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GIS Based Soil Fertility Status of Pudukkottai District

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Abstract: **Soil's yield capacity is depends on often complex and sometimes little understood interactions between the biological, chemical and physical properties of soil. Good farm practice aims to manage the various factors that make up each of these three properties to optimize the yields of crops in environmentally friendly ways. The purpose of the study is to identify the spatial distribution of pH, Electrical Conductivity (EC) and macro nutrient of the soil of the Pudukkottai districts along with fertility index of Nitrogen, Phosphorous and Potassium using Parker's fertility index and its spatial distribution can be derived through ArcGIS software. The results of the study shows that there has been 100 per cent of the soil samples shows the low level of nitrogen, only 32 per cent of the soil samples is high in available phosphorous and only 7.5 per cent of the soil samples is high in available potassium. Soil fertility status of the Pudukkottai district shows that 100 per cent, 30 per cent and 73.5 per cent of the soil samples has low nitrogen fertility, phosphorous fertility and potassium fertility respectively.**

Keywords**: Soil fertility, Pudukkottai district, parker's fertility index, macro nutrients, GIS.**

1. INTRODUCTION

Soil is a significant natural resource available in the top of the earth's lithosphere which is the life supporting element in the earth. Soil contains organic matter like death or living organisms along with gases, minerals and liquids which act as the medium of plant growth. With the high population and fast increase in anthropogenesis activities are the prime responsible for declining in agricultural foot print along with increasing in process of intensification of agriculture (Maskey et al., 2003) and increasing in inappropriate application of fertilizer (Zhang, 2007, Bhola Raya., 2013, Vijaya kumar M., et al., 2015) that ultimately leads to decline in soil fertility (Stefanie V. W. et al., 2004) and crop yield (Ladha J. K., et al., 2003, Katyal, 2003).. Soil quality can be defined by the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Karlen D. L., 1997). Soil has been continuously using without leaving time to restore its fertility. So the quality of the soil must be protected for sustainable use and this responsibility fall on human. For that, they have to understand, monitor and augment the soil quality not only support sustainable agricultural practice for growing population but also it provide economic benefits by increasing agricultural production, improving the air and water quality(USDA – ERS, 1997, Zhang, 2007). Thus the assessment of soil quality can be achieved by measuring physical properties, chemical properties and biological properties of the soil (Adolfo et al., 2007) and the assessment provide current nutrient availability of the soil which help in the recommendations to the farmer about the uses of fertilizer for respective crops so that farmer can maximizing the its production and further it helps to maintain the fertility of the soil results in prevention of land degradation (Ahmed H. R., 2012, Binyam Alemu, 2015, Maragatham S., et al., 2014). India facing sever soil fertility deficiency (Indian institute of soil science report, 2014) the assessment revealed that about 59 per cent, 49 per cent and 9 per cent are low in available Nitrogen, Phosphorous and Potassium respectively. The aim of the study is to assess the soil fertility status of Pudukkottai district based on soil nutrient parameter using GIS techniques which would be a appropriate platform for spatial analysis of soil fertility (Dhayalan et al., 2016, Staal S. J., et al., 2003, Mohamed A. E., et al., 2016, Vijaya kumar M., et al., 2015).

OBJECTIVES:

- To assess the macro nutrients status of the soil of Pudukkottai district.
- To find the spatial distribution of macro nutrients of the soil of Pudukkottai district.
- To find the soil fertility index of Pudukkottai district.
- To delineate the soil fertility map of Pudukkottai district.

STUDY AREA:

Pudukkottai District is one of the 32 districts of Tamil Nadu state in southern India. The Pudukkottai town is the district headquarters.

