GROUND WATER QUALITYIN SHALLOW AQUIFERS OF TELANGANA STATE

Central Ground Water Board,
Department of Water Resources,
RiverDevelopment and Ganga RejuvenationMinistry of Jal Shakti
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Central Ground Water Board,
Department of Water Resources, RD & GR
Ministry of Jal Shakti, Govt. of India

REPORT ON GROUND WATER QUALITY IN SHALLOW AQUIFERS OF TELANGANA STATE

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FOREWORD

Water is the basic necessity for survival of life. Even though Telangana is blessed with large water resources, the ever-increasing growth of population, the steady rise in irrigation activities and rapid expansion of industries keep tremendous pressure on the available water resources. Water is available in two basic forms i.e. Surface water and Ground Water. Groundwater is at the core of sustainable development and is critical for socio economic progress. Unlike many resources that are more static in nature, groundwater available for use and distribution can change drastically from year to year. Over the last few years much of the attention in ground water has shifted from problem of ground water supply to considerations of ground water quality.

Groundwater contamination recently has come to the attention of the public as incidents of contamination are being reported from every state. Central Ground Water Board, Southern Region, for the last nearly five decades has been carrying out hydro geological and hydro chemical investigations and has generated voluminous data. Central Ground Water Board, Southern Region monitors groundwater quality throughout the state of Telangana, once in a year during the months of May, from a network of monitoring stations called "National Hydrograph Network Stations (NHNS)", which comprises open dug wells and Piezometers. This report has been prepared based on the analytical results obtained from the water samples collected from these NHNS stations.

I am sure that this report will be of immense use for the administrators, planners, academicians and other stake holders in the field of Ground water quality management.

The sincere efforts made by Y.Satya Kumar, S.Kumar Ratha and Swati Dhenkula in compilation of data and preparation of this report in present form are highly appreciable.

Hyderabad
February, 2024

(G. Krishnamurthy)
Regional Director

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1.0 INTRODUCTION

Ground water is the water located in the subsurface in fully saturated porous material. Ground water may occur in a geologic formation, which has confining zones (i.e., thick layers of clay or shale) above and below, where it is termed as confined aquifer, or it may have an unconfinedupper boundary where it is called a phreatic or water table aquifer. It may be located above a layer of soil which inhibits downward movement of water. In this case, the water is perched in a region of porous material that is generally unsaturated. It contains a wide variety of dissolved inorganic chemical constituents in various concentrations, resulting from chemical and biochemical interactions between water and the geological materials. Also, the contribution of the atmosphere and surface water bodies and anthropogenic waste are quite considerable as they contribute several elements and determining its quality.

Although hydrologists generally focus on water movement in the subsurface, it is recognized that both ground- and surface-water supplies are important and inseparable parts of our water supply system. In arid areas, lack of rainfall contributes to a reduced amount of surface water. Since surface water is often a source of recharge to ground water, the absence of surface water for a long period of time can cause lowering of ground-water tables and a reduction of ground water supplies. In areas of abundant rainfall, ground water may feed into lakes and streams, keeping the water level in these surface water bodies relatively constant throughout the entire year. Abundant rainfall also provides water, through percolation, that keeps the ground-water level near the surface. It is important to recognize the interaction between ground and surface water when studying the use or contamination of ground water in agricultural areas.

Ground water will often have more dissolved substances than the surface water. The chemical quality of ground water is influenced by various factors, such as acid-base, oxidation reduction and solid phase interactions in the aquifer medium.

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.

Central Ground Water Board has taken up the task of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity in the state. In order to arrive at proper parametric indices of evaluation and judicious development of ground water resources, the Board is monitoring a National Network of Hydrograph Stations (NHS) on long term

basis since 1969 through a network of wells (Dug wells and Piezometers) for studying its long term behavior due to influence of rainfall and ground water development. A historical database on the ground water levels and water quality has been developed over a period of time since the year 1969.

The monitoring mainly comprises measurement of water levels and temperature, four times in a year viz., in the months of May (pre-monsoon), August (mid-monsoon), November (post-monsoon) and January and collection of water samples during May every year, for chemical analysis.

The dug wells tapping unconfined aquifers are mostly confined to village limits, which are used for domestic purpose. Some of these are community wells and the rest belong to private individuals. The Piezometers tapping unconfined and confined aquifers constructed under various projects and exploration programs by the department are monitored manually four times a year. The location of network of monitoring wells is presented in the Fig.1.1.

