

## Research Article

## Assessment of Seasonal Variations in Chemical Fertilizer Residues and Soil Characteristics of Agricultural Soil Samples

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### Abstract

The physico-chemical characteristics of the agricultural fields from Nanjangud near Mysore were analyzed to study the seasonal variations in agro ecosystems. Soil characteristics showed a high pattern of variability in some of the soil constituents. Seasonal variations of main soil chemical characteristics were studied in some representative sampling sites from agricultural lands of Nanjangud taluk. The soil samples were collected during rainy, winter and summer seasons from 15 different agricultural lands and were analyzed for different physico-chemical characteristics. From the study, it was concluded that, the application of chemical fertilizers has greater influence on soil quality. In all the soil samples, during all the seasons, urea and DAP residues were detected. The highest concentration was recorded during Rainy season followed by winter season. In case of cations and anions, concentrations were found to be higher during monsoon, post-monsoon, followed by summer seasons, which indicates that, the amount of fertilizers applied was not completely taken up by the crops. As the study area is having good irrigation facilities, throughout the year, the nitrate and phosphate entry into water resources through surface run-off and leaching was expected to be more.

**Keywords:** Seasons, Soil properties, Acidic Soil, Chemical fertilizers.

### Introduction

Soil is considered as one of the medium for the growth, development and production of crops. The various soil characteristics and biogeochemical cycles have direct influence on ecosystem structure and biodiversity at different temporal and spatial scales. Among these, soil quality is considered as very important for all nutrients needed by the plants for sustainability of soil fertility. Soil productivity primarily depends on its soil physico-chemical characteristics which reflect the magnitude of soil as well as enzymatic activities. Soil properties depend upon various factors which vary both spatially and seasonally. The soil nutrients become integral part of the crop in order to meet the grain need of the humanity. The chemical parameters of the soil vary throughout the season. This has been shown for various parameters such as, humification (Jacquin and Merlet 1975), organic carbon, total phosphorous, (Dormaar *et al.*, 1972) and ammonia-nitrogen, humic acid.

Among various soil parameters, total cationic and anionic content, soil pH, organic carbon, total nitrogen and total phosphorous vary on spatial scale in the topsoil. Some environmental factors such as, climate, land form, topography, soil texture, soil moisture, and plant community composition also influence on soil composition (Maria *et al.*, 2004; Takata *et al.*, 2008). Among these, the total ionic contents and pH

independently influence the soil geochemistry and ultimately the distribution pattern of vegetation in an area. There is a considerable amount of study which has been reported on both direct and indirect influence of seasonal variations on soil nutrients. If the climate turns more arid, then the soil is expected to lose moisture and become less acidic and less fertile (Arora *et al.*, 2002; Paltineanu *et al.*, 2007). Keeping in view of all the informations, the present study has been carried out with an objective to; study the effect of seasonal variations on changes in various characteristics of agro ecological zones of Nanjangud taluk (Mysore district)

### Materials and Methods

**Study area:** Nanjangud is one of the taluks in Mysore district, which is spread over, from 12° 6' 39" N longitude 76° 33' 46" E latitude to 12° 07' 56" N longitude to 76° 42' 9" E latitude with annual rain fall of 697 mm. The total geographical area of Nanjangud taluk covers around 98,541 hectares, out of which, 61,552 hectares of land is used for agricultural purpose. Agriculture is the major occupation in the study area, which is greatly influenced by fertility and type of soil. One can find major part of land having red sandy and laterite soils. As the area is chosen almost with good irrigation facilities, it helps greatly in getting high productivity from agriculture.