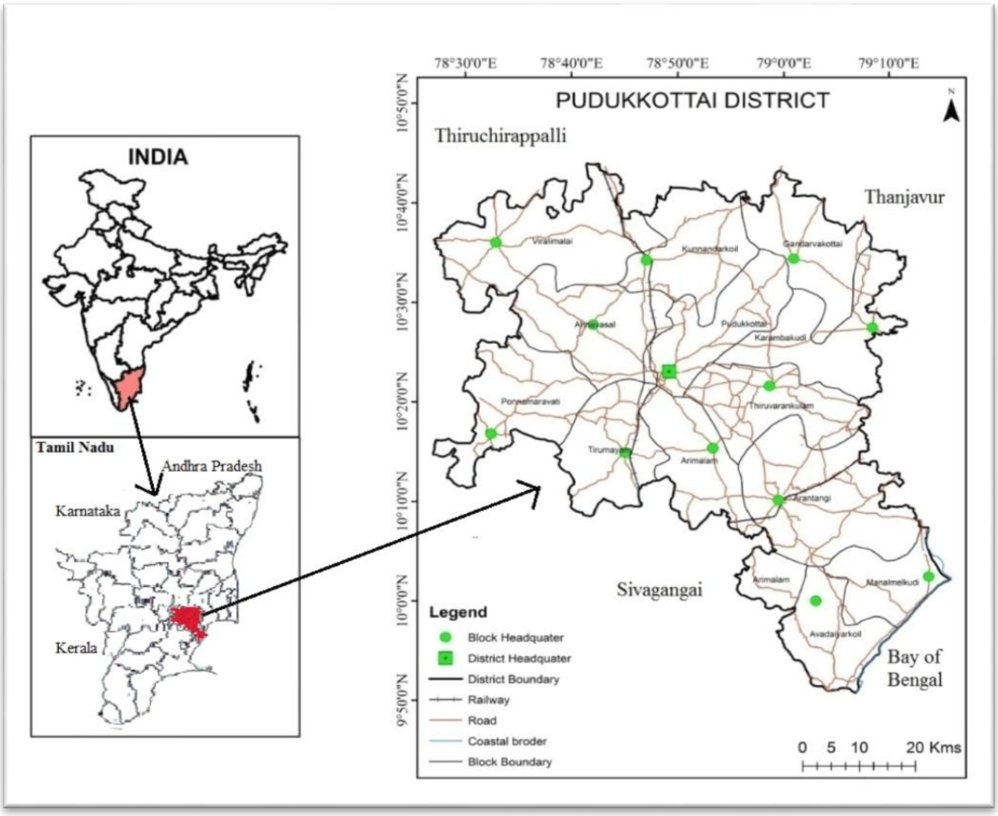

Fig 1

The total geographical area of Pudukkottai district is 4663 km² with a coastline of 42 km. The district lies between 78° 25' and 79° 15' east longitude and between 9° 50' and 10° 40' of the north latitude.. Pudukkottai district is bounded by Sivagangai district in the South, Bay of Bengal in the East, Thiruchirappalli district in the North, Thanjavur district in the North-east and Ramanathapuram district in the South. As per 2011 census the total population of Pudukkottai district is 16,18,345 The Geographical location of Pudukkottai district is shown in the Fig. 1.

2. MATERIAL AND METHODOLOGY

Secondary data of 200 soil sample and its parameters of Electrical conductivity (EC), Pouvoir hydrogen (pH), Available Nitrogen (N), Available Phosphorous (P) and Available Potassium (K) of Pudukkottai district are collected from the soil testing lab, Kudumianmalai research centre, Pudukkottai measure in the year 2016. The collected data are sorted, tabulated and classified into three categories i. e., low, medium and high. It can be spatially analyzed in ArcGIS software 10.1 using Inverse Distance Weighted (IDW) interpolation. Using these fertility classes, soil fertility index can be calculated with the help of the following equation. Single value of the each nutrient must be required to compare with other area so we adopt nutrient index given by Parker et al., 1951.

$$Nutrient\ Index\ = \frac{(N_L X1) + (N_M X2) + (N_H X\ 3)}{N_T}$$

Where,

N_L – Number of samples falling in Low

N_M – Number of samples falling in Medium

N_H – Number of samples falling in High

N_T – Total number of samples

Standard value for the measurement of NPK (Nitrogen, Phosphorous and Potassium) values are given in the Table 1 suggested by Agriculture department, Pudukkottai and nutrient index it has been suggested by Parker et al., 1951.

