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Government of India
Ministry of Jal Shakti
CENTRAL GROUND WATER BOARD

REPORT
ON

GROUND WATER QUALITY IN SHALLOW AQUIFERS OF NCT OF DELHI

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CENTRAL GROUND WATER BOARD,
STATE UNIT OFFICE, NEW DELHI

REPORT
ON
GROUNDWATER QUALITY IN SHALLOW AQUIFER OF NCT OF INDIA

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Table of Contents

केन्द्रीय भूमि जल बोर्ड
राज्य एकक कार्यालय
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास एवं जल संरक्षण विभाग
भारत सरकार, नई दिल्ली

CENTRAL GROUND WATER BOARD
STATE UNIT OFFICE
MINISTRY OF JAL SHAKTI
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GOVERNMENT OF INDIA, NEW DELHI

FOREWARD

Water is an indispensable resource for sustaining life and fostering growth, and the quality of our groundwater is paramount in ensuring the well-being of our communities. The NCT of Delhi, being a densely populated region with a burgeoning urban landscape, faces unique challenges in maintaining the quality of its water resources. Recognizing the significance of the shallow aquifer, this report delves into a thorough analysis to provide a comprehensive understanding of the ground water quality in the region.

This report is the culmination of extensive fieldwork, data collection, and rigorous analysis of chemical data. The objective was to assess the current state of the shallow aquifer along with the temporal analysis that sheds light on the dynamic nature of groundwater quality, revealing changes and trends that are crucial for understanding the system's behaviour. This temporal perspective allows us to identify trends that may be indicative of anthropogenic activities, climatic influences, or other environmental factors affecting the groundwater quality.

As we delve into the contents of this report, it is my hope that the information presented will catalyze meaningful conversations and actions. By raising awareness about the state of our groundwater, we pave the way for informed policies, community initiatives, and technological interventions that can contribute to the sustainable management and protection of this precious resource. Also, the inclusion of the temporal dimension in our report underscores the dynamic nature of the groundwater system and reinforces the need for ongoing monitoring and adaptive management strategies. It is my sincere hope that this temporal analysis will serve as a foundation for developing proactive measures to address emerging challenges and ensure the continued availability of high-quality groundwater for the residents of the National Capital Territory of Delhi.

I extend my heartfelt gratitude to the dedicated team members who contributed to this endeavour. It is my sincere belief that this report will serve as a valuable reference and guide for all those committed to preserving and enhancing the groundwater quality in the National Capital Territory of Delhi.

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1.0 INTRODUCTION

The quality of groundwater is a very sensitive issue. Groundwater is never pure and contains varying amounts of dissolved solids, the type and concentration depend on its source, surface and sub-surface environment, rate of groundwater movement, the residence time, the solubility of minerals present and the amount of dissolved carbon dioxide. In addition to the natural changes, anthropogenic activities such as sewage disposal, agricultural practices, industrial pollution etc. also contribute significantly to changes in groundwater quality. Once the contaminants have entered to the sub-surfacegeological environment, they may remain concealed for many years and may get dispersed over wide areas. Weathering of rock and mineral solubility controls the major ion composition of groundwaters. With increasing anthropogenic activities, a substantial amount of dissolved matter is added to groundwater. The ground water resources are being utilized for drinking, irrigation and industrial purposes. However, due to rapid growth of population, urbanization, industrialization and agriculture activities, ground water resources are under stress. There is growing concern on the deterioration of ground water quality due to geogenic and anthropogenic activities.

NCT of Delhi has varied hydrogeological situations resulting from diversified geological and topographic settings. Water-bearing rock formations (aquifers), range in age from Archaean to Recent. The natural chemical composition of ground water is influenced predominantly by type & depth of soils and subsurface geological formations through which ground water passes. Ground water quality is also influenced by contribution from the atmosphere and surface water bodies. Quality of ground water is also influenced by anthropogenic factors.

A diverse range of dissolved inorganic compounds present in different concentrations characterizes groundwater. These compounds originate from the chemical and biochemical interactions between water and geological substances. Inorganic impurities such as salinity, chloride, fluoride, nitrate, iron, and arsenic play a crucial role in assessing the suitability of groundwater for drinking purposes.

2.0 HYDROGEOLOGY

Behaviour of ground water in NCT of Delhi is highly complicated due to the occurrence of diversified geological formations with considerable lithological and chronological variations, and various hydrochemical conditions. Broadly two groups of rock formations have been identified, on the basis of Ground Water hydraulics viz. Alluvium Deposits and Hard Rock Formations.

2.1 Alluvium Deposits

In NCT Delhi region, exposures of the oldest lithostratigraphic unit, the Delhi Quartzite ridge acts as main recharge zone to subsurface aquifer system. The Quaternary deposits in the form of aeolian and alluvial deposits constitute the major repository of ground water in the area. In the East of the ridge, the thickness of unconsolidated sediments gradually increases away from the ridge, with the maximum reported thickness being 170 m. In the Southwestern, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 297 m below land surface. In Chhattarpur basin, the maximum thickness of sediments is 116 m. The aeolian deposits of South Delhi are mainly comprised of loam, silty loam and sandy loam. The bedrock is overlain by these deposits. Older alluvial deposits consist mostly of inter-bedded, lenticular and inter fingering deposits of clay, silt, and sand along with kankar. These deposits are overlain by the newer alluvium, which occurs mostly in the flood plains of river Yamuna.

2.2 Hard Rock Formation

Quartzite is one of the most physically durable and chemically resistant rocks found in NCT of Delhi. The suits of quartzite and associated mica schist /phyllite bands of Delhi system have undergone multiple folding and different phases of metamorphism. When the mountain ranges are worn down by weathering and erosion, less-resistant and less-durable rocks are destroyed, but the quartzite remains. Therefore, Delhi Quartzite is so often the rock found as linear ridges ranges and covering their flanks as a litter of scree. One of the research study on weathering of Proterozoic quartzite in the semi-arid conditions around Delhi suggested that Quartzite being a resistant rock, dissolution of small amount of pyrites presence, by moving water produced a sulphate-bearing acidic solution and ferrous iron which reacted with alumino-silicate minerals and quartz respectively and has made the Delhi Quartzite porous and subsequent friable. The coupled weathering mechanism, from the core outward and also proceeded initially from fractures towards the inside, produced weathering rinds and subsequent physical erosion of loose sand, produced during rind development in the outermost zones, has given rise to features like tors, spheroids, gullies, cavities and small-scale caves on these quartzites. Thus, the terrain has acquired ruggedness in semi-arid conditions.

In one of the studies of GSI, it is reported three generations of folding in the rocks of Delhi. The fold axes of first-generation folds follow the trend of main ridge i.e. NNE-SSW, the second-generation folds trending NE-SW are observed at Tughlaqabad - Mehrauli area, and third generation fold trending NW-SE is observed at Anand Parbat. The rocks are highly jointed and two sets of conjugate vertical to sub-vertical joints have been reported. Another study of GSI has inferred several faults trending NNE-SSW, NE-SW and WNW-ESE.

3.0 HYDROCHEMISTRY

The water that falls as rain and snow infiltrates into the subsurface soil and rock. Some water remains in the shallow soil layer whereas large portion infiltrate deeper and becomes part of groundwater system. The chemical characteristics of groundwater are mainly based on the surface and subsurface environment, such as the chemical composition of rain, composition of infiltrating surface water, properties of soil and rock in which the groundwater moves. It varies as per duration of contact time and contact surface between groundwater and geological material along its flow path, rate of geochemical (oxidation/reduction ion exchange, dissolution, evaporation, precipitation) process and microbiological process.

3.1 Chemistry of Rainwater

The atmosphere is composed of water vapors, dust particles and various gaseous components such as N_2, O_2, CO_2, CH_4, CO, SO_4, NO_3 etc. Pollutants in the atmosphere can be transported long distances by the wind. These pollutants are mostly washed down by precipitation and partly as dry fall out. Composition of rainwater is determined by the source of water vapors and by the ion, which are taken up during transport through the atmosphere. In general, chemical composition of rainwater shows that rainwater is only slightly mineralized with specific electrical conductance (EC) generally below 50 μS/cm, chloride below 5 mg/l and HCO_3 below 10 mg/l. Among the cations, concentration of Ca, Mg, Na & K vary considerably but the total cations content is generally below 15 mg/l except in samples contaminated with dust. The concentration of sulphates and nitrates in rainwater may be high in areas near industrial hubs.

3.2 Chemistry of Surface Water

Surface water is found extremely variable in its chemical composition due to variations in relative contributions of ground water and surface water sources. The mineral content in river water usually bears an inverse relationship to discharge. The mineral content of river water tends to increase from source to mouth, although the increase may not be continuous or uniform. Other factors like discharge of city wastewater, industrial waste and mixing of waters can also affect the nature and concentration of minerals in surface water. Among anions, bicarbonates are the most important and constitute over 50% of the total anions in terms of milli equivalent per liter (meq/l). In case of cations, alkaline earths or normally calcium predominates but with increasing salinity the hydrochemical facies tends to change to mixed cations or even to Na-HCO_3 type.

3.3 Chemistry of Ground Water

The downward percolating water is not inactive, and it is enriched in CO_2. It can also act as a strong weathering agent apart from general solution effect. Consequently, the chemical composition of ground water will vary depending upon several factors like frequency of rain, which will leach out the salts, time of stay of rain water in the root-zone and intermediate zone, presence of organic matter etc. It may also be pointed out that the water front does not move in a uniform manner as the soil strata are generally quite heterogeneous. The movement of percolating water through larger pores is much more rapid than through the finer pores. The overall effect of all these factors is that the composition of ground water varies from time to time and from place to place.

Before reaching the saturated zone, percolating water is charged with oxygen and carbon dioxide and is most aggressive in the initial stages. This water gradually loses its aggressiveness, as free CO_2 associated with the percolating water gets gradually exhausted through interaction of water with minerals.

$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

$$H^+ + \text{Feldspar} + H_2O \longrightarrow \text{Clay} + H_4SiO_4 + \text{Cation}$$

The oxygen present in this water is used for the oxidation of organic matter that subsequently generates CO_2 to form H_2CO_3. This process goes on until oxygen is fully consumed.

$$CH_2O + O_2 = CO_2 + H_2O$$

(Organic matter)

Apart from these reactions, there are several other reactions including microbiological mediated reactions, which tend to alter the chemical composition of the percolating water. For example, the bicarbonate present in most waters is derived mostly from CO_2 that has been extracted from the air and liberated in the soil through biochemical activity. Some rocks serve as sources of chloride and sulphate through direct solution. The circulation of sulphur, however, may be greatly influenced by biologically mediated oxidation and reduction reactions. Chloride circulation may be a significant factor influencing the anion content in natural water.

3.4 Hydrogeochemistry of NCT of Delhi

The diverse physiographic, topographic and geologic conditions have given rise to diversified groundwater situations and groundwater quality of NCT of Delhi and it varies with depth and space. It is mainly influenced by local geology and inherent salinity, and uneven development of groundwater.

In alluvial formations, in general, the quality of ground water deteriorates with depth, which is variable in different areas. The fresh ground water aquifers mainly exist up to a depth of 25 to 35 m in North West, West and parts of South west districts and in minor patches in North and Central districts. In South, Southeast & Southwest district, especially in Najafgarh *Jheel* area the fresh water occurs up to a depth of 30 to 45 mbgl. A localized area located just north of Kamala Nehru Ridge (part of Delhi ridge falling in Central District) covering area of Dhirpur, Wazirabad and Jagatpur are characterized by shallow depth of fresh water aquifers that is in the range of 22 to 28mbgl, regardless of proximity to River Yamuna. In the flood plains of Yamuna, in general, fresh water aquifers exist down to depth of 30-45mbgl and especially in Palla it reaches to the depth of 60 to 75mbgl below which brackish and saline water exists. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and eastern part (Ridge Area) of South-West districts and also in Chattarpur basin. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards North-West, the thickness of fresh water zone is limited in most parts of west and southwest districts.

4.0 WATER QUALITY CRITERIA

The available quality of groundwater is the resultant of all the processes and reactions, which taken place since the condensation of water in the atmosphere to the time it is retrieved in the form of groundwater from its source. The water has excellent capability to accumulate substances in soluble form as it moves over and into the land resource, from the biological processes and from human activities. Urbanization, agricultural development and discharges of municipal and industrial residues significantly alter characteristics of groundwater resource. The prevailing climatic conditions, topography, geological formations and use and abuse of this vital resource have significant effect on the characteristics of the water, because of which its quality varies with locations.

The definition of criteria and standards for water quality vary with the type of use. The characteristic of water required for human consumption, livestock, irrigation, industriesetc., have different water quality requirements. The term water quality criteria may be defined as the "Scientific data evaluated to derive recommendations for characteristics of water for specific use'. The term standard applies to any definite rule, principle or measure established by any statutory Authority. The distinction between criteria and standards is important, as the two are neither interchangeable nor they become synonyms for the objective or goal. Realistic standards are dependent on criteria, designated uses and implementation as well as identification and monitoringprocedure. The changes in all these factors may provide a basis for alteration instandards. In formulation of water quality criteria, the selection of water quality parameters depends on its use. Sayers, et. al. (1976 as quoted in CGWB & CPCB2000) identified the key water quality parameters according to its various uses **(Table 4.0).**

Table 4.0: Water quality criteria parameters for various uses (Sayers et.al., 1976)

Public Water supply	Industrial Water supply	Agricultural water supply	Aquatic life & wild life water supply	Recreation and Aesthetics
Coliform bacteria Turbidity colour, Taste, Odour TDS, CI, F, SO_4 NO_3, CN, Trace Metals, Trace Organics Radioactive substances	**Processing** pH, Turbidity Colour, Alkalinity, Acidity, TDS, Suspended solids, Trace metals, Trace Organics **Cooling** PH, Temp, Silica, AI, Fe, Mg, Total hardness, Alkalinity / Acidity Suspended solids, Salinity	Farmstead Same as for public supply Live-stock Same as for public supply Irrigation TDS, EC, Na, Ca, Mg, K, B, CI and Trace metals	Temp, DO, pH, Alkalinity, Acidity, TDS Salinity, pH, DCOs, Turbidity Colour, Settleable materials, Toxic substances, Nutrients, Floating materials	Recreations Tem, Turbidity, Colour, Odour, Floating Materials, Settable Materials Nutrients, Coliforms Aesthetics Same as for Recreation and Substances adversely affecting wild life

4.1 Water Quality Criteria for Drinking Purpose

With the objective of safeguarding water from degradation and to establish a basis forimprovement in water quality, standards / guide lines / regulations have been laid down by various national and international organizations such as; Bureau of Indian Standards(BIS), World Health Organization

(WHO), European Economic Community (EEC), Environmental Protection Agency (EPA), United States, and Inland Waters Directorate, Canada. The Bureau of Indian Standards (BIS) earlier known as Indian Standards Institutions (ISI) has laid down the standard specification for drinking water during 1983, which have been revised and updated from time to time. In order to enable the users, to exercise their discretion towards water quality criteria, the maximum permissible limit has been prescribed especially where no alternative sources are available. The national water quality standards describe essential and desirable characteristics required to be evaluated to assess suitability of water for drinking purposes. The important water quality characteristics as laid down in BIS standard (IS 10500: 2012) are summarized in **Table – 4.1**

Table 4.1: Drinking Water Characteristics (IS 10500: 2012)

S. No.	Parameters	Desirable Limits (mg/L)	Permissible limits (mg/L)
Essential Characteristics			
1	Colour Hazen Unit	5	15
2	Odour	Unobjectionable	-
3	Taste	Agreeable	-
4	Turbidity (NTU)	1	5
5	pH	6.5-8.5	No relaxation
6	Total Hardness, $CaCO_3$	200	600
7	Iron (Fe)	1.0	No relaxation
8	Chloride (Cl)	250	1000
9	Residual Free Chlorine	0.2	1
10	Fluoride (F)	1.0	1.5
Desirable Characteristics			
11	Dissolved Solids	500	2000
12	Calcium (Ca)	75	200
13	Magnesium (Mg)	30	100
14	Copper (Cu)	0.05	1.5
15	Manganese (Mn)	0.1	0.3
16	Sulphate (SO_4)	200	400
17	Nitrate (NO_3)	45	No relaxation
18	Phenolic Compounds	0.001	0.002
19	Mercury (Hg)	0.001	No relaxation
20	Cadmium (Cd)	0.003	No relaxation
21	Selenium (Se)	0.01	No relaxation
22	Arsenic (As)	0.01	No relaxation
23	Cyanide (CN)	0.05	No relaxation
24	Lead (Pb)	0.01	No relaxation
25	Zinc (Zn)	5.0	15
26	Hexavalent Chromium	0.05	No relaxation
27	Alkalinity	200	600
28	Aluminum (Al)	0.03	0.2
29	Boron (B)	0.5	2.4
30	Pesticides	Absent	0.001
31	Uranium	0.03	No relaxation

NTU- Nephelometric Turbidity Unit.

N.B. The fluoride limits vary with average annual temperature of the areas. Similarly, the limits for magnesium are based on sulphate contents of water. When sulphate content is 250 mg/L or above, the magnesium should be between 30 and 50 mg/L but ifsulphate is lower, higher content of magnesium is permissible.

4.2 Water Quality Criteria for Irrigation Purpose

Water quality plays a significant role in irrigated agriculture. Many problems originate due to inefficient management of water for agriculture use, especially when it carries high salt loads. The effect of total dissolved salts in irrigation water (measured in terms of electrical conductance) on crop growth is extremely important. Soil water passes in to the plant through the root zone due to osmotic pressure and the plants root able to assimilate water and nutrients. Thus, the dissolved solid contents of the residual water in the root zone also have to be maintained within limits by proper leaching. These effects are visible in plants by their stunted growth, low yield, discoloration and even leaf burns at margin or top. The safe limits of electrical conductivity for crops of different degrees of salt tolerances under varying soil textures and drainage conditions are presented in **Table - 4.2.**

Table 4.2: Safe Limits for electrical conductivity for irrigation water (IS:11624-1986)

S. No.	Nature of soil	Crop Growth	Upper permissible safe limit of electrical conductivity in water µs/cm at 25°C
1	Deep black soil and alluvial soils having clay content more than 30%; soils that are fairly to moderately well Drained	Semi-tolerant	1500
		Tolerant	2000
2	Textured soils having clay contents of 20-30%; soils that are well drained internally and have good surface drainage system	Semi-tolerant	2000
		Tolerant	4000
3	Medium textured soils having clay 10-20%; internally very well drained and having good surface drainage system	Semi-tolerant	4000
		Tolerant	6000

4	Light textured soils having clay lessthan 10%; soils that have excellent internal and surface drainage system.	Semi-tolerant	6000
		Tolerant	8000

In addition to problems caused by total amount of salts, some of the specific ions like sodium, boron and trace elements, if present in water in excess, also render it unsuitable for agricultural use.

4.2.1 SODIUM ADSORPTION RATIO (SAR) & RESIDUAL SODIUM CARBONATE (RSC)

The clay minerals in the soil adsorb divalent cations like calcium and magnesium ions from irrigation water. Whenever the exchange sites in clay are filled by divalent cations, the soil texture is conducive for plant growth. Sodium reacts with soil to reduce its permeability. In case the irrigation water is sodium dominant, the clay lattice is filled with sodium ions due to ion exchange. Such soils become impermeable and sticky and as such the cultivation becomes difficult to support plant growth. However, the cation exchange process is reversible and can be controlled either by adjusting the composition of water or by soil amendment by application of gypsum, which releases cations (Calcium) to occupy the exchange position. The tendency of water to replace adsorbed calcium and magnesium with sodium can be expressed by the Sodium Adsorption Ratio (SAR), where all the ion concentrations are in milli-equivalents per litre (meq/L).

$$\mathbf{SAR} = \frac{\mathbf{Na}}{\sqrt{(\mathbf{Ca} + \mathbf{Mg})/2}}$$

When, water having high bicarbonates and low calcium and magnesium is used for irrigation purpose, precipitation of calcium and magnesium as carbonate takes place, changing the residual water to high sodium water with sodium bicarbonate in solution. It is termed as Residual Sodium Carbonate (RSC) which is expressed as;

$$\mathbf{RSC} = (\mathbf{HCO3} + \mathbf{CO3}) - (\mathbf{Ca} + \mathbf{Mg})$$

(Where all the ions' concentrations are in milli equivalents / litre).

Percentage sodium (%Na):

Percentage sodium (%Na) is an indication of the soluble sodium content of the groundwater and also used to evaluate Na hazard. In all natural waters, %Na is a common parameter to assess its suitability for irrigation purposes since sodium reacts with the soil to reduce permeability.

$$\%\mathbf{Na} = \frac{(\mathbf{Na} + \mathbf{K})}{(\mathbf{Ca} + \mathbf{Mg} + \mathbf{Na} + \mathbf{K})} * \mathbf{100}$$

The quality of water is commonly expressed by classes of relative suitability for irrigation with reference to salinity levels. The recommended classification with respect to Electrical Conductivity, Sodium content, Sodium Adsorption Ratio, and Residual Sodium Carbonate, under customary irrigation conditions has been depicted in **Table - 4.2.1.**

Table 4.2.1: Guidelines for evaluation of quality of irrigation water

Water Class	Alkalinity hazards		
	SAR IS:11624-1986	RSC (meq/L) IS:11624-1986	%Na Wilcox
Low	< 10	< 1.5	< 20
Medium	>10 – 18	1.5 – 3	20 - 60
High	>18 – 26	3 - 6	> 60
Very High	> 26	> 6	

4.3 Effects of Water Quality Parameters on Human Health and Distribution for Various Users

It is essential to ensure that various constituents are within prescribed limits in drinkingwater supplies to avoid impact on human health **(Table – 4.2.3)**. Man, life forms and domestic animals are affected by alteration in water quality due to natural or anthropogenic reasons. The effect of these substances depends on the quantity of water consumed per day and their concentration in water.

Table 4.2.3: Effects of water quality parameters on human health when used for drinking Purpose

S. No.	Parameters	Prescribed limits IS:10500, 2012		Probable Effects
		Desirable Limit	Permissible Limit	
1	Colour (Hazen unit)	5	15	Makes water aesthetically undesirable
2	Odour	Essentially free from objectionable odour		Makes water aesthetically undesirable
3	Taste	Agreeable		Makes water aesthetically undesirable
4	Turbidity (NTU)	1	5	High turbidity indicates contamination / Pollution.
5	pH	6.5	8.5	Indicative of acidic or alkalinewaters, affects taste, corrosivity and the water supply system
6	Hardness as $CaCO_3$ (mg/L)	200	600	Affects water supply system (Scaling), Excessive soap consumption, and calcification of arteries. There is no conclusiveproof but it may cause urinary concretions, diseases of kidney or bladder and stomach disorder.

S. No.	Parameters	Prescribed limits IS:10500, 2012 Desirable Limit	Permissible Limit	Probable Effects
7	Iron (mg/L)	1.0	No relaxation	Gives bitter sweet astringenttaste, causes staining of laundry and porcelain. In traces it isessential for nutrition.
8	Chloride (mg/L)	250	1000	May be injurious to some people suffering from diseases of heart or kidneys. Taste, indigestion, corrosion and palatability are affected.
9	Residual Chlorine (mg/L) Only when water is Chlorinated	0.20	-	Excessive chlorination of drinking water may cause asthma,colitis and eczema.
10	Total Dissolved Solids-TDS (mg/L)	500	2000	Palatability decreases and may cause gastro intestinal irritation in human, may have laxative effect particularly upon transits and corrosion, may damage water system.
11	Calcium (Ca) (mg/L)	75	200	Causes encrustation in water supply system. While in sufficiency causes a severe type of rickets, excess causesconcretions in the body such as kidney or bladder stones and irritation in urinary passages.
12	Magnesium (mg) (mg/L)	30	100	Its salts are cathartics and diuretic. High concentration may have laxative effect particularly on new users. Magnesium deficiency is associated with structural and functional changes. It is essential as an activator of many enzyme systems.
13	Copper (Cu) (mg/L)	0.5	1.50	Astringent taste but essential and beneficial element in human metabolism. Deficiency results in nutritional anemia in infants. Large amount may result in liver damage, cause central nervous system irritation and depression. In water supply it enhance corrosion of aluminum in particular
14	Sulphate (SO_4) (mg/L)	200	400	Causes gastro intestinal irritation along with Mg or Na, can have a cathartic effect on users, concentration more than 750 mg/L may have laxative effect along with Magnesium.
15	Nitrate (NO_3) (mg/L)	45	No relaxation	Cause infant methaemoglobinaemia (blue babies) at very high concentration, causes gastriccancer and affects adversely central nervous system and cardiovascular system.
16	Fluoride (F) (mg/L)	1.0	1.50	Reduce dental carries, very high concentration may cause crippling skeletal fluorosis.

S. No.	Parameters	Prescribed limits IS:10500, 2012 Desirable Limit	Permissible Limit	Probable Effects
17	Cadmium (Cd) (mg/L)	0.003	No relaxation	Acute toxicity may be associated with renal, arterial hypertension, itai-itai disease, (a bone disease).Cadmium salt causes cramps, nausea, vomiting and diarrhea.
18	Lead (Pb) (mg/L)	0.01	No relaxation	Toxic in both acute and chronic exposures. Burning in the mouth, severe inflammation of the gastro-intestinal tract withvomiting and diarrhoea, chronictoxicity produces nausea, severe abdominal pain, paralysis, mental confusion, visual disturbances, anaemia etc.
19	Zinc (Zn) (mg/L)	5	15	An essential and beneficial element in human metabolism. Taste threshold for Zn occurs at about 5 mg/L imparts astringent taste to water.
20	Chromium (Cr^6) (mg/L)	0.05	No relaxation	Hexavalent state of Chromium produces lung tumors can produce cutaneous and nasal mucous membrane ulcers and dermatitis.
21	Boron (B) (mg/L)	0.5	2.4	Affects central nervous system itssalt may cause nausea, cramps, convulsions, coma etc.
22	Alkalinity (mg/L) as $CaCO_3$	200	600	Impart distinctly unpleasant taste may be deleterious to human being in presence of high pH, hardness and total dissolved solids.
23	Pesticides: (m g/l)	Absent	0.001	Imparts toxicity and accumulated in different organs of human body affecting immune and nervous systems may be carcinogenic.
24	Phosphate (PO_4) (mg/L)	No guideline		High concentration may causevomiting and diarrhea, stimulate secondary hyperthyroidism andbone loss
25	Sodium (Na) (mg/L)	No guidelines		Harmful to persons suffering From cardiac, renal andcirculatory diseases.
26	Potassium (K) (mg/L)	No guidelines		An essential nutritional elementbut its excessive amounts is cathartic
27	Silica (SiO_2) (mg/L)	No guidelines		-
28	Nickel (Ni) (mg/L)	0.02		Non-toxic element but may becarcinogenic in animals, can react with DNA resulting in DNAdamage in animals.
29	Pathogens (a) Total coliform (per100ml) (b) Faecal Coliform (per 100ml)	nil		Cause water borne diseases like coliform Jaundice, Typhoid, Cholera etc. produce infections involving skin mucous membrane of eyes, ears and throat.

S. No.	Parameters	Prescribed limits IS:10500, 2012		Probable Effects
		Desirable Limit	Permissible Limit	
30	Arsenic	0.01	**No relaxation**	Various skin diseases, Carcinogenic
31	Uranium	0.03	**No relaxation**	Kidney disease, Carcinogenic

5.0 GROUND WATER QUALITY MONITORING

The International Standard Organization (ISO) has defined monitoring as," The programmed process of samplings, measurements and subsequent recording or signaling or both, of various water characteristics, often with the aim of assessing, conformity to specified objectives". A systematic plan for conducting water quality monitoring is called Monitoring Programme, which includes monitoring network design, preliminary survey, resource estimation, sampling, analysis, data management & reporting.

Monitoring of ground water quality is an effort to obtain information on chemical quality through representative sampling in different hydrogeological units. Ground Water is commonly tapped from phreatic aquifers through dugwells in a major part of the country and through springs and hand pumps in hilly areas. The main objective of ground water quality monitoring programme is to get information on the distribution of water quality on a regional scale as well as lattice is to create a background data bank of different chemical constituents in ground water.

One of the main objectives of the ground water quality monitoring is to assess the suitability of ground water for drinking purpose. The quality of drinking water is a powerful environmental determinant of the health of a community. The problem of the quality of water resources in general, and groundwater resources in particular, is becoming increasingly important in both industrialized and developing nation. In developing countries like India, the essential concerns as regards water resources are their quantity, availability, sustainability and suitability. Groundwater plays a leading role because it has of fundamental importance to all living beings.

Even though water is the most frequently occurring substance on earth, lack of safe drinking water is more prominent in the developing countries. Due to increasing world population, extraction of groundwater is also increasing for irrigations, industries, municipalities and urban and rural households' day by day. During dry season extensive withdrawal of groundwater for irrigation purpose is lowering the water table in the aquifer and also changing the chemical composition of water.

The physical and chemical quality of ground water is important in deciding its suitability for drinking purposes. Bureau of Indian Standards (BIS) formally known as Indian Standard Institute (ISI) vide its document IS: 10500:2012, Edition 3.2 (2012-15) has recommended the quality standards for drinking water. On this basis of classification, the natural ground water of India has been categorized as desirable, permissible and unfit for human consumption.

From the analytical results, it is seen that majority of water samples collected from observation / monitoring wells of CGWB in a major part of the country fall under desirable or permissible category and hence are suitable for drinking purposes. However, a small percentage of well waters are found to have concentrations of some constituents beyond the permissible limits. Such waters are not fit for human consumption and are likely to be harmful to health on continuous use.

5.1 Data Validation / Data Quality Control

Groundwater quality data validation is an essential step in ensuring the reliability and accuracy of the data. Here are some of the main steps for groundwater quality data validation.

a. Checking of Data Consistency: Checking of the data for consistency by comparing the measurements of a particular parameter over time. This will help identify any changes in the groundwater quality due to measurement methodology or equipment
b. Checking the correlation between EC and TDS:
    a. The relationship between the two parameters is often described by a constant (commonly between 0.55 and 0.95 for freshwaters).
    b. Thus: TDS (mg/l) ~ (0.55 to 0.95) x EC (mS/cm).
    c. The value of the constant varies according to the chemical composition of the water. For freshwaters, the normal range of TDS can be calculated from the following relationship:
    d. 0.55 conductivity (mS/cm) < TDS (mg/l) < 0.95 conductivity (mS/cm).
    e. Typically the constant is high for chloride rich waters and low for sulphate rich waters.

c. Checking the cation-anion balance

When a water quality sample has been analysed for the major ionic species, one of the most important validation tests can be conducted: the cation-anion balance.