The Regional Chemical Laboratory (RCL), Southern Region is well established & well equipped laboratory under Central Ground Water Board for analysis of ground water quality in Andhra Pradesh and Telangana States. The laboratory is accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) as per ISO/IEC 17025:2017 for testing of water quality parameters. The accreditation is valid up to 10-01-2026 vide NABL certificate No: TC-6707 for 13 different parameters (pH, Electrical Conductivity, Alkalinity, Chloride, Hardness, Calcium, Magnesium, Sodium, Potassium, Nitrate, Sulphate, Fluoride and Iron) as per APHA Standard methods for the examination of water 23rd edition. The laboratory is equipped with different type of sophisticated instruments like Atomic Absorption Spectrophotometer (AAS), Ion Chromatogram, UV-Visible Spectrophotometer, Ion Meter, Flame Photometer, LED Fluorimeter, Deep freezer etc.,

Laboratory also participated in different type of quality control programmers like Proficiency Testing (PT), Inter Laboratory Comparison (ILC), and Analytical Quality Control (AQC) during the period and was achieved satisfactory results with excellent Z-Score values. Laboratory maintains the internal quality checking; replicate testing, control charts etc., for quality control in testing parameters. Laboratory is using NIST traceable Standard Reference Materials and Certified Reference Materials for standardization and calibration of the equipment.

During the period RCL, CGWB, SR Hyderabad has analysed 892 numbers of samples for basic parameters (pH, Electrical Conductivity, Alkalinity, Chloride, Hardness, Calcium, Magnesium, Sodium, Potassium, Nitrate, Sulphate, Fluoride, Carbonate, Bicarbonate and TDS) and these samples are also analysed for Uranium by using LED-Fluorimeter. The results are discussed in Ground water Quality portion of this report.

1.1 Location and Extent

Telangana State is the 29th State (Act, 2014) formed in India covering geographical area of 1,12,077 Km2 comprising of 33 districts (after transferring 107 villages from Khammam district to residual Andhra Pradesh). It lies between north latitude 15° 48' and 19° 54'and east latitude 77° 12' and 81° 50'. The state is bordered by the states of Maharashtra, Chhattisgarh on the north, Karnataka on the west and Andhra Pradesh on the south, east and north-east. Ground water resources have not been exploited evenly across the state. Administratively, the State is divided into 33 districts (Adilabad, Bhadadri, Hanamkonda, Hyderabad, Jagtial, jangaon, Jayashankar, Jogulamba, Kamareddy, Karimnagar, Khammam, Komarambhim, Mahabubabad, Mahabubnagar, Mancherial, Medak, Medchal, Mulugu, Nagarkurnool, Nalgonda, Narayanpur, Nirmal, Nizamabad, Peddapalle, Rajanna, Rangareddy, Sangareddy, Siddipet, Suryapet, Vikarabad, Wanaparthy, Warangal, Yadadri).