TABLE 1

Category	Nitrogen in Kg/ac	Phosphorous in Kg/ac	Potassium in Kg/ac	Nutrient index
Low	Below 133	Below 4.5	Below 48	Below 1.67
Medium	133 -180	4.5 - 9	48 – 130	1.67 – 2.33
High	Above 180	Above 9	Above 130	Above 2.33

Source: Agricultural department, Pudukkottai and Parker et al., 1951

3. RESULTS AND DISCUSSION

The analyzed results of 200 soil sample its maximum and minimum values of soil parameters for Pudukkottai district are presented in the TABLE 2.

TABLE 2

Parameters	Minimum	Maximum
EC in ds/m	0.01	12
pH	4.5	10.1
Nitrogen in kg/ac	2.8	116.2
Phosphorous in kg/ac	0.2	105
Potassium in kg/ac	0.279	345

SOIL pH

Pouvoir hydrogen is the abbreviation for pH also called as power of Hydrogen or potential of Hydrogen i. e the pH values entirely depends on the presence of Hydrogen ion in the substance. pH value are generally from 0 to 14, if the value is 0 – 6 then the substance is acidic in nature 7 – 14 then the substance is basic in nature. All the neutral substances are range of 6 to 7. For the soil the pH is very important (Shalini K., et al., 2003) to support for the plant it should not be acidic or alkaline and it should be in the range of 6 – 8 where most of the nutrient are available to plants in the soil. Soil pH range and analyzed samples are shown in the TABLE 3. pH of the study area range from 4.5 to 10.1 indicating the existence of acidic, neutral and alkaline soil. Out of the total samples 4.5 per cent i.e. 9 samples are in acidic in nature, 124 samples are neutral in nature i.e. 62 per cent of the total samples and 67 samples are Alkaline in nature i.e 33.5 per cent of the samples.

TABLE 3: Soil pH

Range	Category	No. of samples	Percentage of samples
Below 6	Acidic	9	4.5
6 - 8	Neutral	124	62
Above 8	Alkaline	67	33.5

The spatial distributions of pH of the study area are shown in the Fig No. 2. pH is maximum in the study area with very few acidic soil distributed at the north eastern parts of the districts and alkaline soil are spread north, north eastern, central and south eastern parts of the districts. Agriculture production would affect in the area where the soil is acidic or alkaline.

ELECTRICAL CONDUCTIVITY:

Electrical conductivity of the soil is the measurement of current carrying capacity of soil i.e it shows the presence of soluble salt in the soil. If the value of the EC is low then soluble salt in the soil is low and vice versa. In the study area electrical conductivity of the soil value varied from 0.01 to 12 ds/m. TABLE 4 shows that EC values indicating that 92 per cent (184 samples) of the soil in the study area are low saline which is suitable for good growth of plants. It also shows that 5.5 per cent (11 samples), 2 per cent (4 samples) and 0.5 per cent (1 sample) are slightly saline, medium saline and high saline category respectively.

