research using stratified random sampling method. Stratification was based on the type of land cover, and following land cover patterns were identified forest patches, agriculture land patches, grass land patches and catchments. Sampling points were randomly selected from each land cover types. Minimum distance between two adjacent sampling points was 500m. Soil samples were analyzed for pH, EC, exchangeable K, available P. In each location, soils were collected from top to - 30 cm depth (root zone) using a core sampler and sub soil samples were collected around the geo-reference point to obtain a composite sample. Geostatistical tool of the software (ArcGIS 10.2.2. trail version) was used to construct semi-variograms and spatial structure analysis for the variables. Geostatistical estimation had done by kriging. 13% of agriculture land area was acidic soil and 5.7% alkaline soil. 13% of agriculture land area was identified as saline soil. 67.11% of agriculture lands contain more phosphorous concentration than the optimum range. 3.4% agriculture lands contain higher potassium concentration than the optimum range. 98% of forest lands and 100% of grass lands contains phosphorous concentration higher than the optimum range. But forest lands and catchments shows lower level of potassium concentration. 22% of grass lands contain higher potassium than the optimum level. Agriculture practices leads to change in the soil hence identified soil problems should be reclaimed in order to maintain the fertility of soil for sustainable production. Proper management of soil can be a better solution for supporting the successful agricultural activity of community in future and socio-economic development of this region.

Keywords**:** Geostatistics, Kriging, Semivariogram, Spatial Variation, Stratification, Sustainable Land Use Management

Introduction

Productivity of the soil has changed into worst condition knowingly or unknowingly by the anthropogenic activities as well as natural phenomena. Soil distribution does not unique over an area. Land use management and agricultural practices cause variation (Paz-Gonza´lez et al., 2000, Stenger et al., 2002). Understanding the soil property distribution is important for agriculture practices. Because influences of human to determine the variation of soil properties are high in agricultural land (McBratney and Pringle, 1999). Soil property varies between agricultural land, forest land, grass land patches and settlements. Moreover, natural phenomena also influencing by determining in soil spatial variation. Because, soil is the end product of the influence of the climate, relief (elevation, orientation, and slope of terrain), biotic activities (organisms), and parent materials (original minerals) interacting over time. Gradual change of soil properties occur as a result of function of pedogenetic factors (Trangmar et al., 1985). Microorganism creates the physical structures which can alter the bulk density and excretes can alter the soil chemical properties.

Spatial arrangement of soil properties and nutrient concentration should be considered at detailed level to develop site specific soil management (Goovaerts, 1999). Traditional area scale map of soil spatial variation are not detailed enough to provide soil information for suitable soil management strategies (Cressie, 1993). Producing detailed soil map by conventional soil survey methods are expensive, time consuming and numerous field observation have to make for better accuracy. Geostatistics is the right tool for analysis of spatial variation of soil distribution through spatial interpolation techniques. The objective of research was to produce the accurate map of analyzed selected soil properties by using spatial interpolation technique.

Materials and methods

The study covered the extent of 20.12 km^2 comes under Cheddikulam DS division, Vavuniya District, Sri Lanka. Geographic location of study area is 8°41'00.40" to 8°39'09.29" Northern latitude and 80°16'30.19" to 80°19'11.38" Eastern longitude.

70 sampling points were selected for that research using stratified random sampling method. Stratification was based on the type of land cover, and following land cover patterns were identified forest patches, agriculture land patches, grass land patches and catchments. Sampling points were randomly selected from each land cover types. Minimum distance between two adjacent sampling points was 500m. Table:1 showed the sample size of each land cover type and figure:1 showed soil sampling points in the study area.

Table 1: Soil sampling points in the study area

Land cover	Sample size
Forest patches	15
Agriculture fields	23
Grass lands	20
lowland	12