**Land use patterns and agricultural activity:** The agricultural lands cover most of the area in Nanjangud taluk. The main cropping season is from September to

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January. During this period, Paddy and sugar cane are grown. These crops mainly depend on river; channel and ground water sources used for irrigation throughout all the seasons. The second cropping season is from February to May when paddy, vegetables, pulses and groundnut, turmeric, cucumber, chilly, green leafy vegetables are grown. These crops are mainly dependent on channel water and groundwater. Rice and other crops are sometimes grown in some parts of the area, during May to September which is mainly dependent on groundwater. The most commonly used fertilizers for paddy and sugarcane in this study are urea, NPK complex (20-0-20), diammonium phosphate during farming season. The recommended rate of nitrogen fertilizer application is 100-120 kg for paddy, 160 kg N/ha for sugarcane (per year) and 40–100 kg N/ha for other crops. The amount of chemical fertilizers used varies within the study area, depending on the type of crop and the actual rate of application varies, depending on the farmers practice which may exceed the prescribed rate.

**Collection of the soil samples:** 15 soil samples were collected from selected agricultural areas from different farm lands during rainy, winter and summer seasons respectively. From each of the farm lands, composite soil samples were collected along with one sample from non-agricultural land. The soil samples were collected at 0-15 cm depth, air dried, ground and sieved through 2 mm sieve and stored in polythene bags until analysis. The physico-chemical analyses were carried out as per standard methodology of Arun Kumar Saha (2008), GKVK manual (1999).

**Experimental work:** The soil samples were analyzed for various physico-chemical parameters. The soil moisture content was assessed by gravimetric method. The bulk density and particle density were determined by core sampler method and volumetric flask method. The urea residues were quantified by reaction of urea with diacetylmonoxime under acidic condition using spectrophotometer. The diammonium phosphate residues were calculated by using amount of phosphate (taking difference between agricultural and non-agricultural soil samples) present in soil samples, considering the molecular weight of DAP and weight of phosphate group of DAP. The soil pH was measured in 1:5 soil/water suspensions using the glass electrode pH meter. The electrical conductivity of the soil extract was determined by using conductivity meter. The organic carbon was determined by using potassium dichromate wet oxidation method. The total nitrogen was determined by Kjeldhal distillation method, while the phosphate was determined by o-dianisidinmolybdate method. The sodium and potassium concentrations were determined by flame photometry. Estimation of calcium and magnesium was done by EDTA titration method and the ammoniacal nitrogen by Nessler's reagent method.

## Discussion

The results obtained from the seasonal variations of soil samples from Nanjangud taluks of Mysore district are presented in Tables 1, 2 and 3. Standard methods were

employed for the analysis of chemical fertilizer residues, along with physico-chemical characteristics of soil samples. A comparison of the physico-chemical characteristics has been made with soil quality standards. Following observations were made from different characteristics with respect to different seasons.

**Moisture content:** During the present investigation, the moisture content values in Nanjangud taluk ranged from 13.04 to 36.11 % in rainy, 12.6 to 21.73 % in winter and during summer season, the values ranged from 13.8 to 18.9 %. Highest value was recorded in rainy season. The variation in moisture content depends on the amount of interstitial spaces present in soil, which is related to soil texture.

**Bulk density:** Bulk density is defined as the mass of soil material present per unit volume of moist soil under naturally undisturbed condition. The bulk density of clay and clay loam soil normally ranges from 1 to 1.65 mg/m<sup>3</sup>. During the present study, the variation of bulk density in Nanjangud taluk ranged from 0.92 to 1.52 mg/m<sup>3</sup> in rainy season, 1.01 to 1.61 mg/m<sup>3</sup> in winter season and during summer season, the values ranged from 1.02 to 1.44 mg/m<sup>3</sup>. Bulk density is related to total porosity, or interstitial space present in the soil for air and water movement (Mini et al, 2003; Tester, 1993). Lower bulk density implies greater interstitial space and improved aeration, developing a suitable environment for biological activity (Werner, 1997).

**Particle density:** Particle density is the density of solid particles in a particular sample. During the present study, in Nanjangud taluk, the particle density of soil samples in all the seasons ranged from 2 to 5 mg/m<sup>3</sup>. Normally the particle density range from 2 to 2.65 mg/m<sup>3</sup>, this indicates the presence of clay and quartz minerals in the soil matrix. High particle density indicates the presence of rich iron in soils ex: ferromagnesian mineral density range from 2.9 to 3.5 mg/m<sup>3</sup> and the density of iron oxides and other heavy minerals can exceed 5 mg/m<sup>3</sup>.