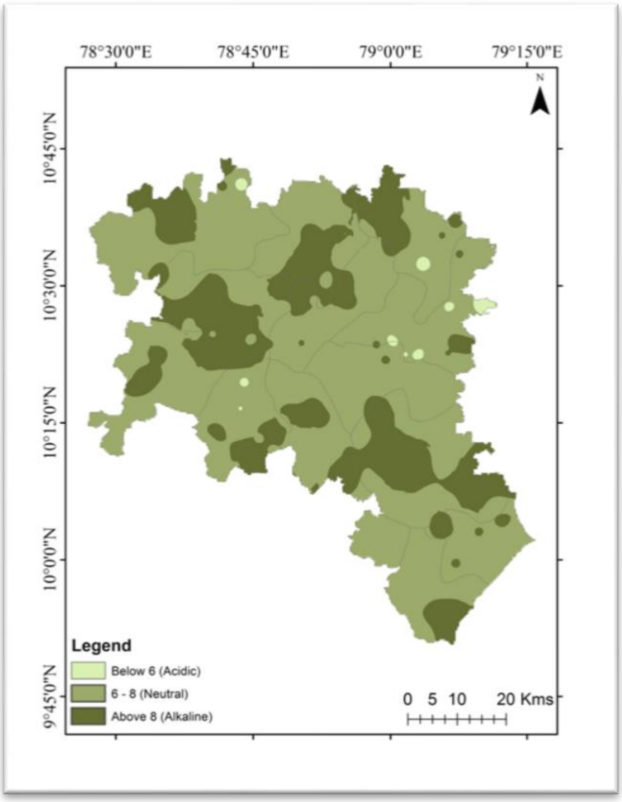

Fig 2: Spatial distribution of Soil pH

TABLE 4: Electrical Conductivity of the soil

Range	Category	No. of samples	Percentage of samples
Below 1	Low saline	184	92
1 - 2	Slightly saline	11	5.5
2 - 3	Medium saline	4	2
Above 3	Highly saline	1	0.5

Fig. 3 shows the spatial distribution of soil EC where majority area are in low salinity with small portion of northern, southern and south eastern parts are having slightly to high salinity.

AVAILABLE NITROGEN:

For the appropriate growth of the plant, it needs appropriate proportion of nitrogen in the soil and it is consider as most essential, but there is universal deficiency of naturally available nitrogen in India. The available nitrogen status of soil is presented in TABLE 5 and TABLE 1 shows that available nitrogen in the study area ranged from 2.8 to 116.2 kg/ac. It is interesting to note that taken soil samples are categorized as the low (below 133 kg/ac) in the study area with 100 per cent.

TABLE 5: Available Nitrogen in Kg/ac

Range	Category	No. of samples	Percentage of samples
Below 133	Low	200	100
133 -180	Medium	0	0
Above 180	High	0	0

Fig. 4 show that spatial distribution of available nitrogen in the study area where entire region categorized as low to very low value of nitrogen.