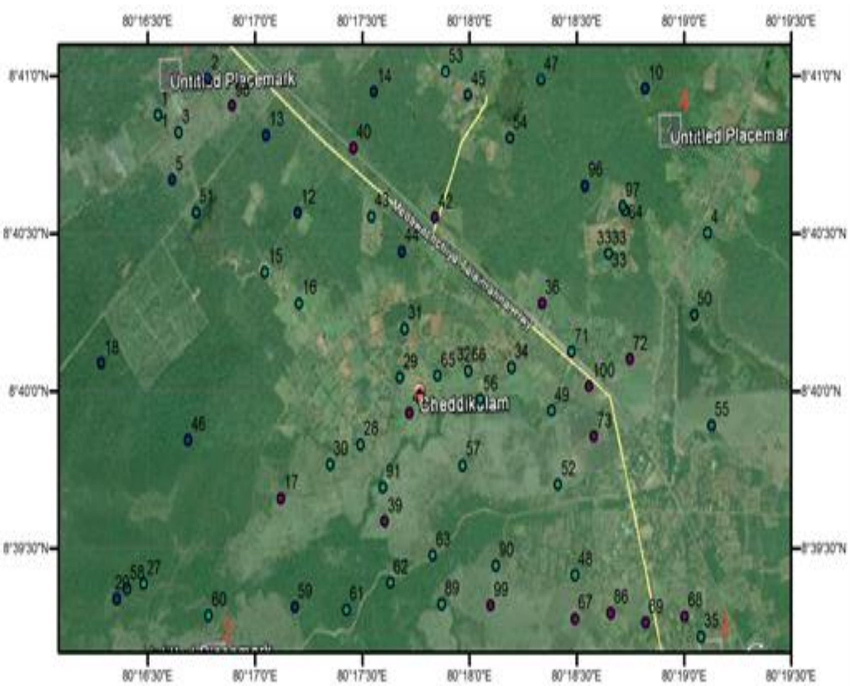


Figure 1: Soil sampling points in the study area

Sample collection was conducted during the period from January to February, 2015 at above mentioned sampling points (Figure:1). Geographical coordinates of all sampling locations were recorded using Global Positioning System (GPS). At each sampling points, soils samples were collected from top to - 30 cm depth (root zone) using core sampler and also sub soil samples collected in order to obtain composite samples.

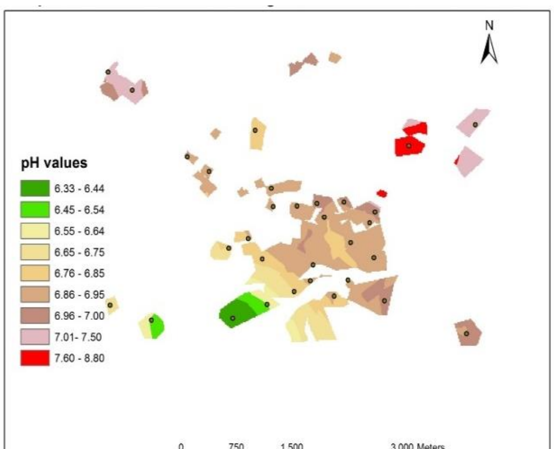
Analysis was carried out to quantify the phosphorous and potassium concentration. Electrical conductivity and pH were measured by suspension method using environmental probe. Phosphate analysis was carried out by Olsen method (Olsen, 1954) and exchangeable potassium was measured by Ammonium acetate extractant method.

Geostatistical software (ArcGIS 10.2 trial version) was used to spatial structure analysis for the variables. Point map was created for each and every property with measured value. Then raster map was created for every point map. Then geostatistical estimation was done by ordinary kriging from raster. Lag interval, nugget, still, range are selected as default value and cell size is 150m.The root mean square error (RMSE) was used to validate the estimated data. RMSE measures mean how much error there is between two datasets. RMSE usually compares a predicted value and an observed value. RMSE was calculated by using mini tab 15 software.

