Status of different forms of Nitrogen in soils of Navsari district of South Gujarat, India

Abstract:

To study the nitrogen fraction under different cropping and management system, the present investigation was carried out at NAU, Navsari (Gujarat) during year 2022-2023. From each taluka of Navsari district, ten soil samples were collected randomly from 0-15 cm and 15-30 cm depth by using different cropping and management systems by GIS base grid sampling method. Soil samples were subjected to preliminary analysis for pH, EC, SOC and then analysis of different N-fractions was carried out. Nitrogen is one of the main limiting factors of crop productivity and many studies have sought possibilities to reduce the need for N application and extend the period of availability to plants. Organic N forms constitute up to 90% of the total N in the plow layer of mineral soils and only about 1–4% is mineralized as plant- available N (NH_4–N and NO_3–N). Plant-available N released from soil organic N (SON) or applied in fertilizer is highly susceptible to loss from the soil– plant system through leaching and denitrification. The overall distribution of avail. N, NO_3-N, NH_4-N and total N in Navsari district was ranged from 72.80 to 375.20 mg kg^{-1}, 5.60 to 92.40 mg kg^{-1}, 30.80 to 114.80 mg kg^{-1} and 140.00 to 1036.00 mg kg^{-1}, respectively for surface soils while, 61.60 to 364.00 mg kg^{-1}, 8.40 to 72.80 mg kg^{-1}, 25.20 to 100.80 mg kg^{-1} and 140.00 to 924.00 mg kg^{-1} for sub-surface soils, respectively. At surface layer, total N was correlated significantly and positively with SOC, CEC and it was negatively correlated with pH and EC. However, total N showed similar correlation with SOC and EC at sub-surface layer. NH_4-N and NO_3-N were positively and significantly correlated with each other at the same depth. The result also revealed that the N fractions were significantly decreased with increasing depth of soil. Overall, our findings suggest that vegetation restoration improved the soil N availability.

Keywords: GIS, N-fractions, Organic N, NH_4–N, NO_3–N.

Introduction:

Soil is an important dynamic natural body that supports all sorts of living things on the earth. It is the most precious natural resource for plant growth and development. Soils, in general, are degrading day by day due to poor management and faulty land-use practices at a rate faster than their natural degeneration. Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is one of the main limiting factors of crop productivity and many studies have sought possibilities to reduce the need for N application and extend the period of availability to plants. Organic N forms constitute up to 90% of the total N in the plow layer of mineral soils and only about 1–4% is mineralized as plant- available N (NH_4–N and NO_3-N). Plant-available N released from soil organic N (SON) or applied in fertilizer is highly susceptible to loss from the soil– plant system through leaching and denitrification. The main sources of N for plant are mineralization of soil organic matter, inorganic fertilizers and organic inputs. Although some plants acquire N from the air by symbiotic N fixation, most plant species rely on uptake of nitrate (NO_3^-) and ammonium (NH_4^+) from the soil solution (Blackmer, 2000).

N-fertilizer recommendations have often been made on the basis of cropping or economics factor rather than soil testing (Mulvaney *et al*., 2001). However, N mineralization studies have largely been confined to the top soil although plants also utilize N from deeper horizons. The topsoil has the largest N mineralization due to higher contents of crop residues, easily decomposable organic matter, the greatest microbial biomass and activity (Soudi *et al*., 1990). However, other studies have shown that a significant proportion of N mineralization occurs in sub soil also (Patra *et al*., 1999).

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Soil is majorly bound with inorganic (NO_2^-, NO_3^-, non-exchangeable (mineral-fixed) NH_4^+, exchangeable NH_4^+, nitrous oxide (N_2O) and dinitrogen gas (N_2)) and organic forms (amino acids, amino sugars and nucleic acid bases) of Nitrogen. Soil N amount depends upon N_2 fixation through microorganisms, losses from leaching and crop removal, volatilization and Emission of N_2O and N_2. Initially NH_4^+ conversion is processed through ammonification followed by the conversion of nitrite to nitrate through nitrification process. (Shafreen *et al.*, 2021).

Methodology:

Location

Gujarat is situated on the west coast of India and lies between 20001' and 24000' North latitude and 68004' and 74004' East longitude. Navsari district is located between 20007' and 21000' North latitude and 72043' and 73000' East longitude. From each taluka of Navsari district, ten soil samples were collected randomly from 0-15 cm and 15-30 cm depth in the year 2022-2023. Out of eight agro-climatic zones of Gujarat state Navsari district comes under South Gujarat Heavy Rainfall Agro-climatic Zone. Net cultivable area of Navsari is 140.1 million ha. The samples were analyzed by using standard laboratory procedure. Locations (longitude and latitude) of sampling point were measured by using a global positioning system (GPS). Details of sampling locations are presented in Table 1.

Table-1:Sampling sites along with the coordinates.