Sum of cations = sum of anions

where:
cations = positively charged species in solution (meq/l)
anions = negatively charged species in solution (meq/l)

The Electronic charge balance is expressed as follows:

$$\text{Electronic Charge Balance (ECB \%)} = \frac{[\sum \text{cations} - \sum \text{anions}]}{[\sum \text{cations} + \sum \text{anions}]} \times 100$$

All concentrations should be in epm. Error charge balance has been computed for the chemical results of 2022-23 and analysis showing more than 10% ECB has not been accepted as it indicates that there has been an error made in at least one of the major cation/anion analyses.

6.0 GROUND WATER QUALITY SCENARIO IN NCT OF DELHI

The quality of groundwater in NCT of Delhi has been evaluated by sampling and analysis of water samples collected from Groundwater Monitoring wells.About **95** Groundwater Monitoring wells were monitored for water quality during May 2022 representing pre-monsoon water quality. The district-wise chemical analysis data of the samples are given in the Annexure – 1 & 2. The summarized results of groundwater quality ranges are given in **Table – 6.1.**

Table - 6.1. Summarized results of groundwater quality ranges, (May 2022)

S. No	Parameters		Range	No. of sample	Percentage
1	Electrical Conductivity µs/cm at 25ºC	Fresh	< 750	22	23.15
		Moderate	750- 2250	42	44.21
		Slightly mineralized	2251- 3000	07	7.36
		Highly mineralized	> 3000	24	25.26
2	Chloride mg/L	Desirable limit	< 250	53	55.78
		Permissible limit	251-1000	31	32.63
		Beyond permissible limit	> 1000	11	11.57
3	Fluoride mg/L	Desirable limit	< 1.0	66	69.47
		Permissible limit	1.0 - 1.5	14	14.73
		Beyond permissible limit	>1.5	15	15.78
4	Nitrate mg/L	Permissible limit	< 45	62	65.26
		Beyond permissible limit	> 45	33	34.73

The groundwater samples collected from submersible pumps and hand pumps tapping phreatic aquifers are analyzed for all the major inorganic parameters. Based on the results, it is found that ground water in the NCT of Delhi is mostly of calcium bicarbonate (Ca-Mg-HCO_3) type when the total dissolved solids of water is below 500 mg/L (corresponding to electrical conductance of 750 µS/cm at 25^{0}C). They are of mixed cations and mixed anion type when the electrical conductance is between 750 and 3000 µS/cm and waters with electrical conductance above 3000 µS/cm are of sodium chloride (Na-Cl) type. However, other types of water are also found among these general classifications, which may be due to the local variations in hydro-chemical environments due to anthropogenic activities. Nevertheless, occurrence of high concentrations of some water quality parameters such as salinity, chloride, fluoride, iron, arsenic and nitrate have been observed in some pockets in few districts of Delhi.

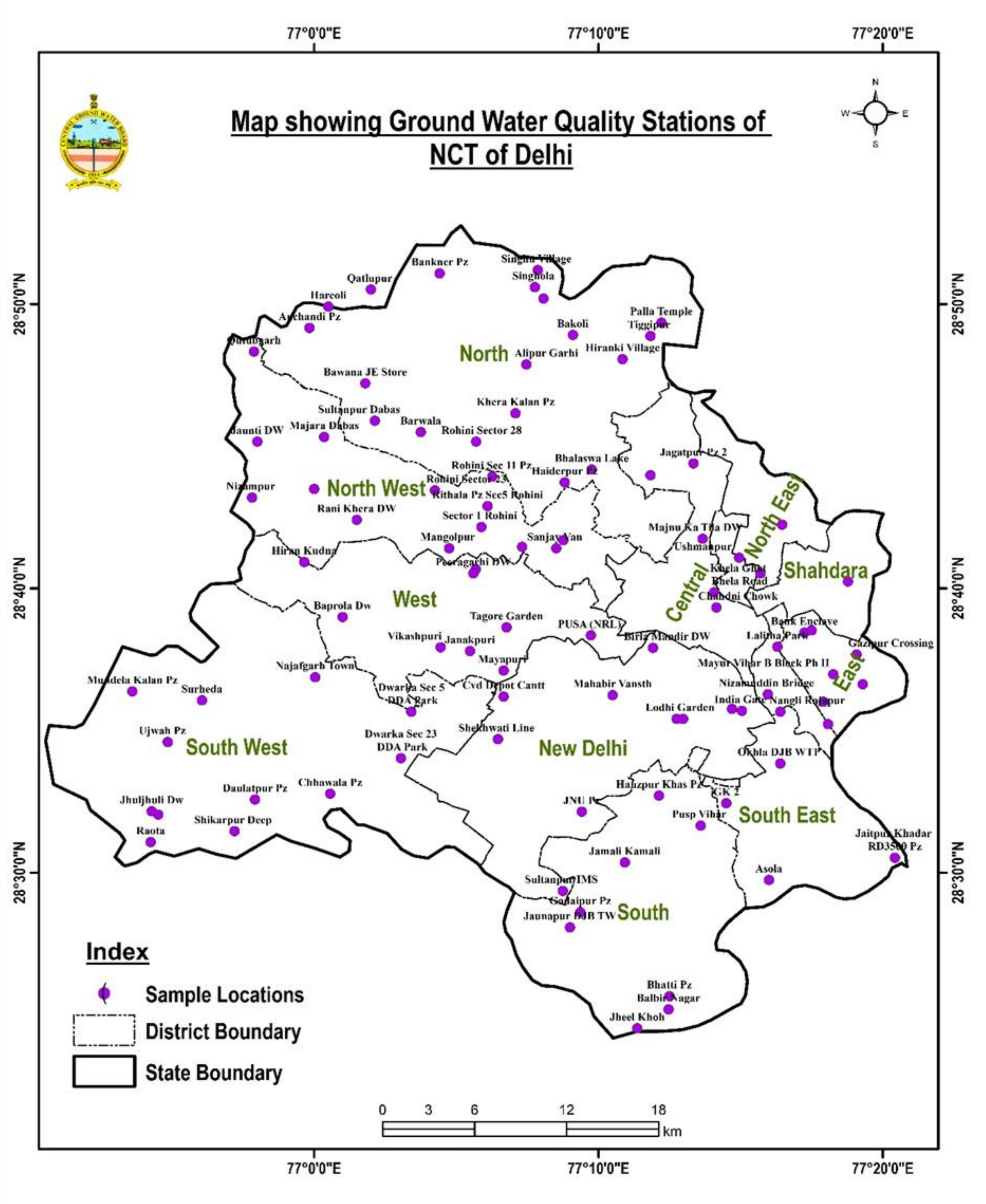

Fig 6.1.1 Map showing location of Sampling Stations in NCT of Delhi (May 2022)

7.0 GROUND WATER QUALITY HOT SPOTS IN UNCONFINED AQUIFERS OF NCT OF DELHI

Unconfined aquifers are extensively tapped for water supply across the State therefore; its quality is of paramount importance. The chemical parameters like TDS, Chloride, Fluoride, Iron, Arsenic and Nitrate etc. are main constituents defining the quality of ground water in unconfined aquifers. Therefore, presence of these parameters in ground water beyond the permissible limit in the absence of alternate source has been considered as groundwater quality hotspots.

Groundwater quality hot spot maps of the NCT of Delhi have been prepared depicting seven main parameters based on their distribution shown on the separate maps. These maps depict the spatial distribution of the following constituents in ground water tapping the unconfined aquifers.

I. Electrical Conductivity
II. Chloride (> 1000 mg/L)
III. Fluoride (>1.5 mg/L)
IV. Nitrate (>45mg/L)
V. Iron (>1.0mg/L)
VI. Arsenic (>0.01 mg/L)
VII. Uranium (>0.03 mg/L)

7.1 Electrical Conductivity

Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution. For example, the measurement of product conductivity is a typical way to monitor and continuously trend the performance of water purification systems. In many cases, conductivity is linked directly to the total dissolved solids (TDS).

Salinity is the saltiness or dissolved salt contents of a water body. Salt content is an important factor in water use. Salinity can be technically defined as the total mass in grams of all the dissolved substances per Kilogram of water. Different substances dissolve in water giving it taste and odour. In fact, humans and other animals have developed senses which are, to a degree, able to evaluate the potability of water, avoiding water that is too salty or putrid.

Salinity always exists in ground water but in variable amounts. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as the permeability of soil, drainage facilities, and quantity of rainfall and above all, the climate of the area. The salinity of groundwater in coastal areas in addition to the above may be due to air borne salts originating from air water interface over the sea and also due to over pumping of fresh water which overlays saline water in coastal aquifer systems.

BIS has recommended a drinking water standard for total dissolved solids a limit of 500 mg/L (corresponding to EC of about 750 μS/cm at 25^0C) that can be extended to a TDS of 2000 mg/L (corresponding to EC of about 3000 μS/cm at 25^0C) in case of no alternate source. Water having TDS more than 2000 mg/L is not suitable for drinking purpose. In Fig 7.1.2, the EC values (in μS/cm at

25^0C) of ground water from observation/monitoring wells have been used to show distribution patterns of electrical conductivity in different ranges of suitability for drinking purposes. It is apparent from the map that majority of the waters having EC values less than 750µS/cm at 25^0C occur mostly in the parts of the South, North-East, South-East and Central districts of the NCT of Delhi.

Groundwater with EC ranging between 750 and 3000µS/cm at 25^0C falling under 'permissible' range are confined mainly to Central and South-Eastern part of the State. These include South, South-East, East, Shahdara, North-East, Central and New Delhi districts of the State. However, in some cases, relatively high values of EC in excess of 3000 µS/cm are observed in many parts of the State, especially Nort and Western parts of the State. Table 7.1.1 shows the list of districts affected by high EC water (EC > 3000 µS/cm) and these areas are water quality hot spots from salinity point of view.

District-wise percentage of wells having EC >3000 µS/cm is shown as a bar diagram in Fig 7.1.1 and the occurrences of Electrical Conductivity in ground water beyond permissible limit (>3000 µS/cm) have been shown on the contour map as Fig 7.1.2, the percentage groundwater samples in various EC range is also illustrated in Fig 7.1.3. Locations details are given in Annexure-3.

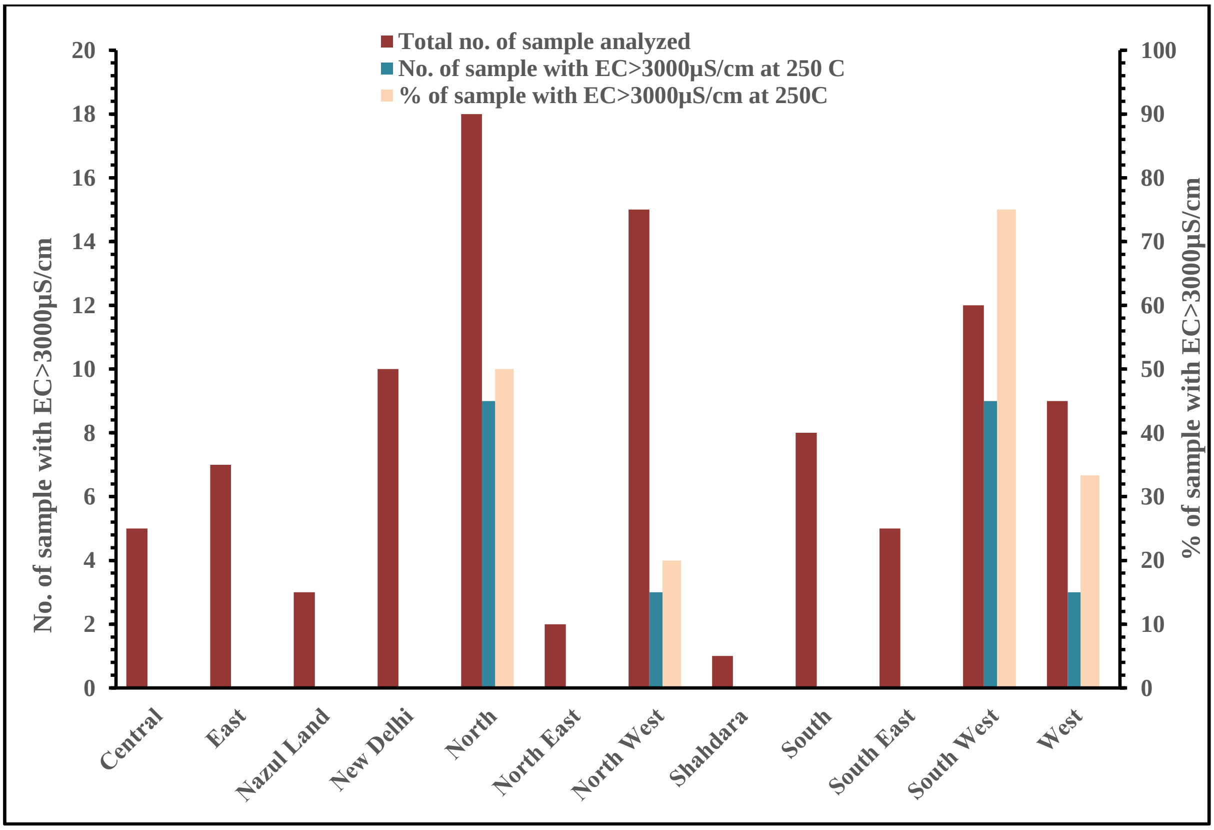

Fig 7.1.1 District-wise percentage of wells having EC >3000 µS/cm.

Table 7.1.1 District-wise percentage of samples having EC >3000 µS/cm

Sr. No	Name of districts	Total no. of Sample Analyzed	No. of Sample with EC>3000µS/cm at 25^0 C	(%) Samples with EC>3000µS/cm at 25^0C
1.	Central	5	0	0
2.	East	7	0	0
3.	Nazul Land	3	0	0
4.	New Delhi	10	0	0
5.	North	18	9	50
6.	North East	2	0	0
7.	North West	15	3	20
8.	Shahdara	1	0	0
9.	South	8	0	0
10.	South East	5	0	0
11.	South West	12	9	75
12.	West	9	3	33.3
	Total	**95**	**24**	

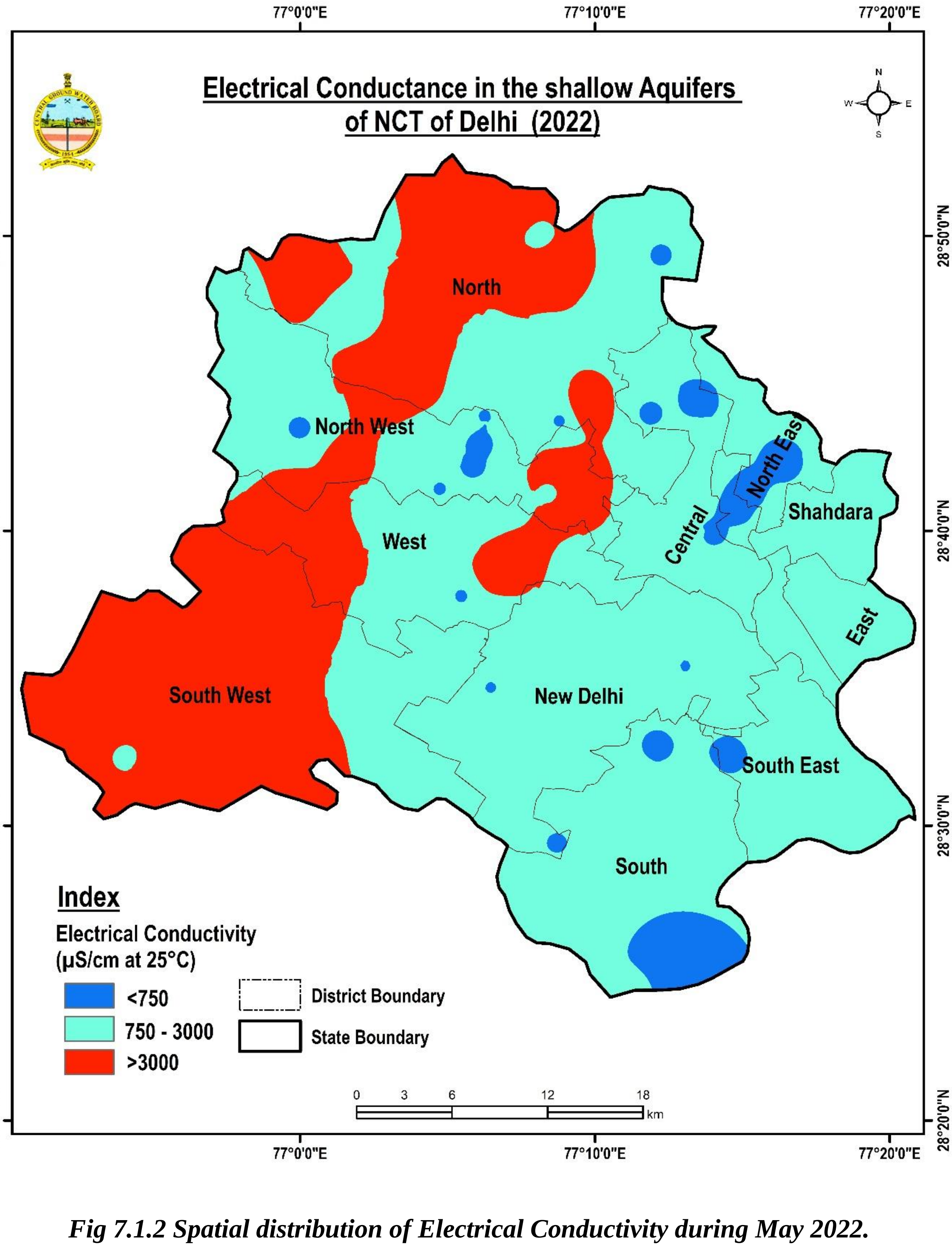

Fig 7.1.2 Spatial distribution of Electrical Conductivity during May 2022.

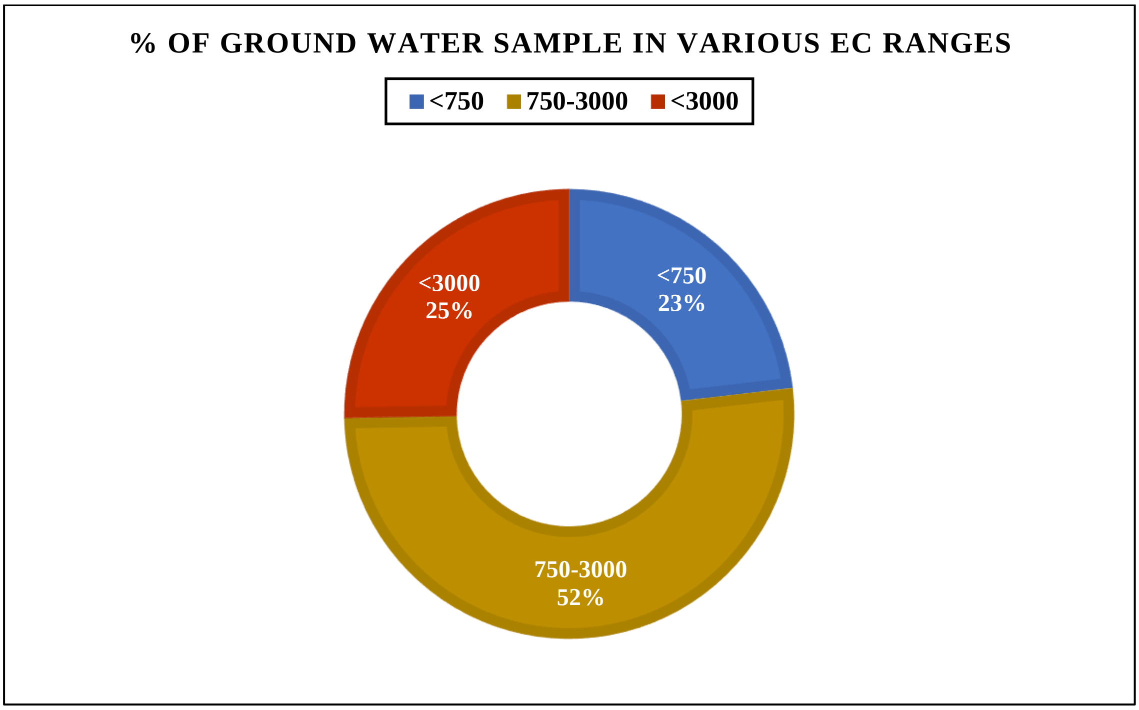

Fig 7.1.3 Percentage groundwater samples in various EC range (NCT of Delhi).

Table 7.1.2: Comparative change in number of districts having EC > 3000 µS/cm in various states.

S. No.	State	Nos. of districts having EC > 3000 µS/cm.		
		2017	**2022**	**Increase/Decrease**
1.	Central	0	0	0
2.	East	0	0	0
3.	New Delhi	0	0	0
4.	North	4	9	5
5.	North East	0	0	0
6.	North West	3	3	0
7.	South	1	0	-1
8.	South East	0	0	0
9.	South West	5	9	4
10.	West	4	3	-1
11.	Nazulland	0	0	0
12.	Shahdara	0	0	0
13.	Central	0	0	0
14.	East	0	0	0
	Total	**17**	**24**	**7**

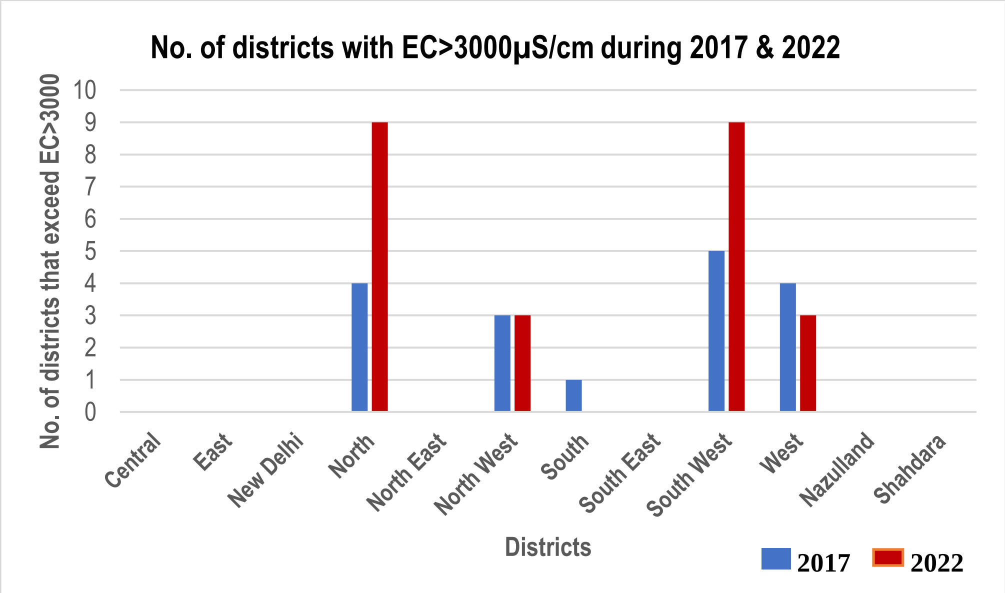

Fig. 7.1.4 Comparison on No of districts exceed EC >3000 µS/cm during 2017 and 2022.

In comparison to 2017 (Table 7.1.2), it has been observed that the no. of districts having EC more than 3000 µS/cm in various States has increased in 2022 by 41.17 %. In North and South West districts, the increase in the no. of location is a matter of concern. However, in some West district it has decreased also, which may be because of dilution in that particular area.

7.1.1 TREND ON ELECTRICAL CONDUCTIVITY

Trend analysis determines whether the measured values of the water quality variables increase or decrease during a time period. The Electrical Conductivity (EC) of groundwater is contributed by all the dissolved ionic constituents. Therefore, it is a measure of the total ionic content of the water. It could be used as a source of inorganic pollution indicator as most of the inorganic compounds are present as ions in water. Hence, EC was taken to assess the trend of ground water quality in NCT of Delhi. The percentage of well exceeds the electrical conductivity more than 3000 µS/cm for the period of 2017 to 2022 were compared and presented in the Table7.1.3 and observed that the percentage of samples exceed the permissible limit of 3000 µS/cm were ranging between 26 - 32 % and no significant trend was noticed. Trend on water quality for Electrical conductivity (EC) prepared for the NCT of Delhi is showing a slightly decreasing trend (Fig. 7.1.5 & 7.1.5a). This may be attributed to dilution factor.

Table 7.1.3: Percentage of wells Exceed EC>3000 µS/cm during the period of 2017-2022

Year	Total Number of samples analysed	No. of districts affected by EC	Total No of locations affected by EC	% of locations affected by EC (EC>3000 µS/cm
2017	64	5	17	**26.56**
2018	65	4	20	**30.77**
2019	64	5	20	**31.25**
2020	66	7	21	**31.82**
2021	79	6	22	**27.85**
2022	95	4	24	**25.26**

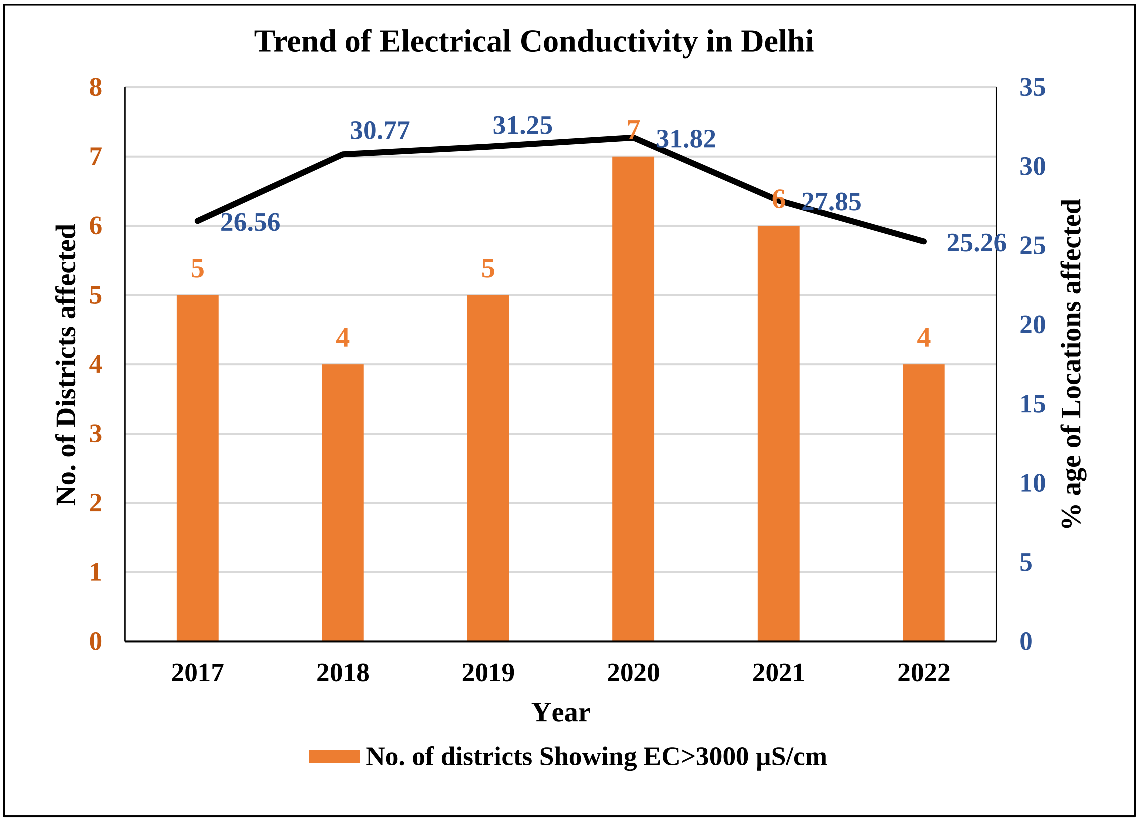

Fig. 7.1.5 Trend of Electrical Conductivity in NCT of Delhi

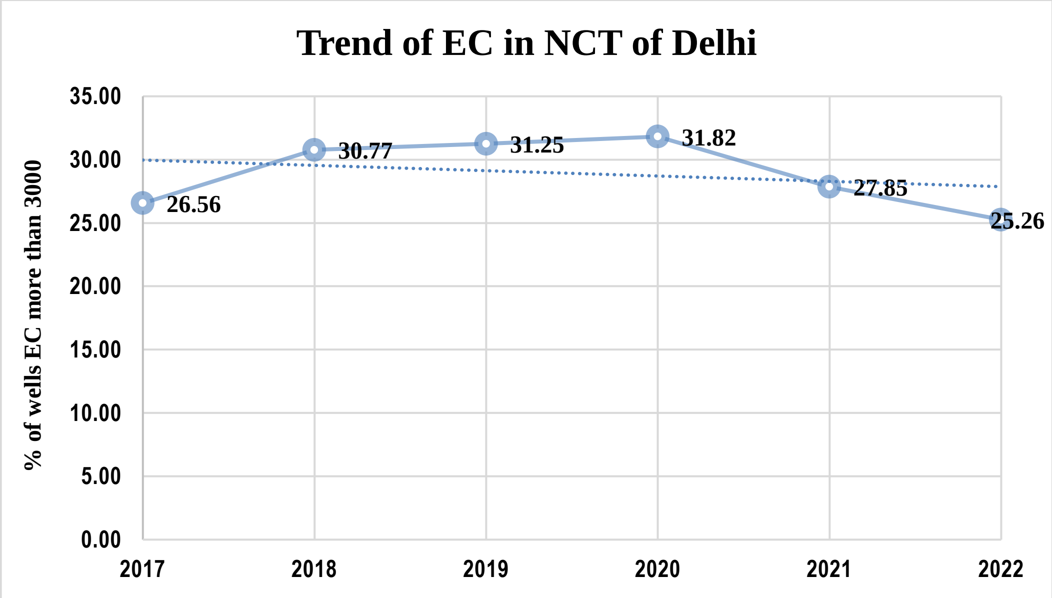

Fig. 7.1.5(a) Trend on Electrical Conductivity in NCT of Delhi for the period of 2017-2022

7.2 CHLORIDE

Chloride is present in all-natural waters, mostly at low concentrations. It is highly soluble in water and moves freely with water through soil and rock. In ground water the chloride content is mostly below 250 mg/L except in cases where inland salinity is prevalent and in coastal areas.

