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GPS AND GIS BASED SOIL FERTILITY MAPS OF NAYAGARH DISTRICT, ODISHA

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ABSTRACT

Soil fertility maps of Nayagarh district, Odisha, India were prepared by using Global Positioning System (GPS) and Geographical Information System (GIS). Detailed geo-reference investigation was carried out to study the plant available nutrient status and to prepare soil fertility maps which would act as an important tool for soil as well as nutrient management for higher and sustainable crop production. The soils of different villages in each block of Nayagarh district were collected using GPS instrument, analysed for chemical properties and maps were prepared subsequently. The results revealed that the soils under investigation were acidic in reaction (pH 5.50 to 6.40) and low to medium in organic carbon status (4.47 to 6.83 g kg^{-1}). The mean available nitrogen content varied from 129.4 to 171.4 kg ha^{-1}, available P content from 6.1 to 12.0 kg P ha^{-1} and potassium status from 158.9 to 257.5 kg ha^{-1}. Thus, on mean basis the soils of Nayagarh didtrict of odisha were deficient in available N and P and medium in potassium status. On the other hand, the soil status of mean available sulphur was high (17.32 to 26.03 mg kg^{-1}) except Khandapada and Daspalla block soils. Hot water soluble boron content was above the critical limit (0.38 to 0.74 mg kg^{-1}) in most of the soils of Nayagarh district.

Keywords: GIS, GPS, Nayagarh district, soil fertility maps

INTRODUCTION

Soil, land and water are essential resources for the sustained quality of human life and the foundation of agricultural development (Das *et al.* 2009). Efficient management of soil and water resources is a major challenge for the scientists, planners, administrators and farmers to ensure food, water and environmental security for the present and future generations (Kanwar 2000). Soil fertility plays an important role in sustaining crop productivity of an area, particularly in situations where input of nutrients application differs and the information on the nutritional status can go a long way to develop economically viable alternatives for management of deficient nutrients in the soil.The modern geospatial technologies such as Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS) and Information Technology (IT) offer immense potential for soil and water resources development and management (Das 2004).Geographical Information System (GIS) is a potential tool used for easy access, retrieval and manipulation of voluminous data of natural resources often difficult to handle manually. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin (Mandal and Sharma 2010). Several databases are available at global and national level that showed for planning management of soil resources. The FAO Soil Map of the World (FAO 1996) is an important source of soil information used world-wide. Collection of soil samples by using Global Positioning System (GPS) is very important for preparing the GPS and GIS based thematic soil fertility maps (Mishra *et al.* 2013). Composite soil samples are collected by GPS instrument to know latitude and longitude of that particular location. It has got great significance in agriculture for future monitoring of soil nutrient status of different locations/villages. Detail systematic study to assess the soil fertility status of Nayagarh district of Odisha has not been done earlier. Therefore, an attempt was made to study the soil fertility status in detail of Nayagarh district with GPS and GIS tool and to prepare the soil fertility maps for easy understanding about the soil fertility status.

MATERIAL AND METHODS

Nayagarh district of Odisha lies between 19^0 $50^{"}$ to $20^0.35^{'}$ North latitude and 84^0 $29^{'}$ to 85^0 $30^{'}$ East longitude Nayagarh district constituted by 1695 villagers spread over 8 C.D. blocks. Six composite GPS based soil samples were collected from selected villages of each block. Total 576 numbers of GPS based soil samples from 8 blocks namely; Khandapada (84), Ranpur (108), Nayagarh (66), Gania (36), Bhapur (36),

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Odagaon (96), Nuagaon (72) and Daspalla (78) were collected. The soil samples were analyzed for pH (1:2.5), EC (1:2.5), organic carbon (Walkley and Black method), available nitrogen (alkaline permanganate method), available phosphorus (Bray's No.-1), available potassium (neutral normal ammonium acetate method), available boron (hot water extraction) and available (0.15% $CaCl_2$) sulphur (Jackson, 1973). Base map of the Nayagarh district were digitized and geo-referenced. Polygons were superimposed on the geo-referred map. Then latitude, longitude and soil characteristics such as soil reaction, organic carbon, available nitrogen, available phosphorus, available potassium, available sulphur and hot water extractable boron content were linked to Arc GIS software for making thematic soil fertility maps.