Results and Discussion

pH of soil

The acquired pH range in the agriculture land (Figure 2(a)) was 6.33-8.80 where the optimal pH range for the crops is 6.5-7.5. Red colour patches indicate basic soil and green colour patches indicate acidic soil in (Figure 2(a)), 13% of area was acidic and 5.7% were alkaline soil. Lime can be applied to reclaim acidic soil. Liming materials (usually Ca or Ca & Mg) are relatively inexpensive & leave no residue in the soil. Acid soil also can be managed by application of biochar due to its slightly alkaline nature (Loganathan, 2015). Acid tolerant cultivars can be cultivated such as Cucumber (5.5-7.0), Corn (5.5-7.5.), Tomato (5.5-7.5), Garlic (5.5-7.5), Pumpkin (6.0-6.5), Sweet potato (5.5-6.0), Carrot (5.5-7.0) and Eggplant (5.5-6.5) pH varied from 6.89 - 6.94 in the forest lands (Figure 2(b)). That is 100% of area lies within the ideal range of soil pH. pH acquired in the grass lands (Figure 2(c)) ranged from 6.6-7.2. That is 100% of area lies within the ideal range of pH for cultivation of crops. Spatial distribution of pH within catchments (Figure 2(d)) was concerned it ranges between 6.4-7.2. pH less than 6.5 is acidic soil. 8.3% of soils under catchments land area were with the prevalence of acidic soil (indicated as green colour). Catchments often receive runoff water from agriculture lands. Excess fertilizer reaches the catchment and creates acidic condition.



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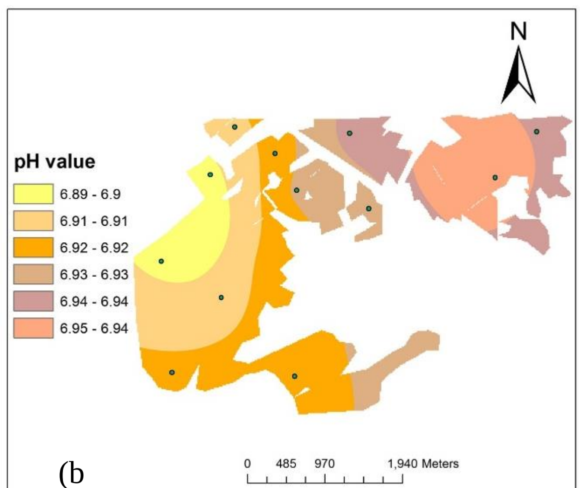

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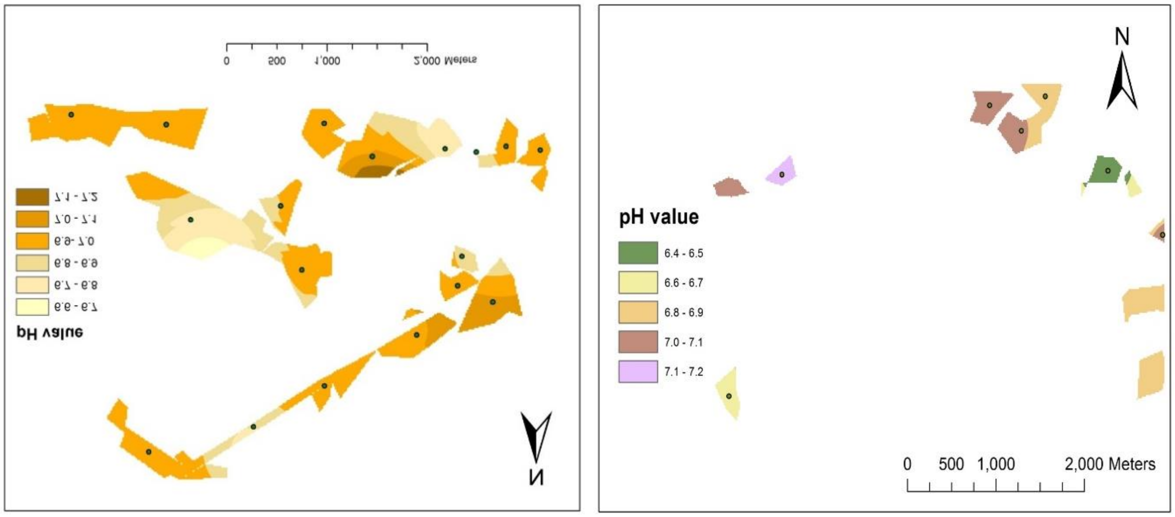


(c) (d)

Figure 2: pH distribution within (a) agriculture land, (b) forest land, (c) grass land, (d) catchments