**Porosity or interstitial space:** Porosity or interstitial space of a soil is that portion of the total soil volume, which is not occupied by solid particles but occupied by air or water. During present investigation, the porosity values in Nanjangud taluk ranged from 34 to 74.7 % in rainy season, 20.5 to 74.4 % in winter season and during summer season, the values ranged from 29.72 to 81 %. The interstitial space of a soil varies with respect to soil texture, shape of individual soil particles, organic carbon content and nature of crop soil management.

**Urea residues:** Urea is one of the most commonly used source of nitrogen for worldwide agriculture. This is mainly due to high nitrogen content, solubility, low cost and its rapid decomposition process. During present investigation, the concentration of urea in Nanjangud taluk ranged from 5.1 to 26.8 ppm in Rainy season, 6.3 to 21.9 ppm in winter season and during summer season, the values ranged from 9.1 to 20.6 ppm. Highest value was

**Table-1:** Physico-chemical characteristics of soil samples collected around agricultural areas of Nanjangud (1 to 15) during Rainy season 2011

Parameters	Normal range	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Urea residues		8.58	10.9	17.7	11.4	5.1	16.8	9.7	6.2	8.16	13.1	12.4	16.6	21.2	26.8	6.8
DAP residues		12.9	19	4.86	12.51	42.96	11.54	18.21	9.87	25.16	5.97	18.49	51.86	5.28	24.61	6.53
Moisture content %	-	16.66	24.39	16.27	15.9	13.58	19.18	13.04	21.42	18.18	18.2	25.64	18.41	23.91	32.43	36.11
Bulk density mg/m <sup>3</sup>	1-1.65	1.52	1.26	1.3	1.3	1.24	1.28	1.28	1.24	1.16	1.46	1.2	1.32	1.3	1.32	0.92
Particle density mg/m <sup>3</sup>	2-2.65	2	2.5	2.5	5	2.65	5	5	2.5	2	2.13	2	3.33	2	5	2.5
Porosity %	30-55	34	49.6	48	74	45	74.4	74.7	50.4	42	43	45	63.37	35	73.6	63.2
pH	6.5-7.5	7.41	6.79	7.23	6.76	6.64	7.32	5.85	5.67	6.73	6.64	6.72	6.9	5.06	5.85	7.42
Conductivity dS/m	0-2	0.29	0.23	0.31	0.16	0.2	0.38	0.13	0.17	0.24	0.16	0.21	0.17	0.15	0.1	0.75
Calcium meq/l	10-30	1.5	2.4	1.4	2	1.8	2.9	2.3	1.7	3.5	2.3	2.4	3.4	4.2	4.5	4.9
Magnesium meq/l	05-10	1.2	1.6	0.7	1.8	1.1	1.2	1.5	1.4	2	1.3	1.6	2.3	1.9	2.1	2
OC %	0.50-0.75	1.68	1.59	1.86	1.05	1.14	0.99	1.77	1.95	1.65	1.38	1.29	1.05	1.14	1.5	0.52
Chloride %	0.020-0.120	0.063	0.575	0.076	0.031	0.07	0.102	0.044	0.061	0.076	0.121	0.083	0.051	0.038	0.044	0.095
TN Kg/ha	200-500	1088	1078	208.3	117.6	1276	1108	790.1	2184	1848	1525	575.8	486.7	508.9	669.6	232.1
Nitrate-nitrogen Kg/ha	-	37.6	43.1	45.9	51.7	50.3	71.8	76.1	80.1	38.1	33.4	38.6	41.7	20.9	84.1	76.3
Sodium Kg/ha	-	18.4	27.6	34.3	42.1	21.4	42.8	51.6	71.9	62.3	19.3	17.6	27.8	31.9	29.16	41.8
Potassium Kg/ha	50-125	12.1	16.4	15.6	21.4	23.4	24.7	26.6	35.1	37.4	10.8	12.1	14.6	15.3	13.8	20.8