RESULTS AND DISCUSSION

The average pH of all the blocks of Nayagarh district is moderately acidic to neutral which ranged from 5.50 to 6.40 (Table 1). The pH of Khandapada block soils varied between 4.66 and 7.68 (moderately acidic to saline) with a mean value of 5.64. Similarly, the blocks namely Ranpur, Nayagarh, Gania, Bhapur, Odagaon, Nuagaon and Daspalla soils had pH between 4.61 and 7.54, 4.68 and 7.09, 5.04 and 7.86, 4.61 and 7.38, 4.70 and 7.71, 5.06 and 7.86 and 4.77 and 7.02, respectively with their respective mean value of 5.57, 5.50, 6.30, 5.72, 6.07, 6.40 and 5.80 (Fig.1). The data revealed that pH of Khandapada, Ranpur, Gania, Odagaon and Nuagaon were acidic to slightly saline whereas, Nayagarh, Bhapur and Daspalla block soil ranged from moderately acidic to neutral. Similar findings were reported by Mandal *et al.* (2013). The electrical conductivity of Khandapada block soils ranged from 0.02 to 0.64 dS m^{-1} with a mean value of 0.11 dSm^{-1}. The lowest electrical conductivity was found in Khandapada and Daspalla block (0.02 dSm^{-1}) soils and highest in Nuagaon block soils (0.87 dSm^{-1}). The mean value of all the blocks varied between 0.09 and 0.18 dSm^{-1} which is very low with respect to no harm for crop cultivation.

Table 1: Range and mean values of pH, EC and organic carbon in soils of Nayagarh district

Block Name	pH		EC (dSm^{-1})		Organic carbon (g kg^{-1})	
	Range	Mean	Range	Mean	Range	Mean
Khandapada (84)	4.66-7.68	5.64	0.02-0.64	0.17	1.39-14.64	5.72
Ranpur (108)	4.61-7.54	5.57	0.04-0.51	0.12	1.05-12.74	6.55
Nayagarh (66)	4.68-7.09	5.50	0.05-0.40	0.10	0.78-9.35	5.27
Gania (36)	5.04-7.86	6.30	0.04-0.35	0.09	2.52-15.52	6.47
Bhapur (36)	4.61-7.38	5.72	0.05-0.24	0.10	2.32-9.11	4.47
Odagaon (96)	4.70-7.71	6.07	0.05-0.38	0.15	0.59-29.50	5.78
Nuagaon (72)	5.06-7.86	6.40	0.05-0.87	0.14	3.31-22.03	6.83
Daspalla (78)	4.77-7.02	5.80	0.02-0.23	0.09	1.56-14.11	6.21

