WATER QUALITY BULLETIN

PRE-MONSOON 2024 | ODISHA

Central Ground Water Board
South Eastern Region
Bhubaneswar, Odisha

December - 2024

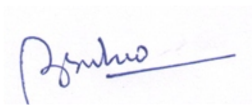
FOREWORD

Water is an essential resource, and as the demand for this limited commodity continues to rise, understanding and managing our groundwater has become crucial. While contamination of water resources is a challenge, the availability of these resources is also critical in many areas. However, the nature of the challenges varies from region to region. Imbalances between available water resources and increasing demands are further worsened by the negative impacts of groundwater extraction and over-exploitation.

In most places, groundwater typically meets established standards—provided there are no serious geo-genic contamination sources present—yet certain regions exhibit notable changes in quality due to human activities. Recognizing these issues early on is vital since aquifer contamination is rarely reversible.

Sustainable water management faces multiple challenges, making it important to share analytical findings with stakeholders in a timely manner. In this context, the Central Ground Water Board has decided to publish water quality bulletins twice a year, presenting the analytical findings from groundwater samples collected in Odisha during the pre-monsoon and post-monsoon periods. This initiative aims to help develop effective sustainable groundwater management strategies and raise awareness among stakeholders about protecting and maintaining water sources, using water efficiently, and safely disposing of sewage to prevent contamination.

This water quality bulletin presents analytical findings from groundwater samples collected in Odisha during the pre-monsoon of 2024. Its goal is to provide policymakers, water professionals, researchers, and stakeholders with crucial insights to facilitate informed decision-making and implement effective groundwater resource management practices.



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20/12/2024

Bhubaneswar

1. INTRODUCTION

Odisha is situated on the eastern coast of India, lying between the latitudes of 17.49'N and 22.34'N and the longitudes of 81.27'E and 87.29'E. The state is bordered by the Bay of Bengal to the east, Chhattisgarh to the west, and Andhra Pradesh to the south. With a coastline stretching around 450 km, Odisha covers an area of 155,707 square km, which represents about 4.87% of India's total land area, and the state comprises 30 districts.

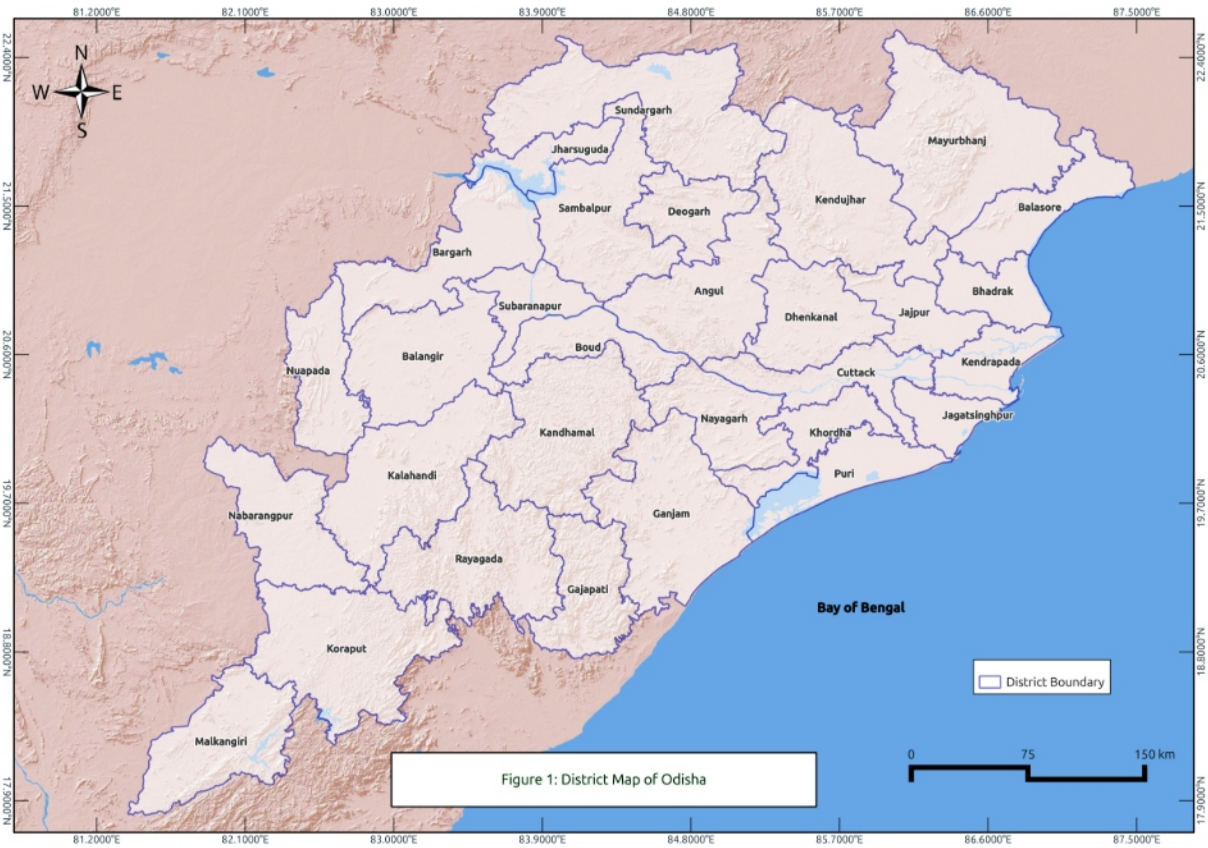

Figure 1: District Map of Odisha

The state of Odisha showcases a diverse geological terrain. The Eastern Ghats form its western boundary and are primarily composed of metamorphic rocks. The coastal region features alluvial deposits, while the northern areas are characterized by sedimentary rocks. The presence of minerals such as iron ore, bauxite, coal, and chromite plays a significant role in the state's economy. The geological formations in Odisha include a variety of rocks ranging from Precambrian to more recent deposits. The hydrogeological framework of the state features various aquifers influenced by its multiple river systems and rainfall, which is around 1,500 mm annually—affecting groundwater recharge patterns. These aquifers support agriculture, industry, and domestic water supply and are primarily composed of weathered and fractured formations. The weathered zone typically includes regolith, saprolite, and decomposed rock, forming unconfined aquifers. Confined aquifers are contributed to by fractured rocks such as granites and schists. The porosity and permeability of these formations vary, impacting the storage and movement of groundwater. Odisha experiences a tropical climate, with hot and humid summers where temperatures often exceed 40°C (104°F). The monsoon season, from June to September, brings essential rainfall for agriculture. Winters are relatively mild, with temperatures ranging from 10°C to 25°C (50°F to 77°F).

2. GROUNDWATER SAMPLE COLLECTION

The Central Ground Water Board monitors groundwater levels throughout the country on a regional scale four times a year during the months of March, April, May, August, November, and January. To monitor groundwater levels, the CGWB has a dedicated network of about 25,000 monitoring stations called "National Hydrograph Network Stations (NHNS)," which includes open dug wells and purpose-built bore/tube wells for water level monitoring known as piezometers.

Groundwater samples are collected from designated monitoring stations in April (pre-monsoon) and November (post-monsoon) to assess water quality. From Odisha, 465 samples were collected for basic analysis, and 465 samples were collected for toxic metal analysis--in the pre-monsoon period of 2024. These samples were analyzed for 13 basic parameters, including pH, electrical conductivity, total dissolved solids (TDS), total hardness (TH), Total Alkalinity (TA), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), Fluoride (F^{-}),carbonate (CO_3^{2-}), bicarbonate (HCO_3^{-}), chloride (Cl^{-}), sulfate (SO_4^{2-}), and nitrate (NO_3^{-}), following the standard procedures outlined in the 24th edition of the APHA.

The samples collected for heavy metals were analyzed for potentially toxic metals and metalloids, including aluminum (Al), arsenic (As), barium (Ba), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), molybdenum (Mo), strontium (Sr), zinc (Zn), boron (B), cadmium (Cd), iron (Fe), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), and uranium (U).