**Table-2:** Physico-chemical characteristics of soil samples collected around agricultural areas of Nanjangud (1 to 15) during winter season 2011-2012

Parameters	Normal range	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Urea residues		9.2	9.1	16.3	14.2	6.3	14.1	10.1	9.8	10.6	11.3	14.6	15.1	21.9	19.8	9.3
DAP residues		26.8	28.6	25.1	19.3	32.8	26.5	28.6	30.4	41.8	20.4	40.4	58	29.6	41.1	33
Moisture content %	-	13.5	21.4	15.3	14.1	12.6	15.9	11.52	18.38	17.9	16.19	21.73	15.32	20.18	24.3	31.9
Bulk density mg/m <sup>3</sup>	1-1.65	1.61	1.21	1.3	1.3	1.34	1.26	1.26	1.36	1.26	1.07	1.21	1.36	1.26	1.28	1.01
Particle density mg/m <sup>3</sup>	2-2.65	2	2.5	2.5	2.5	2.65	5	5	2.5	2	2.13	2	3.33	2	5	2.5
Porosity %	30-55	20.5	51.5	48	48	53.21	64.8	64.8	45.6	37	49.7	39.5	59.2	37	74.4	59.6
pH	6.5-7.5	7.46	7.01	7.21	6.98	7.11	7.3	5.91	5.67	6.76	7.37	7.1	6.98	5.16	6.1	7.17
Conductivity dS/m	0-2	0.38	0.24	0.38	0.19	0.26	0.41	0.18	0.17	0.27	0.18	0.23	0.16	0.13	0.1	0.64
Calcium meq/l	10-30	1.3	1.7	1.4	2.1	1.6	2.3	2.2	1.5	3.1	2	2.2	3	3.4	4.1	4.8
Magnesium meq/l	05-10	0.9	1	0.6	1.3	0.7	1	1.3	0.8	1.9	0.9	1	1.6	2	1.9	1.8
OC %	0.50-0.75	1.36	1.62	1.77	1.51	1.49	1.71	1.1	1.12	1.78	1.52	0.63	1.16	1.21	1.1	0.61
Chloride %	0.020-0.120	0.06	0.46	0.039	0.019	0.051	0.099	0.036	0.049	0.061	0.11	0.062	0.047	0.031	0.036	0.081
TN Kg/ha	200-500	1016	997	239	208	839	949	618	1237	1932	1426	512	526	638	718	246
Nitrate-nitrogen Kg/ha	-	48.7	54.2	56.9	62.8	69.4	82.9	73.2	82.3	49.2	44.8	49.7	56.3	39.4	98.7	59.8
Sodium Kg/ha	-	16.8	32.7	38.9	49.9	52.9	56.7	52.1	70.9	78.1	29.4	19.1	26.3	30.1	27.9	59.3
Potassium Kg/ha	50-125	10.1	17.3	20.8	26.7	30.1	30.6	32.7	41.5	46.8	13.6	11.4	10.8	16.8	11.9	15.3

recorded in Rainy season followed by winter season. The variation in urea concentration was observed in all the seasons, which were mainly influenced due to factors such as, temperature, soil enzymatic activity and soil chemical properties. Apart from all these factors, some of the studies, showed that, the rate of degradation depends on soil pH, temperature, moisture content, organic carbon, quantity of urea applied, which varies with respect to seasons (Bremner *et al* 1978)

*Diammonium phosphate residues:* During the present study, the DAP residues in Nanjangud taluk soil samples, ranged from 4.86 to 51.86 ppm in Rainy season. 16.7 to 26.1 ppm in winter season and during summer season, the values ranged from 8.62 to 43.3 ppm. Highest concentration was reported during Rainy season. High concentration of DAP residues indicates that, the quantity of fertilizer applied to the soil has not been completely utilized by the crops.