Figures in parenthesis indicate number of soil samples

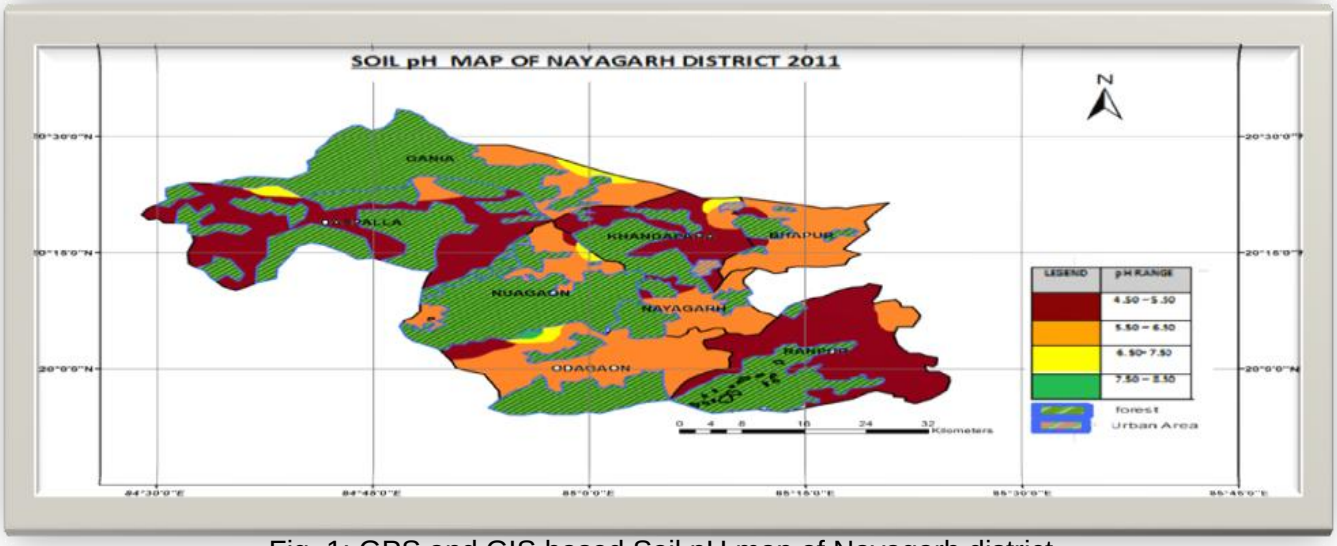

Fig. 1: GPS and GIS based Soil pH map of Nayagarh district

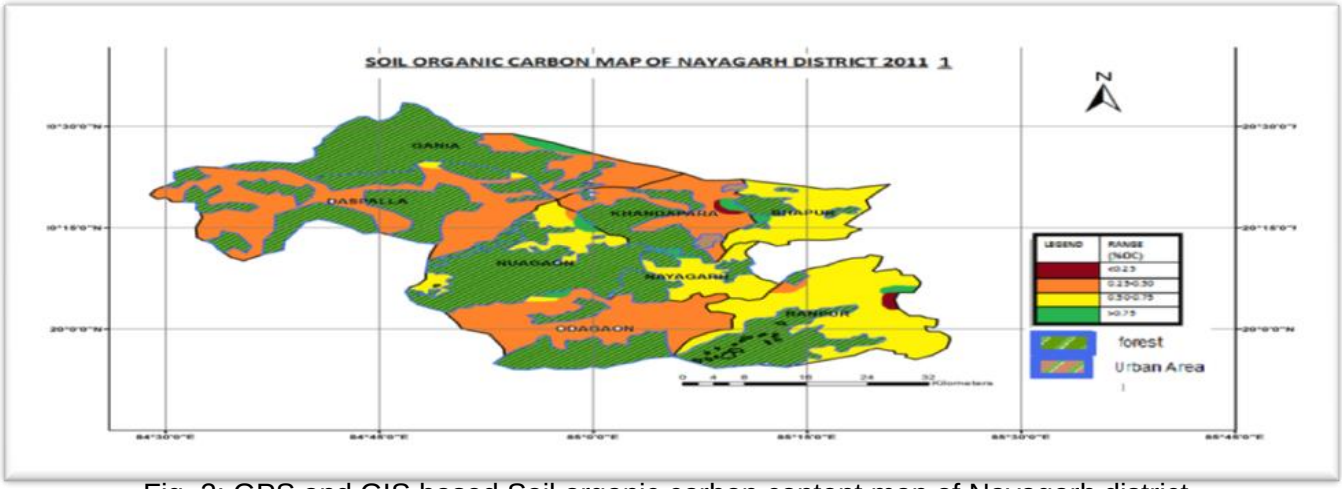

Fig. 2: GPS and GIS based Soil organic carbon content map of Nayagarh district

The organic carbon content of all the blocks varied between low (<0.50%) to high (> 0.75%). The block wise organic carbon content in soils was Khandapada (0.39-14.64g kg^{-1}), Ranpur (1.05-12.74g kg^{-1}), Nayagarh (0.78-9.35g kg^{-1}), Gania (2.52-15.52g kg^{-1}), Bhapur (2.32-9.11g kg^{-1}), Odogaon (0.59-29.50g kg^{-1}), Nuagaon (3.31-22.03g kg^{-1}) and Daspalla (1.56-1.14.11g kh^{-1}). The highest (29.50g kg^{-1}) and lowest (0.59g kg^{-1}) organic carbon content were observed in soils of Odogaon block. The highest average organic carbon content (6.83g kg^{-1}) was found in Nuagaon block. The mean organic carbon content confined within medium range (<0.75%) (Fig.2). Similar results were reported by Mitra *et al.* (2002) and Mandal *et al.* (2013).