Ec of Soil

EC ranged from 0.042- 3.2 in the agriculture lands (Figure 3(a)) where the ideal EC range between 0.01–1 dS/m are ideal for cultivation of most of the crops (Narsimha et al., 2013). 86.9% of area in the agriculture lands was lies within ideal range of EC for crop production and remaining area was recorded with prevalence of saline soil. Pink colour patches indicate the presence of saline soil in the (Figure 3(a)). So it can be reclaimed by reducing the application of excessive potassium fertilizer. The fields should be leached with good quality water and should facilitate adequate drainage. Organic manure such as farmyard manure, *Sesbania rostrata*, *sunhemp* and husk can be applied to improve the soil physical condition and hasten the process of reclamation. Tolerant crops can be cultivated in saline soil. Salt moves with water and some will accumulate in the surface soil or furrow ridge tops as water its salt moves upward and evaporate. Avoid these locations for planting and select salt less location to minimize salt affects. Mulching also reduce the salt accumulation by evaporation. Tillage is also another technique to manage the saline soil. Tillage speeds up the desalinization by mixing easily soluble salts deeper and loosening dense subsoil. The resulted EC range in the forest lands (Figure 3(b)) was 0.082-0.22 which is 100% of area lies within ideal range of EC for crop production. EC acquired in grass lands (Figure 3(c)) ranged from 0.02- 0.26 and total area was lies within ideal range of EC. The resulted EC range in catchments (Figure 3(d)) was 0.09- 0.3. 100% of area in catchments was lies within ideal EC range.

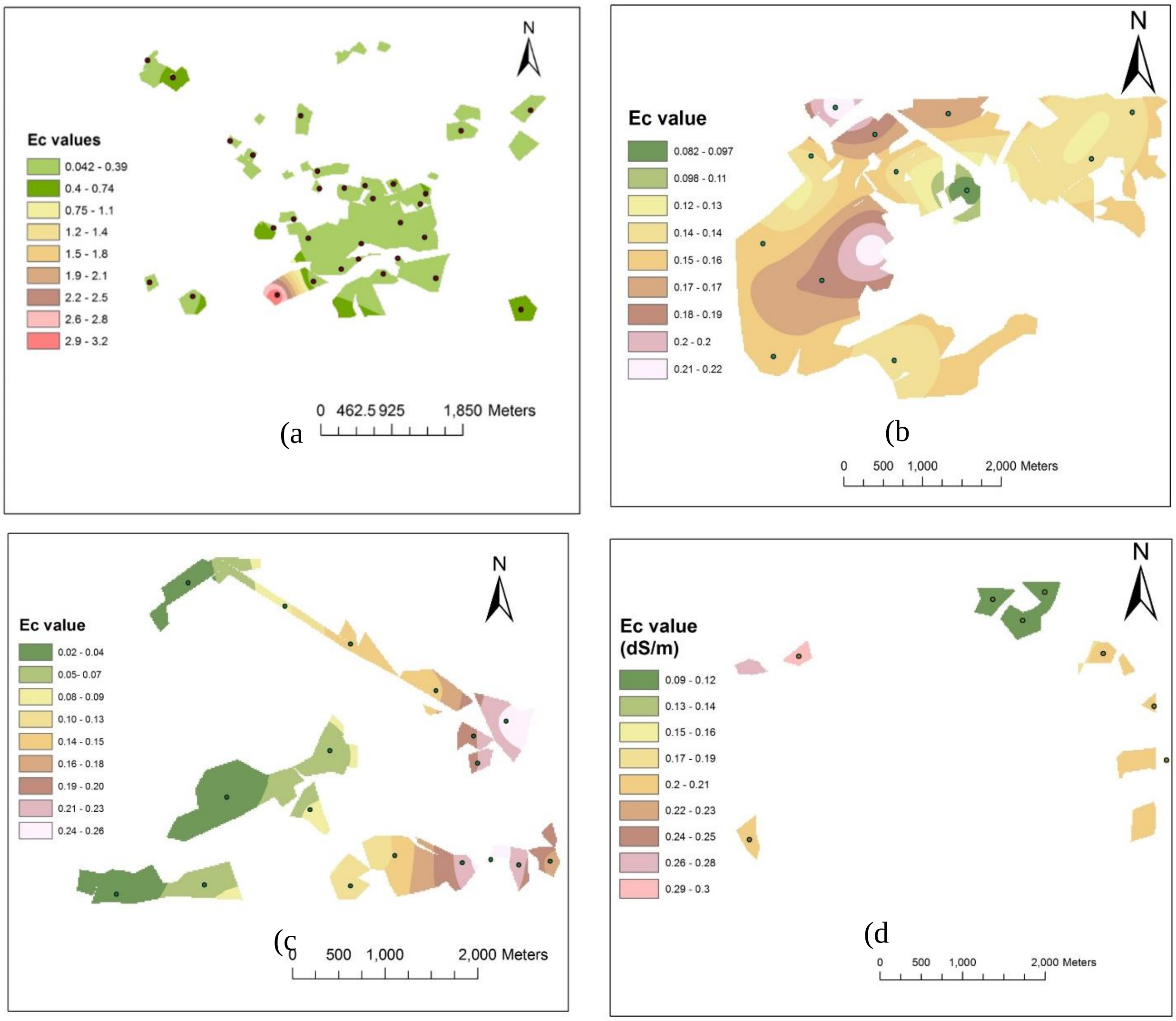
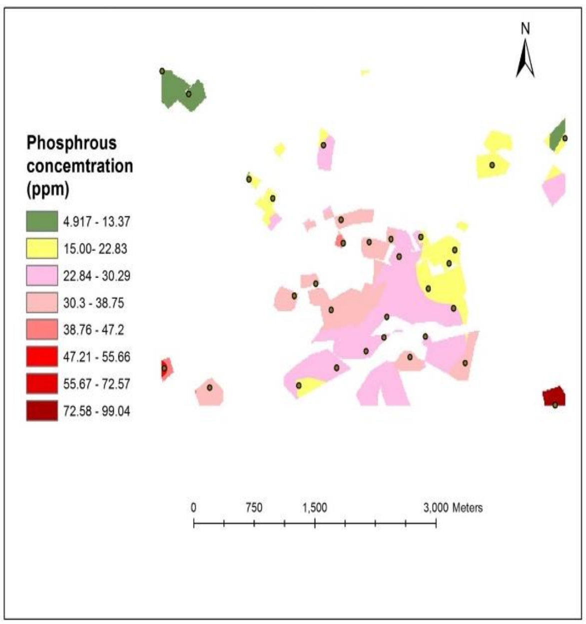