**Table-3:-**Physico-chemical characteristics of soil samples collected around agricultural areas of Nanjangud (1 to 15) and during summer season. 2012

Parameters	Normal range	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Urea residues		9.8	10.2	14.6	18.6	9.1	12.1	14.6	10.9	11.4	16	17.4	ND	18.1	20.2	20.6
DAP residues		28	32.5	13.3	22.3	35	28.9	26.6	15.1	15.1	8.62	3.79	35.8	40	43.3	23.9
Moisture content %		16.21	18.2	14.6	15.7	13.8	17.1	16.4	18.9	17.7	16.9	16.1	15.8	14.9	14.3	13.9
Bulk density mg/m <sup>3</sup>	1-1.65	1.6	1.22	1.3	1.14	1.1	1.12	1.22	1.34	1.12	1.02	1.44	1.26	1.2	1.34	1.14
Particle density mg/m <sup>3</sup>	2-2.65	1.42	2.5	1.66	5	2.5	5	2	1.11	2	3.33	5	2.5	3.33	1.42	3.33
Porosity %	30-55	38.6	31.2	64	77.2	56	77.6	39	81	44	64	71.2	49.6	63.97	59.76	29.72
pH	6.5-7.5	7.46	7.07	7.24	6.99	7.18	7.41	5.99	5.72	6.84	7.36	7.1	7.15	5.47	6.81	7.2
Conductivity ds/m	0-2	0.38	0.26	0.39	0.24	0.28	0.41	0.24	0.21	0.29	0.2	0.25	0.19	0.17	0.14	0.65
Calcium meq/l	10-30	2.4	1.9	2	2.9	1.9	2.8	2.6	3.5	4.3	2.9	4.4	3.9	1.9	4.3	5.1
Magnesium meq/l	05-10	1.2	0.7	1.1	0.9	0.8	1.1	1.5	1.6	2.1	1.8	2.1	1.7	1.5	2	2.1
OC %	0.50-0.75	0.9	0.75	0.72	1.14	1.33	1.5	1.29	1.14	1.11	0.75	0.51	1.02	1.48	0.69	0.96
Chloride %	0.020-0.120	0.128	0.113	0.032	0.134	0.142	0.078	0.127	0.134	0.131	0.213	0.156	0.075	0.039	0.12	0.106
TN Kg/ha	200-500	710	1350	1282	692	292	1112	1282	1430	1677	1350	1589	1747	692	1906	2065
Nitrate Kg/ha		60	72	81	93	178	136	148	152	186	103	59	74	60	134	76
Sodium Kg/ha		61	35	19	120	27	46	54	104	96	108	128	136	94	50	48
Potassium Kg/ha	50-125	34	21	37	50	28	37	19	23	29	31	27	14	16	29	35

**pH:** During the present study, variation of pH was noticed in Nanjangud taluk, from a minimum of 5.06 to a maximum of 7.42 in Rainy season. 5.16 to 7.46 in winter season and during summer season, the values ranged from 5.47 to 7.46 ppm. As per the present investigation, Long term fertilizer application of nitrogenous and phosphorous fertilizers results in low soil pH, which confirms the findings of Aref and Wander *et al* (1998). During the present study, a slight variation in pH was observed in all the seasons. In some of the soil samples, acidic pH was noticed, which may occur due to decomposition of organic matter, or application of acid-forming fertilizers. Rainfall also affects soil pH, it decreases during rainy season (De S, 2009) as water passing through the soil leaches basic nutrients such as calcium and magnesium from the soil (Bernstein L. 1975).