Most of the soils of all the blocks of Nayagarh district were low in available nitrogen content except Khandapada (71.2-340.0 kg ha^{-1}), Ranpur (78.6-360.0 kg ha^{-1}) and Nayagarh (86.25- 277.50 kg ha^{-1}) which ranged from low to medium (Table 2). The average available nitrogen content was low (124.5 kg ha^{-1}). The lowest available nitrogen content was observed in Daspalla block which ranged from 56.3 to 172.5 kg ha^{-1} with mean value of 124.5 kg ha^{-1} and highest in Ranpur block (78.8 to 360.0 kg ha^{-1} mean 168.1 kg ha^{-1}). The highest mean available nitrogen (171.4 kg ha^{-1}) was recorded in Nayagarh block (Fig.3). Similar results were also found by Mitra *et al.* (2002). The available phosphorus content of Khandapada, Ranpur, Nayagarh, Gania, Bhapur and Nuagaon ranged from low (<14kg ha^{-1}) to medium (14-40 kg ha^{-1}) whereas Odogaon and Daspalla between low (<14 kg ha^{-1}) to high (>40 kg ha^{-1}). The mean values of available phosphorus content of all the blocks were low which might be due to phosphorus fixation within the soils (Fig.4). The highest available phosphorus was found in Daspalla block (67.1 kg ha^{-1}) and lowest in Ranpur blocks (0.25 kg ha^{-1}). Similar result was reported by Mitra *et al.* (2002) and Mandal *et al.* (2013) Potassium content in all the blocks of Nayagarh district ranged from low to high (Fig.5). The lowest mean available potassium content was found only in Gania block (158.9 kg ha^{-1}) which has in medium range and highest in Odogaon soils which were also in medium (252.3 kg ha^{-1}) range which may be due to intensive cropping and imbalanced use of fertilizers. Similar results were reported by Mitra *et al.* (2006).

Table 2: Range and mean values of available N, P and K in soils of Nayagarh district

Block Name	Av. N (kg ha^{-1})		Av. P (kg ha^{-1})		Av. K (kg ha^{-1})	
	Range	Mean	Range	Mean	Range	Mean
Khandapada (84)	71.2-340.0	145.9	1.5-27.4	7.6	80.6-800.8	257.5
Ranpur (108)	78.6-360.0	168.1	0.25-37.9	6.6	22.4-596.9	200.9
Nayagarh (66)	86.3-277.5	171.4	0.74-24.2	6.7	50.2-566.7	207.1
Gania (36)	105.0-198.8	146.0	1.05-26.5	10.3	67.2-340.5	158.9
Bhapur (36)	100.0-178.8	139.8	6.37-26.9	12.0	40.3-423.4	208.7
Odagaon (96)	86.3-196.3	130.0	0.74-50.7	10.7	94.1-605.9	252.3
Nuagaon (72)	91.3-190.0	129.5	0.98-25.2	6.1	43.7-400.9	182.6
Daspalla (78)	56.3-172.5	124.5	0.74-67.1	9.5	17.9-730.2	170.8

(Figures in parenthesis indicate number of soil samples collected)