Sr. No.	Sample location	Village	Longitude	Latitude	Sr. No.	Sample location	Village	Longitude	Latitude
1.	Navsari	Vejalpor	2100.226	7258.017	31.	Khergam	Vaad	2040.487	7305.443
2.		Aamadpor	2058.153	7258.092	32.		Panaj	2039.557	7307.149
3.		Tarsadi	2058.148	7300.448	33.		Panikhadak	2038.554	7310.272
4.		Ugat	2056.530	7304.304	34.		Jamanpada	2038.050	7310.226
5.		Nagdhara	2054.362	7305.311	35.		Vadpada	2036.521	7309.055
6.		Boriyach	2052.557	7303.018	36.		Pati	2035.528	7311.432
7.		Ashtgaam	2053.194	7302.359	37.		Debarpada	2037.356	7308.342
8.		Sisodra	2055.493	7259.094	38.		Bahej	2037.326	7307.031
9.		Adda	2054.234	7258.029	39.		Khergam	2037.257	7305.456
10.		Chhapara	2055.221	7255.526	40.		Naranpor	2036.230	7305.003
11.	Vansada	Sindhai	2055.227	7255.527	41.	Gandevi	Kotha	2049.043	7305.561
12.		Lachhakadi	2041.518	7320.492	42.		Ancheli	2049.150	7255.364
13.		Gangpur	2043.335	7319.393	43.		Amalsad	2048.596	7256.533
14.		Limjhar	2044.057	7318.008	44.		Desad	2047.594	7301.424
15.		Pipalkhed	2040.309	7316.430	45.		Gandeva	2051.460	7304.239
16.		Badmal	2037.407	7317.490	46.		Keshali	2046.578	7300.367
17.		hambhala	2043.593	7326.324	47.		Undhach	2044.445	7259.535
18.		haranwada	2046.108	7323.296	48.		Devsara	2046.574	7259.207
19.		Motivaljhar	2047.579	7318.413	49.		Bigari	2044.492	7256.227
20.		Kamboya	2047.322	7314.378	50.		Sonwadi	2044.483	7256.226
21.	Chikhli	Khambhada	2045.429	7307.430	51.	Jalalpore	Vesma	2103.104	7297.047
22.		Gholar	2042.270	7309.149	52.		Umbharat	2101.323	7244.221
23.		Godathal	2040.507	7312.379	53.		Mangrol	2059.231	7248.569
24.		Saravani	2043.213	7313.503	54.		Simalgam	2059.104	7250.580
25.		Rankuwa	2049.079	7309.177	55.		Tavdi	2059.415	7255.447
26.		Bodvank	2052.037	7308.500	56.		Kothamdi	2054.570	7252.704
27.		Pipalgabhan	2052.010	7308.503	57.		Chijgam	2052.157	7253.323
28.		Hond	2044.539	7302.123	58.		Sarav	2051.126	7256.274

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29.		Degaam	2048.068	7304.531	59.		Ponsara	2051.454	7256.105
30.		Chasa	2049.039	7305.568	60.		Hansapore	2054.224	7255.860

The standard methods were followed for determination of chemical properties and forms of N in soils which are given below.

Soil pH was determined in soil: water suspension (1:2.5) using pH meter (Jackson, 1973). Electrical conductivity was estimated from supernant solution of soil water suspension (1:2.5) by using conductivity bridge (Jackson, 1973). Modified method of Walkley and Black (1934) was used for determination of organic carbon.

For Nitrogen fraction, following methods were used:-

1. **Total Nitrogen:** Total N was determined by the Kjeldhal method (Jackson, 1973).
2. **Available nitrogen:** Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija, 1956).
3. **Ammonical nitrogen:** It was determined by Richardson's method (Richardson, 1938)
4. **Nitrate nitrogen:** It was determined after Olsen's extraction for ammonia (Olsen, 1929).

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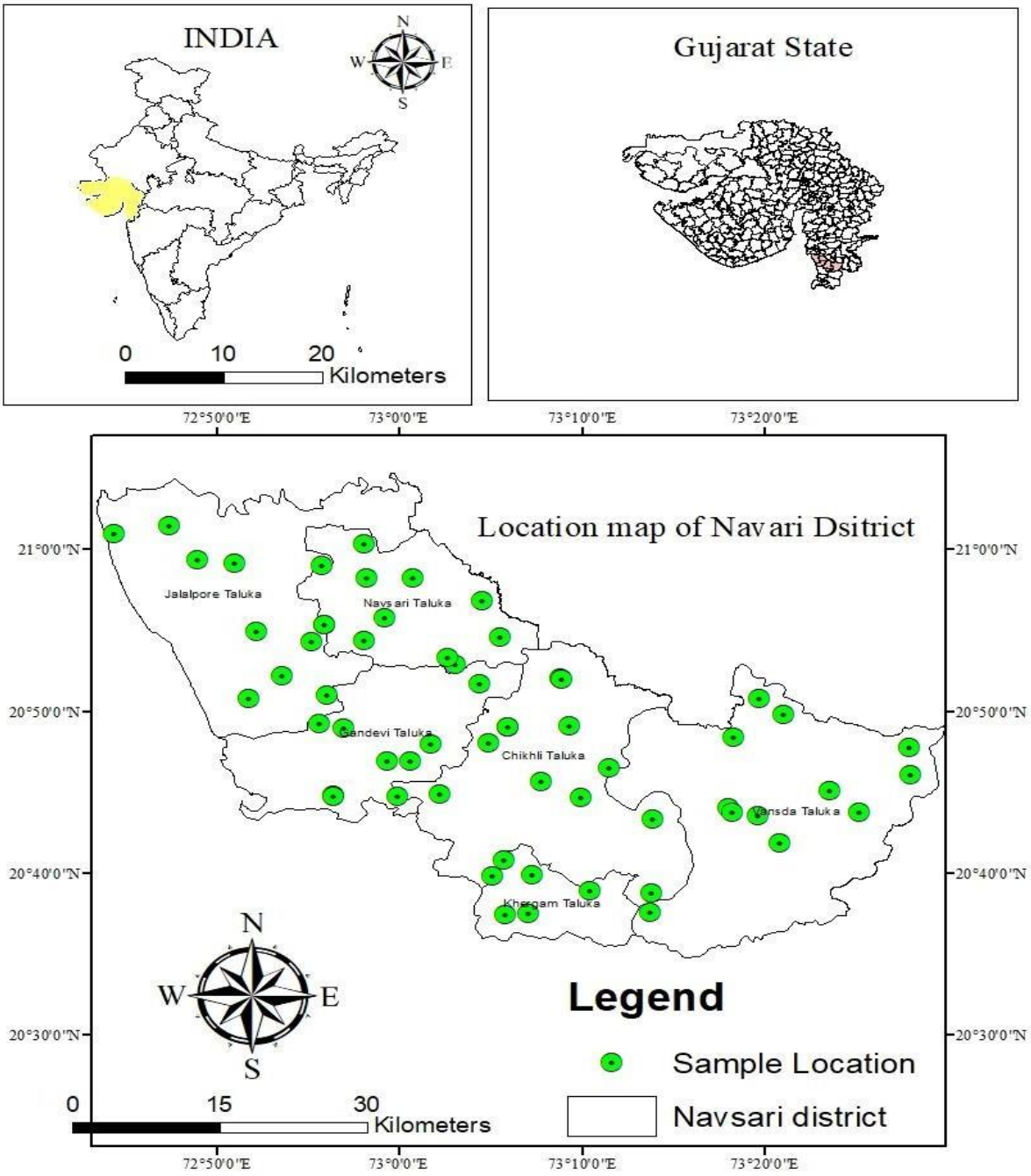