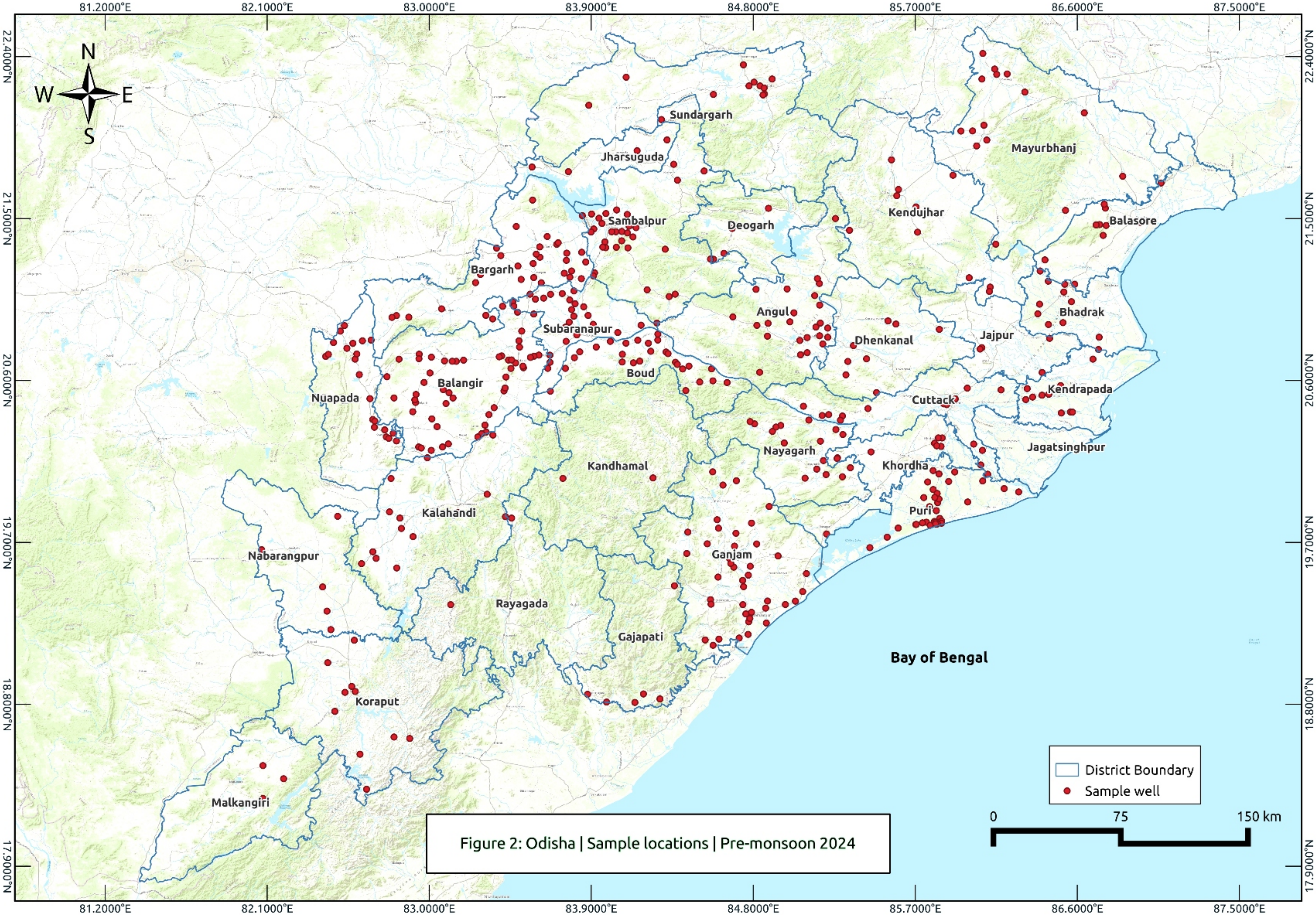

Figure 2: Odisha | Sample locations | Pre-monsoon 2024

Table 1 : District wise sample collection data | 2024 Pre-monsoon							
Sl.No	Districts	No. of Samples		Sl.No	Districts	No. of Samples	
		Basic	No. of Samples			Basic	HM
1	Angul	24	24	16	Kandhamal	2	2
2	Balangir	54	54	17	Kendrapara	11	11
3	Balasore	10	10	18	Kendujhar	10	10
4	Bargarh	31	31	19	Khordha	9	9
5	Baudh	27	27	20	Koraput	10	10
6	Bhadrak	11	11	21	Malkangiri	3	3
7	Cuttack	15	15	22	Mayurbhanj	16	16
8	Debagarh	4	4	23	Nabarangpur	5	5
9	Dhenkanal	8	8	24	Nayagarh	16	16
10	Gajapati	6	6	25	Nuapada	21	21
11	Ganjam	41	41	26	Puri	36	36
12	Jagatsinghpur	1	1	27	Rayagada	2	2
13	Jajpur	4	4	28	Sambalpur	34	34
14	Jharsuguda	4	4	29	Sonapur	25	25
15	Kalahandi	14	14	30	Sundargarh	11	11

3. OVERVIEW OF GROUND WATER QUALITY

The geological formations of watersheds are key factors that influence and control the chemistry of local groundwater systems. The type and characteristics of an aquifer significantly impact groundwater quality. Given that Odisha has a diverse range of geological formations, the variation in water quality parameters is also considerable.

The following table presents the range of physico-chemical parameters observed in the groundwater of Odisha in 2024 Pre-Monsoon period:

Table 2: Range of physico-chemical parameters observed in Odisha's groundwater during the pre-monsoon period of 2024			
Parameter	**Lowest**	**Highest**	**Mean**
pH at 25°C	5.75	8.30	7.66
EC µS/cm at 25°C	57.00	4647.00	864.00
TDS mg/L	37.00	3154.00	487.00
TH mg/L as CaCO3	16.00	1137.00	274.00
TA mg/L as CaCO3	14.00	915.00	230.00
Ca^{2+} mg/L	5.00	372.00	61.00
Mg^{2+} mg/L	1.00	214.00	21.00
Na^{+} mg/L	2.00	1016.00	61.00
K^{+} mg/L	BDL	248.00	6.00
CO_3^{2-} mg/L	BDL	BDL	--
HCO_3^{-} mg/L	17.00	1117.00	281.00
Cl^{-} mg/L	2.20	1505.10	84.60
SO_4^{2-} mg/L	BDL	214.00	18.00
NO_3^{-} mg/L	BDL	214	18.00
F^{-} mg/L	BDL	2.80	0.40

4. DISTRIBUTION OF ELECTRICAL CONDUCTIVITY

Electrical conductivity (specific conductance) of water is an important measure of water quality. Generally, the specific conductance of natural waters closely reflects the concentration of total dissolved solids (TDS), with some adjustments made for correction factors. Using electrical conductivity as an indicator of water quality is useful for estimating the mineralization of the water. Geology and soil type are the main natural factors that determine electrical conductivity in groundwater. Moreover, the amount of time water spends in geological formations and soils has a significant effect on electrical conductivity.

The pre-monsoon electrical conductivity of groundwater ranges from 57 to 4647 µS/cm at 25°C, with the highest measurement of 4647 µS/cm recorded at a well in Krupa Sindura Patna in Puri district. Groundwater samples from coastal districts like Puri, Ganjam, Jagatsinghpur, and Kendrapada show elevated EC values, consistent with those observed in the 2023 pre-monsoon period.

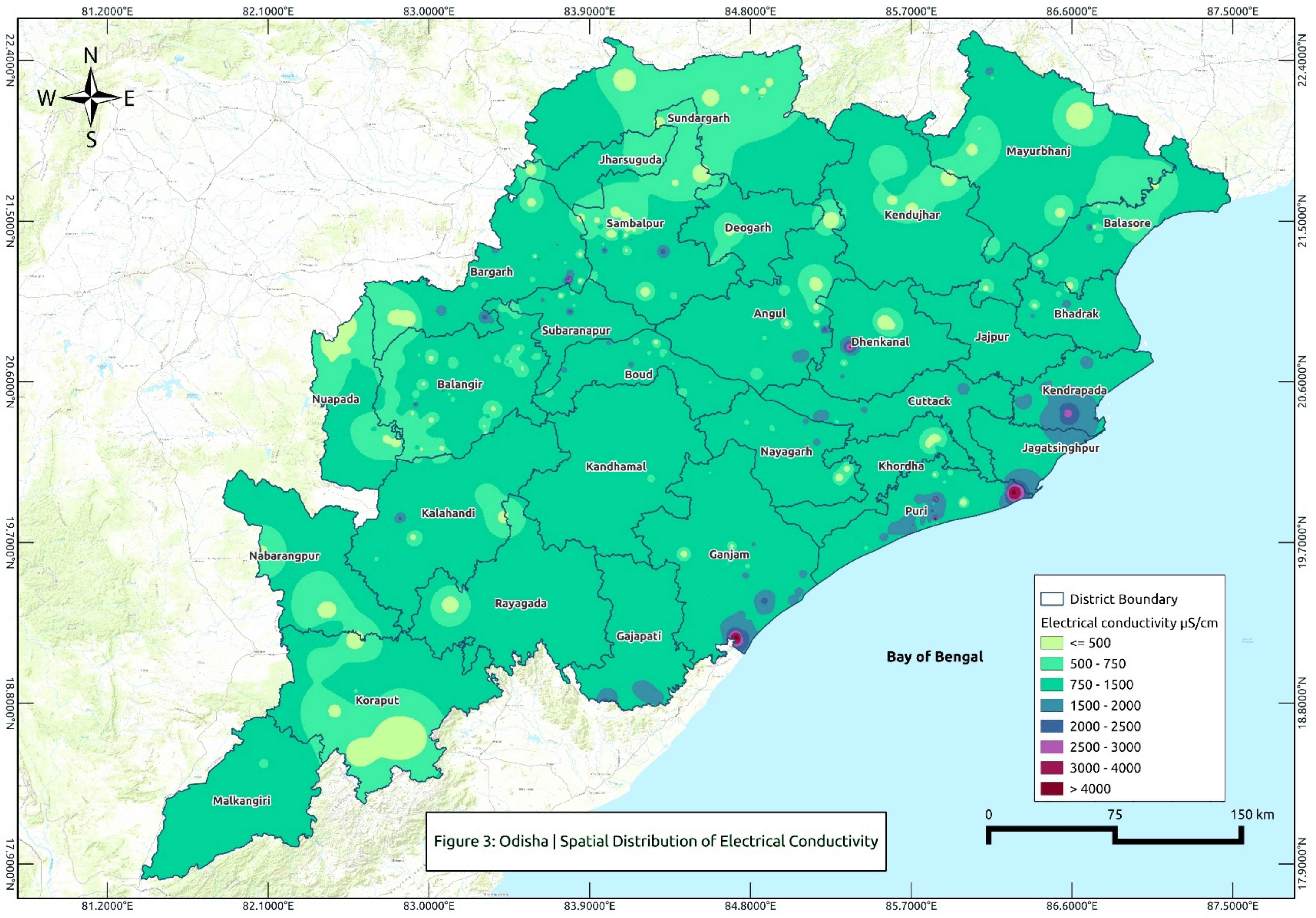

Figure 3: Odisha | Spatial Distribution of Electrical Conductivity

Table 3: Locations of groundwater samples with electrical conductivity exceeding 2000 µS/cm at 25°C.				
S No	**District**	**Block**	**Location**	**EC µS/cm at 25°C**
1	Kendrapara	Kendrapada	Barua	2780
2	Kendrapara	Mahakal Pada	Chadeiguan	2480
3	Kendrapara	Mahakal Pada	Mahakalpara 2	2915
4	Angul	Banarpal	Bhogabereni	2481
5	Dhenkanal	Odapada	Dhaulapur	3061
6	Puri	Brahmagiri	Alipada	2040
7	Puri	Brahmagiri	Rendagada	2161
8	Puri	Satyabadi	Sakhigopal	3368
9	Puri	Sadar	Tulasichoura malatipatpur	2184
10	Puri	Astaranga	Astaranga	4246
11	Puri	Sadar	P-01 Krupa sindura patna	4647
12	Puri	Sadar	P-19 Kashi Jagannathpur	2223
13	Puri	Sadar	P-37 Sweta Ganga	2020
14	Kalahandi	Junagarh	Badbasul	2100
15	Balangir	Turekela	Kantabanji	2436
16	Balasore	Oupada	Tenda	2272
17	Ganjam	Chhatrapur	Tanganapalli 1	2286
18	Ganjam	Rangilunda	Mantridi	2038
19	Ganjam	Chikiti	Surlaroad 1	4515
20	Gajapati	Kashinagara	K Sitapur 1	2072
21	Bargarh	Bheden	Baghapalli	3260
22	Bargarh	Gaisilet	Gaisilet 3	2287
23	Sambalpur	Maneswar	Bausenmura	2308
24	Sonapur	Ulunda	Phulmurthi	2427
25	Sambalpur	Jujomura	Amlipani	2213

Table 4 : Trend in electrical conductivity (EC) values of groundwater samples, with measurements exceeding 3000 µS/cm at 25°C.				
Year	Total No of Samples Analysed	No of Districts affected by EC>3000 µS/cm	Total No of Locations affected by EC>3000 µS/cm	% Locations affected by EC> 3000 µS/cm
2017	1262	6	10	0.79
2018	1241	10	10	0.81
2019	1266	5	9	0.71
2020	783	3	4	0.51
2021	715	2	2	0.28
2022	1283	2	3	0.23
2023	1745	9	19	1.08
2024	465	4	6	1.29