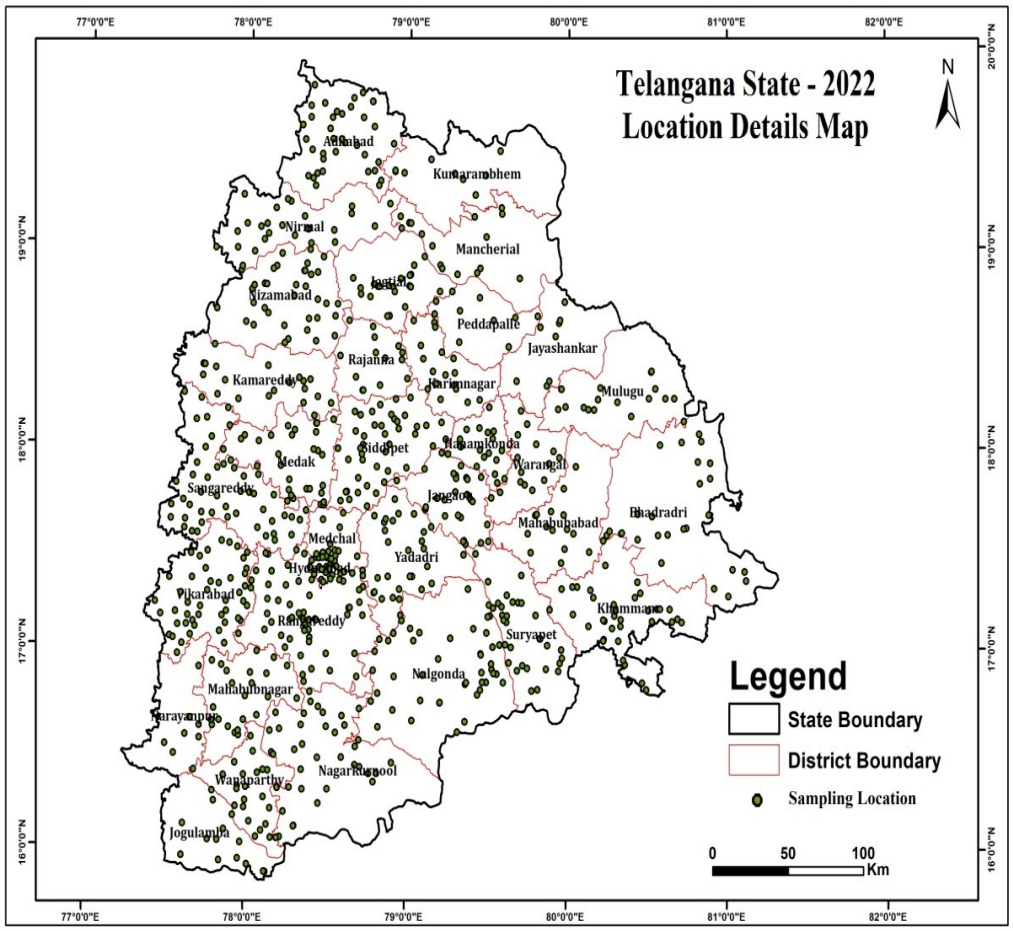


Fig.1.1: Location of GWMS in Telangana State (2022)

2.0 HYDROGEOLOGY

Behavior of ground water in the Indian sub-continent is highly complicated due to the occurrence of diversified geological formations with considerable lithological and chronological variations, complex tectonic framework, climatologically dissimilarities and various hydro-chemical conditions. Broadly two groups of rock formations have been identified, on the basis of Ground Water hydraulics viz. Porous Formations and Fissured Formations.

2.1 POROUS FORMATIONS

Porous formations have been further subdivided into Unconsolidated and Semi – consolidated formations. The areas covered by alluvial sediments of river basins, coastal and deltaic tracts constitute the unconsolidated formations. These are by far the most significant ground water reservoirs for large scale and extensive development. The hydro-geological environment and ground water regime in the Indo-Ganga-Brahmaputra basin indicate the existence of potential aquifers having enormous fresh ground water resources.

The semi-consolidated formations occur mostly in narrow valleys or structurally faulted basins. The Gondwanas, Lathis, Tipams, Cuddalore sandstones and their equivalents are the most extensive productive aquifers. Under favorable situations, these formations give rise to free- flowing wells. In select tracts of northeastern India, these water-bearing formations are quite productive.

Semi-consolidated formations are represented by rocks belonging to Gondwana formations. The Talchirs, Barakaras and Kamthis formations yield more ground water (up to 60 lps). At some place auto flows are encountered.

Unconsolidated formations represented by river alluvium occur along the major rivers Godavari and Krishna and their tributaries in the Telangana state.

2.2 FISSURED FORMATIONS

The Fissured or consolidated formations occupy almost two-thirds of the country. Consolidated formations other than vesicular volcanic rocks have negligible primary porosity. From the hydro geological point of view, fissured rocks are broadly classified into four types viz. Igneous and metamorphic rocks excluding volcanic and carbonate rocks, volcanic rocks, consolidated sedimentary rocks excluding carbonate rocks and Carbonate rocks.

i) Igneous and metamorphic rocks excluding volcanic and carbonate rocks: -The most common rock types are granites, gneisses, charnockites, khondalites, quartzites, schists and associated

phyllites, slates, etc. These rocks possess negligible primaryporosity but attain porosity and permeability due to fracturing and weathering, which facilitates the yield from their rocks.