BIS (Bureau of Indian Standard) have recommended a desirable limit of 250 mg /L of chloride in drinking water; this concentration limit can be extended to 1000 mg/L of chloride in case no alternative source of water with desirable concentration is available. However, ground water having concentration of chloride more than 1000 mg /L are not suitable for drinking purposes.

In Fig 7.2.1, the concentration of chloride (in mg/L) in ground water from observation wells have been used to show distribution patterns of chloride in different ranges of suitability. It is apparent from the map that majority of the samples having chloride values less than 250 mg/L are found mostly along South and Eastern parts of State viz., South, South East, North East, Central, New Delhi and Shahdara districts.

Water with chloride ranging between 250 and 1000 mg/L falling under 'permissible' range are confined mostly to parts of North, North West, West, and South West districts.

Relatively high values of Chloride (>1000 mg/L) are observed in patches in the North, North West, West, and South West districts. Table 7.2.1 shows the district-wise list of locations affected by high chloride water (>1000 mg/L) and these areas are water quality hot spots from high chloride point of view.

The occurrences of chloride in ground water beyond permissible limit (1000 mg/L) have been shown on the contour map as Fig 7.2.1, District-wise percentage of wells having chloride >1000 mg/L is shown as a bar diagram in Fig 7.2.2 and also given location details in Annexure-3.

Table 7.2.1 District-wise percentage of samples having Chloride >1000mg/L

Sr. No	Name of districts	Total no. of Sample Analyzed	No. of Sample with Cl>1000 mg/L	(%) Samples with Cl>1000 mg/L
1.	Central	5	0	0
2.	East	7	0	0
3.	Nazul Land	3	0	0
4.	New Delhi	10	0	0
5.	North	18	5	27.78
6.	North East	2	0	0
7.	North West	15	2	13.34
8.	Shahdara	1	0	0
9.	South	8	0	0
10.	South East	5	0	0
11.	South West	12	3	25
12.	West	9	1	11.10
	Total	**95**	**11**	

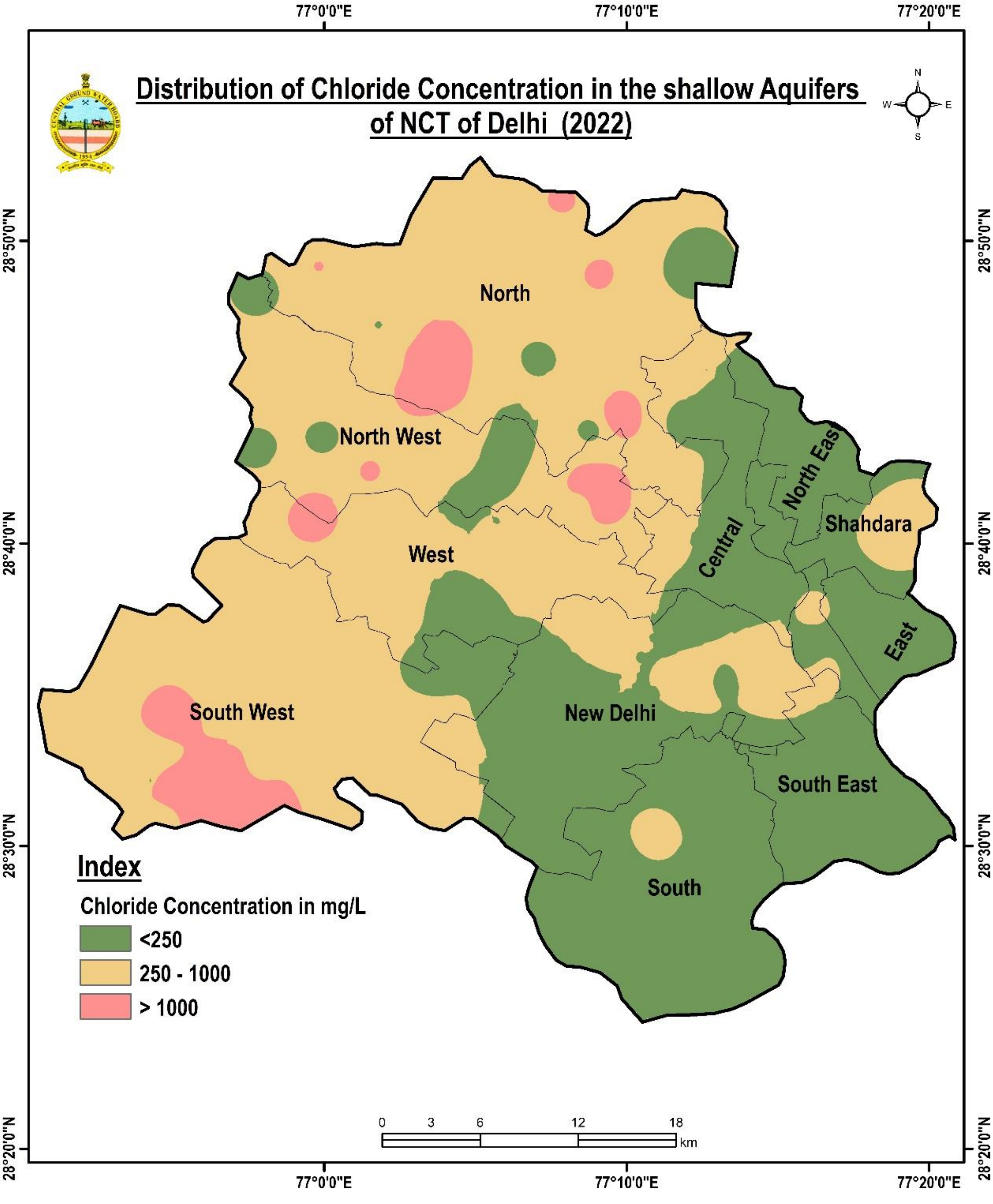

Fig 7.2.1 Spatial Distribution of Chloride during May 2022

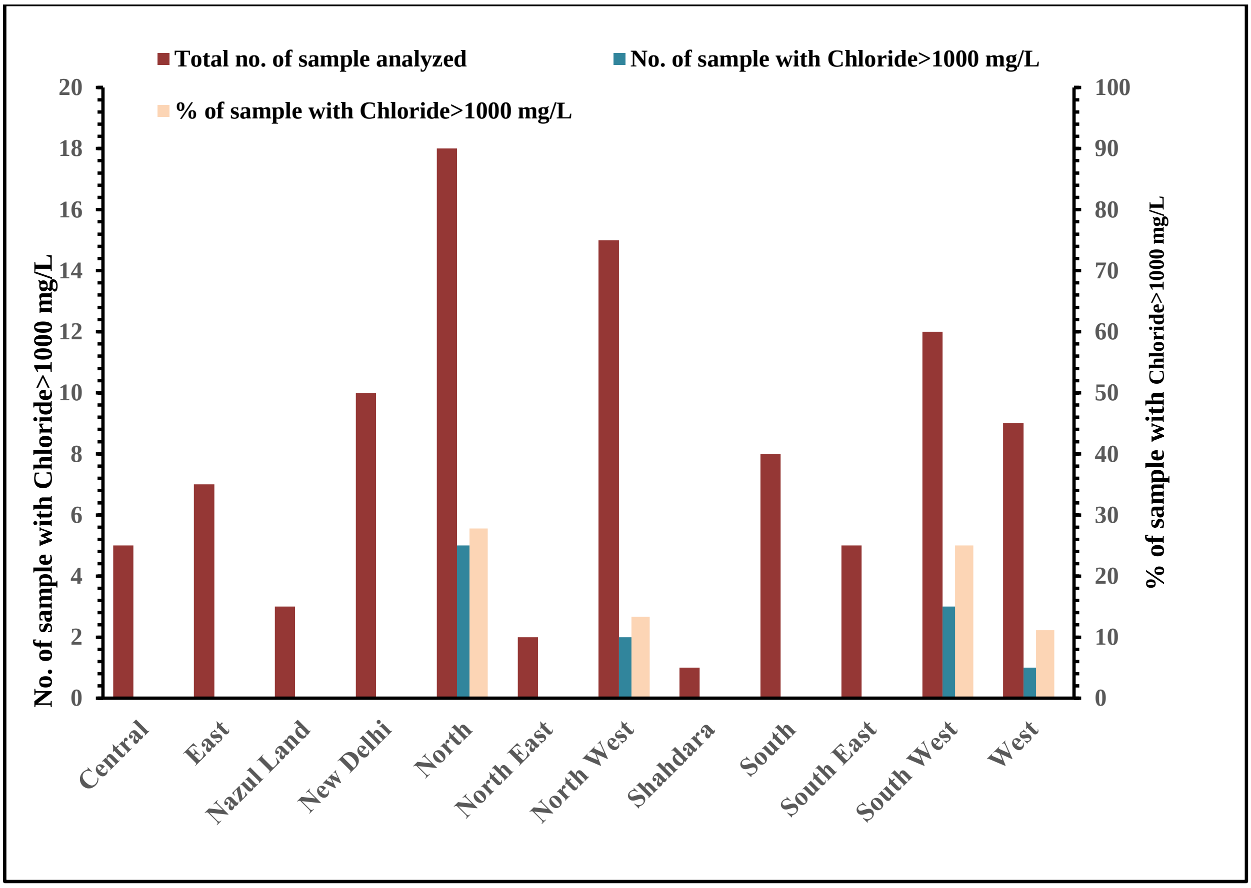

Fig 7.2.2 District-wise percentage of wells having Chloride > 1000 mg/L.

Table-7.2.2: Comparative Change in number of locations having Cl > 1000 mg/L in various districts of NCT of Delhi

S. No.	State	Nos. of districts having Cl>1000 mg/L.		
		2017	**2022**	**Increase/Decrease**
1.	Central	0	0	0
2.	East	0	0	0
3.	New Delhi	0	0	0
4.	North	2	5	3
5.	North East	0	0	0
6.	North West	2	2	0
7.	South	0	0	0
8.	South East	0	0	0
9.	South West	5	3	-2
10.	West	2	1	-1
11.	Nazulland	0	0	0
12.	Shahdara	0	0	0
13.	Central	0	0	0
14.	East	0	0	0
	Total	**11**	**11**	**0**

In comparison to 2017, it has been observed that the no. of districts having chloride more than 1000 mg/Lin various States has remained the same. (Table 7.2.3 & Fig.7.2.3). In North district, the increase in the no. of location is a matter of concern. However, in South West and West, the no. of location with CL>1000 mg/L has decreased also, which may be because of dilution in that particular area.

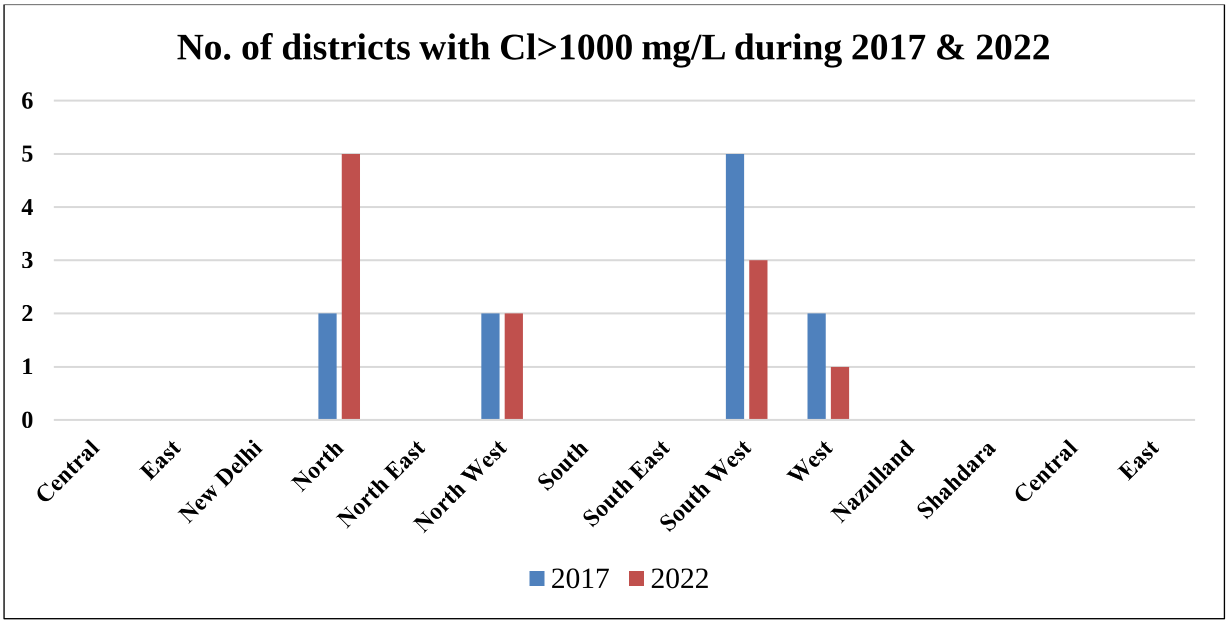

Fig. 7.2.3 Comparison on No of districts exceed Chloride >1000 mg/L during 2017 and 2022.

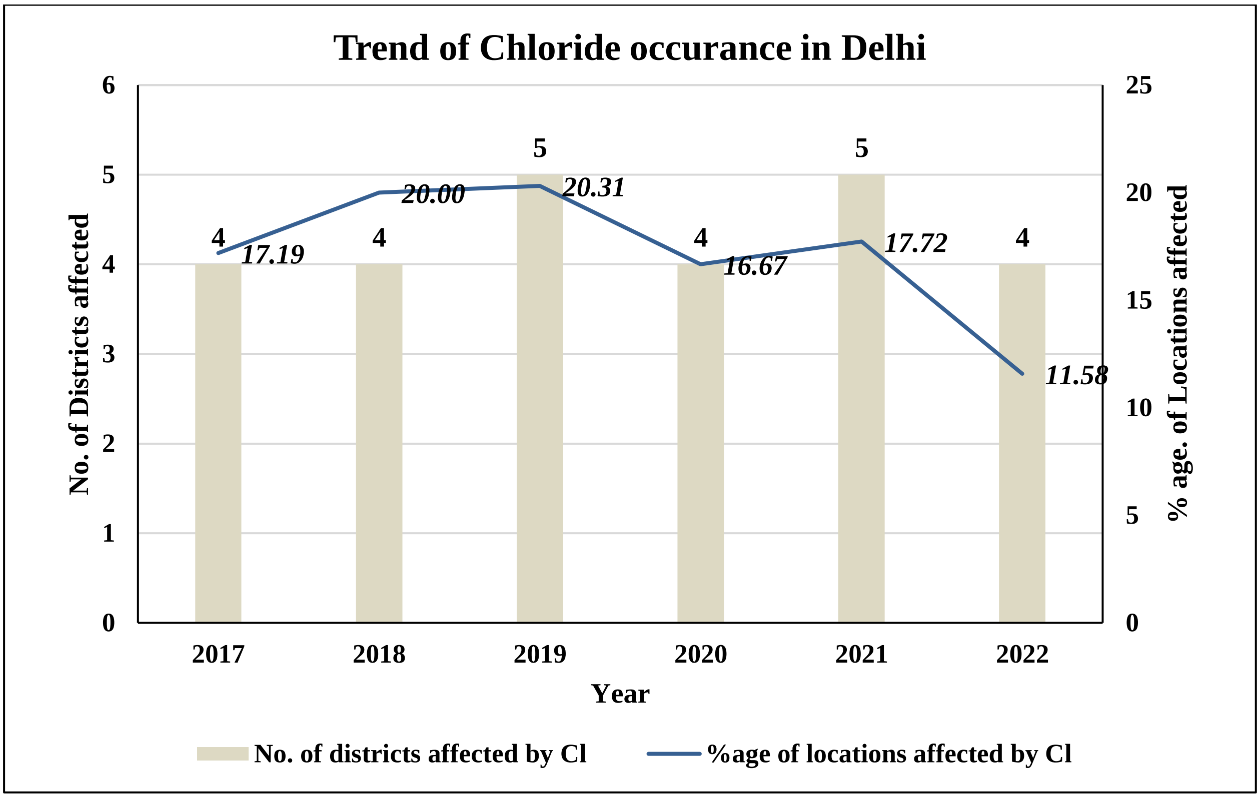

Fig. 7.2.4 Trend of Chloride occurrence in NCT of Delhi

7.3 FLUORIDE

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many types of rock. It exists in the form of fluorides in a number of minerals of which fluorspar, cryolite, fluorite and fluorapatite are the most common. Fluorite (CaF_2) is a common fluoride mineral.

Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in ground water in small amounts. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water. Presence of other ions, particularly bicarbonate and calcium ions also affect the concentration of fluoride in ground water.

It is well known that small amounts of fluoride (less than 1.0 mg/L) have proven to be beneficial in reducing tooth decay. Community water supplies commonly are treated with NaF or fluorosilicates to maintain fluoride levels ranging from 0.8 to 1.2 mg/L to reduce the incidence of *dental carries*. However, high concentrations such as 1.5 mg/L of F and above have resulted in staining of tooth enamel while at still higher levels of fluoride ranging between 5.0 and 10 mg/L, further pathological changes such as stiffness of the back and difficulty in performing natural movements may take place.

BIS has recommended an upper desirable limit of 1.0 mg/L of F^- as desirable concentration of fluoride in drinking water, which can be extended to 1.5 mg/L of F in case no alternative source of water is available. Water having fluoride concentration of more than 1.5 mg/L are not suitable for drinking purposes.

The fluoride content in groundwater from observation wells in a major part of the State is found to be less than 1.0 mg/L. The distribution of ground water samples with fluoride concentration more than 1.5 mg/L have been depicted on the map as Fig. 7.3.1. It is observed that there are several locations in the districts of North, North West, West and South West where the fluoride in ground water exceeds 1.5 mg/L. The details of locations where fluoride concentration more than 1.5 mg/l is given in Annexure-3. The details of districts showing localized occurrence of fluoride in ground water in excess of 1.5mg/L is given in table 7.3.1

The occurrences of fluoride in groundwater beyond permissible limit (1.5 mg/L) have also been shown on the map as Fig. 7.3.1, District-wise percentage of wells having fluoride >1.5mg/L is shown as a bar diagram in Fig 7.3.2.

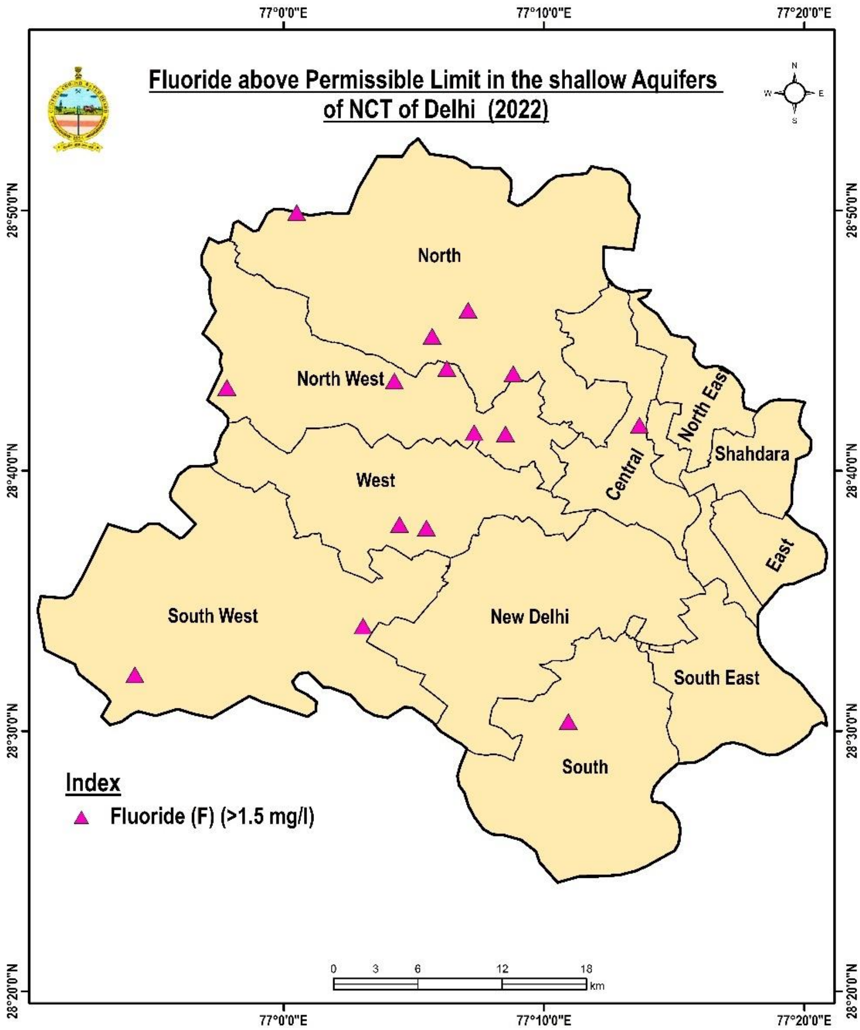

Fig 7.3.1 Locations having Fluoride concentration > 1.5 mg/L during May 2022.

Table 7.3.1 District-wise percentage of wells having fluoride >1.5mg/L

Sr. No	Name of districts	Total no. of Sample Analyzed	No. of Sample with F>1.5 mg/L	(%) Samples with F>1.5 mg/L
1.	Central	5	1	20
2.	East	7	0	0
3.	Nazul Land	3	0	0
4.	New Delhi	10	0	0
5.	North	18	4	22.23
6.	North East	2	0	0
7.	North West	15	5	33.34
8.	Shahdara	1	0	0
9.	South	8	1	12.5
10.	South East	5	0	0
11.	South West	12	2	16.66
12.	West	9	2	22.22
	Total	**95**	**15**	

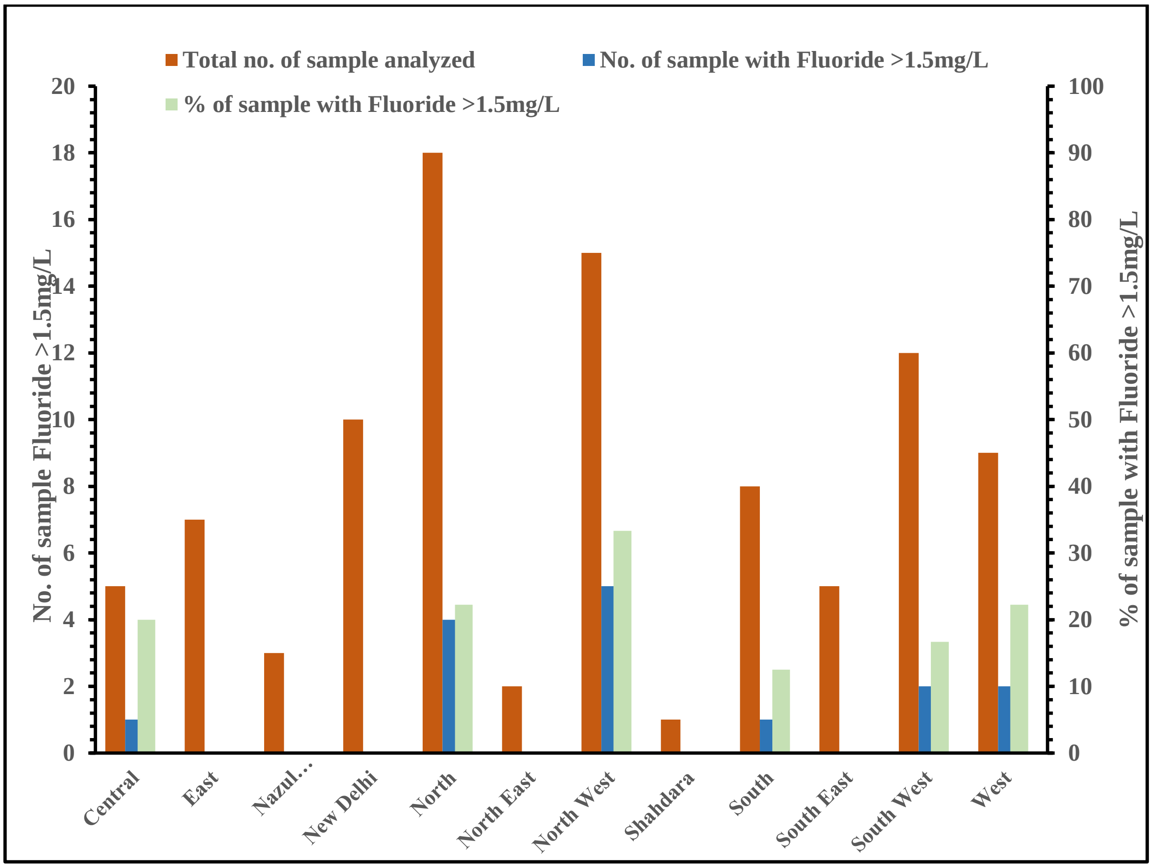

Fig 7.3.2 District-wise percentage of wells having fluoride >1.5 mg/L

Table-7.3.3: Comparative Change in number of locations having F > 1.5 mg/L in various districts.

S. No.	State	Nos. of districts having F> 1.5 mg/L.		
		2015	**2022**	**Increase/Decrease**
1.	Central	0	1	1
2.	East	0	0	0
3.	Nazul Land	0	0	0
4.	New Delhi	1	0	-1
5.	North	2	4	2
6.	North East	0	0	0
7.	North West	3	5	2
8.	Shahdara	0	0	0
9.	South	1	1	0
10.	South East	0	0	0
11.	South West	1	2	1
12.	West	3	2	-1
	Total	**11**	**15**	**04**

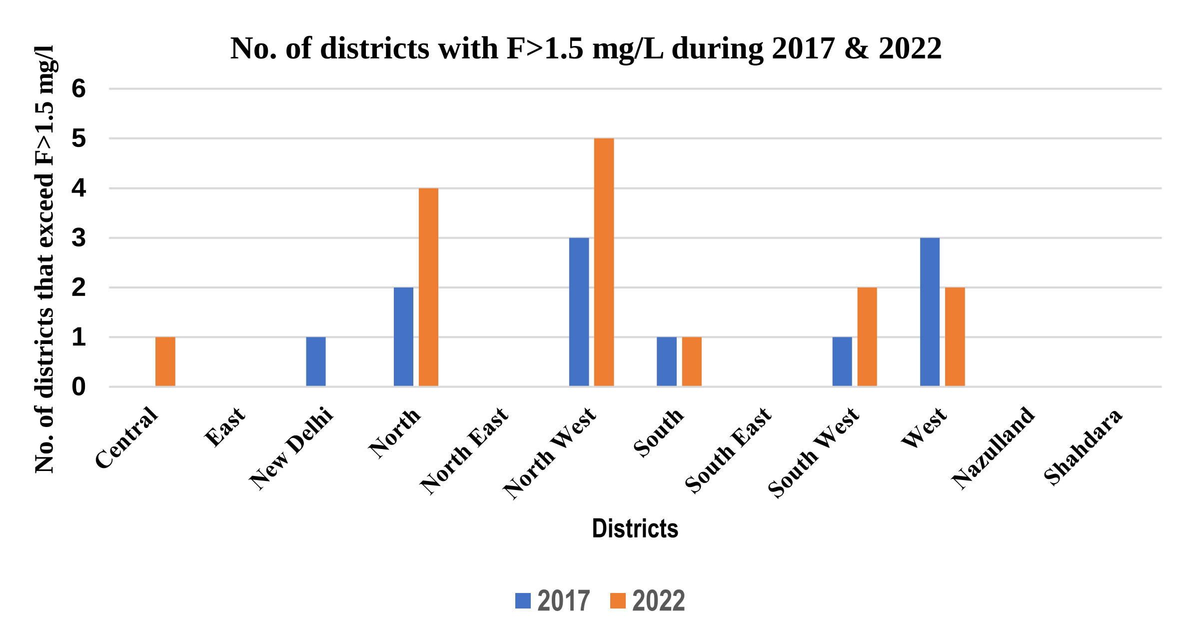

Fig 7.3.3 Comparison on No of districts exceed Fluoride >1.5 during 2017 and 2022

It has been observed (Table 7.3.3) that total number of districts affected by high fluoride in different States has increased by 36.37 % in 2022 as compared to the data available in 2017.

7.3.1 TREND ON FLUORIDE

The occurrence of fluoride in groundwater is mainly due to weathering and leaching of fluoride bearing minerals from rocks and sediments. To assess the trend of ground water pollution due to geogenic activity, the percentage of well exceeds the permissible limit of 1.5mg/L for the period of 2017 to 2022 were compared and presented in the Table 7.3.4 and observed that the percentage of samples exceed the permissible limit of fluoride 1.5 mg/L were ranging between 9 - 17 % and no significant trend was noticed. The number of fluoride affected district has increased in the year 2022 as more number of piezometers (deeper wells) was included in the monitoring wells after 2019. Trend on water quality for fluoride was prepared for the NCT of Delhi is shown in Fig 7.3.4. Trend on fluoride in NCT of Delhi shows (Fig 7.3.5) almost constant trend.