**Electrical conductivity:** Electrical conductivity determines the amount of salts present in soil suspension. During the present investigation, the EC of Nanjangud taluk ranged from 0.10 to 0.75 dS/m in Rainy season, 0.10 to 0.64 dS/m in winter season and during summer season, the values ranged from 0.14 to 0.65 dS/m. The value of electrical conductivity was from zero to 2 dS/m, which is safe for all the crops. During the present investigation, the values of conductivity showed strong variations in different seasons. Highest value was observed during Rainy season, which implies that, in Rainy season salts were dissolved, which will get leached through soil profile during raining (Nazrul- Islam 1995). The EC values for all the soil samples were found to be within the normal range, reflecting that, all the soil samples had safe range of electrical conductivity.

**Calcium and magnesium:** The calcium and magnesium concentrations in Nanjangud taluk ranged from 1.4 to 4.9

meq/l and 0.7 to 2.5 meq/l in Rainy season, 1.3 to 4.8 meq/l and 0.7 to 2.0 respectively in winter and during summer seasons, the values ranged from 1.4 to 4.4 meq/l and 0.7 to 2.0 meq/l respectively. Highest values were recorded during rainy season. For urea applied soils, nitrate ions were formed as an end product after hydrolysis of urea which is not strongly adsorbed by the soil particles which will move down through the soil profile. The negatively charged nitrate ions carry positively charged basic cations, such as calcium, magnesium, sodium, potassium in order to maintain the electrical charge on the soil particles. The depletion of these basic cations will accelerate the acidification process in soil which is another reason for decrease in soil pH and confirms the findings of Nelet *et al* (1996).

**Organic carbon:** Organic carbon is an index of soil productivity. During the present investigation, the organic carbon in Nanjangud taluk ranged from 0.52 to 1.95 % in Rainy season. 0.63 to 1.78 % in winter season and during summer season, the values ranged from 0.51 to 1.5 %. For all the soil samples, the organic carbon was found to be higher compared to the normal range. The high organic carbon was due to accumulation of crop residues on soil surface (Ashok, 1998).

**Total nitrogen:** The total nitrogen content for all the soil samples in all the seasons was found to be higher in range. The total nitrogen values in Nanjangud taluk ranged from 208.32 to 2184 kg/ha in Rainy season, 208 to 1932 kg/ha in winter season and during summer season, the values ranged from 692 to 2065 kg/ha. Highest values were recorded during summer and rainy season. The total nitrogen in all the agricultural soil samples in all the seasons was found to be high, which is due to excessive application of nitrogenous fertilizers and also through leguminous crop rotation (Nel *et al*, 1996), apart from

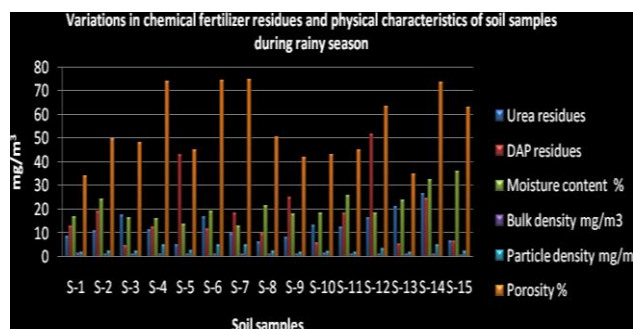
which, Soil chemistry greatly varies with seasonal changes, the C or N contents of soil varied seasonally, due to differential microbial activities for decomposing biomass accumulation and thereby nutrient recycling within the soil environment.

**Ammoniacal- nitrogen and nitrate:** The ammonia and nitrate concentration in Nanjangud taluk, varied from 6.2 to 23.1 ppm and 20.9 to 84.1 ppm respectively in Rainy season. Similarly, 5.7 to 26.1 ppm and 39.4 to 98.7 ppm respectively in winter and summer season, the values ranged from 4.7 to 15.5 ppm and 59 to 186 ppm. The ammoniacal-nitrogen and nitrate was found to be 1.79 and 27.68 kg/ha and in all the agricultural soil samples, it was found to be higher, which mainly depends on moisture content and enzymatic activity of soil system which may vary from one place to another with different seasons (Bremner *et al*, 1978).