Figure 3: EC distribution within (a) agriculture land, (b) forest land, (c) grass land, (d) catchments

Available phosphorus of soil

The available phosphorous ranged from 4.917ppm- 99.04ppm within agriculture lands (Figure 4(a)) where optimal soil phosphorous range is 15-22.5 ppm for cultivation of crops (Dharmakeerthi et al, 2007) and only 25% area was lies within the ideal range of soil phosphorous concentration, 6% area was contain fairly low level of phosphorous concentration, for that application of manure, bone meal and simple compost into the soil, during spring or fall will ensure soil has plenty of phosphorus for several seasons. 67.11% area of agriculture lands was contain more soils phosphorous concentration than the optimum range. They have to avoid the excess application of phosphorous fertilizer and they should analyze the soil phosphorous level prior to the application and should use recommended level for the particular soil type in the field with the help of department of agrarian development in that region. Acquired phosphorous in forest lands (Figure 4(b)) ware ranged 14.8ppm-23.5ppm where 96.5% area was lies within the ideal range of soil phosphorous concentration and remaining area was recorded with lower soil phosphorous concentration. In grass lands (Figure 4(c)), the available phosphorous ranged from 18.06ppm-30.22ppm and only 28.5% area was lies within the optimum range of phosphorous and remaining 71.5% area contain phosphorous concentration more than optimum range. The obtained phosphorous within catchments (Figure 4(d)) ranged from 6.738ppm- 54.34ppm where 26.2% area was lies within optimum phosphorous concentration, 8.3% area was recorded with lower phosphorous concentration and remaining area was recorded with higher phosphorous concentration than optimum range. That is approximately 65% area of catchment was identified with more phosphorous concentration which may results by the runoff from agriculture lands. Pink to red colour patches indicate soil with higher phosphorous is shown in figure 3.