Table 7.3.4: Percentage of wells Exceed fluoride >1.5 mg/L during the period of 2017-2022

Year	Total Number of samples analysed	No. of districts affected by Fluoride	No. of locations affected by Fluoride	% of locations affected by Fluoride (F >1.5mg/L)
2017	64	6	11	17.19
2018	65	5	11	16.92
2019	64	2	6	9.38
2020	66	4	6	9.09
2021	79	6	13	16.46
2022	95	6	15	15.79

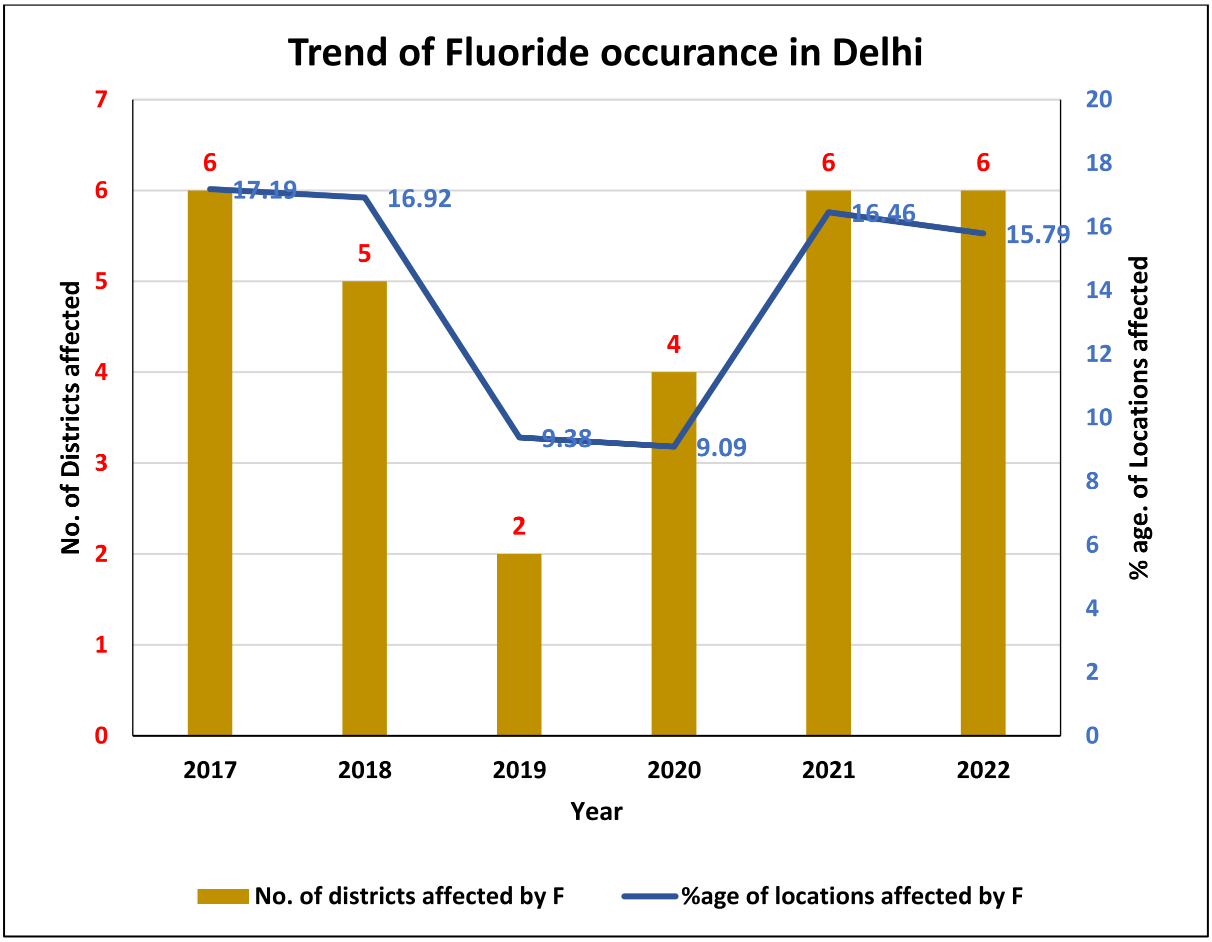

Fig. 7.3.4 Trend of Fluoride occurrence in NCT of Delhi

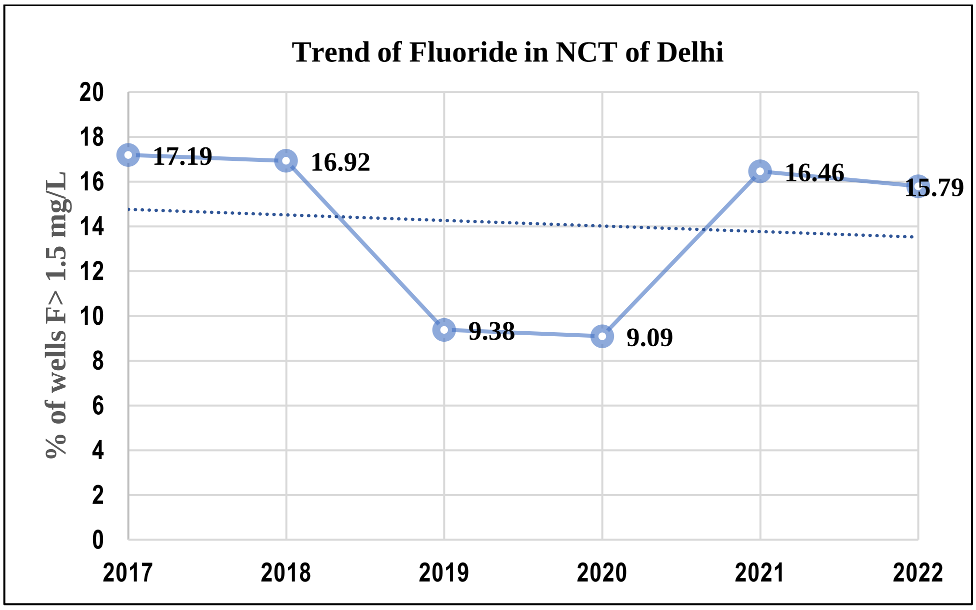

Fig 7.3.5 Trend on Fluoride in NCT of Delhi for the period of 2017-2022

7.4 NITRATE

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved Nitrogen in the form of Nitrate is the most common contaminant of ground water. Nitrate in groundwater generally originates from non-point sources such as leaching of chemical fertilizers & animal manure, groundwater pollution from septic and sewage discharges etc. It is difficult to identify the natural and man-made sources of nitrogen contamination of ground water. Some chemical and micro-biological processes such as nitrification and denitrification also influence the nitrate concentration in ground water.

As per the BIS Standard for drinking water the maximum desirable limit of Nitrate concentration in ground water is 45 mg/L with no relaxation. Though, Nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental health concern arising from increased risks of methemoglobinemia particularly to infants. Adults can tolerate little higher concentrations. The specified limits are not to be exceeded in public water supply. If the limit is exceeded, water is considered to be unfit for human consumption.

The occurrences of Nitrate in ground water beyond permissible limit (45 mg /L) have been shown on the map as a point source Fig 7.4.1 and also given in Annexure-3. Table-7.4.1 shows the districts where nitrate has been found in excess of 45 mg/L in groundwater.

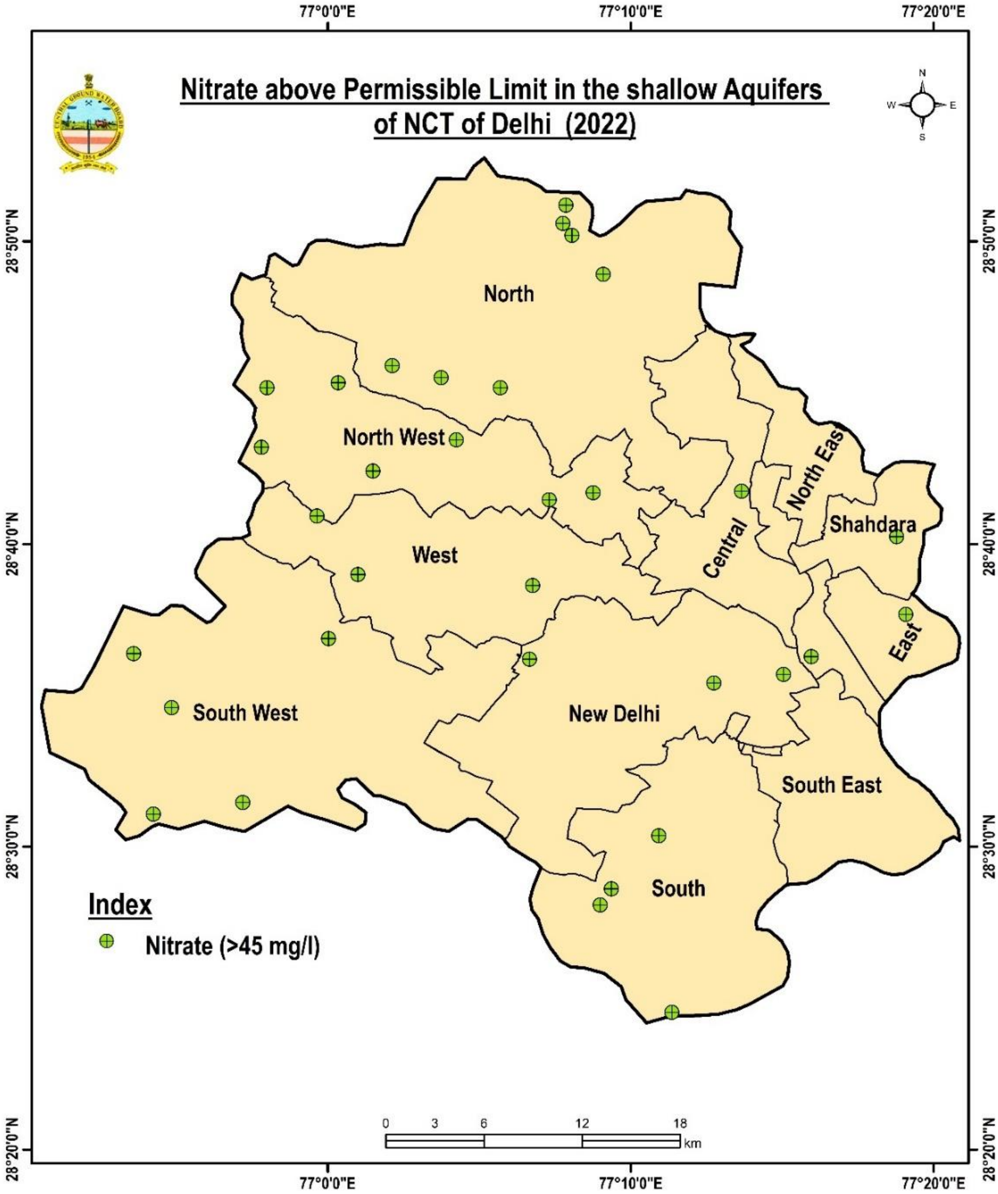

Fig 7.4.1 Locations having Nitrate concentration > 45 mg/L during 2022-23

Table 7.4.1: District-wise percentage of wells having Nitrate > 45 mg/L

Sr. No	Name of Districts	Total no. of Sample Analyzed	No. of Sample with Nitrate>45 mg/L	(%) Samples with Nitrate>45 mg/L
1.	Central	5	1	20.00
2.	East	7	1	14.29
3.	New Delhi	10	3	30.00
4.	North	18	6	33.33
5.	North East	2	0	0.00
6.	North West	15	8	53.33
7.	South	8	4	50.00
8.	South East	5	0	0.00

9.	South West	12	5	41.67
10.	West	9	3	33.33
11.	Nazulland	3	1	33.33
12.	Shahdara	1	1	100.00
	Total	**95**	**33**	**34.74**

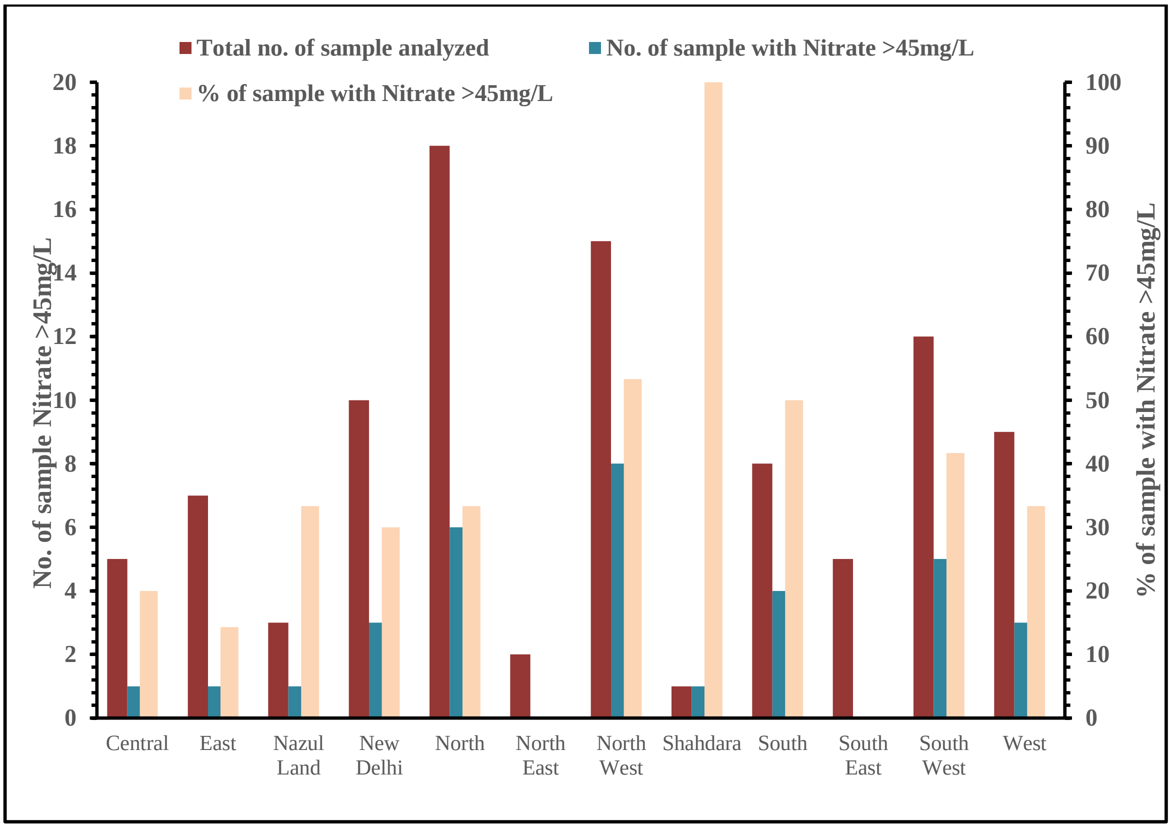

Fig 7.4.2 District-wise samples exceed Nitrate 45 mg/L (NHS 2022-23)

Table-7.4.2: Comparative Change in number of Districts having Nitrate > 45 mg/L in various states

S. No.	State	Nos. of districts having NO_3> 45 mg/L.		
		2017	2022	Increase/ Decrease
1.	Central	1	1	0
2.	East	1	1	0
3.	New Delhi	3	3	0
4.	North	1	6	5
5.	North East	0	0	0
6.	North West	2	8	6
7.	South	3	4	1

S. No.	State	Nos. of districts having NO_3> 45 mg/L.		
		2017	2022	Increase/ Decrease
8.	South East	1	0	-1
9.	South West	5	5	0
10.	West	2	3	1
11.	Nazulland	0	1	1
12.	Shahdara	0	1	1
	Total	**19**	**33**	**14**

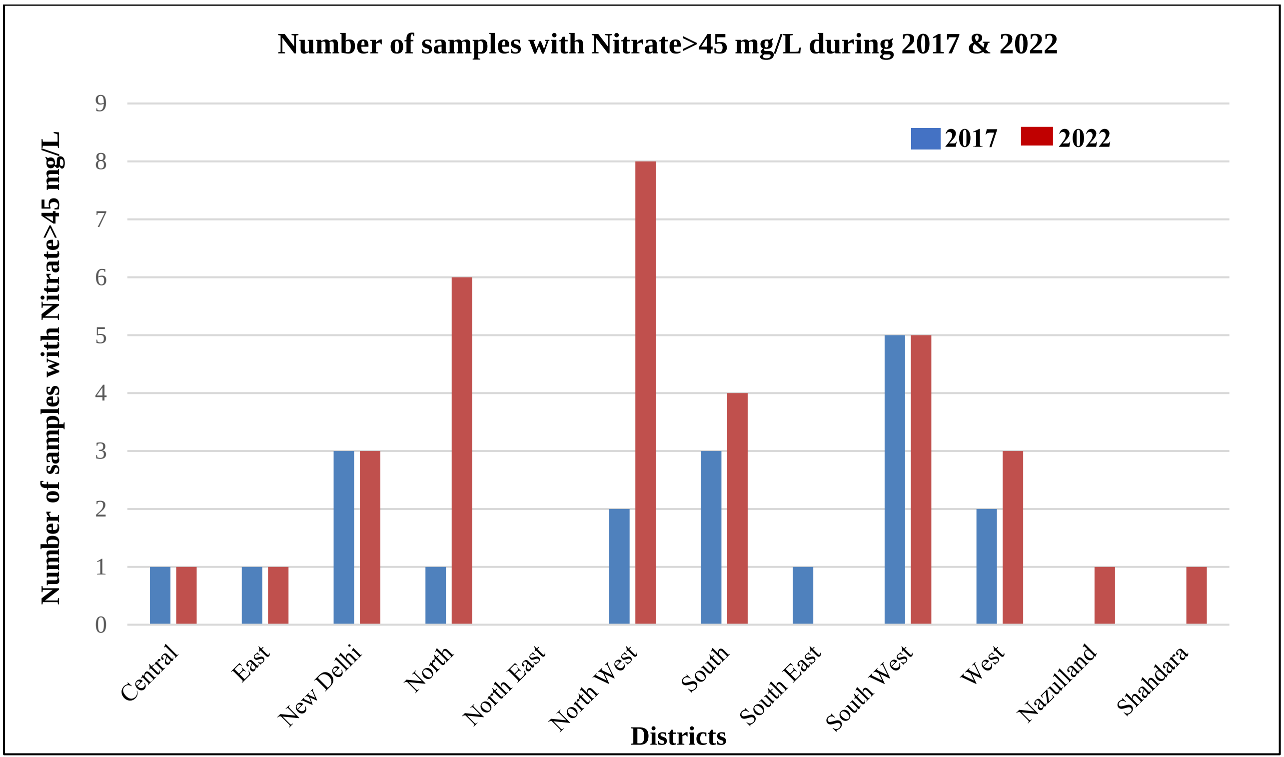

Fig. 7.4.3 Bar diagram comparing no. of Nitrate contaminated (45 mg/L) locations in various districts during year 2017 and 2022

It has been observed (Table 7.4.3) that No. of districts in various States having high Nitrate (more than 45 mg/l) content in ground water has increased by 73.68% in year 2022 as compared to the data available in year 2017.

7.4.1 TREND ON NITRATE

Trend analysis determines whether the measured values of the water quality variables increase or decrease during a time period. Nitrate is one of the major indicators of anthropogenic sources of pollution. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in groundwater can be fairly attributed to infiltration of water through soil containing domestic waste, animal waste, fertilizer and industrial pollution. As the lithogenic sources of nitrogen are very rare, its presence in ground water is almost due to anthropogenic activity. Hence, nitrate was taken to assess the trend of ground water quality in Delhi is due to anthropogenic activity. The percentage of well exceeds the permissible limit of 45mg/L for the period of 2017 to 2022 were compared and presented in the

Table 7.4.3 and Fig 7.4.4 and observed that the percentage of samples exceed the permissible limit of nitrate (> 45 mg/L) were ranging between 15 - 37 % and increase in the trend was noticed. The number of nitrate affected district has increased in the year 2022 in comparison to 2019; this may be attributed to increase in n. of water quality monitoring stations. It is also observed that the type of waste generated is important in causing the nitrate pollution and also indicates that domestic waste leads to more nitrate problem. This could be due to the leaching of nitrate from the open sewerage lines. Trend on water quality for Nitrate prepared for the NCT of Delhi is shown in (Fig 7.4.5).

Table 7.4.3: Percentage of wells Exceed Nitrate >1.5 mg/L during the period of 2017-2022

Year	Total Number of samples analysed	No. of districts affected by Nitrate	No. of locations affected by Nitrate	% age of samples affected by Nitrate (NO_3 >45 mg/L)
2017	64	9	19	29.69
2018	65	9	24	36.92
2019	64	6	10	15.63
2020	66	5	10	15.15
2021	79	7	17	21.52
2022	95	10	33	34.7

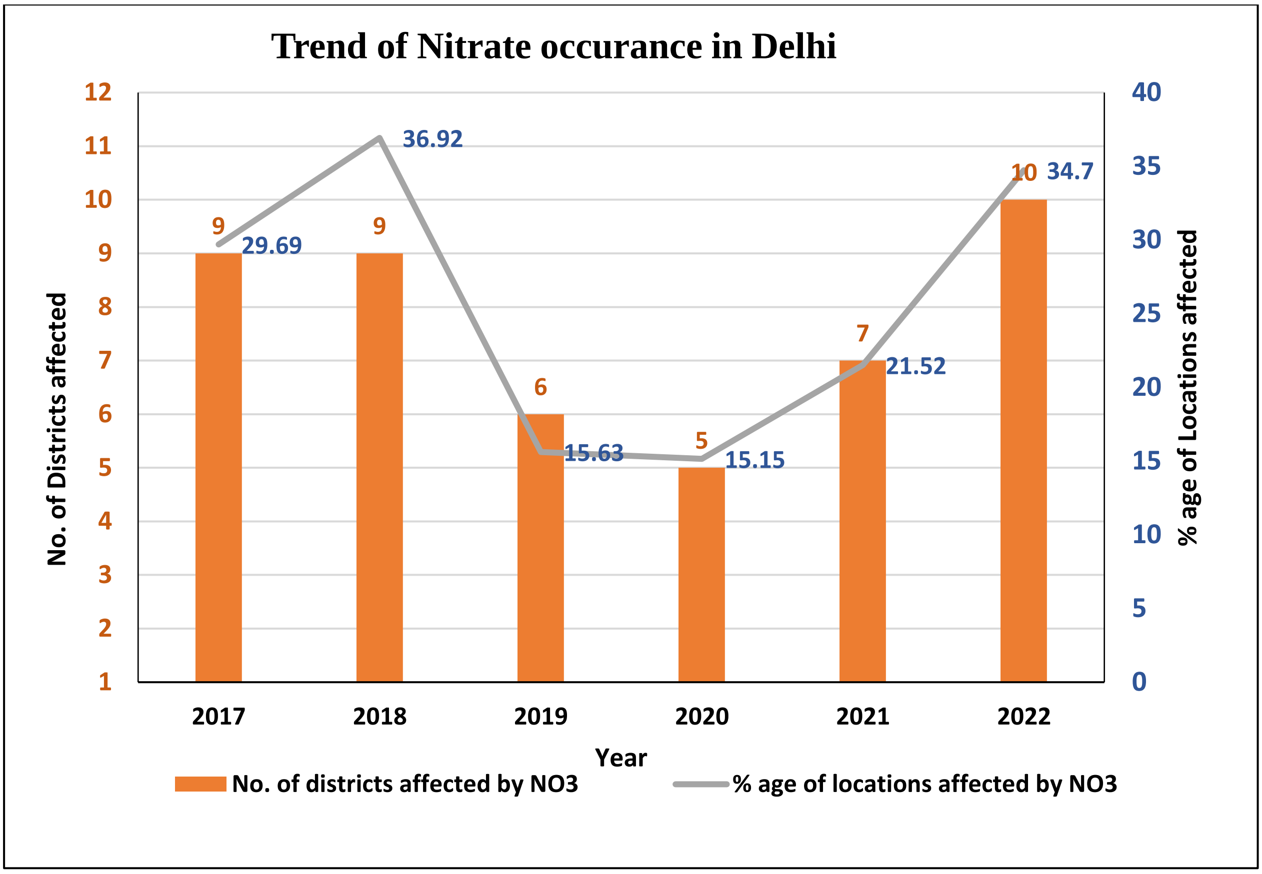

Fig. 7.4.4 Trend of Nitrate occurrence in Delhi

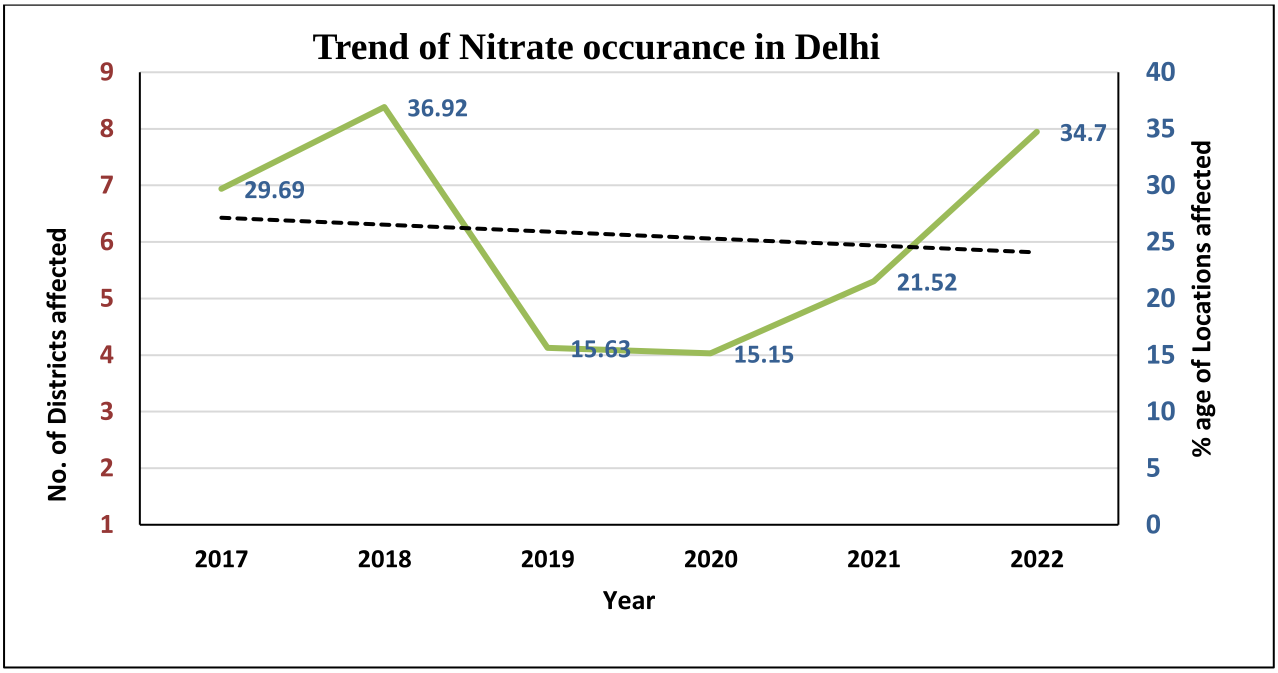

Fig. 7.4.5 Trend of Nitrate occurrence in NCT of Delhi for the period of 2017-2022

7.5 IRON

Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air, the water turns cloudy due to oxidation of ferrous iron into reddish brown ferric oxide.

The concentration of iron in natural water is controlled by both physico-chemical and microbiological factors. It is contributed to groundwater mainly from weathering of ferruginous minerals of igneous rocks such as hematite, magnetite and sulphide ores of sedimentary and metamorphic rocks.

The permissible Iron concentration in ground water is 1.0 mg/L as per the BIS Standard for drinking water. The occurrences of iron in ground water beyond permissible limit (> 1.0 mg /litre) have been shown on the maps as point sources (Fig 7.5.1). It is based on the chemical analysis of water samples mostly collected from the groundwater observation wells/ springs/ hand pumps. The details of the sampling sources are given in Annexure-3. The iron point value map indicates that the shallow aquifers in the NCT of Delhi is generally free from Fe contamination. Only two locations one in each district namely North and South East show iron values beyond the permissible limits for drinking water.