Fig.1 :- Locations map of sampling from various taluka of Navsari district

Results and Discussion:

In order to determine the nitrogen fractions of the soils from different six taluka of Navsari district, one hundred and twenty representative surface and sub surface soil samples were collected from different villages. Soil samples were analyzed for its chemical properties and nitrogen fractions. The correlation between chemical properties and different fractions of nitrogen in soil were also worked out. The results obtained after analysis are presented and discussed as below.

i) Soil analysis of pH, EC and OC of different Taluka of Navsari district

Taluka wise analysis of different soil parameters of surface and sub surface soil are given in Table 2 to 7.

The pH values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 7.10 to 8.37, 6.38 to 7.67, 6.89 to 8.07, 6.52 to 8.12,7.25 to 8.60 and 7.95 to 8.63 with an average value of 7.91, 6.80, 7.52, 7.29, 7.86 and 8.24 respectively in surface soil (0-15 cm) and 7.14 to 8.36, 6.42 to 7.90,

6.41 to 8.27, 6.10 to 8.03, 6.45 to 8.84 and 8.08 to 8.88 with an average value of 7.98,6.95, 7.53, 7.24, 7.80 and 8.47 respectively in surface soil (15-30 cm).

The EC (ds/m) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 0.12 to 0.26, 0.11 to 1.80, 0.11 to 0.25, 0.10 to 0.95,0.14 to 0.29 and 0.14 to 0.36 ds/m with an average value of 0.16, 0.69, 0.18, 0.26, 0.21 and 0.21 ds/m respectively in surface soil (0-15 cm) and 0.11 to 0.57, 0.15 to 2.31, 0.10 to 0.95, 0.11 to 0.81, 0.12 to 0.86 and 0.15 to 0.65 ds/m with an average value of 0.19, 0.85, 0.29, 0.23, 0.20 and 0.27 ds/m respectively in surface soil (15-30cm).

Result revealed that irrespective of different cropping and management systems mean soil pH was found lower in surface soil and higher in sub surface soil of different taluka of Navsari district. The Highest average soil pH was found in Jalalpore taluka at 0-15 and 15-30 cm depth followed by Navsari taluka. The increase in pH in sub surface soil might be due to leaching and accumulation of basic cations in the lower depth of the profiles (Kumar *et al.* 2012). The results of present study corroborated the findings of Datta *et al.* (2015).Similar results were found in case of EC of soils under different cropping and management systems. The result also showed that pH was positively and significantly correlated with EC at 1 % level of significance while.

The OC (%) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 0.37 to 0.89, 0.59 to 1.20, 0.51 to 0.95, 0.52 to 0.85,0.50 to 0.97 and 0.34 to 0.76 % with an average value of 0.70, 0.83, 0.69, 0.67,0.73 and 0.54 % respectively in surface soil (0-15 cm) and 0.25 to 0.73, 0.37 to 0.91, 0.21 to 0.60, 0.40 to 0.75, 0.27 to 0.78 and 0.22 to 0.66 % with an average value of 0.54, 0.60, 0.41, 0.54, 0.48 and 0.36 %respectively in surface soil (15-30 cm).The results pertaining to soil organic carbon at surface and sub-surface layer of soil clearly showed that soil organic carbon in soils of different cropping and management systems at both the depth were low to medium in range except some cropping and management systems. The results further showed that highest average organic carbon at 0-15 cm and 15-30 cm depth was recorded in soils of Vansda taluka (0.83 % and 0.60 %) followed by soils of Gandevi taluka (0.73 % and 0.48 %) respectively. These results had shown resemblance with the findings of Behera *et al.* (2015). This is due to the continuous accumulation of organic matter to the soil. Similar results were obtained by Manjaiah *et al.* (2000). The results were in accordance with findings made by Bhavya *et al.* (2018). The soil organic carbon content decreased with depth, similar findings are made by Sarkar *et al.* (2002).

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Table-2: Soil analysis of pH, EC and OC of Navsari Taluka

Village	pH		EC(dS/m)		OC(%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Vejalpor	8.21	8.25	0.19	0.15	0.37	0.25
Aamadpor	8.05	8.06	0.13	0.11	0.66	0.57
Tarsadi	8.37	8.36	0.15	0.17	0.62	0.41
Ugat	7.40	7.75	0.26	0.15	0.79	0.44
Nagdhara	7.10	7.14	0.13	0.11	0.63	0.38
Boriyach	7.84	8.14	0.12	0.57	0.73	0.71
Ashtgaam	8.01	7.91	0.15	0.20	0.76	0.73
Sisodra	7.74	8.05	0.14	0.16	0.89	0.59
Adda	8.20	8.18	0.18	0.17	0.78	0.72
Chhapara	8.17	7.98	0.15	0.14	0.77	0.59

Max.	8.37	8.36	0.26	0.57	0.89	0.73
Min.	7.10	7.14	0.12	0.11	0.37	0.25
Avg.	7.91	7.98	0.16	0.19	0.70	0.54
Std. dev.	0.40	0.34	0.04	0.14	0.14	0.16