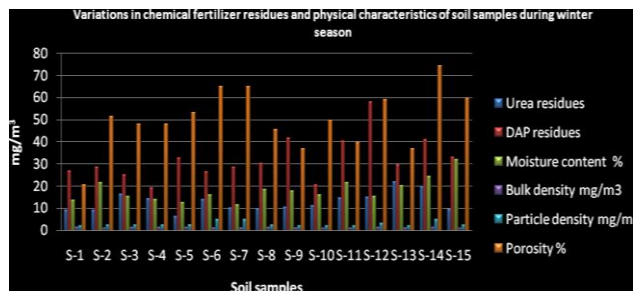
**Sodium and potassium:** Sodium and potassium are important basic cations, which are considered as indicators of nutritional imbalance. During the present study, the sodium and potassium concentrations in the Nanjangud taluk, ranged from 17.6 to 71.9 kg/ha and 10.8 to 37.4 kg/ha respectively in Rainy season, 16.8 to 78.1 ppm and 10.1 to 46.8 ppm respectively in winter season and during summer season, the values ranged from 19 to 1128 and 19 to 37 ppm. In comparison, sodium and potassium concentrations were found to be very less in some of the soil samples in different seasons. This confirms the findings of Nel *et al* (1996) that, his experiments on long term application of different types of chemical fertilizers on soil, resulted in the decline of basic cations.

**Phosphate:** During the present investigation, the phosphate concentrations of Nanjangud taluk soil samples, ranged from 12.6 to 46.4 ppm in rainy season, 13.9 to 56.1 ppm in winter season and during summer season, the values ranged from 6.2 to 31.2 ppm. The high phosphate levels in all the sampling areas were found to be higher than the normal range, which was due to excessive application of phosphate fertilizers. This confirms the experiments of McCollum (1991), on long term phosphate fertilizer application, results in an accumulation of phosphorous in soil, which may persist for many years.

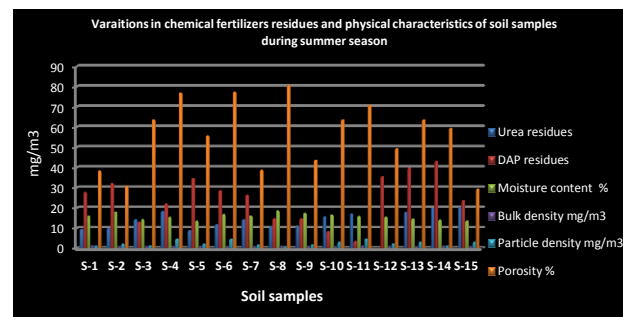
### Graphical representation of seasonal variations in physico-chemical characteristics of soil samples