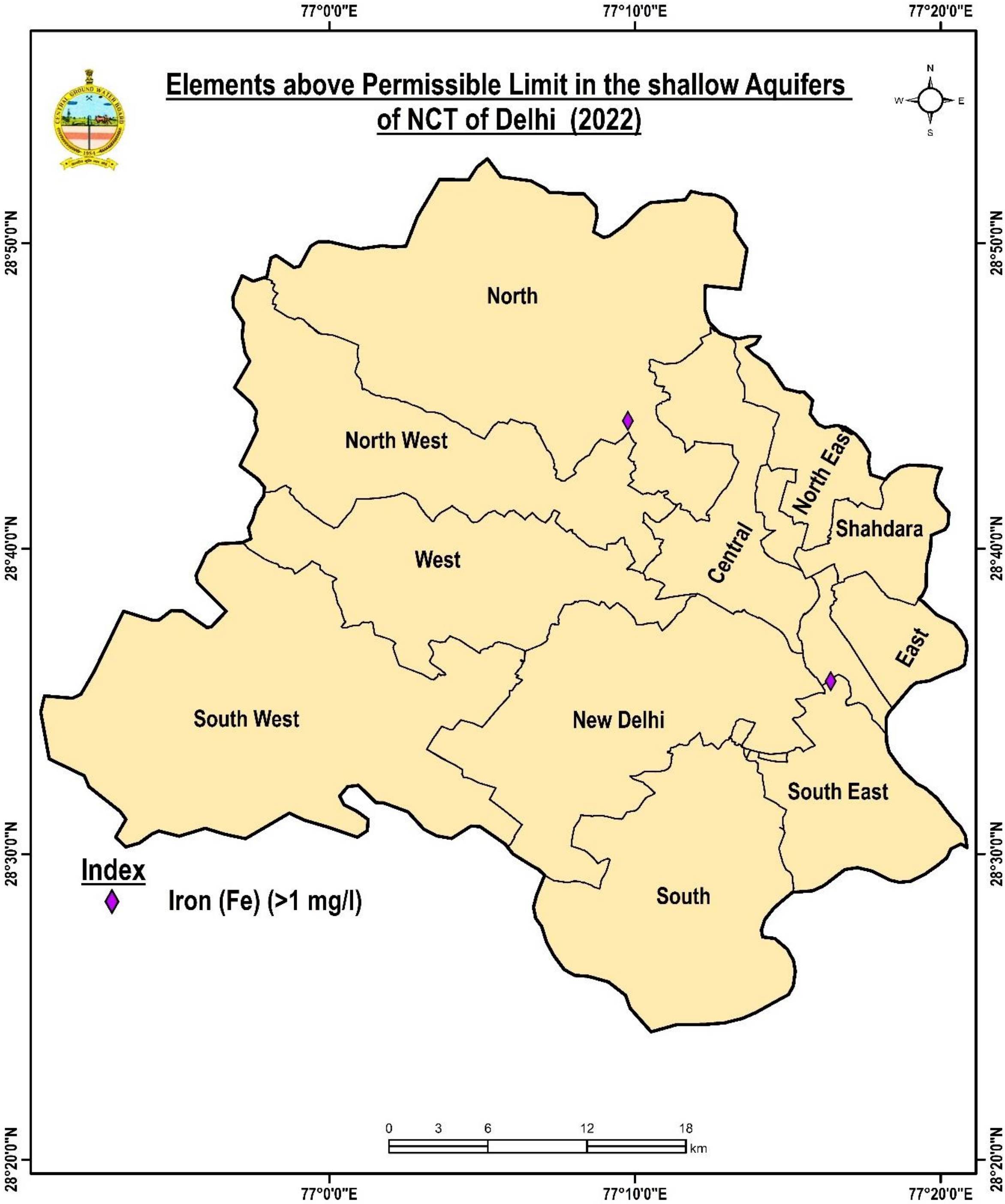

Fig 7.5.1 Map showing areas of Iron contaminated (> 1.0mg/L) groundwater in NCT of Delhi

Table 7.5.1: District-wise percentage of wells having Iron > 1mg/L

Sr. No	Name of Districts	Total no. of Sample Analyzed	No. of Sample with Iron>1 mg/L	(%) Samples with Iron>1 mg/L
1.	Central	5	0	0.00
2.	East	7	0	0.00
3.	New Delhi	10	0	0.00
4.	North	18	1	5.55
5.	North East	2	0	0.00
6.	North West	15	0	0.00
7.	South	8	0	0.00
8.	South East	5	1	20.00
9.	South West	12	0	0.00
10.	West	9	0	0.00
11.	Nazulland	3	0	0.00
12.	Shahdara	1	0	0.00
	Total	**95**	**2**	**2.10**

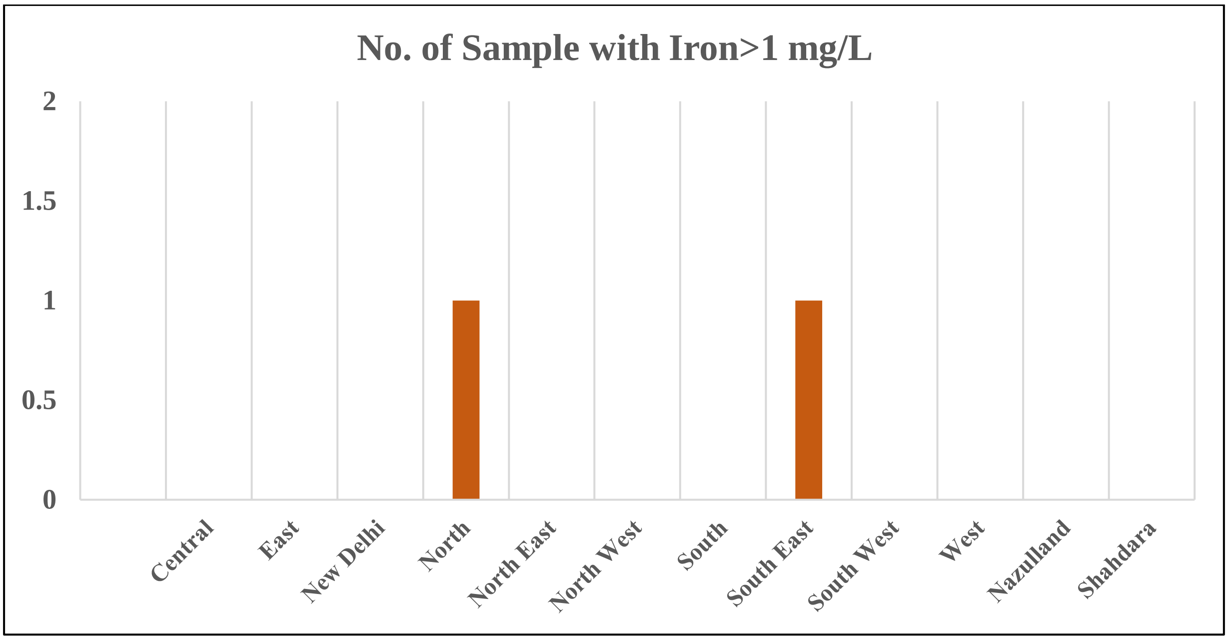

Fig 7.5.2 District-wise samples exceeding Iron 01 mg/L (NHS 2022-23)

Table-7.5.2: Comparative Change in number of Districts having Iron > 1 mg/L in NCT of Delhi

S. No.	State	Nos. of districts having Fe>1 mg/L.		
		2019	2022	Increase/ Decrease
1.	Central	0	0	0
2.	East	0	0	0
3.	New Delhi	0	0	0
4.	North	0	1	1
5.	North East	0	0	0
6.	North West	1	0	-1
7.	South	0	0	0
8.	South East	0	1	1
9.	South West	0	0	0
10.	West	0	0	0
11.	Nazulland	0	0	0
12.	Shahdara	0	0	0
	Total	**1**	**2**	**1**

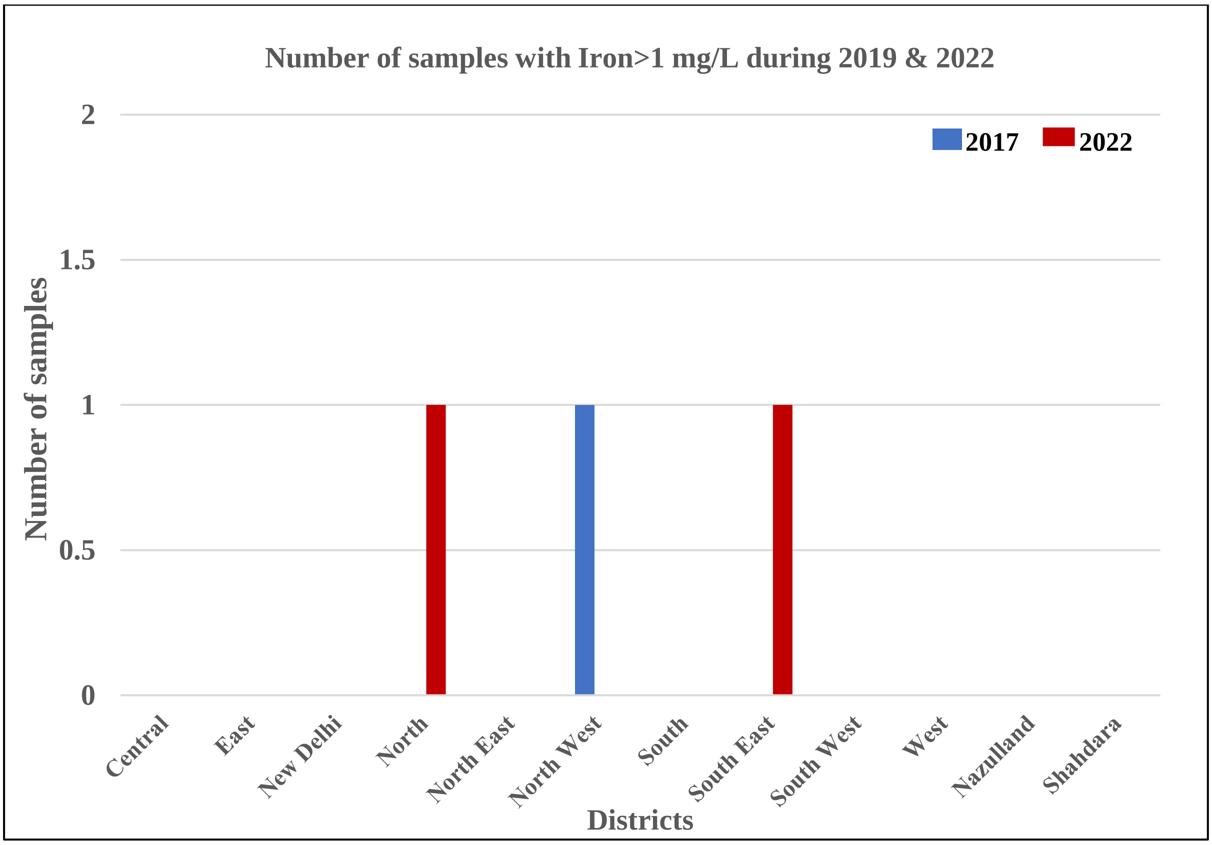

Fig. 7.5.3 Bar diagram comparing no. of Iron contaminated (01 mg/L) locations in various districts during year 2019 and 2022

Table 7.5.3: Percentage of wells Exceed Iron >1 mg/L during the period of 2019-2022

Year	Total Number of samples analysed	No. of districts affected by Iron	No. of locations affected by Iron	% age of samples affected by Iron (Fe >1 mg/L)
2019	64	1	1	1.56
2020	66	3	4	6.06
2021	79	4	4	5.06
2022	95	2	2	2.10

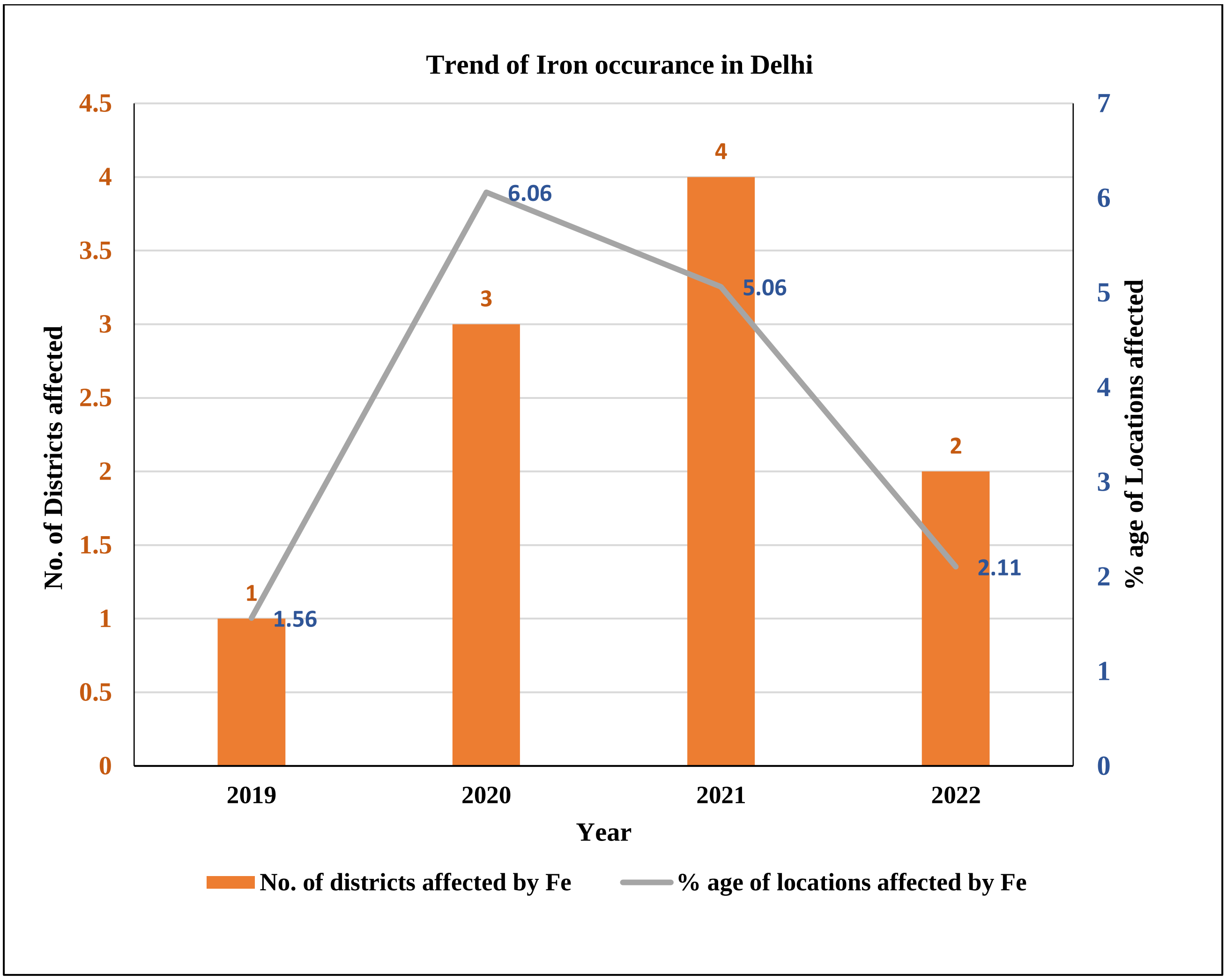

Fig. 7.5.4 Trend of Iron occurrence in NCT of Delhi

As compared to the data available in year 2019, the number of districts having Iron more than 1.0 mg/L in ground water samples has only increased in 1 district.

7.6 Arsenic

Arsenic is a naturally occurring trace element found in rocks, soils and the water in contact with them. Arsenic has been recognized as a toxic element and is considered a human health hazard.

Arsenic is a metalloid. The common valancy of arsenic in unpolluted ground water of geogenic origin are +III & +V as hydrolysis species. The dissociation constant of As (III) and As (V) acids are quite different. The fact that dominant dissolved species are either uncharged or negatively charged suggests that adsorption and ion exchange will cause little retardation as these species are transported along ground water flow path. Organic arsenic compounds such as methyl arsenic acid and dimethyl arsenic acid are not common in ground water. The occurrence of Arsenic in ground water was first reported in 1980 in West Bengal in India.

The map showing distribution of Arsenic in ground water in NCT of Delhi (Fig 7.6.1) has been generated from the data on arsenic concentration in water samples mostly collected from the groundwater observation wells/ hand pumps, Arsenic contaminated areas have been shown as points based on findings of Central Ground Water Board. The point sources are plotted on the map (Fig 7.6.1). Districts having Arsenic > 0.01 mg/L in Ground Water in NCT of Delhi is shown in Table-7.6.1.

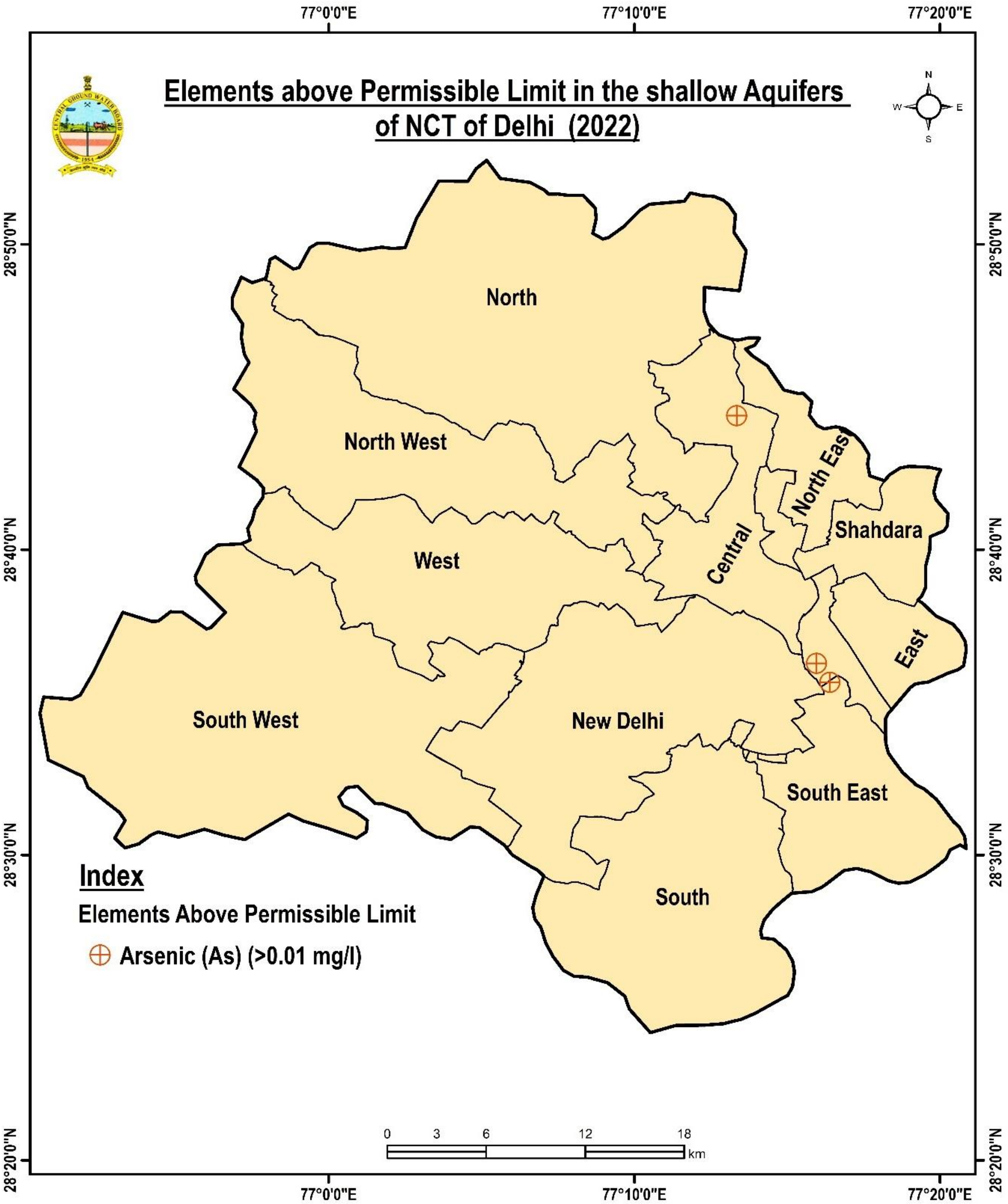

Fig 7.6.1 Map showing areas of Arsenic contaminated (> 0.01 mg/L) groundwater in NCT of Delhi

Table 7.6.1: District-wise percentage of wells having Arsenic > 0.01 mg/L

Sr. No	Name of Districts	Total no. of Sample Analyzed	No. of Sample with Arsenic>0.01 mg/L	(%) Samples with Arsenic>0.01 mg/L
1.	Central	5	1	20
2.	East	7	0	0.00
3.	New Delhi	10	0	0.00
4.	North	18	0	0.00
5.	North East	2	0	0.00
6.	North West	15	0	0.00
7.	South	8	0	0.00
8.	South East	5	1	20
9.	South West	12	0	0.00
10.	West	9	0	0.00
11.	Nazulland	3	1	33.34
12.	Shahdara	1	0	0.00
	Total	**95**	**03**	**3.15**

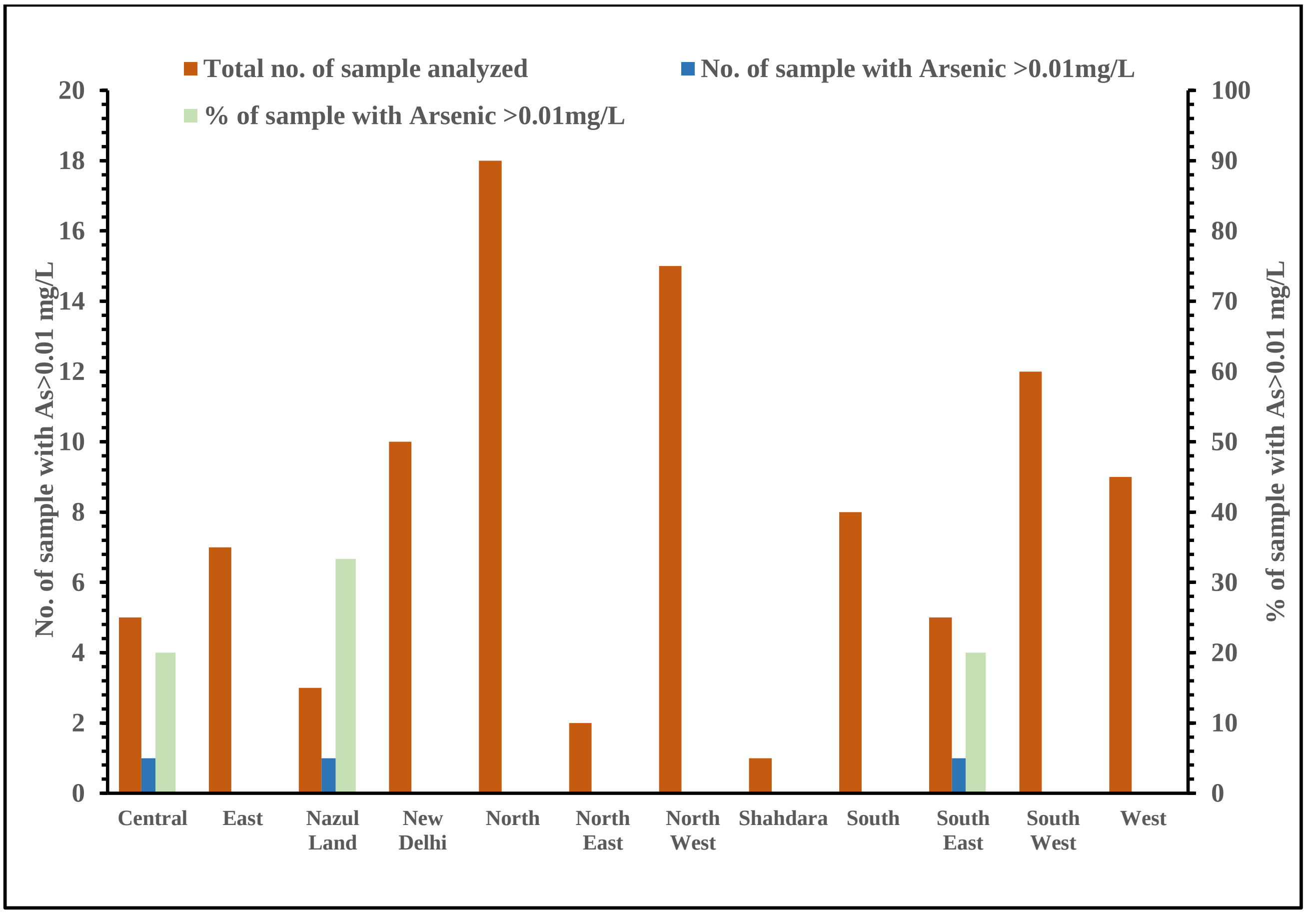

Fig 7.6.2 District-wise samples exceeding Arsenic 0.01 mg/L (NHS 2022-23)

Table-7.6.2: Comparative Change in number of Districts having Arsenic > 0.01 mg/L in districts of NCT of Delhi

S. No.	State	Nos. of districts having As > 0.01 mg/L.		
		2019	2022	Increase/ Decrease
1.	Central	0	1	1
2.	East	0	0	0
3.	New Delhi	0	0	0
4.	North	0	0	0
5.	North East	0	0	0
6.	North West	0	0	0
7.	South	0	0	0
8.	South East	0	1	1
9.	South West	0	0	0
10.	West	0	0	0
11.	Nazulland	1	1	0
12.	Shahdara	0	0	0
	Total	**1**	**3**	**2**

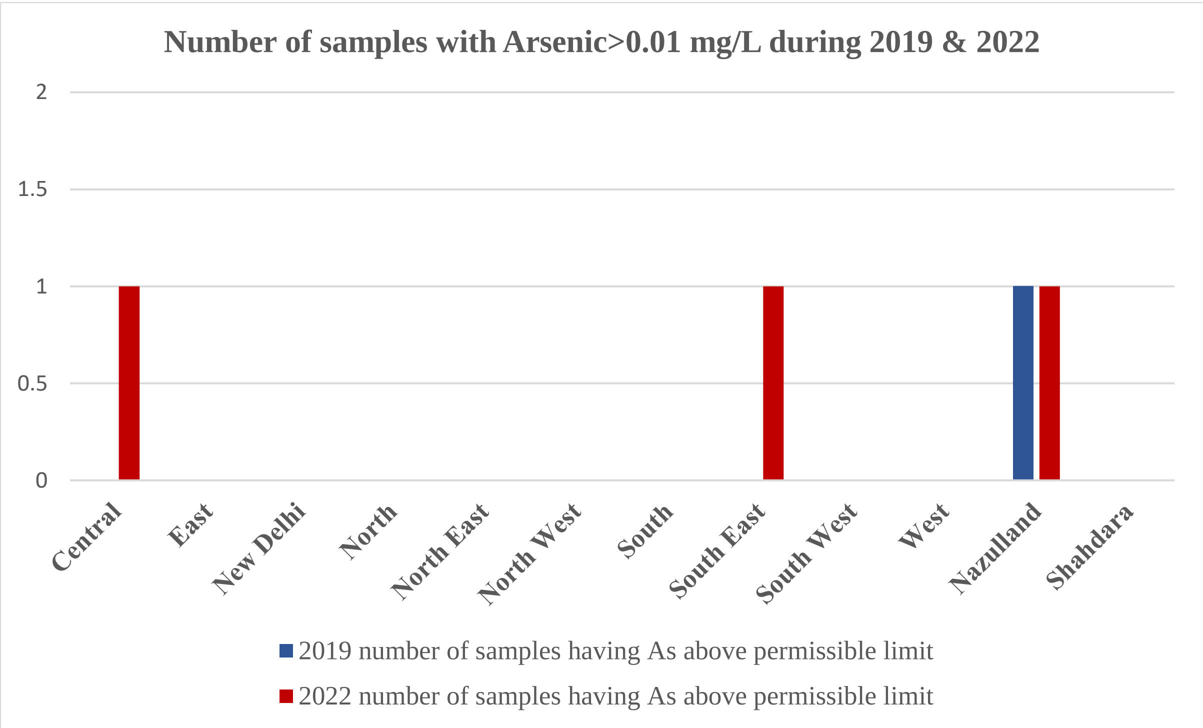

Fig. 7.6.3 Bar diagram comparing no. of Arsenic contaminated (0.01 mg/L) locations in various districts during year 2019 and 2022

It has been observed (Table 7.6.3) that No. of districts in various States having high Arsenic (more than 0.01 mg/l) content in ground water has been reported in two more districts in year 2022 as compared to the data available in year 2019.

7.7 URANIUM

Uranium occurs naturally in groundwater and surface water. Being a radioactive mineral, high uranium concentration can cause impact on water, soil and health. Uranium has both natural and anthropogenic source that could lead to the aquifer. These sources include leaching from natural deposits, release in mill tailings, and emissions from the nuclear industry, combustion of coal and other fuels and the use of phosphate fertilizers that contains uranium and contribute to ground water pollution. Uranium enters in human tissues mainly through drinking water, food, air and other occupational and accidental exposures. Intake of uranium through air and water is normally low, but in circumstances in which uranium is present in a drinking water source, the majority of intake can be through drinking water.

Water with uranium concentration above the recommended maximum permissible concentration of 30 ppb (BIS,10500:2012) is not safe for drinking purposes as it can cause damage to internal organs, on continuous intake. Elevated uranium concentrations in drinking water have been associated with many epidemiological studies such as urinary track cancer as well as kidney toxicity. A recent study, found a strong correlation between uranium concentration in drinking water and uranium in bone, suggesting that bones are good indicators of uranium exposed via ingestion of drinking water. Therefore, such studies trigger further assessment of uranium's adverse health effects on humans and/or the environment for countries where elevated uranium concentration in drinking water has been observed. Hence, it becomes important to study the level of uranium in drinking water for health risk assessment.

Uranium concentration in the shallow ground water varies primarily due to recharge and discharge, which would have dissolved or leached the uranium from the weathered soil to groundwater zone. High uranium concentrations observed in groundwater may be due to local geology, anthropogenic activities, urbanization and use of phosphate fertilizers in huge quantity for agriculture purpose. Studies have shown that phosphate fertilizer possess uranium concentration ranging from 1 mg/kg to 68.5 mg/kg (Brindha K et al., 2011). Hence, the phosphate fertilizers manufactured from phosphate rocks may also contribute uranium to ground water in agriculture region. In ores, uranium is found as uranite (UO_2^{2+}) and pitchblende ($U_3O_8^{2+}$) or in the form of secondary minerals (complex oxides, silicates, phosphates, vanadates).

Table 7.7.1 Summary of uranium concentrations in different types of rocks

Rocks	Range(mg/kg)
Granite	3.4
Limestone/dolomite	2.2
Argillaceous shale	3.7
Sediments	1.4-53
Phosphates	30-100

Table 7.7.2 Standards and guidelines for uranium in drinking water in various countries.

Sl. No	Country / agency	guideline value (μg/L)	Reference
1	Australia	GV 17	NHMRC, Australia (2011)
2	Bulgaria	ML 60	European Food Safety Authority (2009)
3	Canada	MAC 20	Health Canada (2019)
4	Finland	RV 100	European Food Safety Authority (2009)
5	India	RBL 60	AERB, India (2004)
6	India	PL 30	BIS,2012
7	Malaysia	MAV 2	Ministry of Health Malaysia (2004)
8	USA	MCL 30	USEPA (2011)
9	WHO	PGV 30	WHO 2011

GV, Guideline value; ML, Maximum limit; MAC, Most acceptable concentration; RV, Recommended value; RBL, Radiological based limit; PL, Permissible Limit; MAV, Maximum acceptable value; MCL, Maximum contaminant level; PGV, Provisional guideline value

To assess the Uranium concentration and distribution in the ground water, Central Ground Water Board (CGWB) had decided to carry out Uranium sampling of its National Hydrograph Network Stations (NHNS) in the entire country during Pre-monsoon monitoring (May,2019). The sample collection and storage were done according to the standard protocols prescribed by APHA (2017). The groundwater samples were collected in plastic bottles after having been filtered through 0.45-μm filter paper. For the cations and uranium analyses, groundwater samples were immediately acidified below pH 2 by adding nitric acid to prevent precipitation and adsorption to the container walls. Uranium (U) was detected using Inductively Coupled Plasma Mass-spectrometry. To ensure quality control, duplicate and standard checks were performed on every ten samples. In addition, a trace element standard reference material was examined. District wise no. of districts affected by Uranium (>30 ppb) and maximum value observed is given in Table 7.7.4.