Table-3: Soil analysis of pH, EC and OC of Vansda Taluka

Village	pH		EC(dS/m)		OC (%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Sindhai	6.70	7.02	0.12	0.15	0.64	0.46
Lachhakadi	6.77	6.70	1.80	1.49	0.59	0.48
Gangpur	7.67	7.37	0.11	0.15	0.87	0.37
Limjhar	6.74	6.68	0.23	0.57	1.02	0.87
Pipalkhed	7.11	7.00	1.04	2.31	0.82	0.52
Badmal	6.70	6.76	0.83	0.96	1.20	0.91
Khambhala	6.47	6.62	0.93	0.42	0.87	0.58
Charanwada	6.38	6.42	1.02	0.72	0.83	0.62
Motivaljhar	6.96	6.98	0.28	0.98	0.61	0.56
Kamboya	6.54	7.90	0.51	0.71	0.88	0.65
Max.	7.67	7.90	1.80	2.31	1.20	0.91
Min.	6.38	6.42	0.11	0.15	0.59	0.37
Avg.	6.80	6.95	0.69	0.85	0.83	0.60
Std. dev.	0.37	0.43	0.54	0.65	0.19	0.17

Table-4: Soil analysis of pH, EC and OC of Chikhli Taluka

Village	pH		EC(dS/m)		OC(%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Khambhada	7.10	6.59	0.19	0.55	0.66	0.25
Gholar	6.95	6.41	0.16	0.30	0.66	0.35
Godathal	7.64	6.66	0.20	0.21	0.75	0.58
Saravani	6.98	7.54	0.18	0.15	0.64	0.60
Rankuwa	6.89	7.42	0.17	0.10	0.78	0.57
Bodvank	7.84	8.27	0.14	0.13	0.51	0.24
Pipalgabhan	8.03	8.07	0.18	0.13	0.63	0.47
Hond	7.89	8.15	0.11	0.95	0.63	0.21
Degaam	8.07	8.13	0.19	0.17	0.64	0.41
Chasa	7.83	8.08	0.25	0.19	0.95	0.44
Max.	8.07	8.27	0.25	0.95	0.95	0.60
Min.	6.89	6.41	0.11	0.10	0.51	0.21
Avg.	7.52	7.53	0.18	0.29	0.69	0.41
Std. dev.	0.48	0.73	0.04	0.27	0.12	0.15

Table-5: Soil analysis of pH, EC and OC of Khergam Taluka

Village	pH		EC(dS/m)		OC(%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Vaad	8.05	8.03	0.24	0.20	0.62	0.56
Panaj	8.12	7.73	0.34	0.16	0.70	0.50
Panikhadak	6.57	6.67	0.95	0.81	0.59	0.62
Jamanpada	6.81	6.31	0.13	0.11	0.85	0.75
Vadpada	6.52	6.38	0.13	0.20	0.52	0.40
Pati	7.22	7.54	0.16	0.16	0.55	0.40
Debarpada	7.79	6.10	0.25	0.25	0.80	0.67
Bahej	7.95	7.95	0.14	0.17	0.70	0.41
Khergam	6.66	7.76	0.10	0.12	0.81	0.67
Naranpor	7.24	7.97	0.19	0.11	0.54	0.43
Max.	8.12	8.03	0.95	0.81	0.85	0.75
Min.	6.52	6.10	0.10	0.11	0.52	0.40
Avg.	7.29	7.24	0.26	0.23	0.67	0.54

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Std. dev.	0.64	0.78	0.25	0.21	0.12	0.13

Table-6:Soil analysis of pH, EC and OC of Gandevi Taluka

Village	pH		EC(dS/m)		OC(%)	
	0-15cm	**15-30cm**	**0-15cm**	**15-30cm**	**0-15cm**	**15-30cm**
Kotha	7.62	7.42	0.19	0.26	0.66	0.33
Ancheli	8.60	8.84	0.25	0.36	0.85	0.49
Amalsad	7.37	7.93	0.14	0.12	0.79	0.60
Desad	7.77	7.62	0.23	0.15	0.97	0.78
Gandeva	8.01	8.34	0.15	0.17	0.62	0.46
Keshali	8.02	8.12	0.19	0.15	0.65	0.39
Undhach	8.06	7.72	0.29	0.22	0.50	0.44
Devsara	8.31	8..36	0.21	0.22	0.69	0.63
Bigari	7.59	7.72	0.20	0.17	0.75	0.40
Sonwadi	7.25	6.45	0.20	0.18	0.80	0.27
Max.	8.60	8.84	0.29	0.36	0.97	0.78
Min.	7.25	6.45	0.14	0.12	0.50	0.27
Avg.	7.86	7.80	0.21	0.20	0.73	0.48
Std. dev.	0.42	0.66	0.04	0.07	0.13	0.15

Table-7:Soil analysis of pH, EC and OC of Jalalpore Taluka

Village	pH		EC(dS/m)		OC(%)	
	0-15cm	**15-30cm**	**0-15cm**	**15-30cm**	**0-15cm**	**15-30cm**
Vesma	7.96	8.29	0.18	0.18	0.44	0.30
Umbharat	8.06	8.62	0.19	0.17	0.60	0.55
Mangrol	8.18	8.21	0.14	0.21	0.76	0.66
Simalgam	8.41	8.60	0.18	0.15	0.34	0.23
Tavdi	7.95	8.08	0.19	0.31	0.52	0.43
Kothamdi	8.31	8.41	0.18	0.30	0.63	0.32
Chijgam	8.63	8.88	0.36	0.65	0.52	0.34
Sarav	8.14	8.56	0.19	0.22	0.40	0.26
Ponsara	8.38	8.55	0.21	0.21	0.73	0.30
Hansapore	8.37	8.49	0.30	0.26	0.46	0.22
Max.	8.63	8.88	0.36	0.65	0.76	0.66
Min.	7.95	8.08	0.14	0.15	0.34	0.22
Avg.	8.24	8.47	0.21	0.27	0.54	0.36
Std. dev.	0.22	0.23	0.07	0.14	0.14	0.14

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Analysis of different forms of Soil-Nitrogen of different Taluka of Navsari district

Taluka wise analysis of different forms of soil nitrogen of surface and sub surface soil is given in Table 8 to 13.