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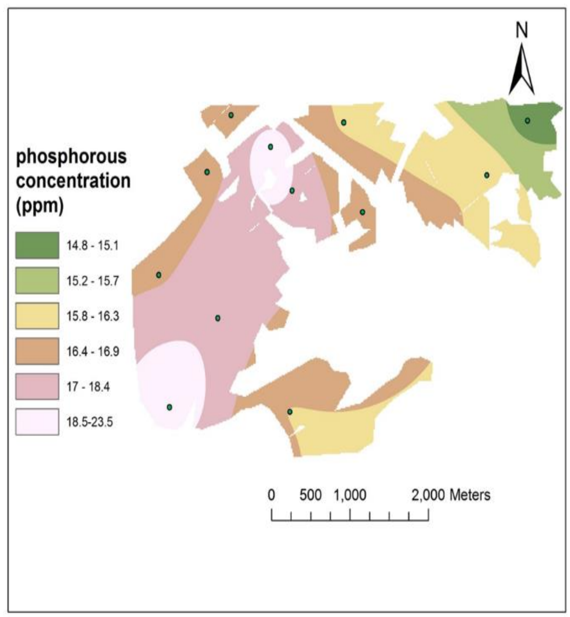

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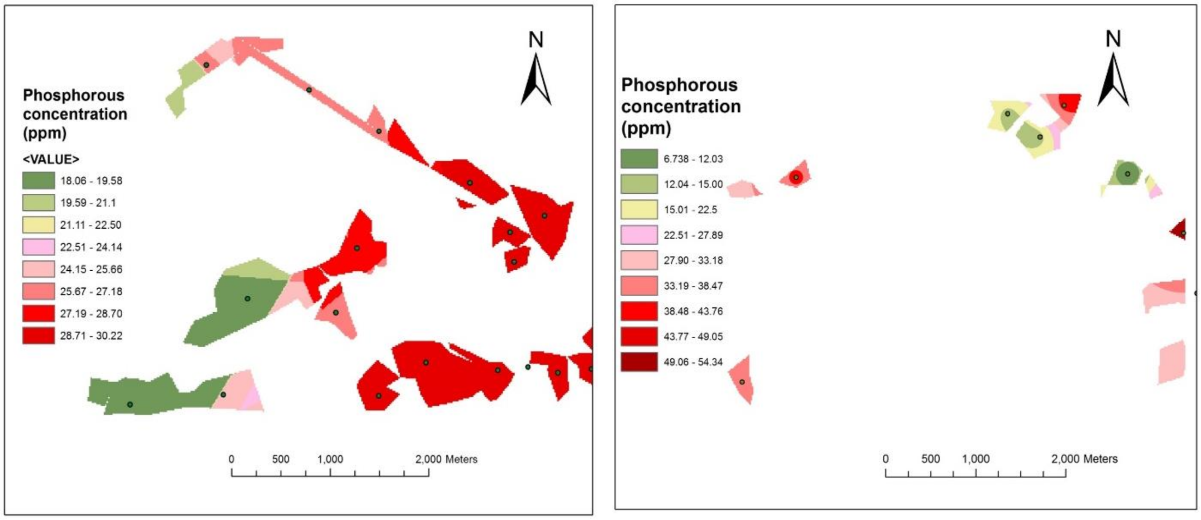

(c (d

Figure 4: Phosphorous distribution within (a) agriculture land, (b) forest land, (c) grass land, (d) catchments