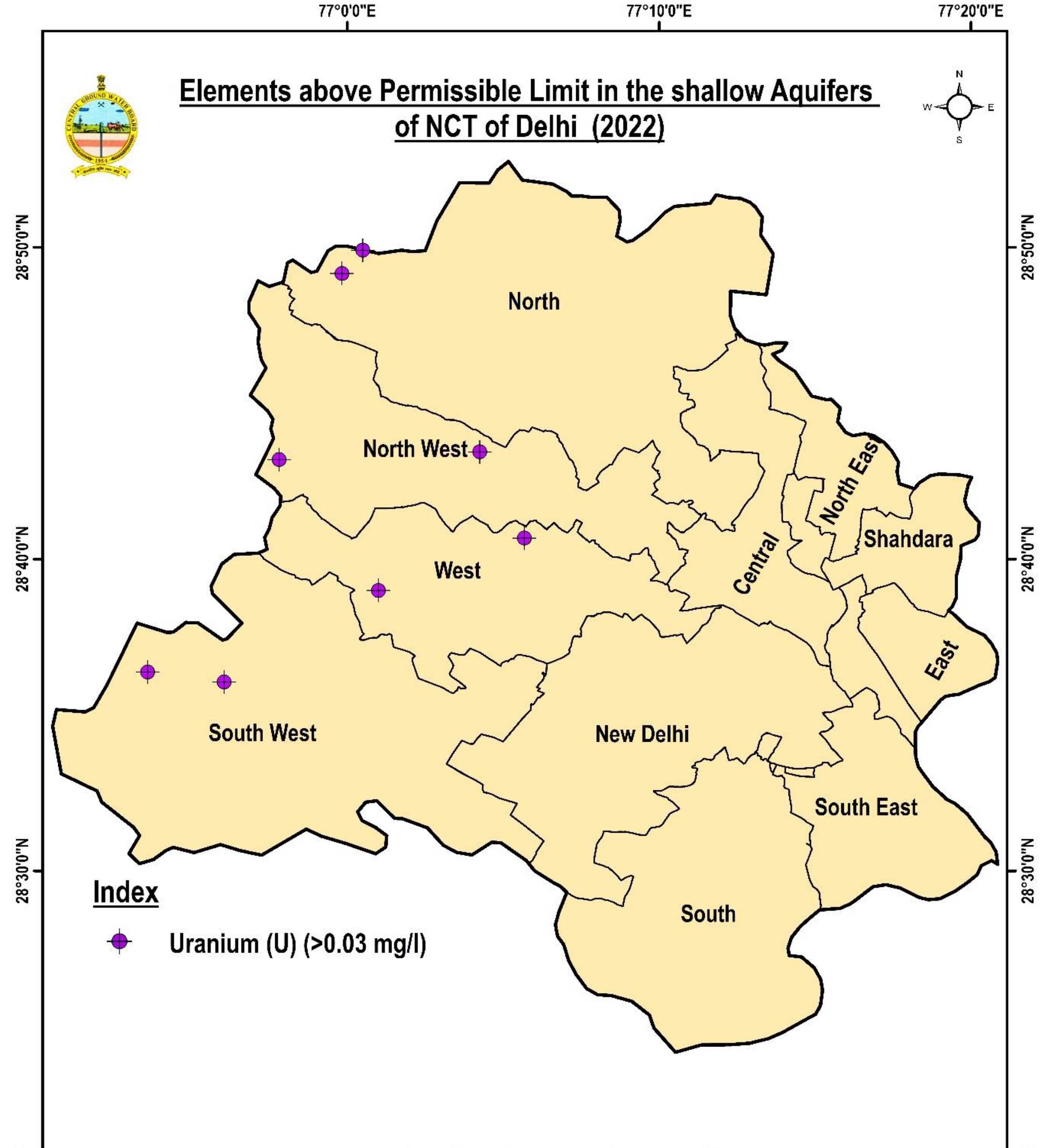

Fig 7.7.1 Map showing areas of Uranium contaminated (> 30 ppb) groundwater in NCT of Delhi

Table 7.7.3: District-wise percentage of wells having Uranium > 30 ppb

Sr. No	Name of Districts	Total no. of Sample Analyzed	No. of Sample with Uranium>30 ppb	(%) Samples with Uranium>30 ppb
1.	Central	5	0	0.00
2.	East	7	0	0.00
3.	New Delhi	10	0	0.00
4.	North	18	2	11.12
5.	North East	2	0	0.00
6.	North West	15	2	13.34
7.	South	8	2	25
8.	South East	5	0	20
9.	South West	12	2	16.67
10.	West	9	0	0.00
11.	Nazulland	3	0	0.00
12.	Shahdara	1	0	0.00
	Total	**95**	**08**	**8.24**

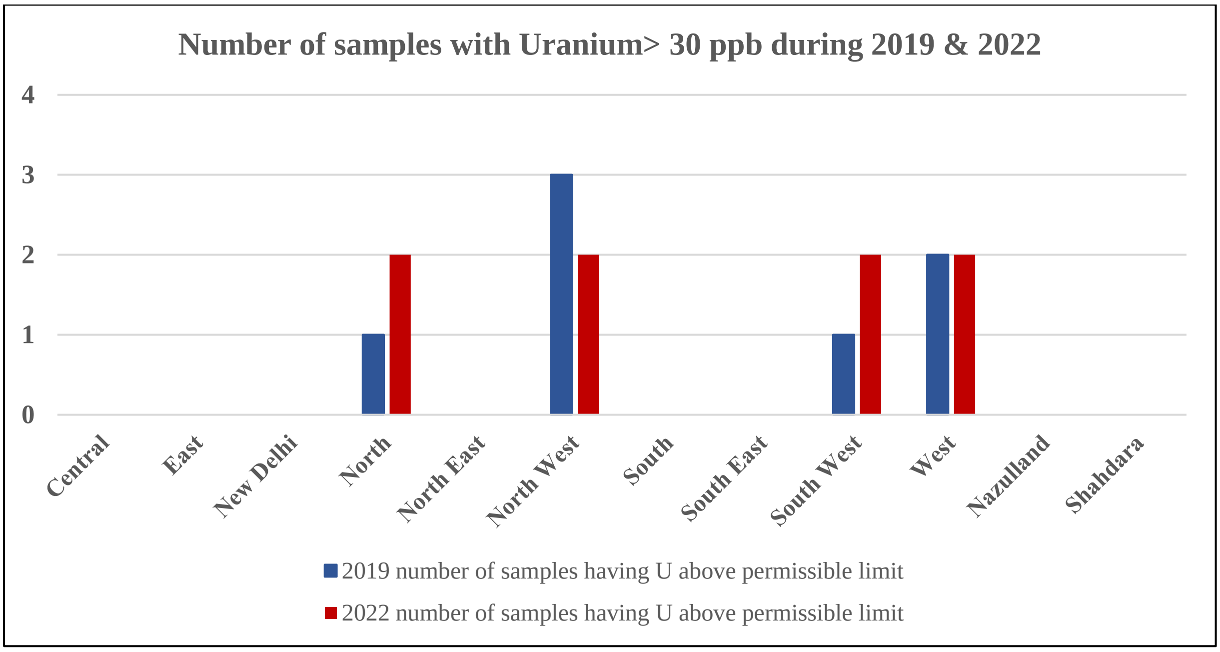

Fig. 7.7.3 Bar diagram comparing no. of Uranium contaminated (30 ppb) locations in various districts during year 2019 and 2022

Table 7.7.4 shows the number of districts partly affected in NCT of Delhi with maximum values recorded. It is observed that North, North West, West and South West are observed to have Uranium concentration above the permissible level of 30 µg/L in some localized pockets.

Uranium concentration varied from 0.0 to 83.519 ppb in the entire country during Pre-monsoon monitoring, indicating that uranium concentrations in groundwater vary by some orders of magnitude. Slight variations seen in Uranium concentrations could be due to the wide variation of geographical locations or regional differences in the hydrogeochemical characteristics of groundwater.

Table 7.7.4: Details of number of districts partly affected with Uranium > 0.03 mg/L (>30ppb) and the maximum values of Uranium in districts of NCT of Delhi

Sl. No.	Districts	No. of location partly affected with U > 30 ppb	Maximum value of Uranium observed (in ppb)
1.	North	02	83.519
2.	North West	02	63.540
3.	West	02	36.158
4.	South West	02	47.260

Table 7.7.5: Percentage of wells Exceed Uranium > 0.03 mg/L during the period of 2019-2022

Year	Total Number of samples analysed	No. of districts affected by Uranium	No. of locations affected by Uranium	% age of samples affected by Uranium (U >0.03 mg/L)
2019	64	4	7	11.67
2020	66	5	5	6.85
2021	79	1	3	3.90
2022	95	4	8	8.42

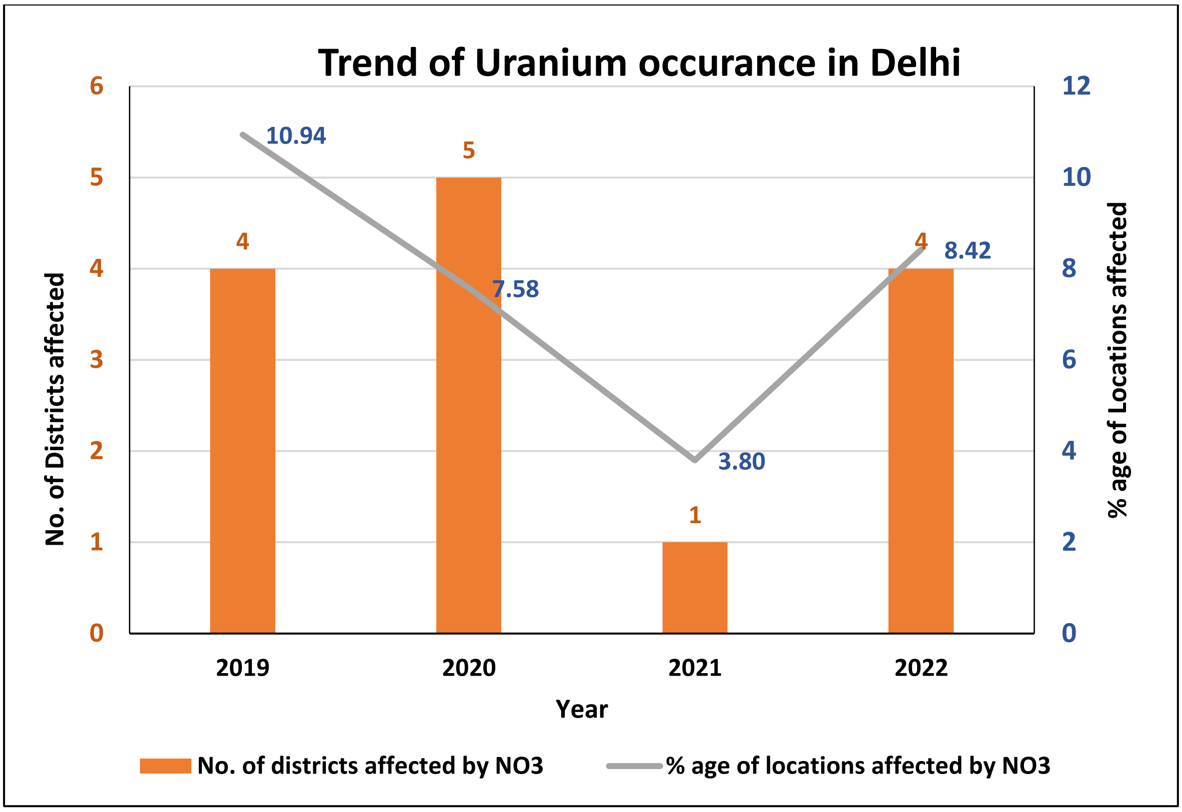

Fig. 7.7.4 Trend of Uranium occurrence in NCT of Delhi

8.0 SUITABILITY OF GROUNDWATER FOR IRRIGATION PURPOSE

The chemical quality of water is an important factor to be considered in evaluating its usefulness for irrigation purposes. Plants grown by irrigation absorb and transpire water but leave nearly all the salts behind in the soil, where they accumulate and eventually prevent plant growth. Excessive concentrations of solute interfere with the osmotic process by which plant root membranes are able to assimilate water and nutrients. In areas where natural drainage is inadequate, the irrigation water infiltrating the root zone will cause water table to rise excessively. In addition to problems caused by excessive concentration of dissolved solids, certain constituents in irrigation water are especially undesirable and some may be damaging even when present in small concentrations. Irrigation indices viz. Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) have been evaluated to assess the suitability of ground water for irrigation purposes.

Alkali Hazard

In the irrigation water, it is characterized by absolute and relative concentrations of cations. If the sodium concentrations are high, the alkali hazard is high and if the calcium & magnesium levels are high, this hazard is low. The alkali soils are formed by the accumulation of exchangeable sodium and are characterized by poor tilt and low permeability. The U.S. Salinity laboratory has recommended the use of sodium adsorption ratio (SAR) as it is closely related to adsorption of sodium by the soil.

SAR is derived by the following equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}Mg^{2+}}{2}}}$$

The water with regard to SAR is classified into four categories

- **S_1 – Low Sodium Water** (SAR <10)

Such waters can be used on practically all kinds of soils without any risk or increase in exchangeable sodium.

- **S_2 – Medium Sodium Water** (SAR 10-18)

Such waters may produce an appreciable sodium hazard in fine textured soil having high cation exchange capacity under low leaching.

- **S_3 – High Sodium Water** (SAR >18-26)

Such waters indicate harmful concentrations of exchangeable sodium in most of the soil and would require special management, good drainage, high leaching and addition of organic matter to the soil. If such waters are used on gypsiferrous soils the exchangeable sodium could not produce harmful effects.

- **S_4 – Very High Sodium Waters** (SAR >26)

Generally, such waters are unsatisfactory for irrigation purposes except at low or perhaps at medium salinity where the solution of calcium from the soil or addition of gypsum or other amendments makes the use of such waters feasible.

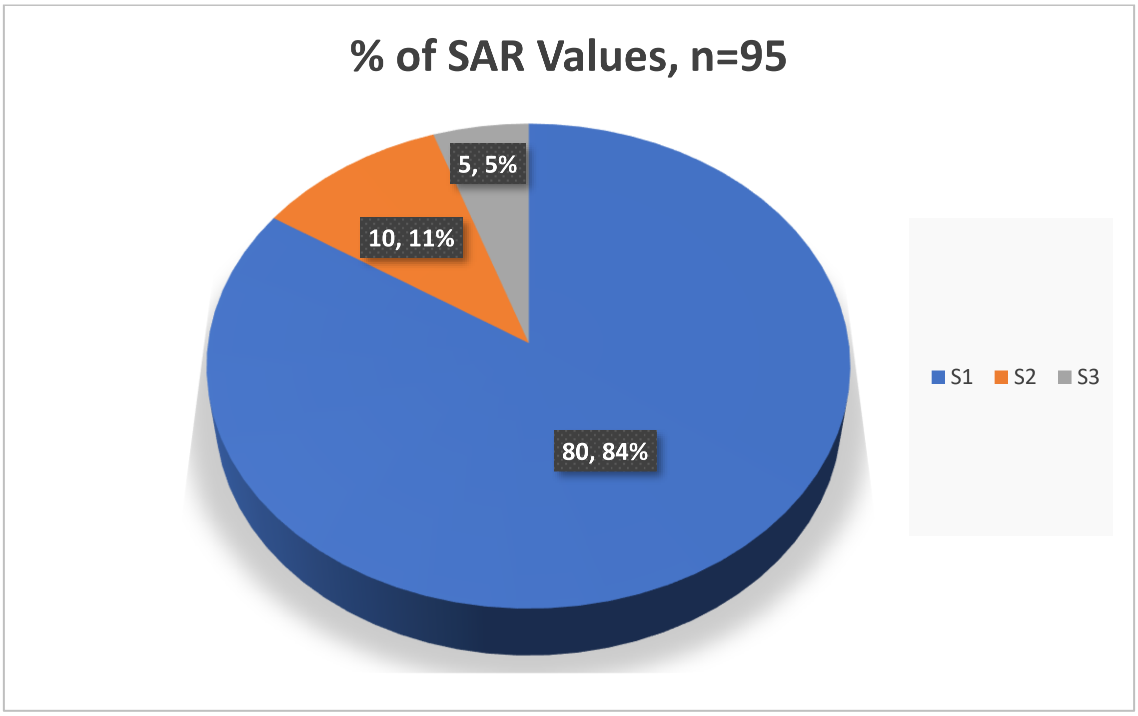

Figure 8.1: Percentage of groundwater samples according to SAR classifications (n=95).

The computed SAR values ranges from 0.05 to 25.07. The maximum SAR value has been found at Shastripark area. It is apparent from Fig. 8.1 that 84.21% samples belong to excellent category (S_1) and none of the water samples are associated with very high sodium category (S_4).

According to SAR classification, 100% of water samples in Central, East, North East, Sahadara, South East and Nazul land fall in excellent category (S_1). (Table 8.1)

It was found that in South West district total 50 % sample fall in S2 and S3 categories, while 22.22 % sample in North district fall in S2 & S3 categories. (Fig. 8.2).

Table 8.1: Summary of irrigation quality of the groundwater samples in various states based on SAR classifications.

District	%. of samples in various SAR range			
	(low Sodium <10)	(medium Sodium 10-18)	(high Sodium 18-26)	(very high Sodium >26)
Central	100.0	0.0	0.0	0
East	100.0	0.0	0.0	0
New Delhi	90.0	10.0	0.0	0
North	77.8	11.1	11.1	0
North East	100.0	0.0	0.0	0

North West	86.7	13.3	0.0	0
Shahdara	100.0	0.0	0.0	0
South	87.5	12.5	0.0	0
South East	100.0	0.0	0.0	0
South West	50.0	25.0	25.0	0
West	88.9	11.1	0.0	0
Nazulland	100.0	0.0	0.0	0

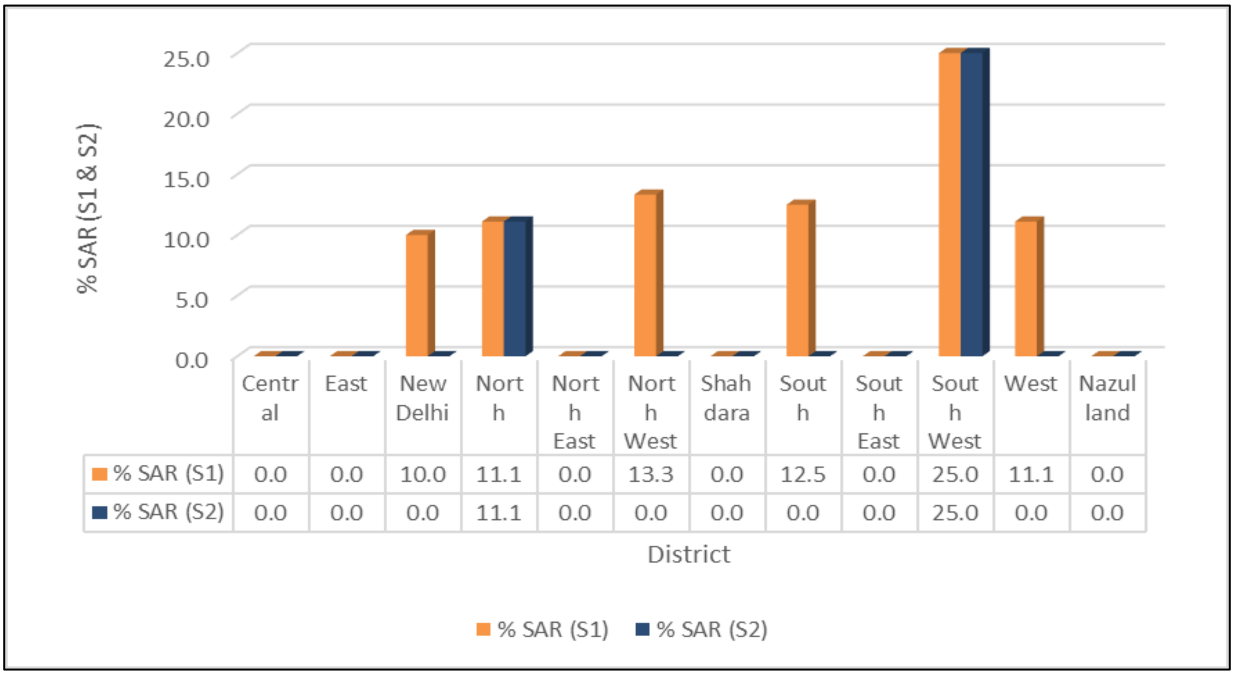

Figure 8.2: Percentage of samples with respect to SAR values.

Residual Sodium Carbonate (RSC)

If the enriched carbonate (residual) concentration becomes relatively high, carbonates get together with calcium and magnesium to form precipitates. The relative abundance of sodium in comparison to alkaline earths and the quantity of bicarbonate and carbonate in excess of alkaline earths also influences the suitability of water for irrigation. This excess is represented in terms of "Residual Sodium Carbonate" (RSC). The highly soluble sodium carbonate known as residual sodium carbonate (RSC) is defined as;

$$RSC = (HCO_3^- + CO_3^-) - (Ca^{2+} + Mg^{2+})$$

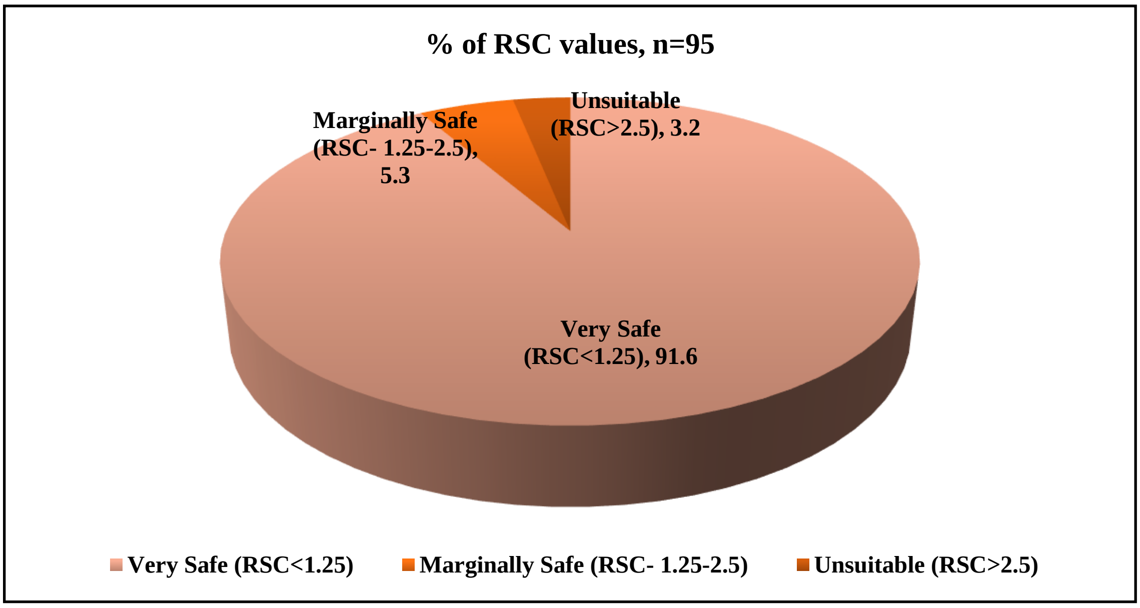

Figure 8.3: Percentage of groundwater samples in various categories according to RSC classifications (n=95) (Wilcox et al.,1954).

Waters with high RSC produces harmful effects on plant development and is not suitable for irrigation. Waters associated with RSC < 1.25 are of excellent irrigation quality and can be safely applied for irrigation for almost all crops without the risks associated with residual sodium carbonate (Wilcox et al.,1954). If the RSC values lie between 1.25 and 2.5, the water is of an acceptable quality for irrigation. Waters associated with RSC values higher than 2.5 are not acceptable for irrigation. In fig. it can be seen that in National Capital Territory of Delhi. 91.6% collected water samples are associated with RSC values less than 1.25 and are safe for use in irrigation practices. Only 3.2% water samples are associated with RSC values more than 2.5 and are unsuitable for irrigation. The water with high RSC values if applied for irrigation causes soil to become infertile owing to deposition of sodium. Table 8.4 summarizes the irrigation quality of the groundwater samples in various states based on RSC values.

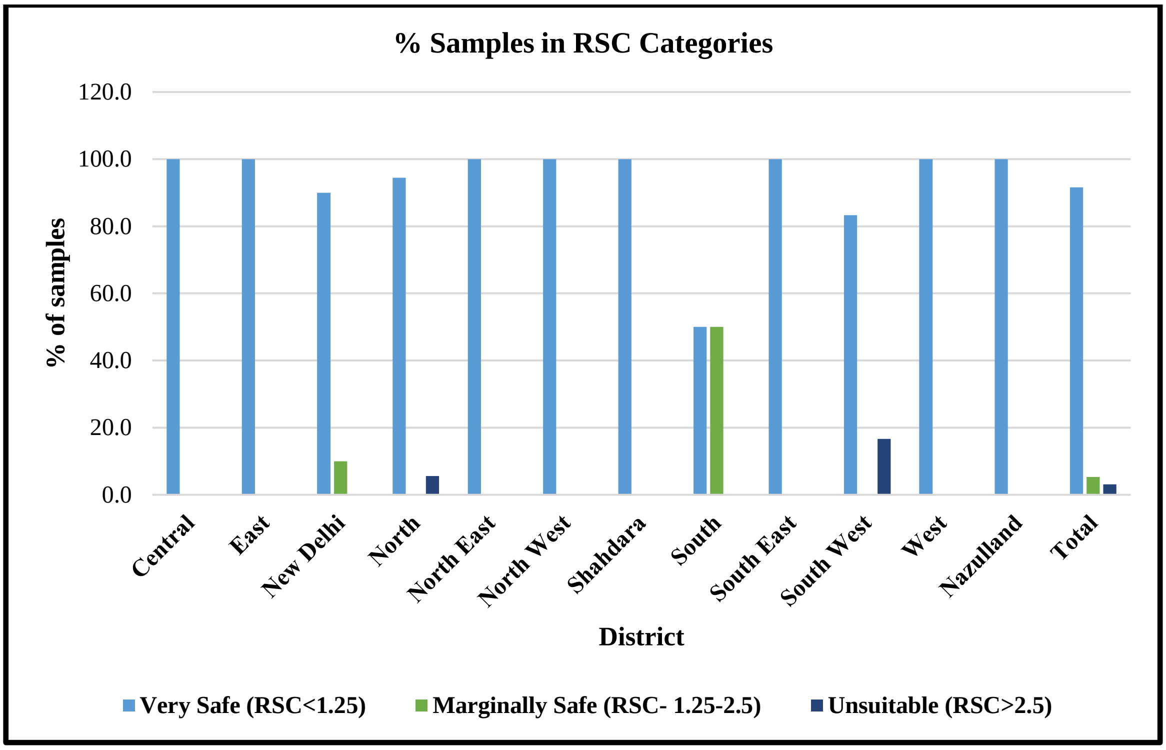

Figure 8.4: Percentage of samples with respect to RSC values.

According to RSC classification 100% of water samples in Central, East, North East, North West, Shahdara, South East and West Districts along with Nazul land fall in very safe category with RSC values less than 1.25.

Table 8.2: Summary of irrigation quality of the groundwater samples in various states based on RSC values.

District	Very Safe (RSC<1.25)	Marginally Safe (RSC- 1.25-2.5)	Unsuitable (RSC>2.5)
Central	100.0	0.0	0.0
East	100.0	0.0	0.0
New Delhi	90.0	10.0	0.0
North	94.4	0.0	5.6
North East	100.0	0.0	0.0
North West	100.0	0.0	0.0
Shahdara	100.0	0.0	0.0
South	50.0	50.0	0.0
South East	100.0	0.0	0.0
South West	83.3	0.0	16.7
West	100.0	0.0	0.0
Nazulland	100.0	0.0	0.0
Total	**91.6**	**5.3**	**3.2**

8.1 Wilcox diagram

EC and sodium concentration are very important in classifying irrigation water. The Wilcox diagram (Wilcox 1948) relating EC and SAR shows (fig. 9.0) that most of the samples are plotted in C2S1, C3S1 and C3S2 showing medium to high salinity and low to medium alkali hazard and suitable for irrigation. Samples falling in C4S2, C4S3, C4S4 are very high salinity with medium to very high alkalinity hazard and are not suitable for irrigation.

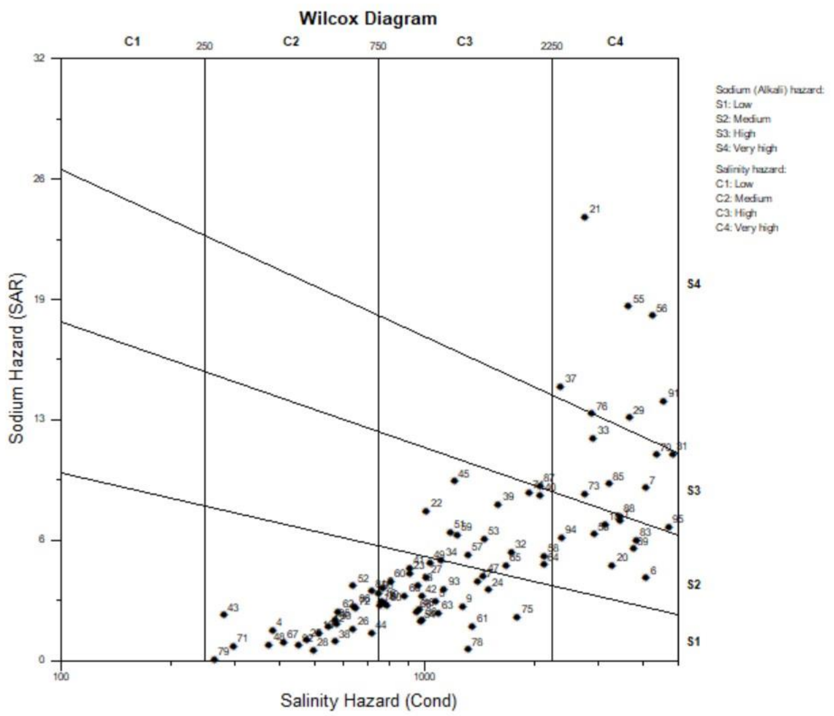

Fig.8.1: Plots of SAR verses electrical conductivity (after Wilcox 1955) in groundwater samples of NCT Delhi.