The available N (mg kg^{-1}) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 114.80 to 176.40, 151.20 to 375.20, 78.40 to 193.20, 131.60 to 224.00, 72.80 to 120.40 and 81.20 to 112.00 mg kg^{-1} with an average value of 145.30, 234.64, 133.45, 182.00, 104.16 and 98.56 mg kg^{-1} respectively in surface soil (0-15cm) and 75.58 to 142.77, 72.80 to 364.00, 78.40 to 165.20, 78.40 to 207.20, 78.40 to 109.20 and 61.60 to 109.20 mg kg^{-1} with an average value of 117.58, 225.12, 113.12, 132.27, 90.16 and 81.76 mg kg^{-1} respectively in sub- surface soil. The results showed that the highest average available N was found in soil of Vansda taluka (234.64, 225.12 mg kg^{-1}) at 0-15 cm and 15-30 cm, respectively. Considering the mean value of available N fraction under different cropping and management systems, higher mean value of available N was found in surface soils over sub surface soils. This result was corroborated with findings of Purnananda *et al.* (2017). The decrease in available N with increase in soil depth may be due to presence of higher organic matter content and favorable environmental conditions for mineralization at surface than sub-surface layers. Similar type of results were also found by Ranjha *et al.* (2002) and Singh and Rathore (2013).

The NO_3^-N (mg kg^{-1}) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 28.00 to 56.00, 22.40 to 50.40, 11.20 to 50.40, 5.60 to 92.40, 19.60 to 72.80 and 44.80 to 78.40 mg kg^{-1} with an average value of 36.68,37.24, 28.56, 24.36, 38.64 and 63.00 mg kg^{-1} respectively in surface soil (0-15cm) and 22.40 to 50.40, 14.00 to 39.20, 8.40 to 56.00, 11.20 to 58.80, 16.80 to 42.00 and 25.20 to 72.80 mg $kg^{-1}$with an average value of 29.40, 29.12, 26.88, 30.80, 25.76 and50.68 mg kg^{-1} respectively in sub-surface soil (15-30cm). The results showed that the highest average NO_3-N was found in soil of Jalalpore taluka (63.00, 50.68 mg kg^{-1}) at 0-15 cm and 15-30 cm, respectively. Comparing the mean value of NO_3- N under different cropping and management systems at different depth, higher NO_3-N was observed at surface soils than sub surface soils. A relatively higher content of nitrate nitrogen in surface soils is due to high nitrification and higher loss of NO_3-N through leaching down sub-surface soil (Purnananda *et al.*, 2017). These observations are similar to those of Puranik *et al.* (1978). The results of correlation have shown that NO_3-N possessed significant and positive correlation with NH_4-N only at 0-15 cm depth at 5 % level of significance.

The NH_4-N (mg kg^{-1}) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 50.40 to 114.80, 58.80 to 98.00, 58.80 to 92.40,30.80 to 72.80, 36.40 to 92.40 and 64.40 to 103.60 mg $kg^{-1}$with an average value of 91.28, 82.04, 68.88, 62.72, 61.88 and 89.32 mg kg^{-1}respectively in surface soil (0- 15cm) and 72.80 to 100.80, 53.20 to 95.20, 42.00 to 84.00, 25.20 to 61.60, 28.00 to 86.80 and 64.40 to 84.00 mg $kg^{-1}$with an average value of 83.16, 71.96, 58.80, 49.00,49.84 and 75.04 mg kg^{-1}respectively in sub-surface soil (15-30cm).The results related to NH_4-N content in soil at surface and sub surface soils under different cropping and management systems revealed that higher mean value of NH_4-N was recorded in surface soils than sub surface soil. The values regarding correlation at surface layer had showed that of significant positive correlation between NH_4-N and NO_3-N at 5 % level of significance. However, in case of sub-surface layer it was observed that there was a non-significant correlation was found between NH_4-N and all the soil properties (pH, EC, SOC) as well as fractions of major nutrients at surface layer

The total N (mg kg^{-1}) values in Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore taluka ranged from 224.00 to 896.00, 280.00 to 1036.00, 308.00 to 952.00, 280.00 to 840.00, 140.00 to 952.00 and 364.00 to 784.00 mg kg^{-1} with an average value of 473.20, 540.40, 520.80, 456.40, 414.40 and 548.00 mg kg^{-1} respectively in surface soil (0-15cm) and 140.00 to 644.00, 252.00 to 924.00, 224.00 to 784.00, 336.00 to 784.00, 168.00 to 868.00 and 252.00 to 616.00 mg kg^{-1} with an average value of 378.00, 490.00, 448.00, 540.40, 383.60 and 487.20 mg kg^{-1} respectively in sub-surface soil. The data pertaining to total N indicated that higher mean value of total N was observed in surface soil

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than sub surface soils. The results further showed that among the different cropping and management systems, highest total N was found in soils of Jalalpore (548 mg kg^{-1} and Vansda (490 mg kg^{-1}) at 0-15 cm and 15-30 cm depth respectively. The higher total N content in organic farm may be attributed to the presence of high organic matter content (1.02-1.74%) in these soils. The results further indicated that decrement in total N content of soil at 0-15 cm and 15-30 cm over its respective highest value occupied cropping and management systems. The correlation of different properties of soil with total nitrogen was found in agreement with result obtained by Dhamak *et al*. (2014).

The overall distribution of avail. N, NO_3-N, NH_4-N and total N in Navsari district was ranged from 72.80 to 375.20 mg kg^{-1}, 5.60 to 92.40 mg kg^{-1}, 30.80 to 114.80 mg kg^{-1} and 140.00 to 1036.00 mg kg^{-1}, respectively for surface soils while, 61.60 to 364.00 mg kg^{-1}, 8.40 to 72.80 mg kg^{-1}, 25.20 to 100.80 mg kg^{-1} and 140.00 to 924.00 mg kg^{-1} for sub-surface soils, respectively (Table 14).