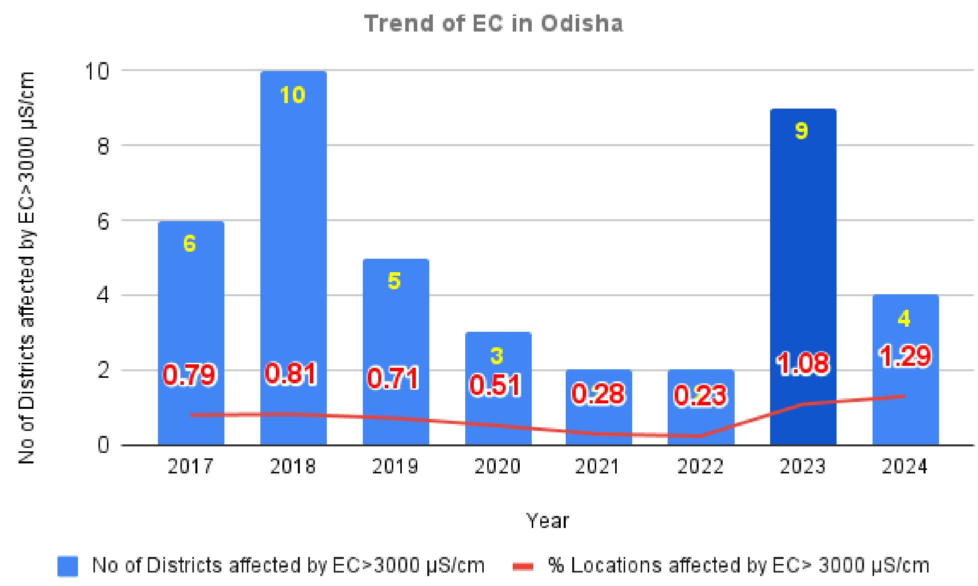

Figure 4: Trend in Electrical Conductivity Levels in Odisha.

5. DISTRIBUTION OF TOTAL DISSOLVED SOLIDS (TDS)

Water serves as a solvent, capable of dissolving and interacting with both organic and inorganic components of soils, as well as minerals found in loose deposits like sand, gravel, and various types of bedrock. The dissolved substances contribute to the total dissolved solids (TDS) found in groundwater, which is a key measure of water quality.

A high TDS measure is not necessarily a health hazard but the implications of elevated TDS levels should not be ignored. The risks associated with TDS are mainly aesthetic or related to sensory perception, including color, taste, and smell. However, high concentrations of TDS can also have technical effects, leading to scale deposits in plumbing systems and appliances, staining household fixtures, and causing the corrosion of pipes and fittings. A high concentration of TDS may also indicate the presence of harmful contaminants such as iron, manganese, sulfate, bromide, fluoride, and arsenic, especially if elevated TDS levels result from human activities.

The TDS levels in the NHNS groundwater samples collected in the pre-monsoon period of 2024, ie, April 2024, range from 37 to 3,154 mg/L, with an average TDS concentration of 487 mg/L. The highest recorded TDS value of 3,154 mg/L was found in a well located in Surlaroad , Ganjam district.

According to the Indian standard for drinking water, IS 10500:2012, the desirable TDS level is set at 250 mg/L, while the maximum permissible limit is 2000 mg/L if no alternative sources are available. In the pre-monsoon NHNS sampling conducted in 2024, TDS levels in 3 locations were found to exceed the maximum permissible limit, rendering the water unsuitable for consumption (please refer to Table 5).

Table 5: Locations with TDS values exceeding maximum permissible limits, making the water unsuitable for drinking (Pre-Monsoon).

SNO	District	Block	Location	TDS mg/L
1	Puri	Astaranga	Astaranga	2755.0
2	Puri	Sadar	P-01 Krupa sindura patna	2749.0
3	Ganjam	CHIKITI	Surlaroad 1	3154.0

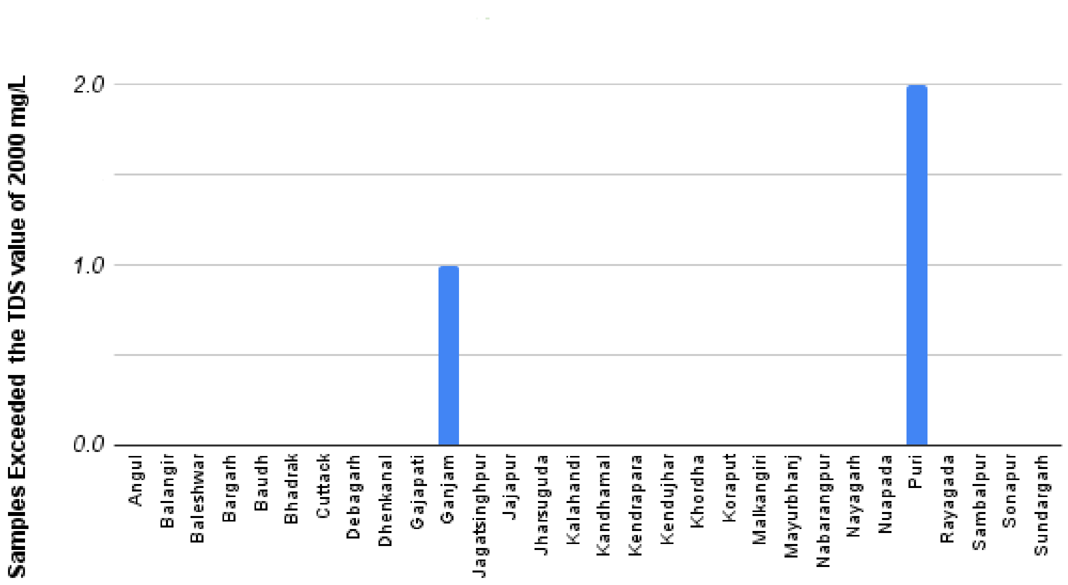

Figure 5: District-wise representation of water samples deemed unsuitable based on total dissolved solids (TDS) values.

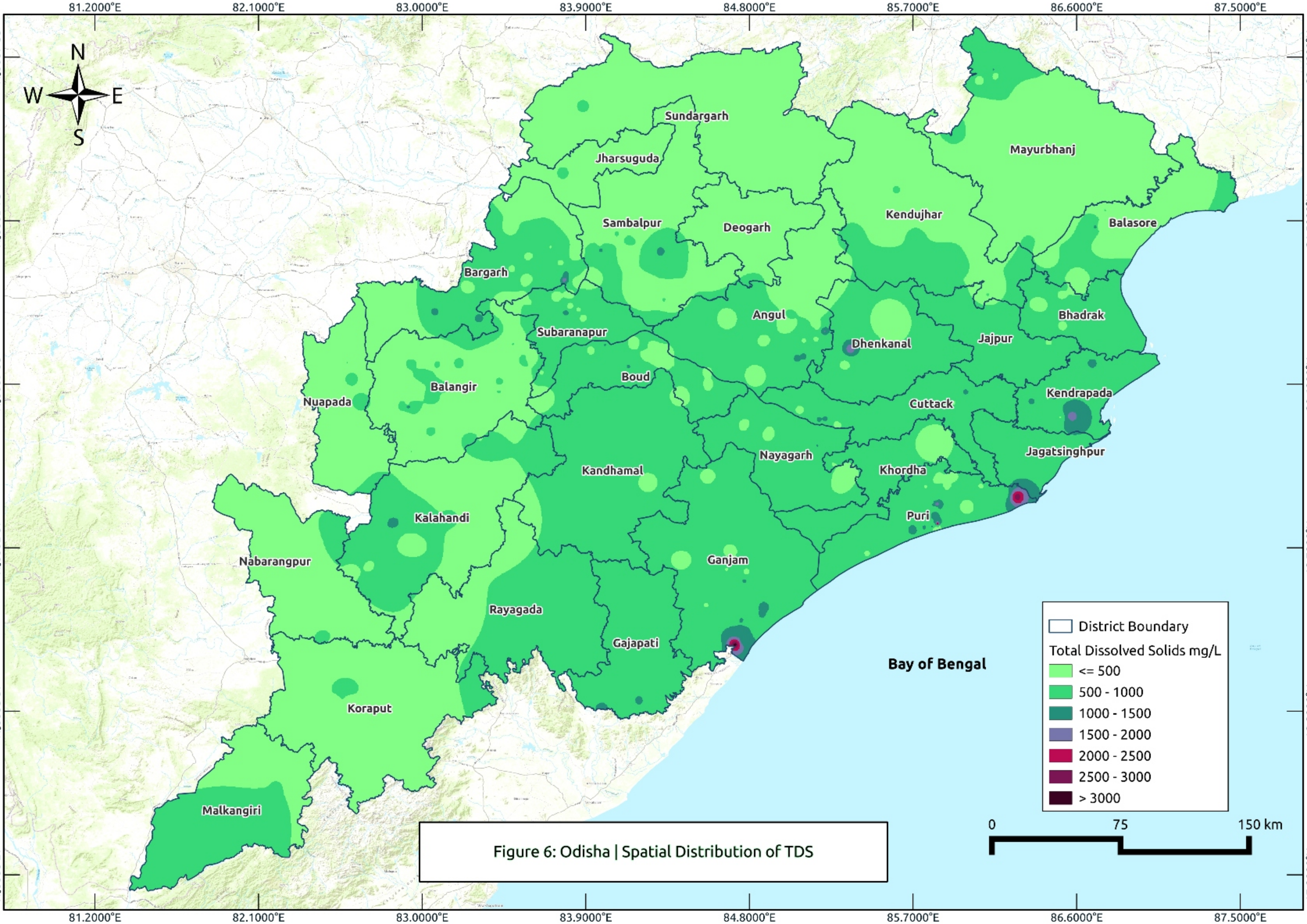

Figure 6: Odisha | Spatial Distribution of TDS

6. DISTRIBUTION OF CHLORIDE

Chloride has a limited number of identifiable sources and is hydrochemically conservative, making it a useful marker in hydrochemistry. In groundwater, chloride primarily originates from two sources: the dissolution of natural halite in aquifer rocks and the intrusion of seawater into coastal wells. The latter typically occurs within a few kilometers of the shoreline, manifesting as rising salinity linked to overpumping that significantly lowers the local water table.

Another source of chloride is sea-derived airborne salts, also known as atmospheric salts. These salts are the most common source of chloride in groundwater, particularly when other sources can be ruled out. Atmospheric chloride tends to dominate in fresh groundwater located more than a few kilometers from the coast and is often present even in areas close to the shoreline.

The distribution of chloride in groundwater samples collected as part of the National Hydrograph Network Stations (NHNS) program in Odisha during April 2024 ranges from 2.20 mg/L to 1505 mg/L, with a mean value of 85 mg/L. In the coastal plain region, where most wells are situated in alluvial deposits, the groundwater exhibits elevated levels of chloride. The highest concentration of chloride is recorded at a well in Krupa Sindura Patna in Puri. The Bureau of Indian Standards (BIS) sets the acceptable limit at 250 mg/L, and the maximum permissible limit of Chloride in drinking water should not exceed 1000 mg/L.