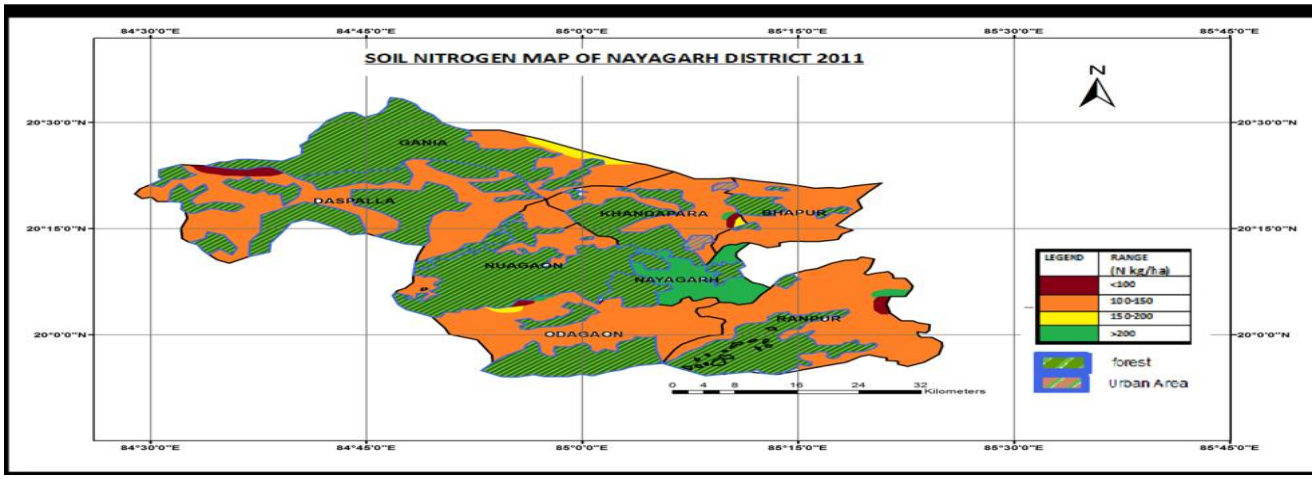

Fig.3: GPS and GIS based Soil available nitrogen content map of Nayagarh district (Odisha)

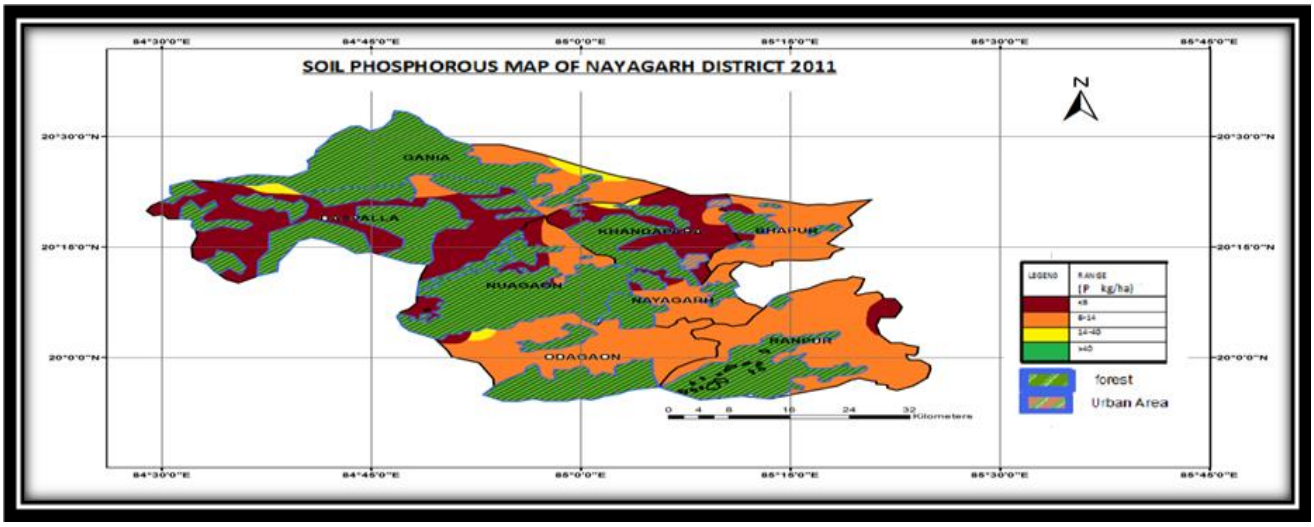

Fig. 4: GPS and GIS based Soil available phosphorus content map of Nayagarh district (Odisha)