The data regarding correlation among various N fractions, revealed that available N was significantly correlated with total N at 1 % and 5 % level of significance at 0-15 cm and 15-30 cm depth respectively. The results of correlation have shown that NO_3-N possessed significant and positive correlation with NH_4-N at both 0-15 cm and 15-30 cm depth at 5 % level of significance.

Table-8: Analysis of different N fractions (mg kg^{-1}) of Soil of Navsari Taluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	15-30 cm	15-30cm	0-15 cm	15-30 cm
Vejalpor	114.80	92.37	30.80	28.00	61.60	81.20	280.00	252.00
Aamadpor	140.00	117.59	39.20	33.60	50.40	78.40	420.00	364.00
Tarsadi	153.97	75.58	30.80	22.40	103.60	84.00	364.00	280.00
Ugat	173.57	111.96	44.80	25.20	114.80	100.80	644.00	336.00
Nagdhara	137.19	142.77	36.40	28.00	106.40	78.40	728.00	644.00
Boriyach	153.97	134.42	33.60	25.20	112.00	84.00	336.00	364.00
Ashtgaam	131.56	120.36	56.00	50.40	95.20	89.60	392.00	364.00
Sisodra	145.58	125.98	39.20	25.20	86.80	75.60	448.00	420.00
Adda	176.40	137.19	28.00	30.80	98.00	72.80	896.00	616.00
Chhapara	125.98	117.59	28.00	25.20	84.00	86.80	224.00	140.00
Max.	176.40	142.77	56.00	50.40	114.80	100.80	896.00	644.00
Min.	114.80	75.58	28.00	22.40	50.40	72.80	224.00	140.00
Avg.	145.30	117.58	36.68	29.40	91.28	83.16	473.20	378.00
Std. dev.	19.73	20.58	8.70	8.06	21.21	8.03	214.24	154.07

Table-9: Analysis of different N fractions (mg kg^{-1}) of Soil of Vansda Taluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Sindhai	151.20	72.80	44.80	28.00	86.80	75.60	280.00	252.00
Lachhakadi	156.80	238.00	25.20	36.40	67.20	64.40	336.00	308.00
Gangpur	215.60	190.36	36.40	22.40	98.00	95.20	364.00	336.00
Limjhar	182.00	207.20	47.60	28.00	89.60	72.80	392.00	364.00
Pipalkhed	210.00	190.40	33.60	22.40	86.80	78.40	420.00	392.00
Badmal	375.20	313.60	50.40	39.20	92.40	70.00	980.00	924.00
Khambhala	347.21	364.00	22.40	14.00	95.20	58.80	1036.00	700.00
Charanwada	288.40	282.80	30.80	25.20	70.00	78.40	812.00	896.00
Motivaljhar	162.40	148.40	30.80	36.40	75.60	72.80	364.00	420.00
Kamboya	257.60	243.60	50.40	39.20	58.80	53.20	420.00	308.00
Max.	375.20	364.00	50.40	39.20	98.00	95.20	1036.00	924.00
Min.	151.20	72.80	22.40	14.00	58.80	53.20	280.00	252.00
Avg.	234.64	225.12	37.24	29.12	82.04	71.96	540.40	490.00
Std. dev.	80.16	83.52	10.40	8.47	13.27	11.66	285.87	252.60

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Table-10: Analysis of different N fractions (mg kg-1) of Soil of Chikhli Taluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Khambhada	78.40	89.60	33.60	28.00	67.20	58.80	420.00	308.00
Gholar	92.40	140.00	42.00	39.20	70.00	47.60	308.00	224.00
Godathal	151.20	165.20	39.20	14.00	58.80	50.40	392.00	420.00
Saravani	106.40	78.40	16.80	11.20	67.20	56.00	420.00	336.00
Rankuwa	173.60	86.80	16.80	36.40	81.20	84.00	392.00	532.00
Bodvank	105.29	98.00	22.40	36.40	58.80	53.20	644.00	420.00
Pipalgabhan	140.00	100.80	11.20	19.60	64.40	42.00	392.00	336.00
Hond	176.40	145.60	25.20	56.00	70.00	64.40	644.00	616.00
Degaam	117.60	84.00	28.00	19.60	58.80	47.60	952.00	784.00
Chasa	193.20	142.80	50.40	8.40	92.40	84.00	644.00	504.00
Max.	193.20	165.20	50.40	56.00	92.40	84.00	952.00	784.00
Min.	78.40	78.40	11.20	8.40	58.80	42.00	308.00	224.00
Avg.	133.45	113.12	28.56	26.88	68.88	58.80	520.80	448.00
Std. dev.	39.27	31.71	12.58	15.06	10.74	14.70	196.31	165.91

Table-11: Analysis of different N fractions (mg kg^{-1}) of Soil of KhergamTaluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Vaad	221.20	126.00	30.80	25.20	70.00	50.40	364.00	504.00
Panaj	182.00	145.60	11.20	33.60	72.80	58.80	392.00	392.00
Panikhadak	154.00	131.60	16.80	14.00	64.40	47.60	420.00	560.00
Jamanpada	154.00	132.66	28.00	58.80	70.00	42.00	476.00	616.00
Vadpada	182.00	126.00	11.20	30.80	67.20	56.00	392.00	532.00
Pati	190.40	159.60	92.40	42.00	72.80	47.60	448.00	700.00
Debarpada	224.00	120.40	19.60	11.20	30.80	25.20	420.00	448.00
Bahej	159.60	78.40	16.80	22.40	58.80	61.60	280.00	532.00
Khergam	221.20	95.20	11.20	28.00	64.40	50.40	840.00	784.00
Naranpor	131.60	207.20	5.60	42.00	56.00	50.40	532.00	336.00
Max.	224.00	207.20	92.40	58.80	72.80	61.60	840.00	784.00
Min.	131.60	78.40	5.60	11.20	30.80	25.20	280.00	336.00
Avg.	182.00	132.27	24.36	30.80	62.72	49.00	456.40	540.40
Std. dev.	32.52	35.02	25.15	14.22	12.54	10.16	150.52	135.29