8.2 Piper Diagram:

Piper diagram (Piper 1944) describes the process responsible for the evolution of hydrogeochemical parameter in groundwater. Based on the major cation and major anion content in the water samples and plotting them in the trilinear diagram, hydrochemical facies could be identified. Hydro-chemical facies are very useful in investigating diagnostic chemical character of water in hydrologic systems. Different types of facies within the same group formations are due to characteristic ground water flow through the aquifer system and effect of local recharge. The types of facies are inter-linked with the geology of the area and distribution of facies with the hydrogeological controls. Hydrochemical facies are delineated by plotting percentage reacting value of major ions on tri-linear diagrams know as Piper Diagram.

In NCT Delhi, cation chemistry is dominated by sodium and potassium followed by magnesium. In anion side chloride is dominating anion followed by sulphate and bicabonate.
The facies mapping shows (Fig.9.1) that NaK-Cl is the dominant hydrogeochemical facies followed by mixed chemical character of hydrogeochemical facies.

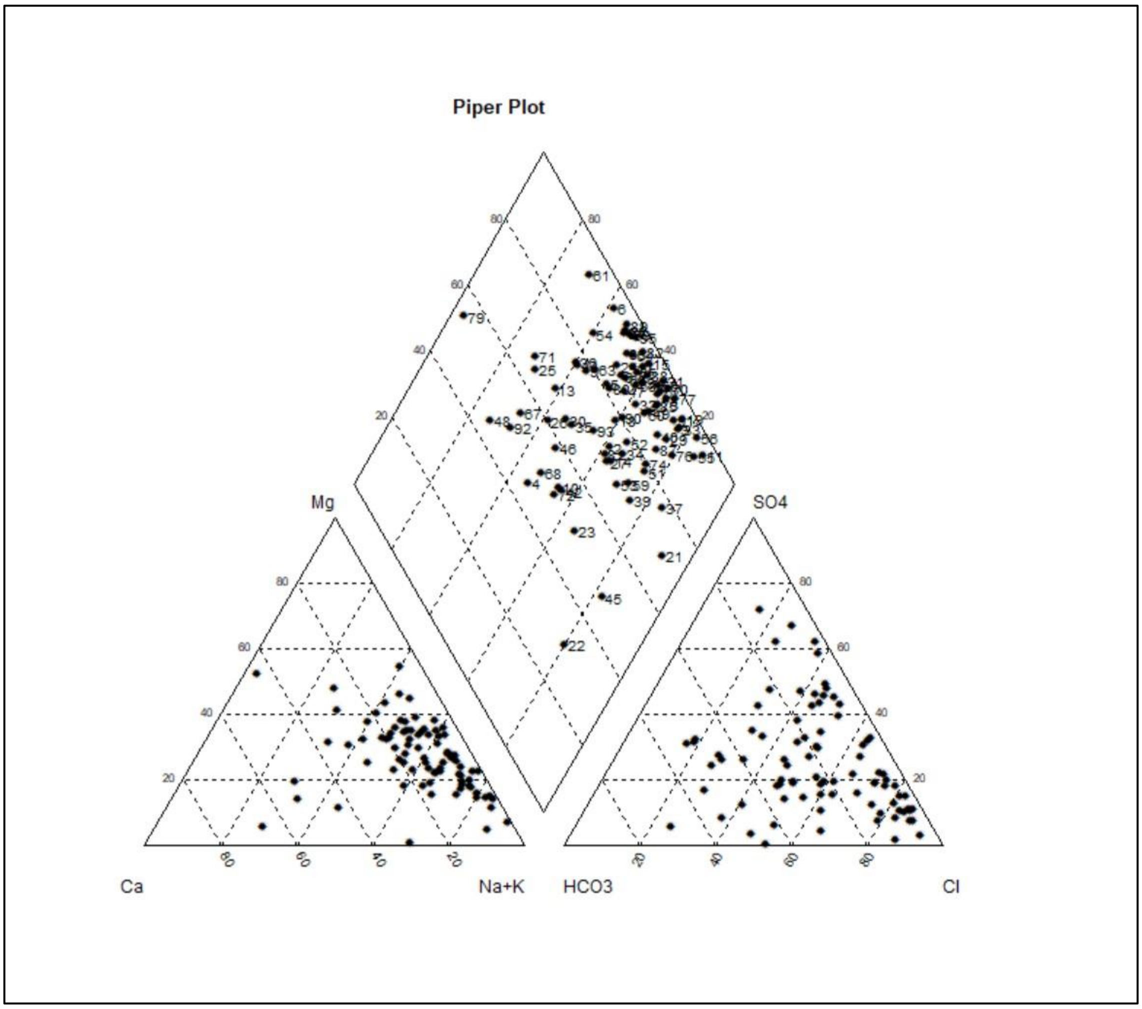

Fig- 8.2 Piper diagram of groundwater of NCT Delhi.

8.3 X-Y Plot:

If halite dissolution is responsible for the sodium, the Na+/Cl- ratio is approximately one, whereas a ratio greater than one, it is typically interpretated as Na+ released from Silicate weathering reaction. In the water samples of the shallow aquifers of Delhi, 8.42% of the samples fall along the equilibrium in the Na+/Cl- plot, indicating common source of halite for both the ions (Fig.9.2). In the water samples of the shallow aquifers of Delhi, 57.89% of the samples have molar ratio greater than one indicating ion exchange is the major process. It is where Na montmorillonite clay reacts with calcium and magnesium and releases sodium (sometimes called natural softening).

$$2Na^{+} - clay + Ca^{2+} \quad = \quad Ca^{2+} - clay + Na^{+}$$

The observed Na+/Cl-< 1 in 33.68% samples, may be attributed to Cl- enrichment from anthropogenic sources such as irrigation return flows or domestic waste disposal. Bivariant plot of NCT Delhi is shown in Fig.9.2.

Na^{+}/Cl^{-}	No of Samples	% Sample
>1	55	57.89
1	8	8.42
<1	32	33.68

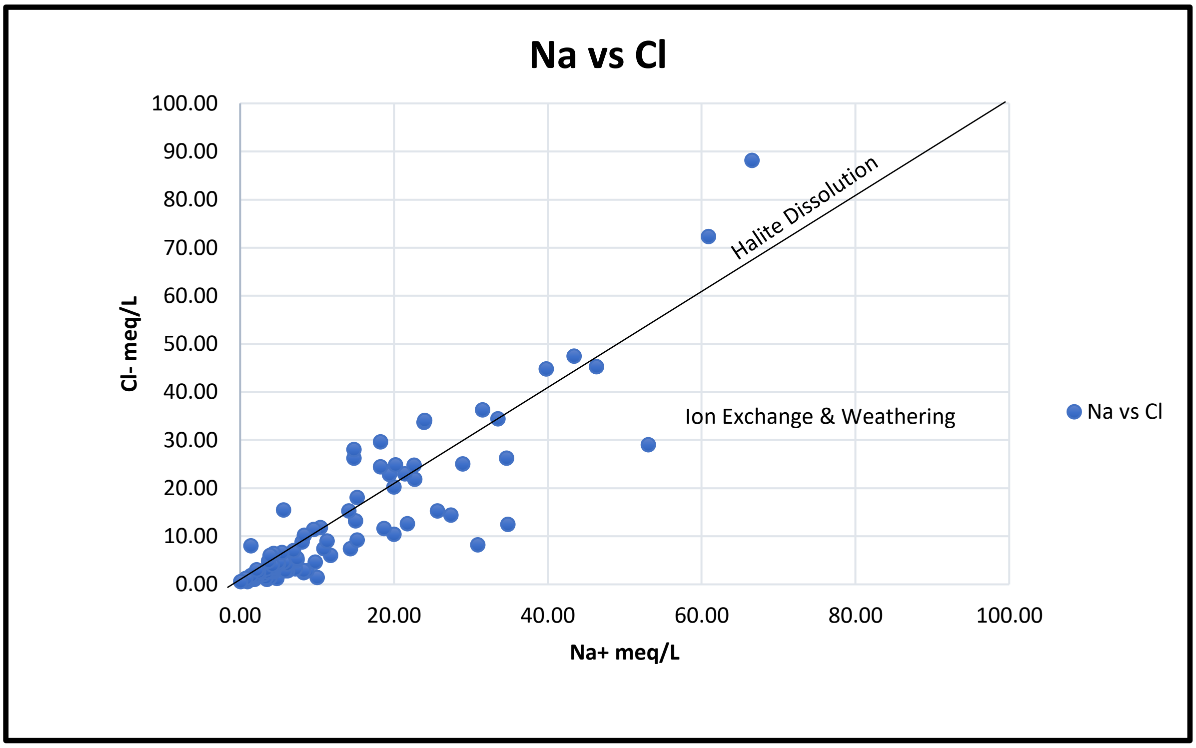

Fig. 8.3: The plot for Na versus Cl in groundwater samples of NCT of Delhi

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ANNEXURE-1: LIST OF GROUNDWATER SAMPLES & CHEMICAL ANALYSIS (BASIC ELEMENTS): MAY 2022

Longitude	Latitude	Location	pH*	EC* in µS/cm at 25⁰ C	CO_3	HCO_3	Cl*	SO_4	NO_3*	F*	PO_4	Ca*	Mg*	Na*	K*	SiO_2	TH *as $CaCO_3$
77.124	28.798	Alipur Garhi	8.46	3440	38	127	880	288	2.3	0.60	0.0	62	144	465	10	19	750
77.267	28.496	Asola	8.54	769	37	102	135	31	19	0.42	0.0	12	29	107	4.0	30	150
76.997	28.819	Auchandi Pz	8.81	7146	87	269	1028	1551	16	1.30	0.0	16	190	1220	17	16	821
77.208	28.420	Balbir Nagar	8.40	382	25	89	36	11	6.0	0.26	0.0	32	5	37	2.0	26	100
77.288	28.641	Bank Enclave	8.37	1070	25	101	163	130	25	0.36	0.0	40	37	114	12	13	250
77.074	28.851	Bankner Pz	8.18	4075	0	115	993	394	27	0.24	0.0	208	153	340	55	24	1151
77.017	28.650	Baprola Dw	8.67	4054	37	127	879	192	212	0.52	0.0	64	109	520	31	25	611
77.063	28.758	Barwala	7.82	9623	0	293	3124	134	49	0.07	0.0	581	11	1530	13	17	1491
77.030	28.787	Bawana JE Store	8.83	1275	51	140	234	77	29	0.86	0.0	26	72	125	7.0	24	360
77.199	28.632	Birla Mandir DW	8.53	773	38	183	92	38	1.6	0.38	0.0	36	22	95	4.0	18	180
77.163	28.736	Bhalaswa Lake	8.26	5316	0	127	1605	283	2.6	0.36	0.0	84	32	1065	15	12	340
77.208	28.428	Bhatti Pz	8.71	545	51	104	64	0	13	0.38	0.0	28	22	52	2.0	25	160
77.197	28.733	Burari DJB Ex Engg. Office	8.45	513	38	76	64	36	1.2	0.54	0.0	32	19	42	5.0	12	160
77.236	28.656	Chandni Chowk	8.60	752	38	101	92	72	28	0.33	0.0	28	17	80	59	21	140
77.009	28.546	Chhawala Pz	8.44	3126	24	76	866	221	8.0	0.17	0.0	144	68	420	8.5	23	640
77.301	28.587	Chilla Regulator	8.62	758	50	127	142	0	8.0	0.25	0.0	32	24	96	12	18	180
77.299	28.600	Chilla Saroda	8.58	1395	50	64	192	260	5.9	0.25	0.0	54	43	170	15	16	310
77.111	28.603	Cvd Depot Cantt	8.63	958	24	104	163	72	56	0.30	0.0	36	27	130	3.0	23	200
76.909	28.534	Daryapur Khurd	8.76	5752	51	127	1683	277	32	0.78	0.0	64	126	998	26	22	680
76.965	28.543	Daulatpur Pz	8.47	3290	38	104	930	149	37	0.64	0.0	108	144	340	39	20	860
77.051	28.567	Dwarka Sec 23 DDA Park	8.94	2770	126	427	540	48	21	2.60	0.0	8	24	590	6.0	24	120

Longitude	Latitude	Location	pH*	EC* in µS/cm at 25^0 C	CO_3	HCO_3	Cl*	SO_4	NO_3*	F*	PO_4	Ca*	Mg*	Na*	K*	SiO_2	TH *as $CaCO_3$
77.057	28.594	Dwarka Sec 5 DDA Park	8.61	1012	45	397	85	25	6.0	1.40	0.0	12	19	190	8.4	21	110
77.156	28.477	Gadaipur Pz	8.74	909	51	177	99	10	91	0.94	0.0	12	32	135	7.5	30	160
77.318	28.628	Gazipur Crossing	8.42	1494	24	104	114	388	71	0.42	0.0	44	63	165	18	28	370
77.242	28.541	GK 2	8.37	474	24	76	64	24	22	1.10	0.0	28	24	32	2.1	23	170
77.274	28.704	Gokulpuri EW	8.50	637	24	127	64	66	19	0.52	0.0	20	34	53	14	22	190
77.292	28.642	Gujrat Vihar Pz	8.71	1012	38	153	149	77	26	0.90	0.0	28	29	140	14	21	190
77.147	28.729	Haiderpur Pz	8.59	495	38	127	43	0	10	3.00	0.0	32	32	17	5.0	21	210
77.008	28.832	Hareoli	8.92	3654	75	226	511	746	16	3.20	0.0	36	88	630	8.0	16	450
77.202	28.545	Hauzpur Khas Pz	8.22	571	0	116	92	48	4.0	0.76	0.0	32	17	55	5.0	11	150
76.994	28.682	Hiran Kudna	8.38	4811	24	76	1285	317	200	0.25	0.0	64	163	725	6.2	20	831
77.181	28.801	Hiranki Village	8.77	1730	62	127	419	53	14	0.41	0.0	16	71	240	13	23	330
77.251	28.595	India Gate	8.70	2911	38	89	447	509	190	0.63	0.0	32	63	500	40	23	340
77.157	28.536	JNU Pz	8.78	1113	62	127	178	62	38	0.67	0.0	24	32	170	2.0	29	190
77.223	28.740	Jagatpur Pz 2	8.57	568	24	104	85	45	1.0	0.63	0.0	16	27	60	8.0	17	150
77.341	28.509	Jaitpur Khadar RD3500 Pz	8.86	984	51	116	170	72	1.0	0.24	0.0	12	66	85	10	22	300
77.182	28.506	Jamali Kamali	8.22	2373	0	317	369	346	66	3.00	0.0	8	41	460	9.0	24	190
77.091	28.630	Janakpuri	8.72	567	51	165	36	0	12	1.90	0.0	24	34	32	20	18	200
77.150	28.468	Jaunapur DJB TW	8.70	1597	75	216	213	106	100	1.00	0.0	8	44	270	7.0	30	200
76.967	28.753	Jaunti DW	8.60	2084	38	140	469	106	110	0.63	0.0	28	54	345	8.0	23	290
77.189	28.409	Jheel Khoh	8.81	911	62	216	99	0	48	0.77	0.0	8	34	142	1.6	30	160
76.905	28.536	Jhuljhuli Dw	8.61	982	51	226	149	2	2.4	2.20	0.0	20	41	115	17	11	220
77.000	28.725	Kanjhawala	8.85	280	51	24	36	0	2.0	0.40	0.0	8	10	43	5.3	14	60
77.234	28.664	Khela Ghat Bhela Road	8.53	716	38	76	107	53	31	0.46	0.0	28	36	50	31	28	220

Longitude	Latitude	Location	pH*	EC* in µS/cm at 25⁰ C	CO_3	HCO_3	Cl*	SO_4	NO_3*	F*	PO_4	Ca*	Mg*	Na*	K*	SiO_2	TH *as $CaCO_3$
77.118	28.769	Khera Kalan Pz	8.73	1211	105	268	50	125	3.5	2.10	0.0	8	22	230	7.2	24	110
77.322	28.611	Kondli DJB WTP	8.77	969	75	165	121	19	40	0.65	0.0	16	54	100	15	25	260
77.272	28.633	Lalitha Park	8.65	1453	38	116	312	98	28	0.36	0.0	40	54	185	17	23	320
77.216	28.590	Lodhi Garden	8.41	374	24	92	28	22	8.0	0.32	0.0	20	22	22	0.7	23	140
77.175	28.604	Mahabir Vansth	8.44	1037	38	64	249	41	8.0	0.58	0.0	24	29	160	4.0	25	180
77.006	28.756	Majara Dabas	8.43	2921	38	76	639	231	241	0.53	0.0	76	80	350	154	36	520
77.228	28.696	Majnu Ka Tila DW	8.66	1178	36	122	99	207	80	1.70	0.0	20	24	190	12	14	150
77.079	28.690	Mangolpur	8.70	637	24	73	99	70	2.0	1.10	0.0	20	15	96	2.0	18	110
77.111	28.619	Mayapuri	8.58	1459	36	244	163	205	28	0.80	0.0	16	46	225	18	10	230
77.304	28.616	Mayur Vihar B Block Ph II	8.61	974	36.0	73	114	188	11	0.43	0.0	44	44	80	14	9.0	290
76.893	28.606	Mundela Kalan Pz	8.92	3642	48	122	291	990	240	1.20	0.0	24	51	710	13	15	270
77.001	28.615	Najafgarh Town	8.37	4229	36	61	443	1052	290	0.82	0.0	16	78	800	18	18	360
77.273	28.594	Nangli Rajapur	8.71	1316	36	37	362	43	11	0.76	0.0	16	44	192	16	24	220
77.134	28.837	Narela DJB WTP	8.79	2136	36	110	263	340	110	0.51	0.0	24	80	250	11	21	390
76.964	28.720	Nizampur	8.95	1226	36	159	99	190	90	4.20	0.0	16	32	200	5.4	22	170
77.266	28.605	Nizamuddin Bridge	8.69	807	24	49	142	64	64	0.72	0.0	20	22	114	14	29	140
77.273	28.564	Okhla DJB WTP	8.70	1356	24	49	213	267	18	0.69	0.0	140	32	90	6.0	20	480
77.204	28.823	Palla Temple	8.73	579	24	37	71	92	26	1.00	0.0	24	19	70	5.8	9.0	140
77.095	28.678	Peeragarhi TW	8.21	1087	0	122	227	96	22	1.10	0.0	48	44	100	29	11	300
77.093	28.676	Peeragarhi DW	8.56	2136	24	85	320	461	28	1.20	0.0	60	84	260	3.0	16	500
77.162	28.639	PUSA (NRL)	8.70	1670	12	85	405	144	25	1.00	0.0	16	78	220	2.0	10	360
77.227	28.528	Pusp Vihar	8.70	883	24	61	43	269	9	0.79	0.0	20	36	110	3.0	11	200
77.033	28.842	Qatlupur	8.39	410	12	98	36	44	11	0.47	0.0	44	7	26	9.0	10	140

Longitude	Latitude	Location	pH*	EC* in µS/cm at 25⁰ C	CO_3	HCO_3	Cl*	SO_4	NO_3*	F*	PO_4	Ca*	Mg*	Na*	K*	SiO_2	TH *as $CaCO_3$
76.965	28.806	Qutubgarh	8.45	948	24	232	50	120	12	1.40	0.0	32	36	90	7.0	16	230
77.025	28.707	Rani Khera DW	8.38	3766	24	98	1050	117	195	0.40	0.0	96	173	420	18	14	951
76.904	28.518	Raota	8.47	4340	24	73	888	613	220	0.63	0.0	52	139	665	18	13	700
77.102	28.715	Rithala Pz Sec5 Rohini	8.41	297	12	49	28	41	5.0	0.44	0.0	40	2	18	2.5	19	110
77.104	28.732	Rohini Sec 11 Pz	8.92	645	24	159	50	62	7.0	3.70	0.0	20	24	77	6	21	150
77.071	28.724	Rohini Sector 23	8.90	2759	36	110	412	421	240	4.60	0.0	28	92	430	3.6	19	450
77.095	28.753	Rohini Sector 28	8.68	1938	36	195	263	247	140	2.70	0.0	28	46	330	1.2	14	260
77.213	28.590	Safdarjung tomb	8.39	1804	12	49	547	0	90	0.41	0.0	52	119	130	5.2	15	620
77.122	28.691	Sainik Vihar	8.66	2889	48	183	774	19	120	3.30	0.0	28	56	522	9.0	10	300
77.146	28.695	Sandesh Vihar	8.21	8679	0	134	2563	447	180	0.74	0.0	84	253	1400	30	11	1251
77.142	28.690	Sanjay Van	8.61	1320	60	232	284	0	0.0	2.30	0.0	120	78	32	8.0	21	620
77.098	28.703	Sector 1 Rohini	8.37	264	12	61	21	29	2.0	0.54	0.0	24	17	1.5	1.0	14	130
77.262	28.676	Shastri Park	8.55	788	36	73	121	93	2.0	0.58	0.0	20	34	92	8.0	27	190
77.108	28.578	Shekhwati Line	8.63	716	48	98	107	38	4.0	0.50	0.0	20	22	100	3.0	10	140
76.953	28.524	Shikarpur Deep	8.17	7249	0	171	1588	1067	150	0.62	0.0	132	312	915	24	10	1612
77.129	28.843	Singhola	8.24	3826	0	183	809	455	180	0.45	0.0	72	182	446	12	13	931
77.131	28.853	Singhu Village	8.22	5095	0	171	1207	504	220	0.47	0.0	196	204	552	16	17	1331
77.036	28.765	Sultanpur Dabas	8.76	3210	72	146	814	110	120	1.50	0.0	110	60	492	12	17	520
77.146	28.489	Sultanpur IMS	8.94	643	72	183	36	0	1.0	0.68	0.0	20	24	80	4	11	150
77.245	28.596	Sunder Nursery	8.77	2070	60	171	327	305	14	1.10	0.0	44	39	350	7.0	15	270
76.934	28.601	Surheda	8.61	3445	60	122	717	464	29	1.40	0.0	24	151	460	38	15	681
77.113	28.644	Tagore Garden	8.18	7417	0	170	929	1955	260	0.55	0.0	304	290	796	24	21	1952
77.197	28.815	Tiggipur	8.67	749	36	73	92	112	4	0.94	0.0	20	24	100	6	23	150
76.914	28.577	Ujwah Pz	8.76	4562	72	159	1221	208	110	0.90	0.0	68	102	770	16	10	590
77.249	28.685	Ushmanpur	8.70	450	36	98	21	48	2	0.72	0.0	32	17	22	19	17	150
77.074	28.632	Vikashpuri	8.88	1134	60	159	149	106	10	2.50	0.0	40	39	140	7	19	260

Longitude	Latitude	Location	pH*	EC* in µS/cm at 25^0 C	CO_3	HCO_3	Cl*	SO_4	NO_3*	F*	PO_4	Ca*	Mg*	Na*	K*	SiO_2	TH *as $CaCO_3$
77.313	28.671	Vivek Vihar	8.49	2375	36	110	540	192	90	0.82	0.0	30	96	325	10	21	470
77.152	28.815	Bakoli	8.41	4697	36	98	1193	371	170	0.51	0.0	128	200	550	15	10	1141

ANNEXURE-2: LIST OF GROUNDWATER SAMPLES & CHEMICAL ANALYSIS (HEAVY METALS): MAY 2022

Longitude	Latitude	Block	Location	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	U
				mg/L(ppm)						µg/L(ppb)				
77.124	28.798	Alipur	Alipur Garhi	BDL	0.054	0.237	BDL	0.002	0.144	0.320	0.035	0.086	0.326	25.015
77.267	28.496	Kalkaji	Asola	BDL	0.003	0.040	BDL	0.003	0.103	0.095	0.345	0.350	0.700	2.946
76.997	28.819	Narela	Auchandi Pz	BDL	0.017	0.027	BDL	0.002	0.041	0.379	0.173	0.115	0.231	83.519
77.208	28.420	Saket	Balbir Nagar	BDL	0.015	0.056	BDL	0.002	0.090	0.044	0.000	0.190	0.725	0.302
77.288	28.641	Preet vihar	Bank Enclave	BDL	0.394	0.466	BDL	0.002	0.148	9.466	0.207	0.116	0.418	3.695
77.074	28.851	Narela	Bankner Pz	BDL	0.029	0.048	BDL	0.001	0.043	0.363	0.190	0.078	0.102	14.753
77.017	28.650	Punjabi bagh	Baprola Dw	BDL	0.150	0.047	BDL	0.001	0.049	0.178	0.069	0.142	0.239	32.249
77.063	28.758	Narela	Barwala	BDL	0.554	0.159	BDL	0.001	0.065	0.143	0.104	0.110	0.205	1.341
77.030	28.787	Narela	Bawana JE Store	BDL	0.024	0.036	BDL	0.001	0.099	0.538	0.086	0.154	0.324	18.982
77.199	28.632	Chanakyapuri	Birla Mandir DW	BDL	0.041	0.031	BDL	0.001	0.013	BDL	0.000	0.012	0.468	0.051
77.163	28.736	Model town	Bhalaswa Lake	BDL	0.218	13.469	BDL	0.001	0.706	0.148	0.000	0.098	0.657	1.311
77.208	28.428	Saket	Bhatti Pz	BDL	0.002	0.065	BDL	0.003	0.106	0.036	0.069	0.159	1.320	6.641
77.197	28.733	Civil lines	Burari DJB Ex Engg. Office	BDL	0.438	0.576	BDL	0.001	0.151	6.641	0.000	0.115	0.625	1.289
77.236	28.656	Kotwali	Chandni Chowk	BDL	0.003	0.085	0.003	0.003	0.138	0.394	0.069	0.234	1.029	1.503
77.009	28.546	Kapeshera	Chhawala Pz	BDL	0.038	0.092	BDL	0.003	0.042	0.153	0.069	0.147	0.654	10.427
77.301	28.587	Mayur vihar	Chilla Regulator	BDL	0.052	0.038	BDL	0.014	0.063	0.323	0.000	0.118	0.497	5.239
77.299	28.600	Mayur vihar	Chilla Saroda	BDL	0.462	0.886	BDL	0.002	0.041	5.839	0.035	0.107	0.618	4.547
77.111	28.603	Delhi cantonment	Cvd Depot Cantt	BDL	0.003	0.069	BDL	0.003	0.108	0.138	0.069	0.124	1.218	7.276
76.909	28.534	Najafgarh	Daryapur Khurd	BDL	0.005	0.018	BDL	0.002	0.031	0.163	0.086	0.147	2.167	16.216
76.965	28.543	Kapeshera	Daulatpur Pz	BDL	0.020	0.079	BDL	0.001	0.062	0.188	0.000	0.122	0.393	7.707
77.051	28.567	Dwarka	Dwarka Sec 23 DDA Park	BDL	0.011	0.029	BDL	0.002	0.046	0.158	0.017	0.125	0.453	13.777
77.057	28.594	Dwarka	Dwarka Sec 5 DDA Park	BDL	0.002	0.077	BDL	0.002	0.150	0.181	0.017	0.143	0.715	5.351

Longitude	Latitude	Block	Location	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	U
77.156	28.477	Mehrauli	Gadaipur Pz	BDL	0.005	0.124	BDL	0.002	0.076	0.097	0.017	0.183	0.975	2.239
77.318	28.628	Preet vihar	Gazipur Crossing	BDL	0.025	0.076	BDL	0.004	0.052	4.885	0.104	0.106	0.559	15.043
77.242	28.541	Kalkaji	GK 2	BDL	0.002	0.097	BDL	0.003	0.062	0.138	0.052	0.442	1.063	4.348
77.274	28.704	Karawal nagar	Gokulpuri EW	BDL	0.191	0.055	BDL	0.002	0.595	0.231	0.012	0.471	2.006	5.936
77.292	28.642	Preet vihar	Gujrat Vihar Pz	BDL	0.235	0.107	BDL	0.002	0.044	0.512	0.012	0.166	0.806	10.125
77.147	28.729	Alipur	Haiderpur Pz	BDL	0.006	0.016	BDL	0.002	0.090	0.485	0.071	0.054	1.089	10.146
77.008	28.832	Narela	Hareoli	BDL	0.037	0.204	BDL	0.001	0.169	0.126	0.343	0.060	0.800	37.337
77.202	28.545	Hauz khas	Hauzpur Khas Pz	BDL	0.003	0.045	BDL	0.002	0.060	0.746	0.036	0.128	0.514	1.435
76.994	28.682	Punjabi bagh	Hiran Kudna	BDL	0.067	0.043	BDL	0.001	0.121	0.262	0.000	0.016	0.272	14.435
77.181	28.801	Alipur	Hiranki Village	BDL	0.026	0.016	BDL	0.002	0.027	0.213	0.024	0.125	0.339	17.516
77.251	28.595	Chanakyapuri	India Gate	BDL	0.033	0.044	BDL	0.001	0.069	0.127	0.047	0.048	0.747	13.733
77.157	28.536	Vasant vihar	JNU Pz	BDL	0.001	0.033	BDL	0.001	0.028	0.118	0.201	0.048	0.371	12.364
77.223	28.740	Civil lines	Jagatpur Pz 2	BDL	0.024	0.026	BDL	0.010	0.197	12.726	BDL	0.063	1.555	1.226
77.341	28.509	Sarita vihar	Jaitpur Khadar RD3500 Pz	BDL	0.169	0.075	BDL	0.001	0.054	1.056	BDL	0.036	0.583	4.854
77.182	28.506	Mehrauli	Jamali Kamali	BDL	0.015	0.356	BDL	0.001	0.109	0.291	0.426	0.056	0.603	12.994
77.091	28.630	Patel nagar	Janakpuri	BDL	0.003	0.244	BDL	0.002	0.092	0.103	BDL	0.111	0.729	12.455
77.150	28.468	Mehrauli	Jaunapur DJB TW	BDL	0.002	0.057	BDL	0.002	0.252	0.059	0.095	0.080	0.782	20.701
76.967	28.753	Kanjhawala	Jaunti DW	BDL	0.000	0.024	BDL	0.001	0.162	0.302	0.272	0.027	0.479	12.295
77.189	28.409	Mehrauli	Jheel Khoh	BDL	0.001	0.028	BDL	0.002	0.081	0.289	0.071	0.073	0.624	10.161
76.905	28.536	Najafgarh	Jhuljhuli Dw	BDL	0.001	0.015	BDL	0.002	0.044	1.910	0.154	0.047	0.610	4.231
77.000	28.725	Kanjhawala	Kanjhawala	BDL	0.056	0.064	BDL	0.003	0.192	0.755	0.059	0.073	1.075	0.417
77.234	28.664	Civil lines	Khela Ghat Bhela Road	BDL	0.003	0.059	BDL	0.002	0.119	1.274	0.083	0.120	1.055	5.895
77.118	28.769	Alipur	Khera Kalan Pz	BDL	0.020	0.042	BDL	0.001	0.087	1.083	0.083	0.211	0.654	29.262
77.322	28.611	Mayur vihar	Kondli DJB WTP	BDL	0.034	0.042	BDL	0.001	0.047	0.310	0.036	0.124	0.686	21.785