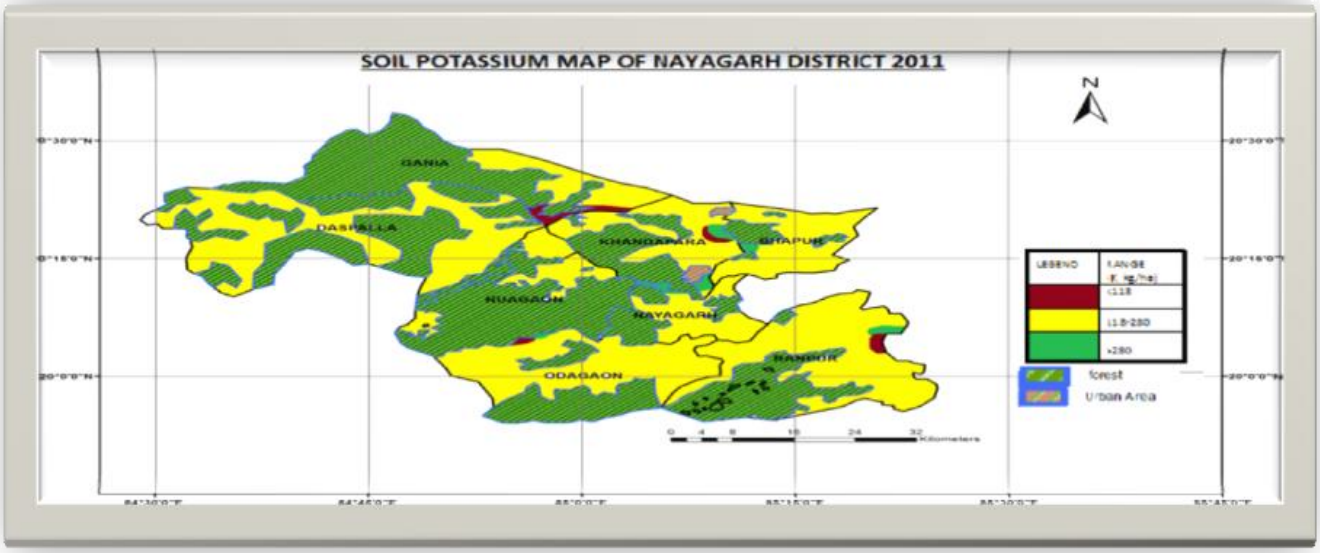

Fig.5: GPS and GIS based Soil available potassium content map of Nayagarh district

The status of available sulphur and hot water soluble boron content are presented in Table 3. Data revealed that the mean available sulphur (0.15% $CaCl_2$ extractable) status of the soils of all the blocks was above critical limit (10ppm). Highest available sulphur (102.90 mg kg^{-1}) lowest available S (2.10 mg kg^{-1}) status was observed in soils of Ranpur block (Fig.6). The mean available sulphur content in soils of different blocks of Nayagarh district ranged from 17.32 to 26.03 mg kg^{-1}. Most of the soils of Nayagarh district were adeguate in available sulphur(Sarkar *et al.* 2007, Das *et al.,* 2012, Singh 2015). The mean value of hot water soluble boron content in Ranpur, Nayagarh, Gania and Daspalla was above the critical limits (>0.5 ppm) whereas Khandapada, Bhapur, Odogaon and Nuagaon below critical limit. Highest (3.08 mg kg^{-1}) and lowest (0.09 mg kg^{-1}) hot water soluble boron content was observed in soils of Khandapada block (Fig. 7).

Table 3. Available sulphur and hot water soluble boron content in soils of Nayagarh district

Block name	Sulphur (mg kg^{-1})		Boron (mg kg^{-1})	
	Range	Mean	Range	Mean
Khandapada (84)	2.45-93.45	17.32	0.09-3.08	0.46
Ranpur (108)	2.10-102.90	23.39	0.18-1.15	0.74
Nayagarh (66)	4.20-85.75	21.25	0.32-1.15	0.66
Gania (36)	7.70-52.15	23.70	0.36-1.05	0.70
Bhapur (36)	7.70-51.10	22.92	0.18-1.19	0.44
Odagaon (96)	10.50-26.03	26.03	0.14-0.73	0.38
Nuagaon (72)	4.55-40.60	22.93	0.14-0.73	0.41
Daspalla (78)	3.50-40.60	19.99	0.18-1.10	0.50