Table-12: Analysis of different N fractions (mg kg-1) of Soil of GandeviTaluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Kotha	72.80	98.00	58.80	42.00	84.00	86.80	196.00	168.00
Ancheli	106.40	84.00	22.40	30.80	53.20	33.60	196.00	224.00
Amalsad	92.40	78.40	19.60	16.80	47.60	50.40	728.00	868.00
Desad	98.00	95.20	72.80	30.80	42.00	44.80	252.00	308.00
Gandeva	120.40	89.60	42.00	16.80	47.60	36.40	364.00	252.00
Keshali	109.20	89.60	28.00	22.40	36.40	28.00	952.00	672.00
Undhach	112.00	86.80	42.00	30.80	72.80	50.40	364.00	364.00
Devsara	103.60	81.20	28.00	19.60	92.40	56.00	140.00	252.00
Bigari	112.00	109.20	33.60	16.80	81.20	58.80	420.00	308.00
Sonwadi	114.80	89.60	39.20	30.80	61.60	53.20	532.00	420.00
Max.	120.40	109.20	72.80	42.00	92.40	86.80	952.00	868.00
Min.	72.80	78.40	19.60	16.80	36.40	28.00	140.00	168.00
Avg.	104.16	90.16	38.64	25.76	61.88	49.84	414.40	383.60
Std. dev.	13.70	8.93	16.58	8.53	19.55	16.48	258.92	220.49

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Table-13: Analysis of different N fractions (mg kg^{-1}) of Soil of Jalalpore Taluka

Village	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Vesma	100.80	109.20	44.80	72.80	95.20	84.00	784.00	616.00
Umbharat	112.00	61.60	70.00	67.20	64.40	72.80	364.00	308.00
Mangrol	95.20	70.00	58.80	33.60	89.60	64.40	504.00	532.00
Simalgam	81.20	64.40	67.20	53.20	72.80	81.20	672.00	616.00
Tavdi	103.60	92.40	67.20	50.40	89.60	75.60	420.00	336.00
Kothamdi	103.60	75.60	70.00	33.60	103.60	67.20	588.00	532.00
Chijgam	86.80	81.20	58.80	47.60	92.40	70.00	644.00	588.00
Sarav	103.60	89.60	67.20	53.20	81.20	75.60	672.00	616.00
Ponsara	112.00	98.00	78.40	70.00	100.80	84.00	448.00	476.00
Hansapore	86.80	75.60	47.60	25.20	103.60	75.60	392.00	252.00
Max.	112.00	109.20	78.40	72.80	103.60	84.00	784.00	616.00
Min.	81.20	61.60	44.80	25.20	64.40	64.40	364.00	252.00
Avg.	98.56	81.76	63.00	50.68	89.32	75.04	548.80	487.20
Std. dev.	10.71	15.32	10.50	16.30	13.10	6.70	142.89	139.19

Table-14: Different forms of N of Soil of Navsari district

	Avail. N(mg kg^{-1})		NO_3-N (mg kg^{-1})		NH_4-N (mg kg^{-1})		Total N(mg kg^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Max.	375.201	364.000	92.400	72.800	114.800	100.800	1036.000	924.000
Min.	72.799	61.598	5.600	8.400	30.800	25.200	140.000	140.000
Avg.	149.685	126.667	38.080	32.107	76.020	64.633	492.333	454.533

Table 15: Simple correlation between various forms of Nitrogen at 0-15 cm and 15-30 cm

	Avl.N (0-15)	Total-N (0-15)	NH_4-N (0-15)	NO_3-N (0-15)	Avl N (15-30)	Total-N (15-30)	NH_4-N (15-30)	NO_3-N(15-30)
Avl.N(0-15)	1							
Total-N(0-15)	.363**	1						
$NH4^+$-N(0-15)	0.0910	0.0790	1					
NO_3-N(0-15)	-0.2120	-0.0440	.308*	1				
AvlN(15-30)	.816**	.326*	0.1060	-0.1340	1			
Total-N(15-30)	.423**	.818**	-0.0350	-0.0330	.283*	1		
NH_4^+-N(15-30)	0.0260	-0.0230	.750**	.314*	0.0470	-0.1170	1	
NO_3^-N(15-30)	-0.2180	0.0450	0.1640	.484**	-0.0990	0.0750	.269*	1

Note: (*)-5% level of significance and (**)-1% level of significance

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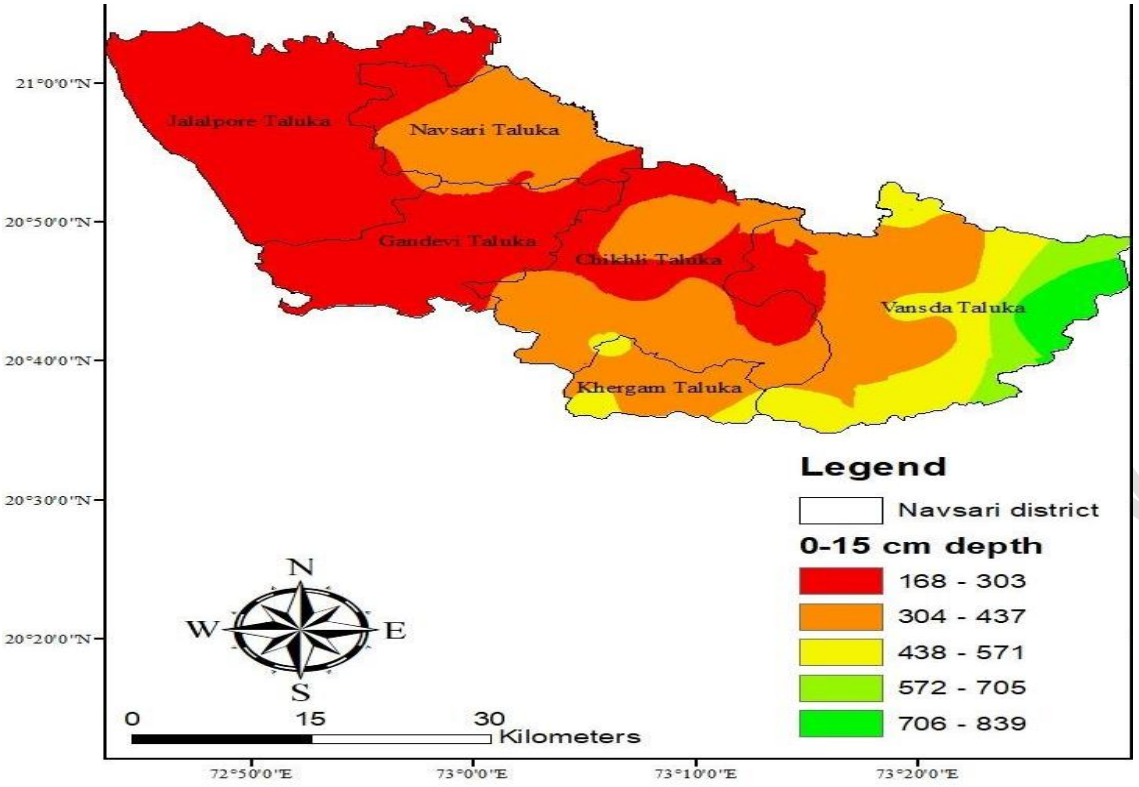