ii) Volcanic rocks: -The predominant types of the volcanic rocks are the basaltic lava flows of Deccan Plateau. Water bearing properties of different flow units control ground water occurrence and movement in Deccan Traps. The Deccan Traps haveusually poor to moderate permeabilities depending on the presence of primary and secondary pore spaces including vesicles/fractures.

iii) Consolidated sedimentary rocks excluding carbonate rocks:-Consolidated sedimentary rocks occur in Cuddapahs, Vindhyans and their equivalents. These formations consist of conglomerates, sandstones, shales, slates and quartzites. The presence of bedding planes, joints, contact zones and fractures controls the groundwater occurrence, movement and yield potential of aquifers.

iv) Carbonate rocks: - Limestones in the Cuddapah, Vindhyan and Bijawar groups of rocks dominates the carbonate rocks other than the marbles and dolomites. In carbonate rocks, the circulation of water creates solution cavities thereby increasing the permeability of the aquifers. Solution activity leads to widely contrastingpermeability within short distances in such rocks.

In Telangana Crystalline rocks of Archaean age, Meta sedimentary rocks of Cuddapahs, Kurnools and basaltic lava flows of Deccan traps are included in these formations. The crystalline rocks which occupy ~83 % of area, generally lack primary porosity and secondary porosity is developed due to weathering, fracturing, development of solution cavities and channels and interconnection of vesicles. In these rocks, depth of weathering varies from 3 to 20 m bgl and majority of fractures occur within 100 m depth. In these rocks dug wells/ dug cum bore wells and bore wells are the most prevalent abstraction structures. Ground water yield from these rocks varies from 0.1 lps to 5 lps.

Pakhals, Penganga and Sullavais are relatively poor to moderate potential aquifers and basalts are hard and compact and possess meager primary porosity (by virtue of interconnected vesicles). Fractures in basalts are developed due to columnar joints and tectonic activities. Yield of ground water in these rocks varies from 0.1 to 3 lps and potential zones exist down to 38-200 m depth.

3.0 HYDROCHEMISTRY

Hydrochemistry is an interdisciplinary science that deals with the chemistry of water in the natural environment. Professional fields such as chemical hydrology, aqueous chemistry, hydrochemistry, water chemistry and hydro-geochemistry are all more or less synonyms. The classical use of chemical characteristics in chemical hydrology is to provide information aboutthe regional distribution of water qualities. At the same time, hydrochemistry has a potential use for tracing the origin and history of water. The hydrochemistry can also be of immense help inyielding information about the environment through which water has circulated. Hydrochemistry can be helpful in knowing about residence times, flow paths and aquifer characteristics as the chemical reactions are time and space dependent. It is essential to study the entire system like atmospheric water (rainwater), surface water and ground water simultaneously in evaluating their hydrochemistry and pollution effect.

3.1 Chemistry of Rain Water

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 □S/cm, chloride below 5 mg/l and HCO_3 below10 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. Otherfactors 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 themost 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 hydro chemical 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 ina 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.

$$\underset{\text{(Organic matter)}}{CH_2O} + O_2 = CO_2 + H_2O$$

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 fromthe 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.

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 dischargesof municipal and industrial residues significantly alter characteristics of groundwater resource. The prevailing climatic conditions, topography, geological formations and use andabuse of this vital resource have significant effect on the characteristics of the water, becauseof 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, industries etc., 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 monitoring procedure. The changes in all these factors may provide a basis for alteration in standards. 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)**

The Regional Chemical Laboratory (RCL), Southern Region analyse different basic parameters (pH, Electrical Conductivity, Alkalinity, Chloride, Hardness, Calcium, Magnesium, Sodium, Potassium, Nitrate, Sulphate, Fluoride, Iron etc.) for the evaluation of ground water samples characteristics as per APHA Standard methods 24th edition. The laboratory is equipped with sophisticated instruments like Atomic Absorption Spectrophotometer (AAS) for trace metals analysis (Cu, Zn, Cd, Pb, Fe etc.) of ground water samples.