Exchangeable potassium level in soil

Exchangeable potassium ranges within agriculture lands (Figure 5(a)) from 17.41ppm-156.7ppm where optimum potassium range is 78-97.5 ppm for crop cultivation (Dharmakeerthi et al., 2000). From that 3% area was identified soils with higher potassium concentration and remaining area was recorded with lower soil potassium concentration. Proper amounts of potassium in soil helps with photosynthesis, helps plants absorb other nutrients more efficiently; creates a favorable environment for micro bacterial action; or the ability of plants to stay upright. Distribute excess potassium more evenly by thoroughly working dense soil until it is loose and friable. Dilute and flush out large amounts of potassium by watering the soil any time it appears dry to a depth of one inch. Schedule fertilizing within several weeks before planting, so that the potassium doesn't have time to accumulate during the off-season. To minimize long-term potassium buildup, consider using aged or composted animal manure as a substitute for commercial fertilizers, as its components break down more slowly to keep up with plant demand. If using manure, apply it at a rate of 40 pounds for every 100 feet, and work it into the soil to a depth of 6 to 9 inches (Rachel Lovejoy and Demand Media, n.d.). Red colour patches indicate soil with higher potassium in (Figure 5(a)). Increase K uptake by improving soil management practices on root health (e.g., deep tillage to improve percolation to at least 3-5 mm d-1 and to avoid excessively reducing conditions in soil). Incorporate rice straw to reclaim the potassium deficiency in soil. If straw burning is the only option for crop residue management, spread the straw evenly over the field (e.g., as it is left after combine harvest) before burning. Ash from burnt straw heaps should also be spread over the field. And apply optimum doses of N and P fertilizers and correct micronutrient deficiencies and also apply farmyard manure, or other materials (rice husk, ash, and compost) to replenish K removed in harvested crop products. The results of exchangeable potassium ranged from 2.35ppm-86.9ppm in forest lands (Figure 5(b)) where only 3% area of forest lands was lies within the optimum potassium concentration and remaining area was recorded with lower exchangeable potassium concentration. Exchangeable potassium obtained in grass lands (Figure 5(c)) ranges from 23.24ppm-86.5ppm; around 22% area of grass lands were lies within the range of optimum exchangeable potassium for cultivation of crops and remaining area were recorded with lower soil potassium concentration. The exchangeable potassium results ranged in catchments (Figure 5(d)) from 39.15ppm-40.66ppm and 100% area was lies within the range of lower soils potassium for cultivation of crops.