Table 6: Locations with Chloride Concentrations Exceeding the Acceptable Limit of 250 mg/L.

S No	District	Block	Sample Site	Chloride mg/L
1	Cuttack	Cuttack sadar	Tangi 1	328.5
2	Kendrapara	Kendrapada	Barua	517.8
3	Kendrapara	Mahakal pada	Chadeiguan	683.9
4	Kendrapara	Marsaghai	Giranga	349.9
5	Kendrapara	Kendrapada	Jantilo	353.3
6	Kendrapara	Mahakal pada	Mahakalpara 2	696.8
7	Kendrapara	Rajkanika	Makundapur	258.3
8	Angul	Banarpal	Bhogabereni	287.0

Table 6: Locations with Chloride Concentrations Exceeding the Acceptable Limit of 250 mg/L.				
S No	District	Block	Sample Site	Chloride mg/L
9	Dhenkanal	Odapada	Dhaulapur	614.4
10	Puri	Brahmagiri	Alipada	276.5
11	Puri	Brahmagiri	Rebana nuagaon	383.5
12	Puri	Brahmagiri	Rendagada	458.6
13	Puri	Satyabadi	Sadanandapur	270.6
14	Puri	Satyabadi	Sakhigopal	919.1
15	Puri	Sadar	Tulasichoura malatipatpur	283.0
16	Puri	Astaranga	Astaranga	1502.8
17	Puri	Brahmagiri	Gokhara	336.1
18	Puri	Brahmagiri	Gola	397.6
19	Puri	Sadar	P-01 Krupa sindura patna	1505.1
20	Puri	Sadar	P-19 Kashi Jagannathpur	485.4
21	Kalahandi	Junagarh	Badbasul	358.4
22	Kalahandi	Jayapatna	Bijamara	284.6
23	Sonapur	Tarbha	Sargaj 1	374.4
24	Balasore	Oupada	Tenda	266.0
25	Bhadark	Dhamnagar	Dhamnagar 1	299.3
26	Mayurbhanj	Bahalda	Poliakunda	266.6
27	Boudh	Boudh Sadar	Dahya	346.1
28	Boudh	Kantamal	Auinla chua chhak	268.7
29	Boudh	Boudh Sadar	Khajuripada	251.0
30	Boudh	Harbhanga	Kusanga	289.6
31	Ganjam	Polasara	Polasora	280.7
32	Ganjam	Asika	Aska 1	256.4
33	Ganjam	Purusottampur	Bananai	277.3
34	Ganjam	Chhatrapur	Narendrapur	371.7
35	Ganjam	Rangilunda	Mantridi	350.3
36	Ganjam	Chikiti	Surlaroad 1	1189.4
37	Ganjam	Kukudakhandi	Padmanavapur	287.5
38	Gajapati	Kashinagara	K Sitapur 1	398.9
39	Gajapati	Parlakhemundi	Kantragada	360.5
40	Gajapati	Parlakhemundi	Garabandh	277.3
41	Bargarh	Bheden	Baghapalli	557.0
42	Bargarh	Gaisilet	Gaisilet 3	400.0
43	Bargarh	Sohela	Grinjal	280.0
44	Bargarh	Attabira	Shukutapali	267.0
45	Sambalpur	Maneswar	Bausenmura	400.0
46	Sambalpur	Maneswar	Sahaspur	275.0
47	Sonapur	Dunguripali	Baghahandi	252.0
48	Sonapur	Sonepur	Nandahamal	267.0
49	Sonapur	Ulunda	Phulmurthi	395.0
50	Sambalpur	Jujomura	Amlipani	454.0

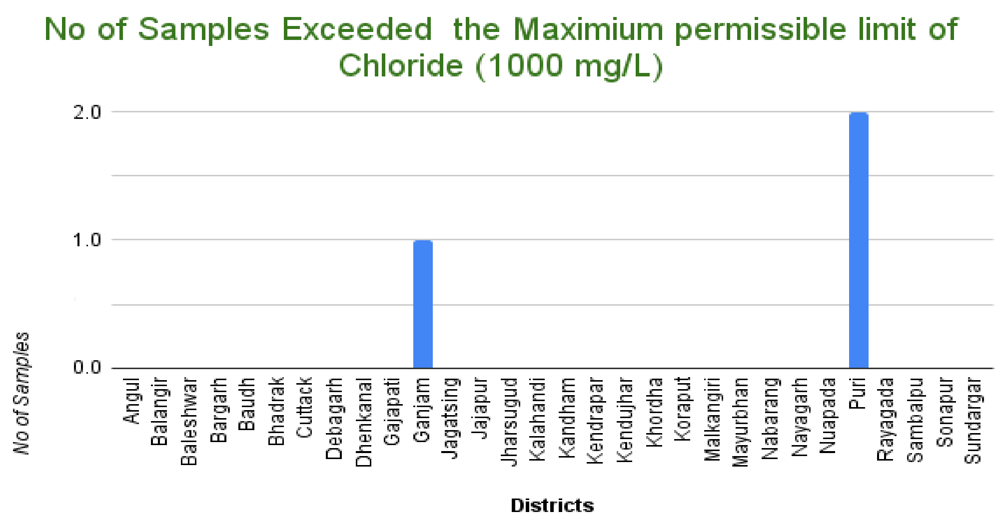

Figure 7: District-wise representation of samples deemed unsuitable based on Chloride values.

Table 7 :Trend in chloride values , with measurements exceeding 1000 mg/L.

Year	Total No of Samples Analysed	No of Districts affected by Cl>1000 mg/L	Total No of Locations affected by Cl>1000mg/L	% Locations affected by Cl > 1000mg/L
2017	1262	3	4	0.32
2018	1241	4	4	0.32
2019	1266	2	2	0.16
2020	783	0	0	0
2021	715	0	0	0
2022	1283	0	0	0
2023	1745	3	10	0.57
2024	465	2	3	0.65

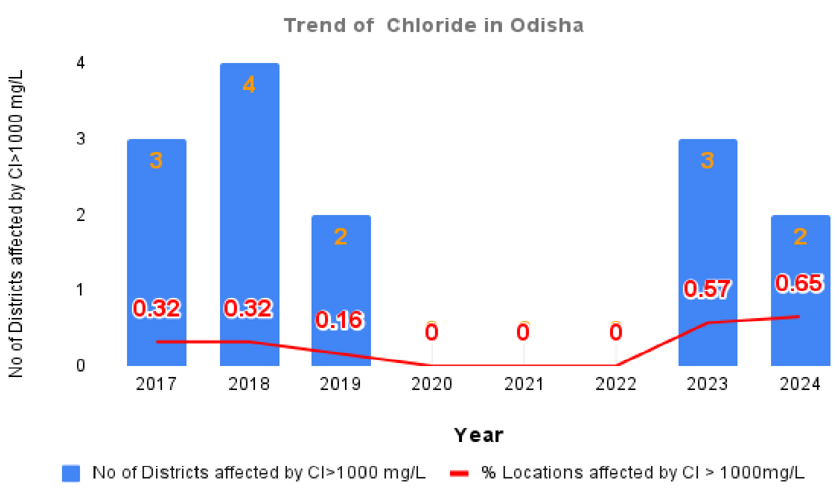

Figure 8: Trend in Chloride Levels in Odisha.

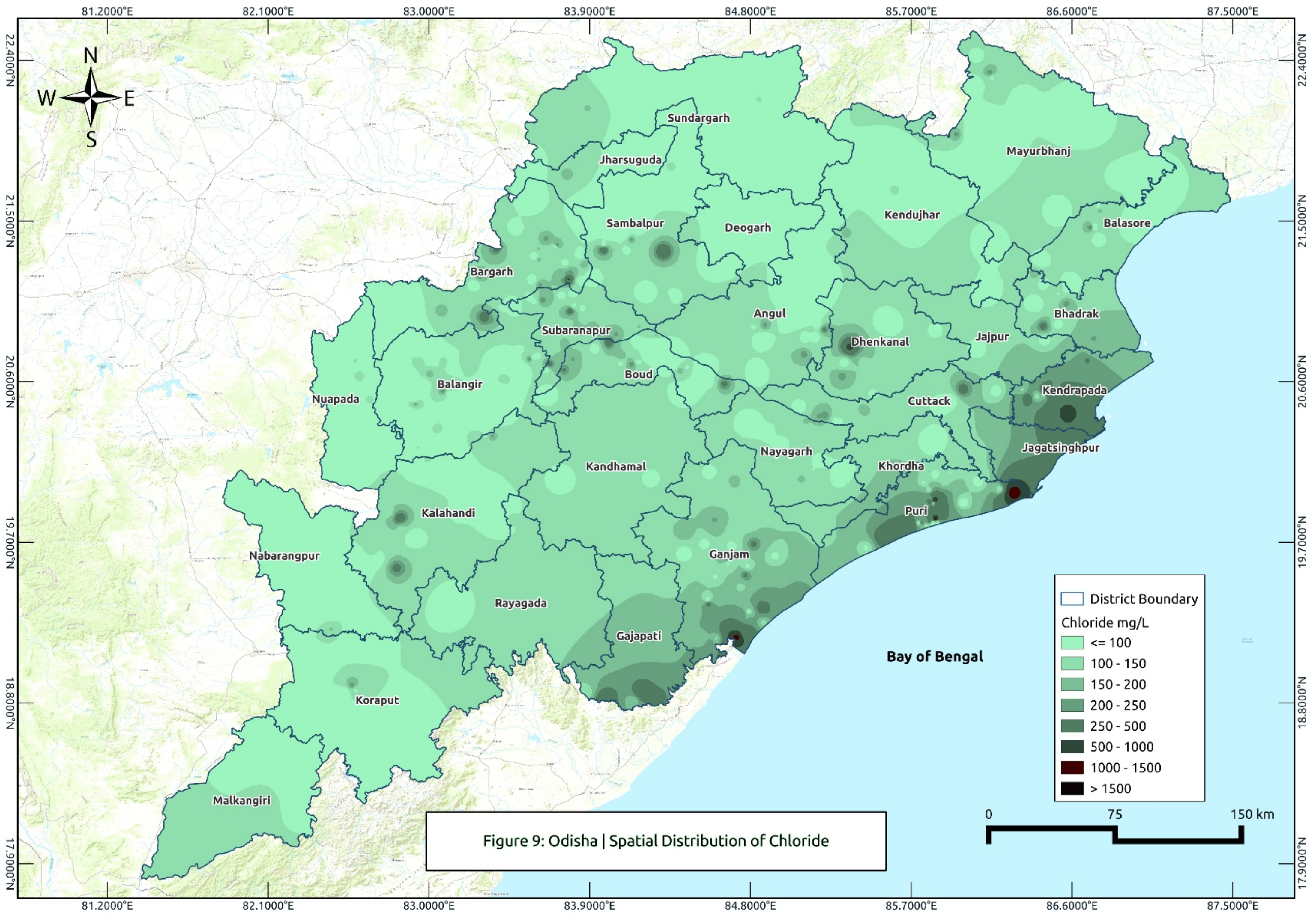

Figure 9: Odisha | Spatial Distribution of Chloride

7. DISTRIBUTION OF NITRATE (NO_3^-)

Nitrate has become a concerning contaminant in groundwater and surface water resources worldwide. Its formation is a key part of the nitrogen cycle and occurs through both natural processes, such as atmospheric fixation and lightning storms, as well as human activities, including fertilizer application and improper septic system use. Nitrate easily enters the hydrosphere, and its ingestion poses health risks to humans, including methemoglobinemia (often referred to as "blue baby syndrome"), cancer, and diabetes, along with risks to livestock. Agricultural practices and fertilizer application, along with anthropogenic sources like animal urine and human wastewater, are the primary contributors to elevated nitrate levels in groundwater.