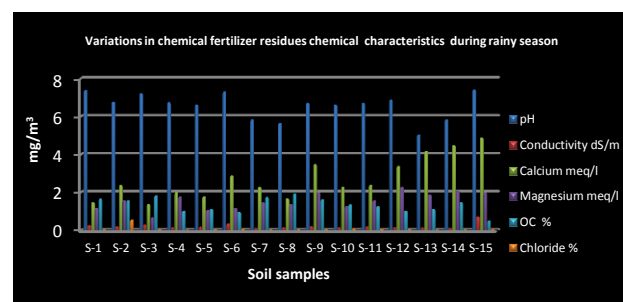
Graph-1



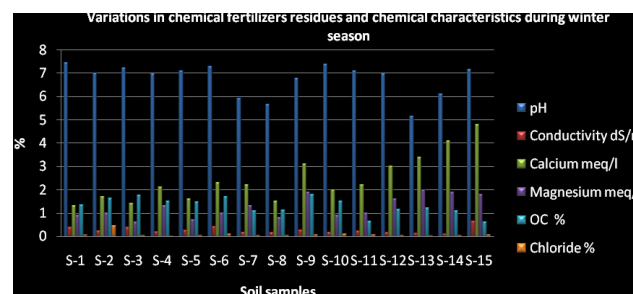
Graph-2



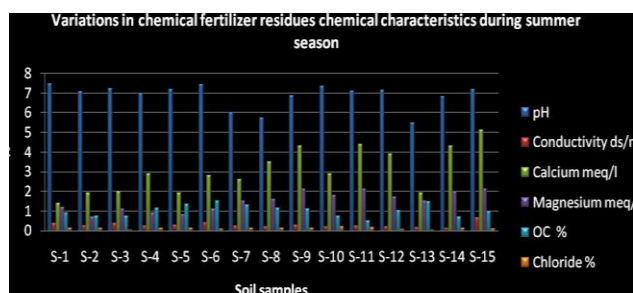
Graph-3



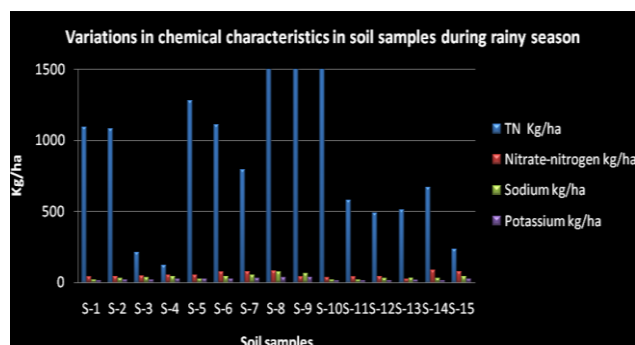
Graph-4



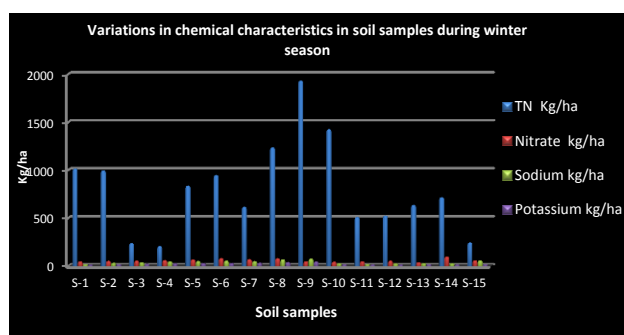
Graph-5



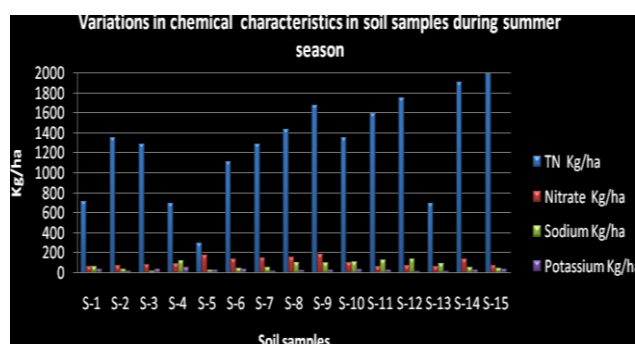
Graph-6



Graph-7



Graph-8



Graph-9

## Conclusions

From the present study, it confirms that, the application of chemical fertilizers has greater influence on soil. Most of the soil samples were found to be acidic in nature and the ions like calcium, magnesium, sodium and potassium were found to be reduced. Phosphate level was found to be higher in all the sampling areas, which was due to over-use of phosphate fertilizers. The total nitrogen, ammoniacal-nitrogen and nitrate concentrations were found to be higher. From the results of seasonal variations of soil characteristics, it was found that, majority of all the cations and anions in soil were found to be higher during monsoon season followed by post-monsoon and lesser during summer. The different sources of flooding water and the fertilization habits can be responsible to some extent, for the soil chemical characteristics variability along with seasons. One can also state that, judicious application of chemical fertilizers may help to maintain

soil quality and productivity. However, it is necessary to apply liming material to reduce the acidifying effect on agricultural lands in order to maintain basic cation levels in soil.

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