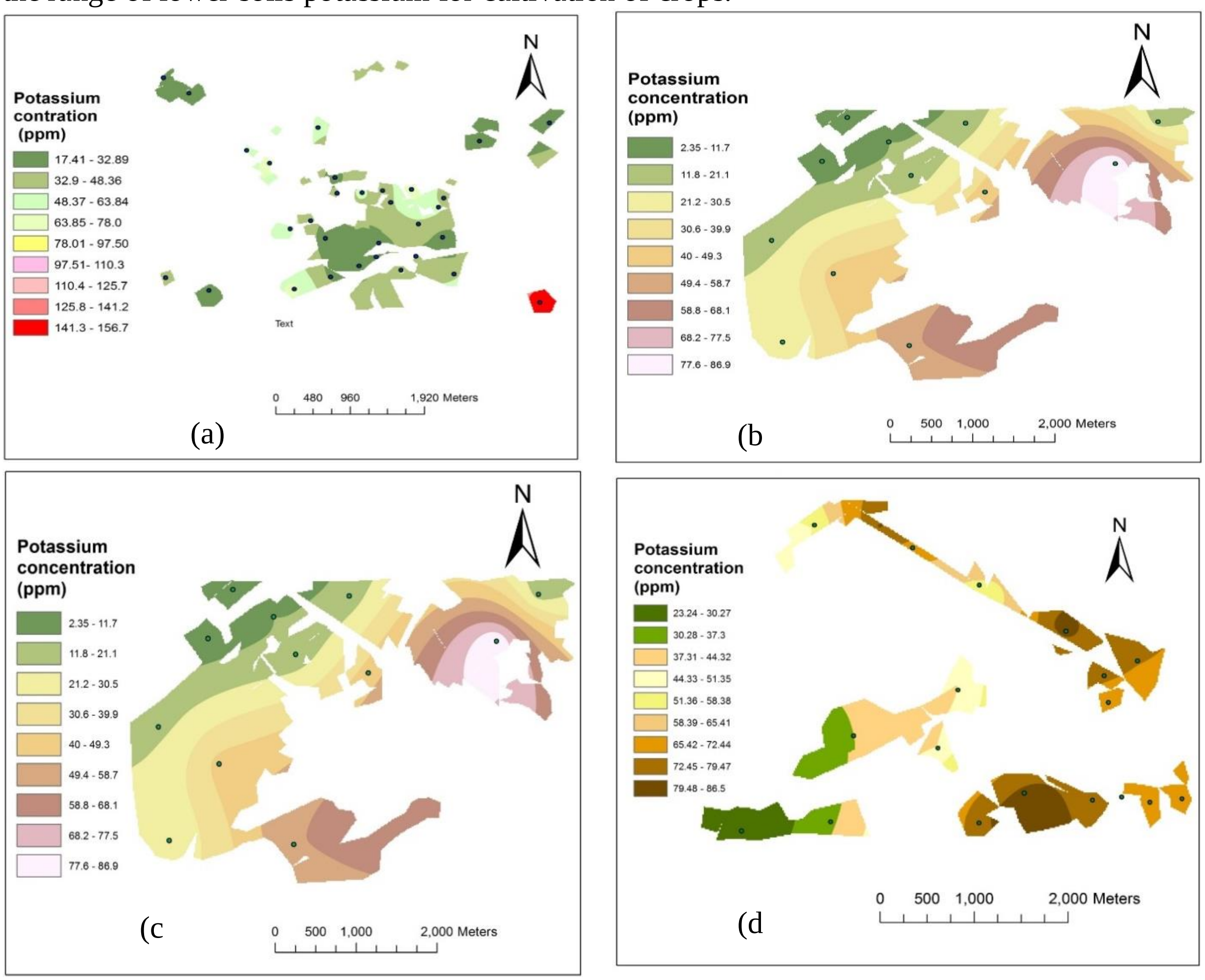

Figure 5: Exchangeable Potassium concentration distribution within (a) agriculture land, (b) forest land, (c) grass land, (d) catchments

Conclusion and Recommendations

Geostatistical method can be applicable for the spatial variation analysis of soil properties such as soil pH, electric conductivity, available potassium and phosphorous using reference data or ground truth values. Acidity, alkalinity, salinity, excessive phosphorous, and excessive potassium were recorded in agriculture land respectively 13%, 6%, 13%, 67%, and 6%. The problem soil should be reclaimed by the suitable techniques and fertilizer should be applied to field based on soil analysis. 22% of grass lands contain excess potassium than the optimum level and 100% of grass land contains excess phosphorous. Soil pH and EC of grassland was under acceptable range. According to the study any meaningful action should be needed in soil management in Cheddikulam area and awareness should be created among farmers about existing scenario.

References

Campbell, J. B., 1978. Spatial variation of sand content and pH within single contiguous delineation of two soil mapping units. *Soil science society of American Journal*, 333-341.

Cerri, C.C., Bernoux, M., Arrouays, D., Feigl, B.J., and Piccolo, M.C., 1999. Carbon stocks in soils of the Brazilian Amazon. In Lal R. J., Kimble R.J.M. and Stewart B.A., *Global Climate Change and Tropical Ecosystems.* Advances in Soil Science.pp33-50.

Dharmakeerthi, R.S., Indrartne, S. P. and Kumaragamage, D., 2007. *Manual of soil sampling and analysis.* (S. P. Dharmakeerthi R.S, Ed.) Soil science society of Srilanka. pp. 43-75.

Goovaerts, P., 1998. Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. *Biol. Fertil. Soils 27*, 315-334.

Loganathan, P., 2015. Reclamation of Soil Problems in Organic Farming. In *Organic Farmin and Health Safety* (First Edition ed.). Vavuniya: Loganathan., P, Faculty of Applied Science, Vavuniya Campus of the University of Jaffna. pp. 56-70.

McBratney. A.B. and Pringle, M.J., 1999. Estimating average and proportional variograms of soil properties and their potential use in precision agriculture. Prec. Agric. 1, 125 – 152.

Narsimha. A, Narshimha. CH, Srinivasulu. P. and Sudarshan. V., 2013 . Relating apparent electrical conductivity and pH to soil and water in Kanagal. Pelagia Research Library , 4(2), pp. 25-31.

Olsen, S. R., Cole, C. V., Watanabe, F. S., and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S: Department of Agriculture, Circular No:939.

Paz-Gonza´lez, A., Vieira S.R., and Taboada Castr, M.T., 2000. The effect of cultivation on the spatial variability of selected properties of an umbric horizon. *Geoderma 97*, 273 – 292.

Rachel Lovejoy and Demand Media, n.d. Ways to Treat High Potassium in Soil. [Online] Available at: http://homeguides.sfgate.com/ways-treat-high-potassium-soil-102992.html (Accessed on: 4th January, 2015)

Stenger, R., Priesack, E., and Beese, F., 2002. Spatial variation of nitrate-N and related soil properties at the plot-scale. *Geoderma 105*, 259 – 275.

Trangmar, B.B., Yost, R.S., and Uehara, G., 1985. Application of Geostatistics to Spatial Studies of Soil Properties. In *Advances in Agronomy*. San Diego: Academic Press. pp. 45-94.