As a point source pollutant, the distribution of nitrate (NO_3^-) in groundwater shows significant variability across the state of Odisha. Nitrate concentrations range from below detection level to 214 mg/L, with a mean concentration of 18 mg/L. The highest recorded nitrate concentration, 214 mg/L, was found in a well located in Padampur in the Rajborasambar block of Bargarh district.

The table below summarizes the locations in Odisha where nitrate concentrations exceeded 45 mg/L in the year 2024(pre-monsoon).

Table 8: Locations in Odisha with Nitrate (NO_3^-) Concentrations Exceeding 45 mg/L.

S No	District	Block	Sample Site	NO_3^- mg/L
1	Kendrapara	Kendrapada	Barua	66.7
2	Koraput	Lamtapur	soguru	87.5
3	Koraput	Jeypore	Umuri 1	106.3
4	Koraput	Jeypore	C-kusumi-1	54.5
5	Malkangiri	Khairput	Kudumulagumma	52.4
6	Angul	Angul	Bantala	60.0
7	Angul	Angul	Barbahal	64.0
8	Angul	Banarpal	Bhogabereni	100.0
9	Angul	Chhenidpada	Durgapur	86.0
10	Angul	Chhenidpada	Katada	74.0
11	Angul	Angul	Panchmahala	51.0
12	Angul	Banarpal	Tulsipal	55.0
13	Cuttack	Badamba	Abhimanpur	139.8
14	Cuttack	Narasinghpur	Balijhari 1	171.9
15	Dhenkanal	Hindol	Babandh	78.3
16	Dhenkanal	Hindol	Balmi	52.0

Table 8: Locations in Odisha with Nitrate (NO_3^-) Concentrations Exceeding 45 mg/L.				
17	Dhenkanal	Bhuban	Bhuban	97.4
18	Dhenkanal	Odapada	Dhaulapur	205.1
19	Dhenkanal	Sadar	Jhumpuria	45.7
20	Khordha	Chilika	Balugaon	121.8
21	Khordha	Begunia	Begunia 1	71.1
22	Nayagarh	Khandapada	Benagadia	74.2
23	Nayagarh	Khandapada	Kana singhi	81.5
24	Puri	Brahmagiri	Alipada	149.6
25	Puri	Sadar	P-37 jagannath ballav matha	83.3
26	Puri	Chilila lake	Satapada 1	91.0
27	Puri	Brahmagiri	Gokhara	45.7
28	Puri	Sadar	P-32 Gobardhan Matha	60.2
29	Kalahandi	Junagarh	Badbasul	102.3
30	Kalahandi	Bhawanipatna	Sargigora	62.0
31	Kalahandi	Kesinga	Tundala 1	55.2
32	Rayagada	Kashipur	Kashipur	58.2
33	Balangir	Puintala	Bairasar	56.1
34	Balangir	Belpara	Dumabata	48.0
35	Balangir	Patnagarh	Ghambari	55.2
36	Balangir	Muribahal	Haldia	88.4
37	Balangir	Titlagarh	Ichagaon	62.1
38	Balangir	Deogaon	Kacgerpalli	47.7
39	Balangir	Belpara	Kapani	65.0
40	Balangir	Titlagarh	Minapalli	48.3
41	Balangir	Patnagarh	Sarmohan 1	55.4
42	Balangir	Saintala	Tikrapada 1	60.4
43	Nuapada	Khariar	Bada-Maheswar	55.5
44	Nuapada	Komana	Komna1	77.8
45	Nuapada	Khariar	Sanmaheswar	77.6
46	Nuapada	Komana	Tarbod	62.2
47	Sonapur	Tarbha	Sargaj 1	58.5
48	Balasore	Oupada	Tenda	53.5
49	Nayagarh	Daspalla	Rangamatia	56.6
50	Kandhamala	Tumudibandha	Kurtamgarh	115.0
51	Kandhamala	Tumudibandha	Raikia	70.8
52	Boudh	Harbhanga	Tilesar	76.0
53	Boudh	Harbhanga	Radha Nagar	55.9
54	Boudh	Boudh Sadar	Anlapali	64.0
55	Boudh	Kantamal	Palasaguda	83.5
56	Boudh	Boudh Sadar	Gundulia	67.1
57	Boudh	Boudh Sadar	Khajuripada	51.8
58	Bargarh	Bheden	Baghapalli	73.0
59	Bargarh	Bheden	Bheden	49.0
60	Bargarh	Bheden	Chichinda	153.0
61	Bargarh	Gaisilet	Dangabahali	61.0
62	Bargarh	Gaisilet	Gaisilet 3	87.0
63	Bargarh	Sohela	Ghens 1	117.0
64	Bargarh	Sohela	Grinjal	131.0

Table 8: Locations in Odisha with Nitrate (NO_3^-) Concentrations Exceeding 45 mg/L.

65	Bargarh	Bargarh	Khuntapali	121.0
66	Bargarh	Bheden	Khutlipalli	48.0
67	Bargarh	Rajborasambar	Padampur 2	214.0
68	Bargarh	Attabira	Shukutapali	89.0
69	Bargarh	Sohela	Sohela 1	64.0
70	Sambalpur	Maneswar	Bausenmura	52.0
71	Sambalpur	Maneswar	Jhankarbahali	60.0
72	Sambalpur	Dhankauda	Sambalpur	49.0
73	Sonapur	Binika	Antarda	54.0
74	Sonapur	Sonepur	Arjunpur	60.0
75	Sonapur	Dunguripali	Baghahandi	160.0
76	Sonapur	Sonepur	Khaliapali	72.0
77	Sonapur	Sonepur	Nandahamal	77.0
78	Sonapur	Ulunda	Phulmurthi	150.0
79	Sonapur	Binika	Sakama	140.0
80	Sonapur	Binika	Saledi	145.0
81	Sonapur	Dunguripali	Samalaichuan	85.0
82	Sambalpur	Jujomura	Amlipani	138.0
83	Sambalpur	Jujomura	Badsahir	101.0
84	Sambalpur	Maneswar	Bhoipali	118.0
85	Sambalpur	Naktideul	Chandrapura	51.0

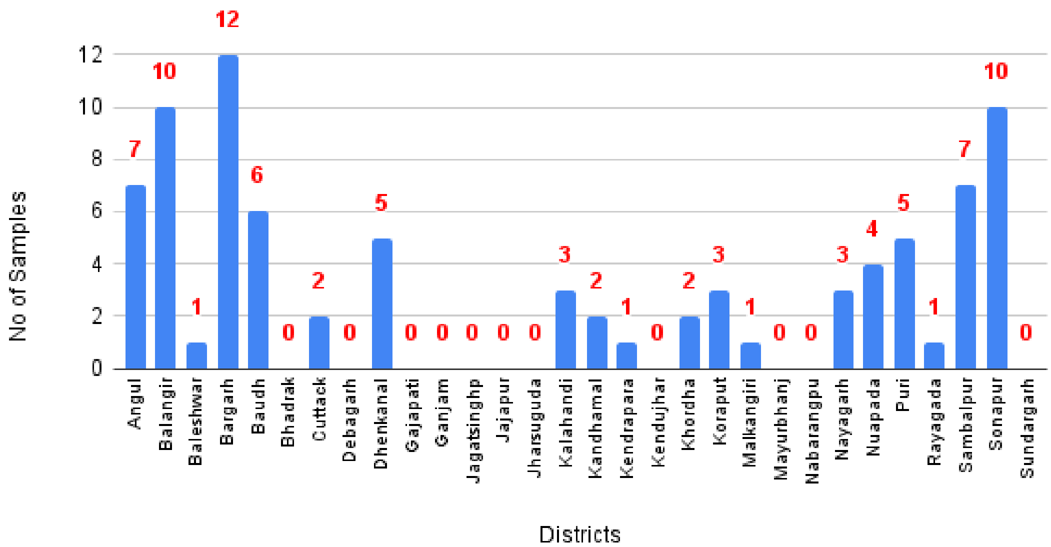

Figure 10: District-wise representation of water samples deemed unsuitable based on Nitrate values.