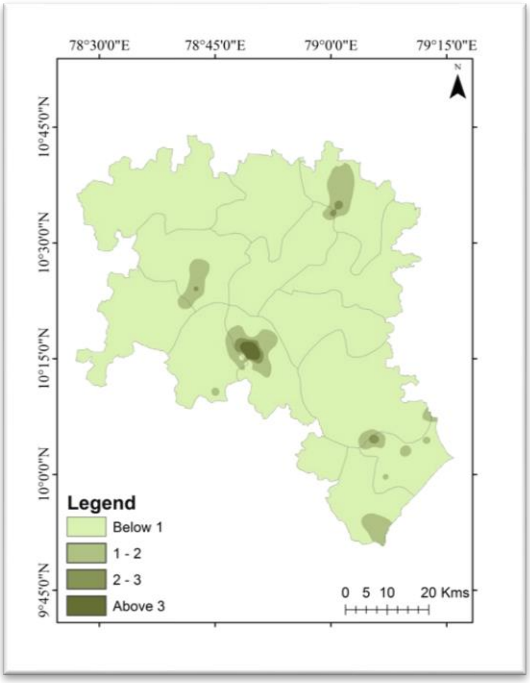

Fig 3: Spatial distribution of Soil EC

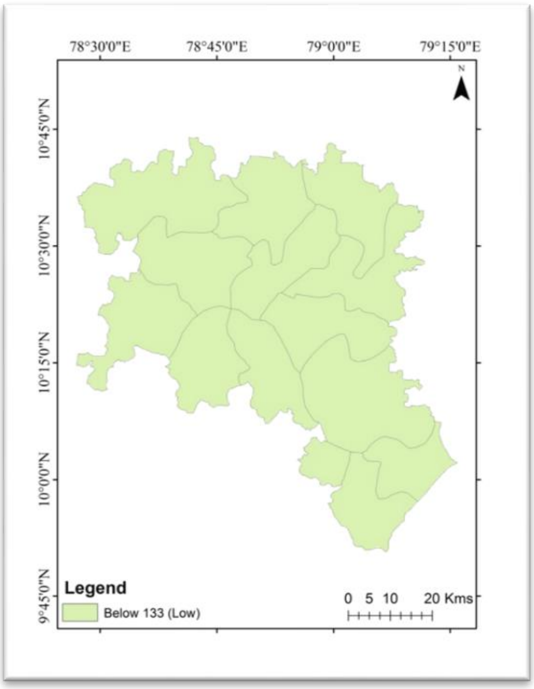

Fig 4: Spatial distribution of Available Nitrogen

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AVAILABLE PHOSPHOROUS:

Nitrogen and phosphorous are the most significant nutrients for the crop yield. Decrease in the phosphorous in the soil will directly affect the production of crop, this nutrient is also called as 'Master key to agriculture'. Phosphorous is used by the plant for the development of different stages of its growth. In this study availability of phosphorous is measure based on the Olsen method. Minimum and maximum values of phosphorous are 0.2 and 105 kg/ac shown in the TABLE 2. Available phosphorous in the study are given in the TABLE 6. 110 samples are reported low available of phosphorous categorized below 4.5 kg/ac it constitutes 55 per cent of the total samples. 26 samples are fall in the medium category of 4.5 to 9 kg/ac which is 13 per cent of the total area. 64 samples are showing high phosphorous content range above 9 kg/ac this constitutes only 32 per cent of the total samples.

TABLE 6: Available Phosphorous in Kg/ac

Range	Category	No. of samples	Percentage of samples
Below 4.5	Low	110	55
4.5 - 9	Medium	26	13
Above 9	High	64	32

Spatial distribution of the Majority area of the south eastern and North eastern parts of the district categorized into high to medium available phosphorous. Central and small parts of the south are categorized into high to medium of available phosphorous. North western and some parts of the central district are categorized into low phosphorous region shown in the Fig. 5.

AVAILABLE POTASSIUM:

Potassium is called as quality nutrient as it responsible for the quality of the plant and it also responsible for the proper growth of the plant along with reproduction of the plant. Plants absorb potassium in its ionic for K+. In this study potassium value are ranged between 0.279 to 345 kg/ac. Out of the 200 samples 114 samples are categorized into low availability of potassium which is below 48 kg/ac, 71 samples are ranged in medium category of available potassium and only 15 samples are fall in the category of high availability of potassium TABLE 7.