Longitude	Latitude	Block	Location	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	U
77.272	28.633	Nazul land	Lalitha Park	BDL	0.250	0.082	BDL	0.001	0.193	1.358	0.012	0.101	1.299	8.152
77.216	28.590	Chanakyapuri	Lodhi Garden	BDL	0.026	0.472	BDL	0.002	0.277	0.086	0.142	0.158	1.019	3.282
77.175	28.604	Chanakyapuri	Mahabir Vansth	BDL	0.004	0.050	BDL	0.001	0.050	0.094	0.189	0.123	0.838	2.817
77.006	28.756	Saraswati vihar	Majara Dabas	BDL	0.019	0.023	BDL	0.001	0.067	0.247	0.272	0.022	0.187	28.186
77.228	28.696	Civil lines	Majnu ka Tila DW	BDL	0.029	0.052	BDL	0.002	0.074	0.452	0.331	0.095	0.538	8.825
77.079	28.690	Rohini	Mangolpur	BDL	0.107	0.369	BDL	0.001	0.124	0.565	0.012	0.020	0.386	0.648
77.111	28.619	Rajouri garden	Mayapuri	BDL	0.007	0.054	BDL	0.002	0.490	0.429	0.216	0.045	1.047	9.304
77.304	28.616	Mayur vihar	Mayur Vihar B Block Ph II	BDL	0.386	0.051	BDL	0.002	0.042	7.000	0.031	0.069	0.664	3.541
76.893	28.606	Najafgarh	Mundela Kalan Pz	BDL	0.056	0.035	BDL	0.001	0.038	0.375	0.002	0.076	0.246	30.414
77.001	28.615	Najafgarh	Najafgarh Town	BDL	0.042	0.039	BDL	0.000	0.023	0.047	0.131	0.046	0.056	9.830
77.273	28.594	Defence colony	Nangli Rajapur	BDL	0.963	13.078	BDL	0.001	0.083	61.947	0.017	0.053	0.568	0.057
77.134	28.837	Narela	Narela DJB WTP	BDL	0.104	0.035	BDL	0.001	0.041	0.421	0.074	0.024	0.117	25.949
76.964	28.720	Kanjhawala	Nizampur	BDL	0.019	0.092	BDL	0.004	0.142	0.312	0.002	0.279	0.665	63.540
77.266	28.605	Nazulland	Nizamuddin Bridge	BDL	0.401	0.607	BDL	0.002	0.095	23.589	0.002	0.121	0.827	1.695
77.273	28.564	Kalkaji	Okhla DJB WTP	BDL	0.002	0.044	BDL	0.001	0.072	0.199	0.145	0.049	0.408	5.759
77.204	28.823	Alipur	Palla Temple	BDL	0.033	0.032	BDL	0.002	0.244	1.185	0.002	0.060	0.779	7.381
77.095	28.678	Punjabi bagh	Peeragarhi TW	BDL	0.028	0.066	BDL	0.001	0.089	0.121	0.002	0.057	0.359	36.158
77.093	28.676	Punjabi bagh	Peeragarhi DW	BDL	0.000	0.018	BDL	0.005	0.037	1.033	0.858	0.060	0.247	12.549
77.162	28.639	Patel nagar	Pusa (NRL)	BDL	0.009	0.128	BDL	0.001	0.063	0.125	0.131	0.083	0.798	10.019
77.227	28.528	Hauz khas	Pusp Vihar	BDL	0.001	0.040	BDL	0.002	0.150	0.141	0.088	0.043	1.501	15.989
77.033	28.842	Narela	Qatlupur	BDL	0.005	0.045	BDL	0.002	0.074	0.490	0.002	0.045	0.602	24.304
76.965	28.806	Saraswati vihar	Qutubgarh	BDL	0.034	0.473	BDL	0.002	1.273	0.390	0.002	0.040	0.609	17.649

Longitude	Latitude	Block	Location	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	U
77.025	28.707	Rohini	Rani Khera DW	BDL	0.076	0.042	BDL	0.001	0.065	0.367	0.002	0.022	0.207	29.281
76.904	28.518	Kapeshera	Raota	BDL	0.029	0.049	BDL	0.001	0.034	0.359	0.031	0.024	0.266	7.349
77.102	28.715	Rohini	Rithala Pz Sec 5 Rohini	BDL	0.004	0.037	BDL	0.003	0.238	0.638	0.088	0.084	0.626	0.888
77.104	28.732	Rohini	Rohini Sec 11 Pz	BDL	0.002	0.019	BDL	0.002	0.081	2.773	0.088	0.152	0.386	7.039
77.071	28.724	Rohini	Rohini Sec 23	BDL	0.098	0.041	BDL	0.001	0.051	0.289	0.116	0.035	0.268	38.088
77.095	28.753	Alipur	Rohini Sec 28	BDL	0.044	0.090	BDL	0.001	0.104	0.494	0.116	0.092	0.346	21.508
77.213	28.590	Chanakyapuri	Safdarjung Tomb	BDL	0.015	0.198	BDL	0.002	0.062	0.106	0.302	0.166	0.866	16.643
77.122	28.691	Saraswati vihar	Sainik Vihar	BDL	0.084	0.018	BDL	0.001	0.051	1.362	0.017	0.061	0.291	22.390
77.146	28.695	Saraswati vihar	Sandesh vihar	BDL	0.007	0.024	BDL	0.000	0.033	0.213	0.017	0.050	0.155	11.259
77.142	28.690	Saraswati vihar	Sanjay Van	BDL	0.026	0.021	BDL	0.002	0.179	0.279	0.017	0.092	0.397	21.226
77.098	28.703	Rohini	Sector 1 Rohini	BDL	0.004	0.026	BDL	0.003	0.187	0.589	0.059	0.058	0.695	1.066
77.262	28.676	Nazul land	Shastri Park	BDL	0.019	0.048	BDL	0.002	0.056	1.727	0.002	0.077	0.579	5.192
77.108	28.578	Delhi cantonment	Shekhawati Line	BDL	0.001	0.021	BDL	0.003	0.141	0.423	0.110	0.083	0.868	5.440
76.953	28.524	Kapeshera	Shikarpur Deep	BDL	0.119	0.026	BDL	0.001	0.023	0.262	0.186	0.033	0.129	18.570
77.129	28.843	Alipur	Singhola	BDL	0.088	0.137	BDL	0.002	1.844	0.065	0.064	0.112	0.867	11.550
77.131	28.853	Alipur	Singhu Village	BDL	0.002	0.091	BDL	0.001	0.042	0.136	0.232	0.028	0.247	10.080
77.036	28.765	Rohini	Sultanpur Dabas	BDL	0.007	0.023	BDL	0.001	0.035	0.394	0.095	0.039	0.189	25.080
77.146	28.489	Vasant vihar	Sultanpur IMS	BDL	0.002	0.115	BDL	0.004	1.064	0.499	0.125	0.362	2.444	6.611
77.245	28.596	Chanakyapuri	Sunder Nursery	BDL	0.037	0.136	BDL	0.002	0.060	0.235	0.186	0.094	0.622	16.836
76.934	28.601	Najafgarh	Surheda	BDL	0.148	0.033	BDL	0.002	0.082	0.276	0.110	0.081	0.503	47.260
77.113	28.644	Rajouri garden	Tagore Garden	BDL	0.007	0.205	BDL	0.003	0.098	0.134	0.079	0.150	0.747	21.863
77.197	28.815	Alipur	Tiggipur	BDL	0.146	0.043	BDL	0.003	0.136	1.392	0.003	0.093	0.575	5.077
76.914	28.577	Najafgarh	Ujwah Pz	BDL	0.002	0.013	BDL	0.001	0.027	0.382	0.140	0.066	0.198	21.691

Longitude	Latitude	Block	Location	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	U
77.249	28.685	Seelam pur	Ushmanpur	BDL	0.740	0.158	BDL	0.003	0.378	1.150	0.155	0.145	0.944	7.356
77.074	28.632	Patel nagar	Vikaspuri	BDL	0.010	0.093	BDL	0.002	0.422	0.460	0.034	0.204	1.434	26.883
77.313	28.671	Vivek vihar	Vivek vihar	BDL	0.027	0.149	BDL	0.002	0.299	0.138	0.399	0.076	0.711	12.179
77.152	28.815	Alipur	Bakoli	BDL	0.027	0.023	BDL	0.001	0.042	0.090	0.247	0.021	0.239	10.502

ANNEXURE-3: ASSESSMENT FOR SUITABILITY OF WATER FOR DRINKING PURPOSES AS PER INDIAN STANDARD DRINKING WATER - SPECIFICATION - IS 10500 : 2012.

S. No.	Location	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	Iron (as Fe)	Total arsenic (as As)
			µ S/cm		mg/L												µg/l
1	Alipur Garhi	8.46	3440	2201.6	750	62	144	465	10	38	127	880	288	2.3	0.6	0.2373	0.3203
2	Asola	8.54	769	492.16	150	12	29	107	4	37	102	135	31	19	0.42	0.0403	0.0946
3	Auchandi Pz	8.81	7146	4573.44	821	16	190	1220	17	87	269	1028	1551	16	1.3	0.0269	0.3786
4	Balbir Nagar	8.4	382	244.48	100	32	5	37	2	25	89	35.5	11	6	0.26	0.0564	0.0439
5	Bank Enclave	8.37	1070	684.8	250	40	37	114	12	25	101	163	130	25	0.36	0.4658	9.4661
6	Bankner Pz	8.18	4075	2608	1151	208	153	340	55	0	115	993	394	27	0.24	0.0484	0.3634
7	Baprola Dw	8.67	4054	2594.56	611	64	109	520	31	37	127	879	192	212	0.52	0.0474	0.1783
8	Barwala	7.82	9623	6158.72	1491	581	11	1530	13	0	293	3124	134	49	0.07	0.1589	0.1428
9	Bawana JE Store	8.83	1275	816	360	26	72	125	7	51	140	234	77	29	0.86	0.0359	0.5384
10	Birla Mandir DW	8.53	773	494.72	180	36	22	95	4	38	183	92	38	1.6	0.38	0.0312	0.0000
11	Bhalaswa Lake	8.26	5316	3402.24	340	84	32	1065	15	0	127	1605	283	2.6	0.36	13.4691	0.1478
12	Bhatti Pz	8.71	545	348.8	160	28	22	52	2	51	104	64	0	13	0.38	0.0648	0.0363
13	Burari DJB Ex Engg. Office	8.45	513	328.32	160	32	19	42	5	38	76	64	36	1.2	0.54	0.5760	6.6405
14	Chandni Chowk	8.6	752	481.28	140	28	17	80	59	38	101	92	72	28	0.33	0.0847	0.3938
15	Chhawala Pz	8.44	3126	2000.64	640	144	68	420	8.5	24	76	866	221	8	0.17	0.0920	0.1529
16	Chilla Regulator	8.62	758	485.12	180	32	24	96	12	50	127	142	0	8	0.25	0.0383	0.3228
17	Chilla Saroda	8.58	1395	892.8	310	54	43	170	15	50	64	192	260	5.9	0.25	0.8855	5.8390
18	Cvd Depot Cantt	8.63	958	613.12	200	36	27	130	3	24	104	163	72	56	0.3	0.0694	0.1377
19	Daryapur Khurd	8.76	5752	3681.28	680	64	126	998	26	51	127	1683	277	32	0.78	0.0182	0.1631
20	Daulatpur Pz	8.47	3290	2105.6	860	108	144	340	39	38	104	930	149	37	0.64	0.0793	0.1884

S. No.	Location	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	Iron (as Fe)	Total arsenic (as As)
21	Dwarka Sec 23 DDA Park	8.94	2770	1772.8	120	8	24	590	6	126	427	540	48	21	2.6	0.0289	0.1580
22	Dwarka Sec 5 DDA Park	8.61	1012	647.68	110	12	19	190	8.4	45	397	85	25	6	1.4	0.0767	0.1808
23	Gadaipur Pz	8.74	909	581.76	160	12	32	135	7.5	51	177	99	10	91	0.94	0.1239	0.0971
24	Gazipur Crossing	8.42	1494	956.16	370	44	63	165	18	24	104	114	388	71	0.42	0.0764	4.8854
25	GK 2	8.37	474	303.36	170	28	24	32	2.1	24	76	64	24	22	1.1	0.0970	0.1377
26	Gokulpuri EW	8.5	637	407.68	190	20	34	53	14	24	127	64	66	19	0.52	0.0545	0.2306
27	Gujrat Vihar Pz	8.71	1012	647.68	190	28	29	140	14	38	153	149	77	26	0.9	0.1073	0.5121
28	Haiderpur Pz	8.59	495	316.8	210	32	32	17	5	38	127	43	0	10	3	0.0161	0.4851
29	Hareoli	8.92	3654	2338.56	450	36	88	630	8	75	226	511	746	16	3.2	0.2039	0.1256
30	Hauzpur Khas Pz	8.22	571	365.44	150	32	17	55	5	0	116	92	48	4	0.76	0.0452	0.7459
31	Hiran Kudna	8.38	4811	3079.04	831	64	163	725	6.2	24	76	1285	317	200	0.25	0.0428	0.2624
32	Hiranki Village	8.77	1730	1107.2	330	16	71	240	13	62	127	419	53	14	0.41	0.0158	0.2131
33	India Gate	8.7	2911	1863.04	340	32	63	500	40	38	89	447	509	190	0.63	0.0443	0.1272
34	JNU Pz	8.78	1113	712.32	190	24	32	170	2	62	127	178	62	38	0.67	0.0329	0.1177
35	Jagatpur Pz 2	8.57	568	363.52	150	16	27	60	8	24	104	85	45	1	0.63	0.0259	12.7258
36	Jaitpur Khadar RD3500 Pz	8.86	984	629.76	300	12	66	85	10	51	116	170	72	1	0.24	0.0748	1.0560
37	Jamali Kamali	8.22	2373	1518.72	190	8	41	460	9	0	317	369	346	66	3	0.3564	0.2910
38	Janakpuri	8.72	567	362.88	200	24	34	32	20	51	165	36	0	12	1.9	0.2445	0.1034
39	Jaunapur DJB TW	8.7	1597	1022.08	200	8	44	270	7	75	216	213	106	100	1	0.0568	0.0588
40	Jaunti DW	8.6	2084	1333.76	290	28	54	345	8	38	140	469	106	110	0.63	0.0244	0.3022
41	Jheel Khoh	8.81	911	583.04	160	8	34	142	1.6	62	216	99	0	48	0.77	0.0283	0.2895
42	Jhuljhuli Dw	8.61	982	628.48	220	20	41	115	17	51	226	149	2	2.4	2.2	0.0153	1.9101
43	Kanjhawala	8.85	280	179.2	60	8	10	43	5.3	51	24	36	0	2	0.4	0.0640	0.7554
44	Khela Ghat Bhela Road	8.53	716	458.24	220	28	36	50	31	38	76	107	53	31	0.46	0.0587	1.2739

S. No.	Location	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	Iron (as Fe)	Total arsenic (as As)
45	Khera Kalan Pz	8.73	1211	775.04	110	8	22	230	7.2	105	268	50	125	3.5	2.1	0.0423	1.0831
46	Kondli DJB WTP	8.77	969	620.16	260	16	54	100	15	75	165	121	19.2	40	0.65	0.0424	0.3101
47	Lalitha Park	8.65	1453	929.92	320	40	54	185	17	38	116	312	98	28	0.36	0.0817	1.3582
48	Lodhi Garden	8.41	374	239.36	140	20	22	22	0.73	24	92	28	22	8	0.32	0.4721	0.0859
49	Mahabir Vansth	8.44	1037	663.68	180	24	29	160	4	38	64	249	41	8	0.58	0.0504	0.0938
50	Majara Dabas	8.43	2921	1869.44	520	76	80	350	154	38	76	639	231	241	0.53	0.0227	0.2465
51	Majnu Ka Tila DW	8.66	1178	753.92	150	20	24	190	12	36	122	99	207	80	1.7	0.0519	0.4517
52	Mangolpur	8.7	637	407.68	110	20	15	96	2	24	73	99	70	2	1.1	0.3694	0.5646
53	Mayapuri	8.58	1459	933.76	230	16	46	225	18	36	244	163	205	28	0.8	0.0539	0.4287
54	Mayur Vihar B Block Ph II	8.61	974	623.36	290	44	44	80	14	36	73	114	188	11	0.43	0.0514	6.9999
55	Mundela Kalan Pz	8.92	3642	2330.88	270	24	51	710	13	48	122	291	990	240	1.2	0.0350	0.3753
56	Najafgarh Town	8.37	4229	2706.56	360	16	78	800	18	36	61	443	1052	290	0.82	0.0391	0.0466
57	Nangli Rajapur	8.71	1316	842.24	220	16	44	192	16	36	37	362	43	11	0.76	13.0783	61.9474
58	Narela DJB WTP	8.79	2136	1367.04	390	24	80	250	11	36	110	263	340	110	0.51	0.0354	0.4205
59	Nizampur	8.95	1226	784.64	170	16	32	200	5.4	36	159	99	190	90	4.2	0.0920	0.3116
60	Nizamuddin Bridge	8.69	807	516.48	140	20	22	114	14	24	49	142	64	64	0.72	0.6066	23.5890
61	Okhla DJB WTP	8.7	1356	867.84	480	140	32	90	6	24	49	213	267	18	0.69	0.0439	0.1986
62	Palla Temple	8.73	579	370.56	140	24	19	70	5.8	24	37	71	92	26	1	0.0319	1.1848
63	Peeragarhi TW	8.21	1087	695.68	300	48	44	100	29	0	122	227	96	22	1.1	0.0659	0.1206
64	Peeragarhi DW	8.56	2136	1367.04	500	60	84	260	3	24	85	320	461	28	1.2	0.0175	1.0328
65	PUSA (NRL)	8.7	1670	1068.8	360	16	78	220	2	12	85	405	144	25	1	0.1281	0.1247
66	Pusp Vihar	8.7	883	565.12	200	20	36	110	3	24	61	43	269	9	0.79	0.0402	0.1411
67	Qatlupur	8.39	410	262.4	140	44	7	26	9	12	98	36	44	11	0.47	0.0445	0.4904
68	Qutubgarh	8.45	948	606.72	230	32	36	90	7	24	232	50	120	12	1.4	0.4725	0.3897
69	Rani Khera DW	8.38	3766	2410.24	951	96	173	420	18	24	98	1050	117	195	0.4	0.0422	0.3671
70	Raota	8.47	4340	2777.6	700	52	139	665	18	24	73	888	613	220	0.63	0.0493	0.3589

S. No.	Location	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	F^-	Iron (as Fe)	Total arsenic (as As)
71	Rithala Pz Sec5 Rohini	8.41	297	190.08	110	40	2	18	2.5	12	49	28	41	5	0.44	0.0375	0.6383
72	Rohini Sec 11 Pz	8.92	645	412.8	150	20	24	77	5.5	24	159	50	62	7	3.7	0.0191	2.7731
73	Rohini Sector 23	8.9	2759	1765.76	450	28	92	430	3.6	36	110	412	421	240	4.6	0.0413	0.2890
74	Rohini Sector 28	8.68	1938	1240.32	260	28	46	330	1.2	36	195	263	247	140	2.7	0.0899	0.4945
75	Safdarjung tomb	8.39	1804	1154.56	620	52	119	130	5.2	12	49	547	0	90	0.41	0.1985	0.1062
76	Sainik Vihar	8.66	2889	1848.96	300	28	56	522	9	48	183	774	19	120	3.3	0.0181	1.3615
77	Sandesh Vihar	8.21	8679	5554.56	1251	84	253	1400	30	0	134	2563	447	180	0.74	0.0242	0.2130
78	Sanjay Van	8.61	1320	844.8	620	120	78	32	8	60	232	284	0	0	2.3	0.0206	0.2788
79	Sector 1 Rohini	8.37	264	168.96	130	24	17	1.5	1	12	61	21	29	2	0.54	0.0257	0.5890
80	Shastri Park	8.55	788	504.32	190	20	34	92	8	36	73	121	93	2	0.58	0.0482	1.7273
81	Shekhwati Line	8.63	716	458.24	140	20	22	100	3	48	98	107	38	4	0.5	0.0209	0.4230
82	Shikarpur Deep	8.17	7249	4639.36	1612	132	312	915	24	0	171	1588	1067	150	0.62	0.0262	0.2618
83	Singhola	8.24	3826	2448.64	931	72	182	446	12	0	183	809	455	180	0.45	0.1375	0.0655
84	Singhu Village	8.22	5095	3260.8	1331	196	204	552	16	0	171	1207	504	220	0.47	0.0907	0.1358
85	Sultanpur Dabas	8.76	3210	2054.4	520	110	60	492	12	72	146	814	110	120	1.5	0.0225	0.3941
86	Sultanpur IMS	8.94	643	411.52	150	20	24	80	4	72	183	36	0	1	0.68	0.1146	0.4995
87	Sunder Nursery	8.77	2070	1324.8	270	44	39	350	7	60	171	327	305	14	1.1	0.1362	0.2349
88	Surheda	8.61	3445	2204.8	681	24	151	460	38	60	122	717	464	29	1.4	0.0334	0.2763
89	Tagore Garden	8.18	7417	4746.88	1952	304	290	796	24	0	170	929	1955	260	0.55	0.2054	0.1337
90	Tiggipur	8.67	749	479.36	150	20	24	100	6	36	73	92	112	4	0.94	0.0426	1.3922
91	Ujwah Pz	8.76	4562	2919.68	590	68	102	770	16	72	159	1221	208	110	0.9	0.0134	0.3817
92	Ushmanpur	8.7	450	288	150	32	17	22	19	36	98	21	48	2	0.72	0.1580	1.1504
93	Vikashpuri	8.88	1134	725.76	260	40	39	140	7	60	159	149	106	10	2.5	0.0927	0.4602
94	Vivek Vihar	8.49	2375	1520	470	30	96	325	10	36	110	540	192	90	0.82	0.1494	0.1378
95	Bakoli	8.41	4697	3006.08	1141	128	200	550	15	36	98	1193	371	170	0.51	0.0234	0.0903

S. No.	Location	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	Iron (as Fe)	Total arsenic (as As)
No. of samples; >Permissible limit)		**61**		**24**	**20**	**3**	**18**					**11**	**14**	**33**	**15**	**2**	**3**
% of samples; >Permissible limit)		**64**		**25**	**21**	**3**	**19**					**12**	**15**	**35**	**16**	**2**	**3**
BIS DWS-IS 10500: 2013	Permissible Limit	<6.5- >8.6		2000	600	200	100	N/A	N/A	N/A	N/A	1000	400	45	1.5	1	0.01

ANNEXURE-4: ASSESSMENT FOR SUITABILITY OF WATER FOR IRRIGATION PURPOSE.

Sl No.	Well site	Suitability of water for irrigation purposes				
		TDS (EC* 0.64)	S S P%	SAR	Percent Sodium	Residual Carbonate
		Na*100/ Ca+Mg+Na	Na*100/ Ca+Mg+Na	Na / √ (Ca+Mg) / 2	((Na+K) / (Ca+Mg+Na+K)*100	$(HCO_3 + CO_3)$ – (Ca + Mg)
1	Alipur Garhi	2202	58	7.40	57.81	-11.60
2	Asola	492	61	3.81	61.44	-0.08
3	Auchandi Pz	4573	76	18.52	76.50	-9.13
4	Balbir Nagar	244	44	1.61	45.23	0.28
5	Bank Enclave	685	50	3.12	51.08	-2.56
6	Bankner Pz	2608	39	4.36	41.34	-21.11
7	Baprola Dw	2595	65	9.17	65.80	-8.86
8	Barwala	6159	69	17.20	69.08	-25.15
9	Bawana JE Store	816	43	2.86	43.74	-3.23
10	Birla Mandir DW	495	53	3.08	53.99	0.66
11	Bhalaswa Lake	3402	87	25.07	87.24	-4.75
12	Bhatti Pz	349	41	1.79	41.88	0.19
13	Burari DJB Ex Engg. Office	328	37	1.45	38.20	-0.65
14	Chandni Chowk	481	55	2.94	64.07	0.12
15	Chhawala Pz	2001	59	7.23	59.10	-10.75
16	Chilla Regulator	485	54	3.12	55.64	0.17

17	Chilla Saroda	893	54	4.19	55.50	-3.52
18	Cvd Depot Cantt	613	58	3.99	58.77	-1.52
19	Daryapur Khurd	3681	76	16.67	76.47	-9.79
20	Daulatpur Pz	2106	46	5.04	47.79	-14.28
21	Dwarka Sec 23 DDA Park	1773	92	23.56	91.58	8.82
22	Dwarka Sec 5 DDA Park	648	79	7.95	79.68	5.84
23	Gadaipur Pz	582	64	4.62	65.23	1.37
24	Gazipur Crossing	956	49	3.74	50.85	-4.88
25	GK 2	303	29	1.07	30.00	-1.33
26	Gokulpuri EW	408	38	1.67	41.23	-0.92
27	Gujrat Vihar Pz	648	62	4.43	63.01	-0.01
28	Haiderpur Pz	317	15	0.51	17.01	-0.89
29	Hareoli	2339	75	12.89	75.34	-2.84
30	Hauzpur Khas Pz	365	44	1.95	45.67	-1.10
31	Hiran Kudna	3079	66	10.95	65.62	-14.57
32	Hiranki Village	1107	61	5.73	61.86	-2.50
33	India Gate	1863	76	11.81	77.05	-4.06
34	JNU Pz	712	66	5.34	66.02	0.31
35	Jagatpur Pz 2	364	46	2.12	48.23	-0.52
36	Jaitpur Khadar RD3500 Pz	630	38	2.13	39.60	-2.43
37	Jamali Kamali	1519	84	14.57	84.29	1.42
38	Janakpuri	363	26	0.98	32.26	0.41
39	Jaunapur DJB TW	1022	75	8.29	74.79	2.02
40	Jaunti DW	1334	72	8.78	72.25	-2.28
41	Jheel Khoh	583	66	4.89	66.04	2.41
42	Jhuljhuli Dw	628	53	3.38	55.42	1.03

43	Kanjhawala	179	60	2.39	62.13	0.87
44	Khela Ghat Bhela Road	458	33	1.47	40.49	-1.85
45	Khera Kalan Pz	775	82	9.52	82.18	5.68
46	Kondli DJB WTP	620	45	2.69	47.45	-0.04
47	Lalitha Park	930	56	4.48	56.84	-3.28
48	Lodhi Garden	239	25	0.81	25.77	-0.50
49	Mahabir Vansth	664	66	5.20	66.33	-1.27
50	Majara Dabas	1869	59	6.68	64.86	-7.87
51	Majnu Ka Tila DW	754	74	6.78	74.24	0.22
52	Mangolpur	408	65	3.95	65.43	-0.24
53	Mayapuri	934	68	6.47	69.09	0.61
54	Mayur Vihar B Block Ph II	623	37	2.04	39.74	-3.42
55	Mundela Kalan Pz	2331	85	18.81	85.26	-1.80
56	Najafgarh Town	2707	83	18.32	83.01	-5.02
57	Nangli Rajapur	842	65	5.62	66.47	-2.61
58	Narela DJB WTP	1367	58	5.51	58.91	-4.78
59	Nizampur	785	72	6.64	72.03	0.37
60	Nizamuddin Bridge	516	64	4.18	65.43	-1.21
61	Okhla DJB WTP	868	29	1.78	29.70	-8.03
62	Palla Temple	371	52	2.59	53.61	-1.36
63	Peeragarhi TW	696	42	2.51	45.83	-4.02
64	Peeragarhi DW	1367	53	5.08	53.47	-7.72
65	PUSA (NRL)	1069	57	5.04	57.14	-5.43
66	Pusp Vihar	565	55	3.40	55.10	-2.16
67	Qatlupur	262	29	0.96	32.91	-0.77
68	Qutubgarh	607	46	2.59	47.30	0.04

69	Rani Khera DW	2410	49	5.92	49.60	-16.63
70	Raota	2778	67	10.92	67.68	-12.04
71	Rithala Pz Sec5 Rohini	190	27	0.75	28.13	-0.96
72	Rohini Sec 11 Pz	413	53	2.75	53.99	0.43
73	Rohini Sector 23	1766	68	8.83	67.70	-5.97
74	Rohini Sector 28	1240	73	8.92	73.51	-0.79
75	Safdarjung tomb	1155	31	2.27	31.84	-11.19
76	Sainik Vihar	1849	79	13.10	79.25	-1.41
77	Sandesh Vihar	5555	71	17.22	71.14	-22.83
78	Sanjay Van	845	10	0.56	11.39	-6.62
79	Sector 1 Rohini	169	2	0.06	3.38	-1.20
80	Shastri Park	504	51	2.91	52.56	-1.40
81	Shekhwati Line	458	61	3.67	61.17	0.40
82	Shikarpur Deep	4639	55	9.91	55.61	-29.48
83	Singhola	2449	51	6.37	51.48	-15.58
84	Singhu Village	3261	47	6.59	47.88	-23.79
85	Sultanpur Dabas	2054	67	9.37	67.54	-5.65
86	Sultanpur IMS	412	54	2.85	54.64	2.42
87	Sunder Nursery	1325	74	9.26	74.02	-0.61
88	Surheda	2205	59	7.67	60.63	-9.63
89	Tagore Garden	4747	47	7.84	47.43	-36.28
90	Tiggipur	479	59	3.57	60.23	-0.58
91	Ujwah Pz	2920	74	13.80	74.20	-6.79
92	Ushmanpur	288	24	0.78	32.49	-0.19
93	Vikashpuri	726	54	3.77	54.62	-0.60
94	Vivek Vihar	1520	60	6.52	60.50	-6.40
95	Bakoli	3006	51	7.08	51.54	-20.05