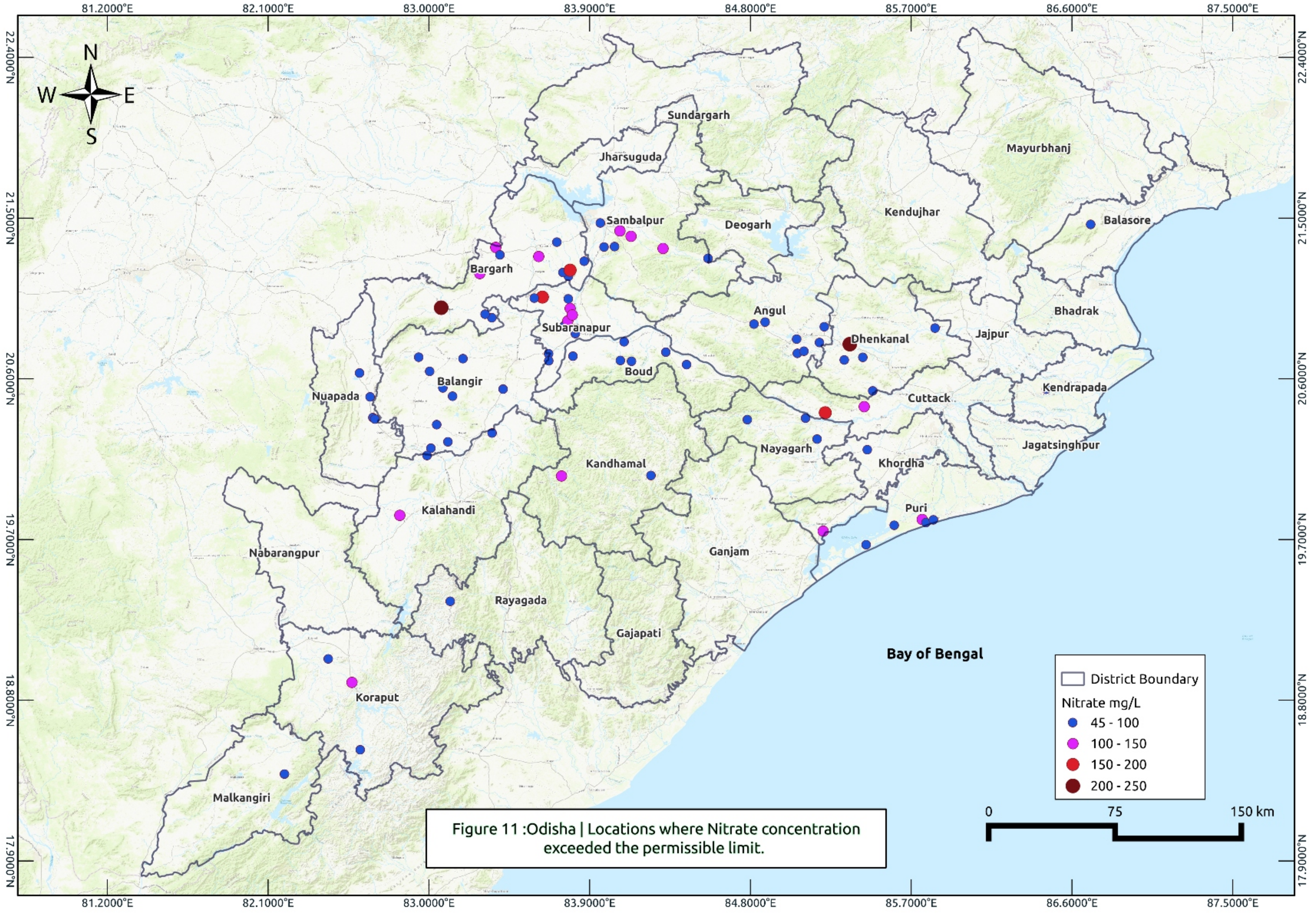

Figure 11 :Odisha | Locations where Nitrate concentration exceeded the permissible limit.

Table 9: Trend in Nitrate Concentrations of Groundwater Samples Exceeding 45 mg/L.

Year	Total No of Samples Analyzed	No of Districts affected by NO_3^->45 mg/l	Total No of Locations affected by NO_3^->45 mg/l	% Locations affected by NO_3^->45 mg/l
2017	1262	No Data	No Data	No Data
2018	1241	No Data	No Data	No Data
2019	1266	10	65	5.13
2020	783	20	127	16.22
2021	715	12	45	6.29
2022	1283	21	83	6.47
2023	1745	21	154	8.82
2024	465	19	85	18.2

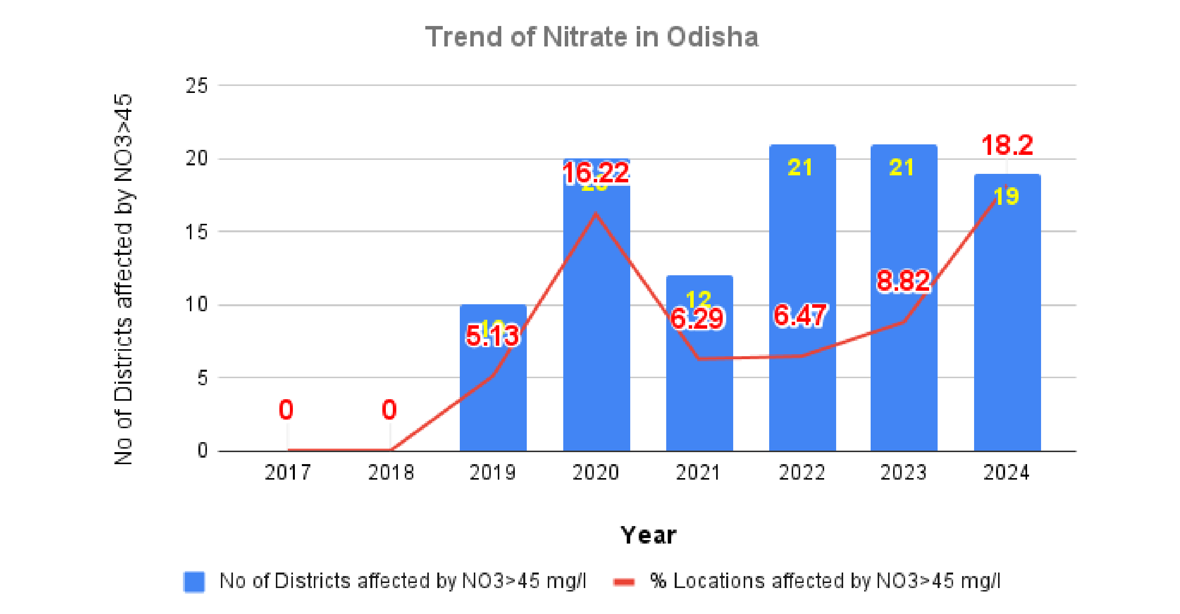

Figure 12. Trend of Nitrate (NO_3^-)occurrence in Odisha

8. DISTRIBUTION OF pH

The pH of a solution refers to the concentration of hydrogen ions (H^+). This concentration is mathematically expressed as the negative logarithm of the hydrogen ion concentration, meaning a lower concentration of free hydrogen ions corresponds to a higher pH level. The pH scale ranges from 0 to 14, with a value of

7 indicating neutrality. Values below 7 are considered acidic, while those above 7 are categorized as alkaline or basic. pH is regarded as one of the most important physicochemical parameters influencing various water quality indicators and the concentration of metals in aquatic environments. Chemical processes in these systems—including acid-base reactions, solubility reactions, oxidation-reduction reactions, and complexation—are influenced by the concentration of hydrogen ions.

pH can impact microbial life and the bioavailability of other contaminants in water. Extreme pH level, whether very high or very low—can make water unsuitable for specific applications. In high pH conditions, metals are likely to precipitate, and alkaline water often has unpleasant odors and tastes. In low pH environments, the solubility of metals typically increases, and chemicals such as cyanide and sulfide can exhibit heightened toxicity. Therefore, measuring pH can serve as a sensitive indicator of contamination.

Out of a total of 465 groundwater samples analyzed, 463 samples(99.5%) had pH levels that fell within the acceptable range of 6.5 to 8.5, as outlined in the Bureau of Indian Standards (IS 10500:2012) for drinking purposes. However, there were 2 samples from the Koraput and Mayurbhanj Districts that exhibited pH values outside the recommended range.

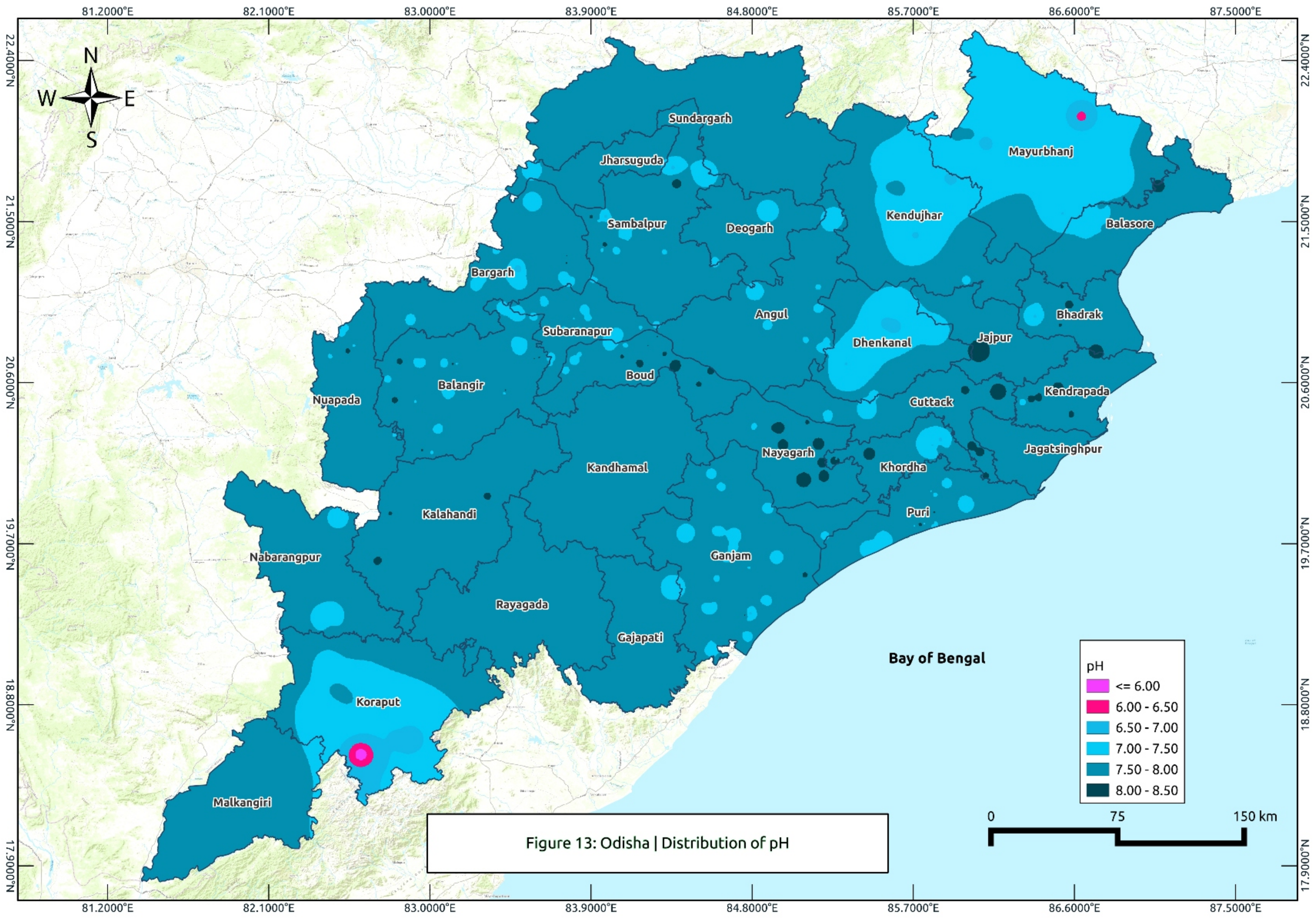

Figure 13: Odisha | Distribution of pH

9. DISTRIBUTION OF FLUORIDE.

Fluoride in drinking water at low concentrations has been shown to help prevent dental caries; however, elevated concentrations pose significant risks to human health. Prolonged exposure to high levels of fluoride can lead to a range of adverse health effects, which may vary from mild dental fluorosis to severe skeletal fluorosis. Research indicates a potential association between high fluoride exposure and various health concerns, including carcinogenicity, neurotoxicity, thyroid dysfunction, genotoxicity, and fertility issues. Studies have also shown that children living in areas with high fluoride concentrations may face developmental and maturation challenges during both prenatal and postnatal periods, particularly within the first twelve months of life and during adolescence. The Bureau of Indian Standards (BIS) sets the acceptable limit at 1.0 mg/L, and the maximum permissible limit of fluoride in drinking water should not exceed 1.5 mg/L.