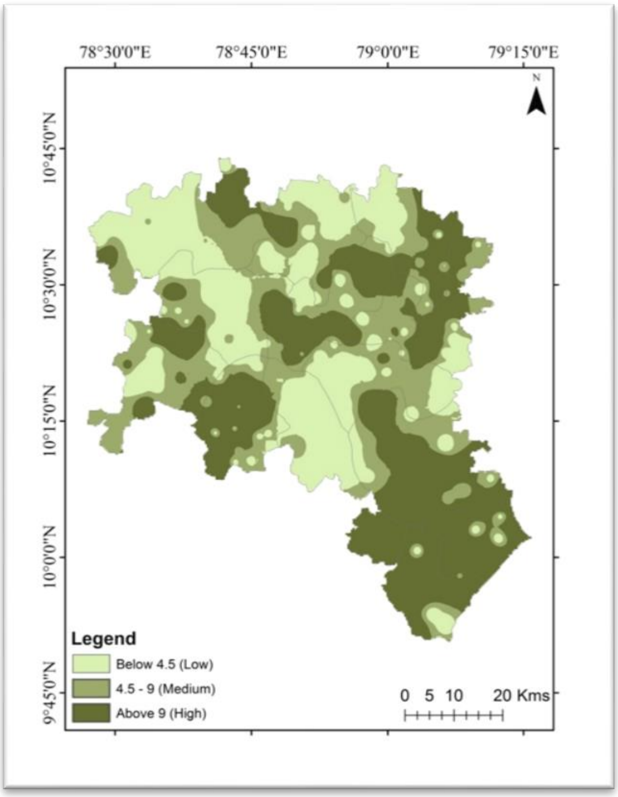

Fig 5: Spatial distribution of available phosphorous

TABLE 7: Available Potassium in Kg/ac

Range	Category	No.of Samples	Percentage of samples
Below 48	Low	114	57
48 - 130	Medium	71	35.5
Above 130	High	15	7.5

Spatial distribution of available potassium shown in the Fig. 6. Major parts of the district are categorized into low to medium of available potassium. Only very small portion of the district categorized into high which constitute only 7.5 per cent of the total samples. 35.5 per cent of the total samples are in the medium category of available potassium. More than 57 per cent of the samples are fall into low category of available potassium.

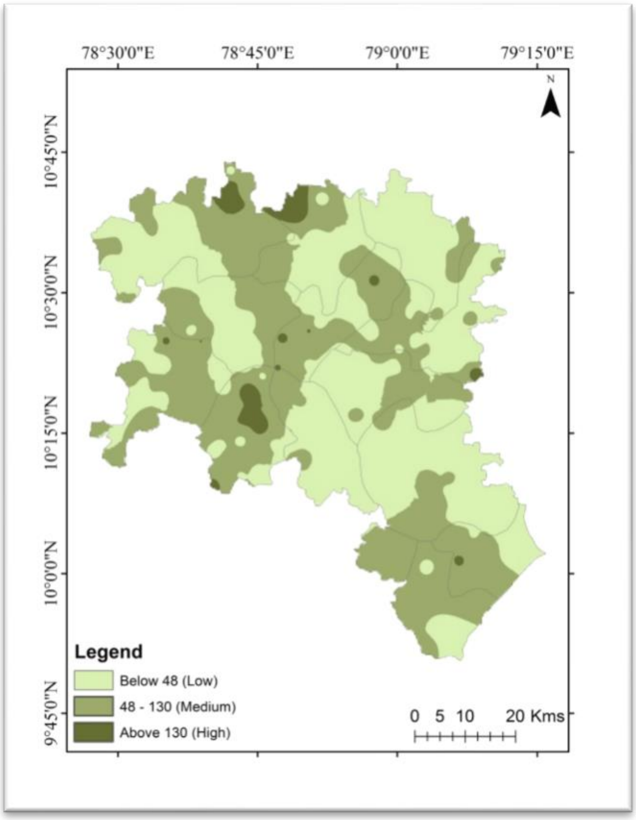

Fig 6: Spatial distribution of available potassium

SOIL NUTRIENT INDEX:

NITROGEN FERTILITY INDEX:

Nitrogen fertility is low in entire region of the study area. All the 200 samples are categorized below 1.67 so the value of the nutrient index for nitrogen in the study area is 1.0 shown in the TABLE 8.

TABLE 8: Nitrogen fertility index

Nutrient Index	Rating	No. of Samples	Percentage of samples
Below 1.67	Low	200	100
1.67 - 2.33	Medium	0	0
Above 2.33	High	0	0

Spatial distribution of nitrogen fertility status shown in the Fig. 7. Entire district are low in nitrogen fertility it covers 100 per cent of the total samples. Study are does not have medium or high nitrogen fertility region.