Fig. 2:-Available Nitrogen(kg/ha) status at 0-15 cm depth

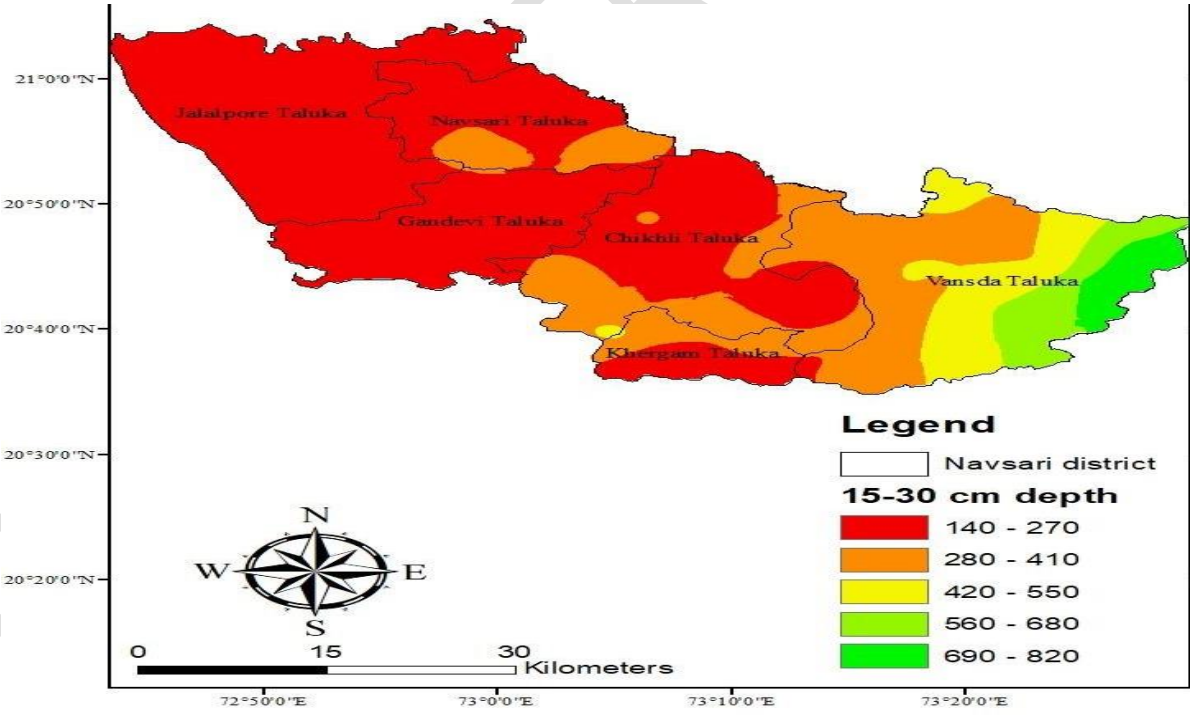

Fig. 3:-Available Nitrogen (kg/ha) status at 15-30 cm depth

Conclusions:

Based on the results of present study the conclusions are made which are as cited below:

- Wide variation was observed in different fractions of nitrogen as well as various soil properties at surface and sub surface layer. Available major nutrient nitrogen as well as SOC was higher in surface soils than sub surface soils.
- From the overall surveyed samples analysis, available N (30%, 61.67% and 8.33 %) were found under low, medium and high category respectively.
- The highest available nitrogen was found in soils of Vansda (840.45 and 815.36 kg/ha), in surface soil (0-15 cm) and sub- surface soil (15- 30 cm) in surveyed soil samples of Navsari district respectively. Among the surveyed soil samples, the NO_3-N, NH_4-N and total N(mg kg^{-1}) values were found highest in Khergam (92.40 & 58.80 mg/kg), Navsari (114.80 & 100.80 mg/kg) and Vansda (1036 & 924 mg/kg) taluka of surveyed area of Navsari district in surface soil (0-15 cm) and sub- surface soil (15-30 cm) respectively.
- The overall distribution of avail. N, NO_3-N, NH_4-N and total N in Navsari district was ranged from 72.80 to 375.20 mg kg^{-1}, 5.60 to 92.40 mg kg^{-1}, 30.80 to 114.80 mg kg^{-1} and 140.00 to 1036.00 mg kg^{-1}, respectively for surface soils while, 61.60 to 364.00 mg kg^{-1}, 8.40 to 72.80 mg kg^{-1}, 25.20 to 100.80 mg kg^{-1} and 140.00 to 924.00 mg kg^{-1} for sub-surface soils, respectively.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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