The fluoride concentration in the samples ranges from levels below the detection limit to concentrations as high as 2.80 mg/L. The highest recorded fluoride concentration was found in Nuagaon, located in the Naygarh district. Among the 465 samples analyzed, 34 samples exceeded the acceptable fluoride limit set by the Bureau of Indian Standards (IS 10500:2012).

Below is a table detailing the locations/stations where the fluoride concentration in groundwater exceeded the permissible limit of 1.50 mg/L, in accordance with the drinking water standards outlined in IS 10500:2012. The maximum permissible limit prescribed by the standard is 1.50 mg/L for areas where there is no alternate source of water.

Table 10: Locations with Fluoride Concentrations Exceeding 1.50 mg/L (Pre-Monsoon).

S No	District	Block	Site Name	F^- mg/L
1	Angul	Angul	Barbahal	1.50
2	Nayagarh	Nuagaon	Nuagaon 1	2.80
3	Kalahandi	Junagarh	Badbasul	2.50
4	Balangir	Balangir	Bijakhaman 1	2.60

Table 10: Locations with Fluoride Concentrations Exceeding 1.50 mg/L (Pre-Monsoon).				
S No	District	Block	Site Name	F^- mg/L
5	Balangir	Khaprakho	Phulkimunda	1.70
6	Balangir	Deogaon	Sagarpali	1.80
7	Boudh	Harbhanga	Laxmanpur	2.10
8	Sundargarh	Bisra	R-14 Banposh (Urban)	2.40

Table 11: Trend in Fluoride Concentrations of Groundwater Samples Exceeding 1.50 mg/L.				
Year	Total No of Samples Analysed	No of Districts affected by F>1.50 mg/l	Total No of Locations affected by F>1.50 mg/l	% Locations affected by F>1.50 mg/l
2017	1262	13	24	1.9
2018	1241	11	37	2.98
2019	1266	16	36	2.84
2020	783	12	30	3.83
2021	715	8	14	1.96
2022	1283	12	30	2.34
2023	1745	19	64	3.66
2024	465	5	8	1.50

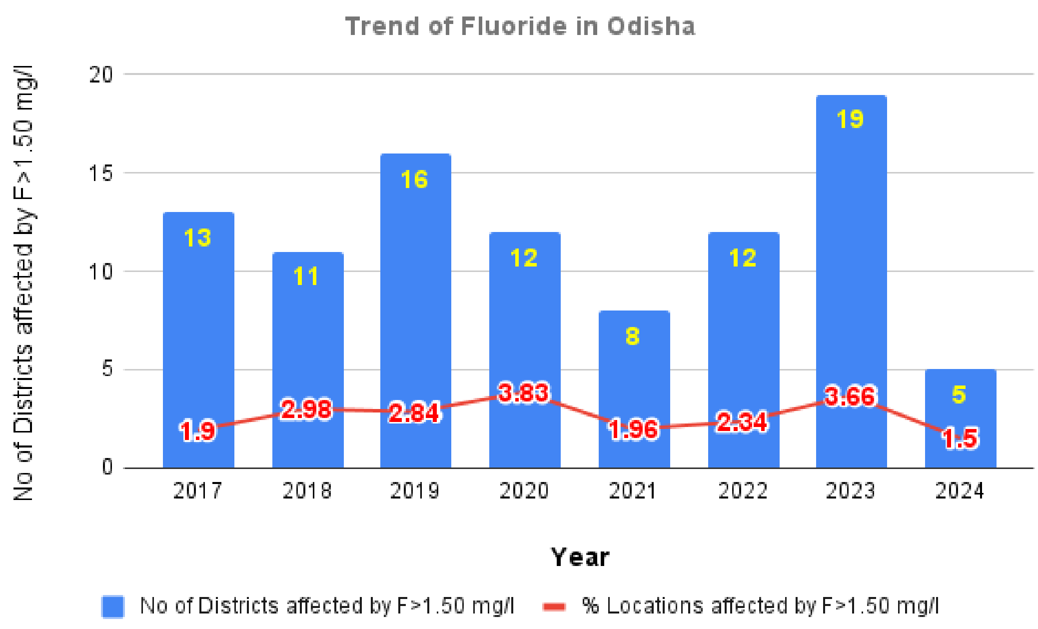

Fig 14. Trend of Fluoride occurrence in Odisha

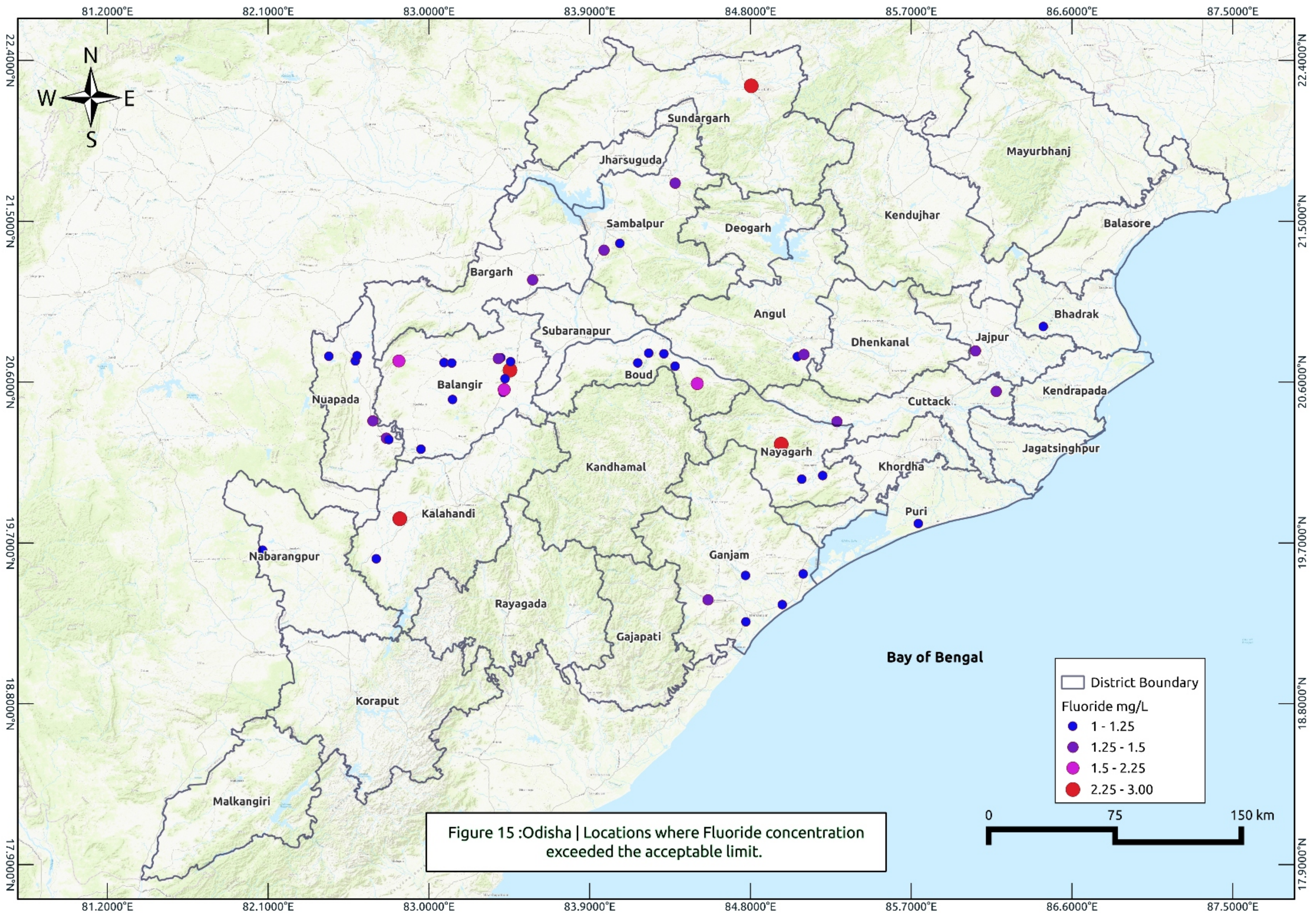

Figure 15 :Odisha | Locations where Fluoride concentration exceeded the acceptable limit.

10. TOTAL HARDNESS

Total hardness in water primarily results from cations like calcium and magnesium, along with anions such as bicarbonate and sulfate. It is measured by summing the concentrations of calcium and magnesium, expressed as $CaCO_3$ in mg/L. Hardness indicates water's ability to react with soap, as calcium, magnesium, and organic compounds can form insoluble soap compounds. Total hardness, represented as $CaCO_3$ mg/L, is determined through EDTA titration.

The hardness of water is largely determined by its interaction with soil and rock formations. Water percolating through limestone or gypsum-rich regions often acquires higher levels of calcium and magnesium, leading to increased hardness.

Individuals prone to kidney and bladder stones are advised to avoid water with high calcium and magnesium content. The Bureau of Indian Standards (BIS) sets the permissible limit of hardness at 600 mg/L. Elevated total hardness has been observed in groundwater across various districts, and the details are given in the following table (Table 12).

Table 12: District-Wise Data of Locations with Total Hardness Greater than 600 mg/L in Odisha.