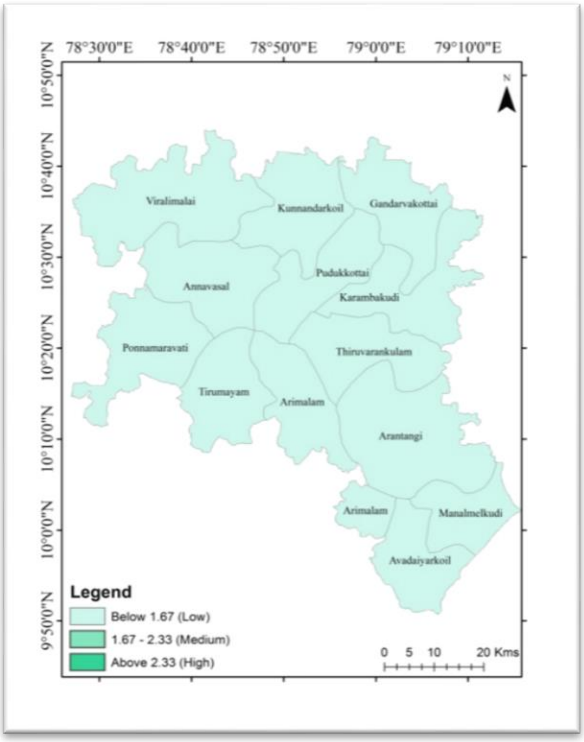

Fig 7: Spatial distribution of Nitrogen fertility index

PHOSPHOROUS FERTILITY INDEX:

Phosphorous fertility status are shown in the TABLE 9, 60 samples are low in phosphorous nutrient index, 118 samples are fall in medium category of nutrient index and 22 samples are fall in the high category of nutrient index. 30 per cent, 59 per cent and 11 per cent of the total samples are categorized into low, medium and high phosphorous nutrient index.

TABLE 9: Phosphorous fertility index

Nutrient index	Rating	No. of Samples	Percentage of samples
Below 1.67	Low	60	30
1.67 - 2.33	Medium	118	59
Above 2.33	High	22	11

Spatial distribution of fertility status of phosphorous shown in the Fig. 8. It reveals that most parts of Aranthangi, Avudaiyarkoil and southern parts of Arimalam has high to medium phosphorous fertility status. Entire block of Manamelkudi, Pudukkottai, Kunandarkoil and Thirumayam are categorized into medium level of phosphorous fertility. Annavasal, North of Arimalam, Thiruvarankulam, and Viralimalai are very low region of phosphorous fertility. Karambakudi and ponnamaravathi are categorized into low to medium of phosphorous fertility.

POTASSIUM FERTILITY INDEX:

Out of the 200 samples 147 samples are listed in the low category of potassium fertility which is 73.5 per cent of the total samples followed by 53 samples are medium category of potassium fertility which is 26.5 per cent of the total samples and there is no region fall in the high category of potassium fertility shown in the TABLE 10.

TABLE 10: Potassium fertility index

Nutrient index	Rating	No. of Samples	Percentage of samples
Below 1.67	Low	147	73.5
1.67 - 2.33	Medium	53	26.5
Above 2.33	High	0	0

Fig No. 9 shows the spatial distribution of potassium fertility status of Pudukkottai district. Blocks of Pudukkottai, Thirumayam, Arimalam and Avudaiyarkoil has categorized into low to medium of potassium fertility status. Blocks of Thiruvarakulam, Karambakudi, Gandarvakottai, Viralimalai, Annavasal, Ponnamaravathi, Arantangi and Manamelkudi has categorized into low potassium fertility status. Here no region with high category of potassium fertility.