Figures given in the parenthesis are number of collected soil samples

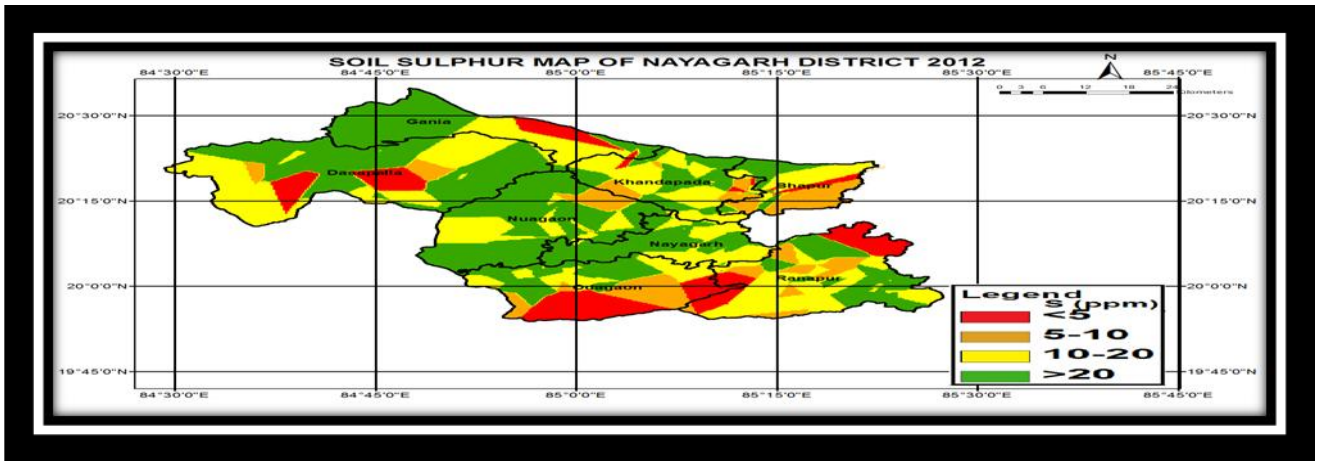

Fig.6: GPS and GIS based available sulphur content map of Nayagarh district

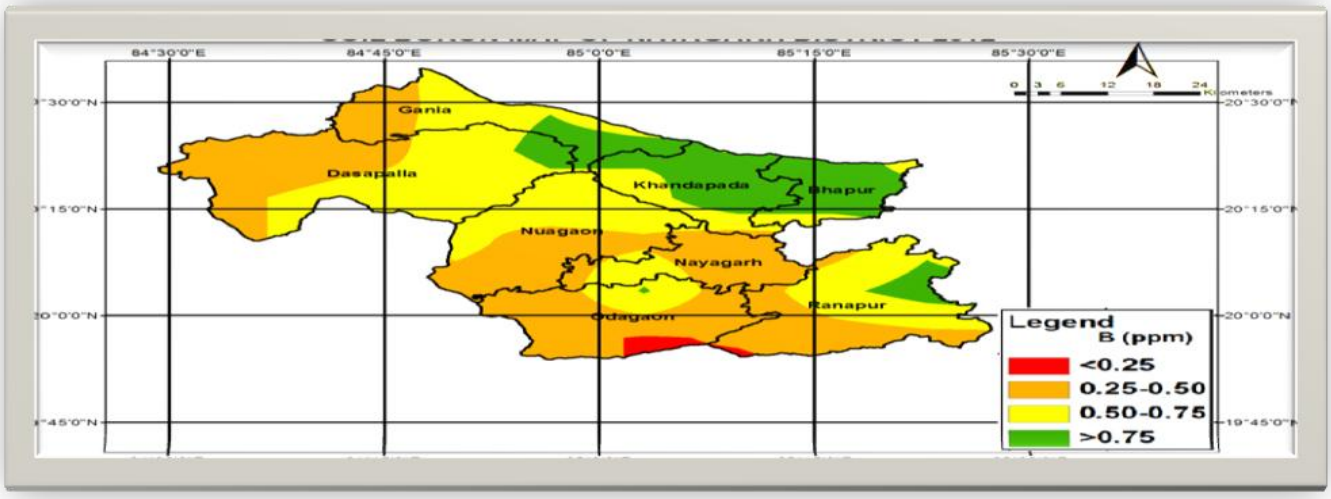

Fig.7: GPS and GIS based hot water soluble boron status map of Nayagarh district

Similar findings were reported by Mitra *et al.* (2002). The mean available boron in soils of different blocks of Nayagarh district ranged from 0.38 to 0.74 mg kg^{-1}. The lowest and highest mean values of available boron were recorded in soils of Odagaon and Ranpur block respectively. It can be concluded that these soils were acidic in soil reaction and low to medium in organic carbonstatus. Available nitrogen and phosphorus contents were low whereas, potassium was medium. On the other hand, the status of available sulphur of most of the blocks was high. Hot water soluble boron content was adequate in the soils of Nayagarh district. The soil fertility maps were prepared which are useful for planning, monitoring and sustainable crop production.

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REFERENCES

Das, D.K. (2000) Boron. In *Micronutrients: Their behaviour in Soils and Plants.* Kalyani Publishers, Ludhiana, pp. 127-155.

Das, D.K. (2004) Role of geoinformatics in sustainable agriculture: Research, extension and service to the farmers. Chairman's address. In: *Proceedings of the symposium Geoinformatics Applications for Sustainable Development*, 1-11, *Indian Society of Agrophysics*, IARI, New Delhi.

Das, D.K., Bandyopadhyay, S., Chakraborty, D. and Srivastava, Rajeev. (2009) Application of modern techniques in characterization and management of soil and water Resources, *Journal of the Indian Society of Soil Science* 57(4): 445-460.

Das, K.N., Basumatari, A. and Borkotoki, B. (2012) Forms of sulphur in some rapeseed-growing soils of Assam. *Journal of the Indian society of Soil Science.* **60**, 13-19.