Sl. No	Districts	No. of Samples	No. of Samples TH>600 mg/L	(%) Samples TH>600 mg/L	Sl.No	Districts	No. of Samples	No. of Samples TH>600 mg/L	(%) Samples TH>600 mg/L
1	Angul	24	1	0.22	16	Kandhamal	2		0.00
2	Balangir	54	1	0.22	17	Kendrapara	11	1	0.22
3	Baleshwar	10	1	0.22	18	Kendujhar	10		0.00
4	Bargarh	31	1	0.22	19	Khordha	9		0.00
5	Baudh	27		0.00	20	Koraput	10		0.00
6	Bhadrak	11		0.00	21	Malkangiri	3		0.00
7	Cuttack	15		0.00	22	Mayurbhanj	16		0.00
8	Debagarh	4		0.00	23	Nabarangpur	5		0.00
9	Dhenkanal	8		0.00	24	Nayagarh	16		0.00
10	Gajapati	6		0.00	25	Nuapada	21		0.00
11	Ganjam	41	1	0.22	26	Puri	36	1	0.22
12	Jagatsinghpur	1		0.00	27	Rayagada	2		0.00
13	Jajapur	4		0.00	28	Sambalpur	34	2	0.43
14	Jharsuguda	4		0.00	29	Sonapur	25	2	0.43
15	Kalahandi	14	1	0.22	30	Sundargarh	11		0.00
	Total						**465**	**12**	**2.58**

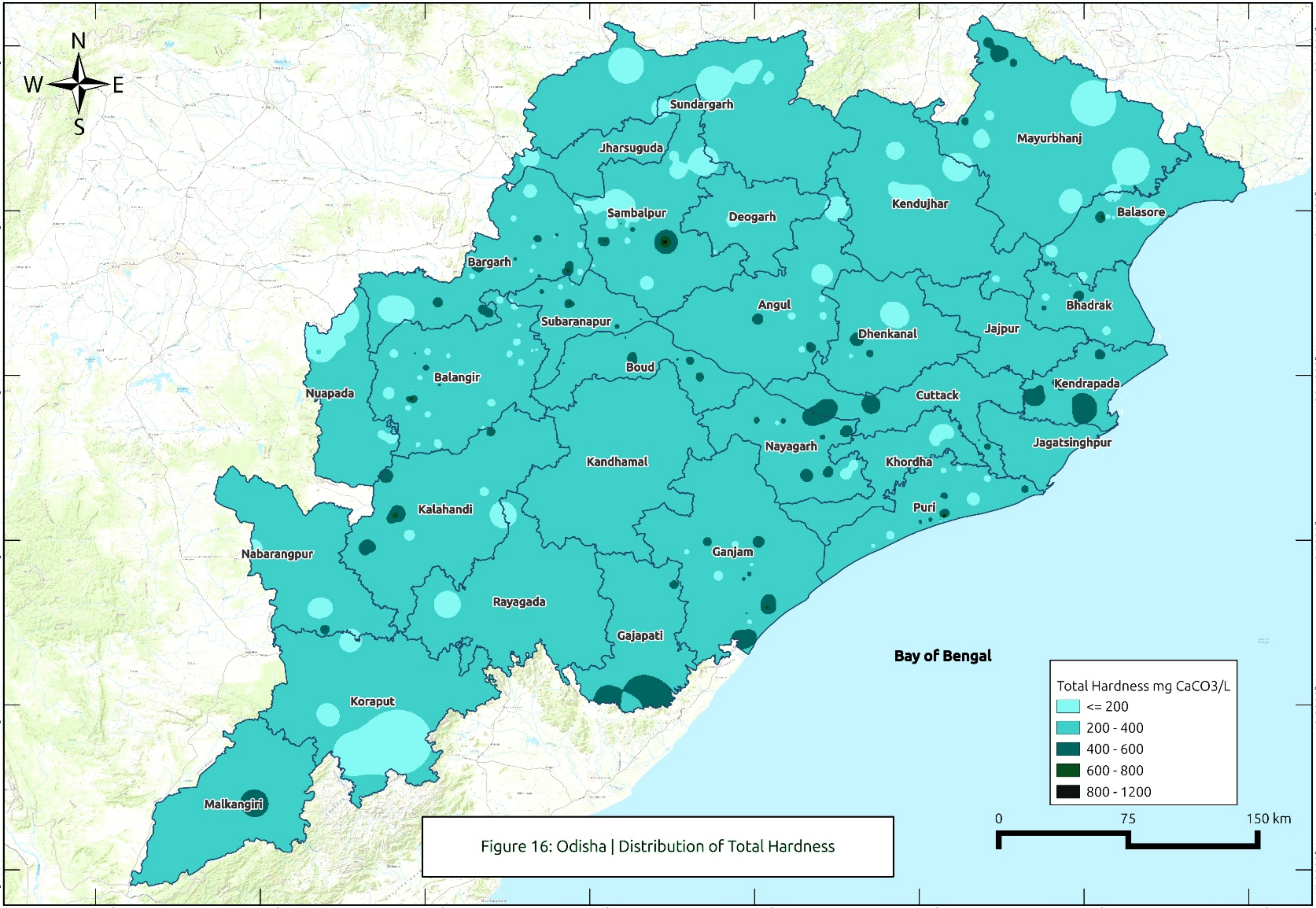

Figure 16: Odisha | Distribution of Total Hardness

11. ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING PURPOSES.

The suitability of groundwater for drinking purposes is evaluated based on the standards specified by the Bureau of Indian Standards (IS 10500:2012), considering the basic parameters analyzed in this study. Groundwater quality is influenced by chemical constituents as well as biological components, such as bacteria, and physical characteristics, including color, turbidity, and odor. To meet the comprehensive requirements of IS 10500:2012, more than 64 parameters must be tested, including pesticide residues and bacteriological criteria, which were not analyzed in this evaluation. Accordingly, the recommendation for suitability is based exclusively on the tested basic parameters.

The results of the chemical analysis for the collected groundwater samples, indicating their suitability for drinking purposes, are presented in the table below.

Table 13: Groundwater Quality Status in Odisha for Drinking Purposes Based on NHS Pre-Monsoon 2024 Data.

Parameters	Drinking water Specification (IS 10500:2012)		Number of Samples		
	Acceptable Limit	Permissible Limit in the Absence of Alternate Source	Suitable	Acceptable	Unsuitable
pH	6.5-8.5	No Relaxation	463	-	2
TDS, mg/L	500	2000	237	225	3
TH mg/L as CaCO3	200	600	134	319	12
TA mg/L as CaCO3	200	600	178	282	5
Ca^{2+} mg/L	75	200	280	174	11
Mg^{2+} mg/L	30	100	310	141	14
Cl^{-}mg/L	250	1000	415	47	3
SO_4^{2-} mg/L	200	400	458	5	2
NO_3^{-} mg/L	45	No Relaxation	380	-	85
F - mg/L	1	1.5	419	39	8

11.1 Toxic metal contamination:

A total of 465 samples were analyzed for potentially toxic metal and metalloids using the IS 3025: Part 65: 2022 method (ICP-MS). The summary of the analysis, along with a comparison to IS10500:2012, is provided below.

Table 14: Summary of potentially toxic metal and metalloids occurrence:(Pre-Monsoon_NHNS 2024)							
Element	Min-imum	Maximum	Mean	IS 10500:2012(Reaffirmed 2023) requirements		Percentage of sample Exceeding limits	
	Values are in µg/L			Acceptable Limit	Permissible Limit	Acceptable Limit	Permiss-ible Limit
Aluminium (Al)	BDL	3139.41	68.41	30	200	(251) 54.0%	(18) 3.9%
Arsenic (As)	0.01	135.23	1.35	10	No relaxa-tion	(7) 1.5%	--
Barium (Ba)	3.17	1049.17	126.76	700	No relaxa-tion	(3) 0.6%	--
Chromium (Cr)	BDL	48.33	1.19	50	No relaxa-tion	0	--
Copper (Cu)	BDL	83.80	6.04	50	150	(2) 0.43%	0
Lead 208 (Pb)	BDL	131.99	1.77	10	No relaxa-tion	(3) 0.65%	--
Manganese (Mn)	BDL	6628.07	241.32	100	300	(174) 37.4 %	(90) 19.35 %
Molybdenum (Mo)	BDL	16.32	1.05	70	No relaxa-tion	0	0
Strontium (Sr)	15.49	1866.07	441.04				
Zinc (Zn)	BDL	27653.03	362.98	5000	15000	(7) 1.5 %	(4) 0.86 %
Boron (B)	BDL	814.73	27.47	500	1000	3 (0.65%)	0
Cadmium (Cd)	BDL	7.66	0.13	3	No relaxa-tion	2 (0.43 %)	-
Iron (Fe)	BDL	65922.20	1272.19	1000	No relaxa-tion	72 (15 .48%)	-
Mercury (Hg)	BDL	0.86	0.04	1	No relaxa-tion	0	-
Nickel (Ni)	0.03	38.11	2.46	20	No relaxa-tion	6 (1.29 %)	-
Selenium (Se)	BDL	8.28	0.44	10	No relaxa-tion	0	-
Silver (Ag)	BDL	253.64	25.80	100	No relaxa-tion	31(6.67%)	-
Uranium 238 (U)	BDL	41.88	2.57	30	No relaxa-tion	2 (0.43 %)	-

13. SUMMARY

Water quality varies widely based on local geological formations and human activities. These variations influence the chemical, physical, and biological characteristics of water, impacting its suitability for consumption. Below is a detailed summary of the water quality findings from the study:

Total Dissolved Solids (TDS)

High TDS levels were observed in samples from the coastal districts of Puri and Ganjam, where three samples exceeded the permissible limit of 2000 mg/L.

Elevated TDS may be linked to seawater intrusion in coastal aquifers or dissolution of minerals in the underlying geology.

Nitrate Contamination

Of the 465 samples collected during the pre-monsoon season of 2024, 85 samples showed nitrate levels above the permissible limit of 45 mg/L. Excess nitrate in drinking water is often associated with poor sanitation practices, inadequate well construction, and insufficient source protection. This highlights the need for better waste management and wellhead protection measures.

Fluoride

Fluoride levels exceeding the permissible limit of 1.5 mg/L were detected in 8 samples from various districts: Angul (1 sample), Balangir (3), Boudh (1), Nayagarh (1), Kalahandi (1), and Sundergarh (1). Chronic exposure to high fluoride concentrations can lead to dental and skeletal fluorosis, emphasizing the need for alternate water sources and community awareness programs in these areas.

Iron Contamination

Iron contamination remains widespread in hand pump water sources, while dug wells are generally less affected due to aeration, which facilitates the natural oxidation and precipitation of iron. Elevated iron levels cause staining, an unpleasant metallic taste, and potential long-term health effects when combined with other contaminants.

Manganese Contamination

A total of 90 samples exceeded the maximum permissible limit for manganese. High manganese levels, often found under anoxic (oxygen-deprived) conditions.

Overall Water Quality

While the overall water quality across the state is generally acceptable for drinking based on the basic parameters tested, specific issues persist. These include localized contamination from human activities, poor well construction, and naturally occurring geogenic contaminants such as fluoride. Addressing these challenges requires an integrated approach, including the identification of alternative water sources, better sanitation practices, and regular monitoring of groundwater quality.

Disclaimers

1. Sampling and Analysis

This report is based on a single sampling activity conducted during the pre-monsoon period of 2024. For accurate and reliable conclusions, repeated sampling and analysis over different seasons and timeframes are essential.

2. Spatial Distribution Plots

The spatial distribution plots included in this document are generated through statistical analysis(IDW). Data gaps, outliers, and limitations in sampling density may affect the accuracy and precision of these plots. They should be interpreted as general information rather than definitive representations of spatial trends.

End of report