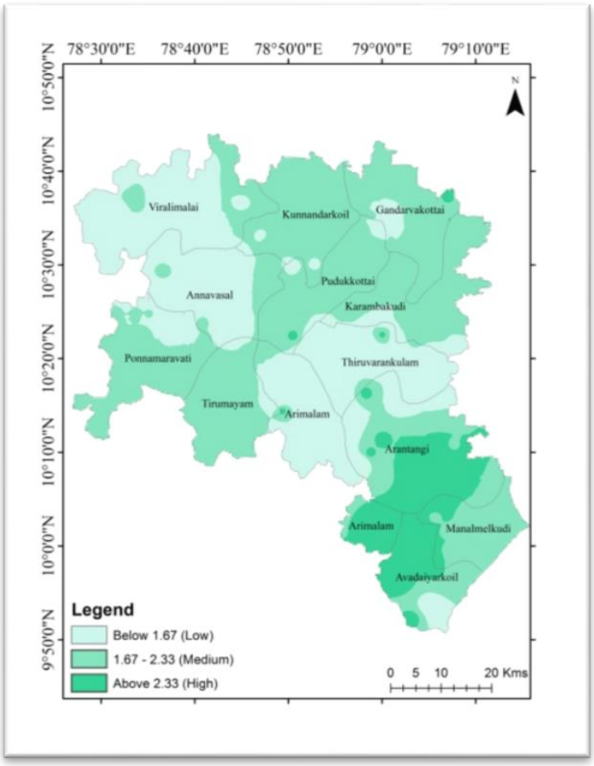

Fig 8: Spatial distribution of Phosphorous fertility index

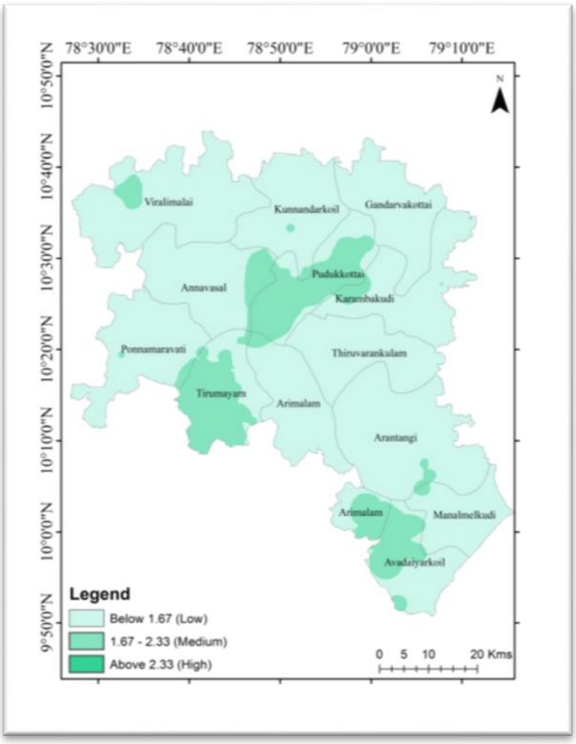

Fig 9: Spatial distribution of potassium fertility index

4. CONCLUSION

Economic activity of our study area is largely depends on agriculture so the managing soil fertility status becomes increasing important for the sustainable growth of agriculture in the study area. Good soil nutrient management also is a key to high yields and farm profitability. This study reveals that more than 92 per cent samples are safe in terms of electrical conductivity of the soil only 0.5 per cent samples shows high salinity. pH of the study area shows that only 62 per cent of the samples are neutral soil that would be suitable for agriculture but 4.5 per cent and 33.5 per cent samples are acidic and alkaline soils respectively it must need special attention to bring the soil to neutral. Availability of Nitrogen isn100 per cent of the soil samples are below 133 kg/ac indicating that entire region of the study area are lacking in nitrogen. The study also reveals that high availability of Phosphorous in the study area is only 32 per cent of the soil remaining 55 per cent of the samples shows low availability of phosphorous and only 7.5 per cent of the samples shows high concentration of Potassium, more than 57 per cent of the soil samples show low category of potassium in the soil. Nitrogen fertility index shows 100 per cent of the soil samples are below 1.67 range, it indicates that the entire study area are low nitrogen fertility, only11 per cent of the soil samples shows high category of phosphorous fertility, 59 per cent of the soil samples are categorized into medium of phosphorous fertility and 30 per cent of the soil samples are low category of phosphorous fertility. The results also reveals that entire region fall within low to medium category of potassium fertility, there is no region with high potassium fertility. The spatial analyze shows that south western and central parts of the district has suitable fertility status provided with application of nitrogen based fertilizer. The study concludes that GIS is an effective tool to analyze the spatial distribution of the soil fertility.

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