FAO. (1996). The digitized soils map of the World including derived soil properties, FAO, Rome.

Jackson, M.L. (1973) Soil Chemical Analysis Prentice Hall of India Private Limited, New Delhi.

Kanwar, J.S. (2000) Soil and Water resources management for sustainable agriculture-imperatives from India. In: Development and Conservation. Int. Conf. Agricultural Production in 21st Century. Feb.14-18, New Delhi, pp 17-37.

Mandal, A.K. and Sharma, R.C. (2010) Computerized Database of Salt-affected Soils in Peninsular India using Geographic Information System. *Journal of the Indian Society of Soil Science* 58(1): 105-116.

Mandal, D., Deeg, S.K. and Baruah, T.C. (2013) status of major nutrients in rubber soils of north-east India in relation to soil acidity. Annals of plant and soil research 15(1) : 23-26.

Mishra, Antaryami., Das, D. and Saren, S. (2013) Preparation of GPS and GIS based soil fertility maps for Khurda district, Odisha. *Indian Agriculturist* **57**(1):11-20.

Mitra, G.N., Mishra, U.K. and Sahu, S.K. (2002) *Macro and micronutrient status of the soils of Orissa*, IFFCO, Kolkata.

Mitra, G.N., Rout, K.K. and Sahu, S.K. (2006) Nutrient status of soils of Orissa, In: *Nutrient Management of Crops in Soils of Orissa*, Editor: G.N.Mitra, pp.19-44.

Sahu, G.C. (2006) Nutrient status of soils of Orissa, In: *Nutrient Management of Crops in Soils of Orissa*, Editor: G.N. Mitra, pp.1-18.

Sarkar, M., Ghosh, S.K., Mukhopadhyay, P. and Pal, S.K. (2007) Distribution os sulphur and its relationship with soil properties in some soil series (Alfisols) of West Bengal. *Agropedology* 17: 113-117.

Singh, S. (2015) Forms of sulphur in relation to soil properties under pearl millet cultivation in soils of Agra, Uttar Pradesh. Annals of Plant and soil research 17(4) : 362-365