Table 4 : Water quality criteria parameters for various uses (Sayers et.al., 1976)

Public Water supply	Industrial Water supply (Processing)	Agricultural water supply	Aquatic life & wild life water supply	Recreation and Aesthetics
Coliform bacteria, Turbidity, colour,Taste, Odour, TDS, Cl,F, SO_4 NO_3, CN, Trace Metals, Trace Organics, Radioactive substances	pH, Turbidity Colour, Alkalinity, Acidity, TDS, Suspended solids, Tracemetals, TraceOrganics **Cooling** PH, Temp,Silica, AI, Fe,Mg, Total hardness, Alkalinity /AcidditySuspended 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 Temp., Turbidity, Colour, Odour, Floating Materials, Settable Materials Nutrients, Coliforms Aesthetics Same as for Recreation and S u b s t a n c e s adversely affectingwild life

4.1 Water Quality Criteria for Drinking Purpose

With the objective of safeguarding water from degradation and to establish a basis for improvement 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 if sulphate 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 less than 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).

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

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;

$$\mathbf{RSC = [HCO_3 + CO_3] - [Ca + Mg]}$$

(Where all the ion's 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.

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

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 drinking water supplies to avoid impact on human health (**Table – 4.3.1**). 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 4.3.1: Effects of water quality parameters on human health when used for drinking Purpose

Sl. No.	Parameters	Prescribed limits IS:10500, 2012		Probable Effects
		Desirable Limit	Permissible Limit	
1	Colour (Hazen unit)	5	1 5	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 alkaline waters, 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 conclusive proof but it may cause urinary concretions, diseases of kidney or bladder and stomach disorder.
7	Iron (mg/L)	1.0	No relaxation	Gives bitter sweet astringent taste, causes staining of laundry and porcelain. In traces it is essential 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 causes concretions 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 gastric cancer 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.
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 with vomiting and diarrhea, chronic toxicity produces nausea, severe abdominal pain, paralysis, mental confusion, visual disturbances, anemia etc.,
19	Zinc (Zn) (mg/L)	5	1 5	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, nasal mucous membrane ulcers and dermatitis.
21	Boron (B) (mg/L)	0.5	2.4	Affects central nervous system its salt 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 guidelines		High concentration may cause vomiting and diarrhea, stimulate secondary hyperthyroidism and bone loss
25	Sodium (Na) (mg/L)	No guidelines		Harmful to persons suffering From cardiac, renal and circulatory diseases.
26	Potassium (K) (mg/L)	No guidelines		An essential nutritional element but its excessive amounts are cathartic.
27	Silica (SiO_2) (mg/L)	No guidelines		-
28	Nickel (Ni) (mg/L)	0. 0 2		Non-toxic element but may be carcinogenicity in animals, can react with DNA resulting in DNA damage in animals.
29	Pathogens (a) Total coliform (per100ml) (b) Faecal Coliform (per 100ml)	nil	No relaxation	Cause water borne diseases like coliform Jaundice, Typhoid, Cholera etc. produce infections involving skin mucous membrane of eyes, ears and throat.
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 throughrepresentative 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 asregards 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 hasbeen 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 water 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:

i. The relationship between the two parameters is often described by a constant (commonly between 0.55 and 0.95 for freshwaters).

ii. Thus: TDS (mg/l) ≅ (0.55 to 0.95) x EC (mS/cm).

iii. The value of the constant varies according to the chemical composition of the water.

iv. For freshwaters, the normal range of TDS can be calculated from the following relationship: ***0.55 conductivity (mS/cm) < TDS (mg/l) < 0.95 conductivity (mS/cm).***

v. Typically, the constant is high for chloride rich waters and low for sulphate richwaters.

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

Cations = positively charged species in solution (meq/L)

Anions = negatively charged species in solution (meq/L)

The Electronic charge balance is expressed as follows:

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

All concentrations should be in epm. Error charge balance has been computed for the chemical results of 2022-23 and analysis showing more than 5% 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 TELANGANA STATE

The quality of shallow ground water in Telangana has been evaluated by sampling and analysis of water sample collected from Ground Water Monitoring wells. A total of 892 groundwater samples from GWMS were collected during pre-monsoon season of May, 2022 for basic constituents (**Fig.6.1**). All the samples are analyzed in the Regional Chemical Laboratory (Accredited by National Accreditation Board for Testing and Calibration Laboratories-NABL), CGWB, SR, Hyderabad. Sampling, preservation, and storage of groundwater have been carried out by following the standard guidelines (APHA 2017, 23rd Edition). Fifteen major parameters such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^{-}),Chloride (Cl^{-}), Sulphate (SO_4^{2-}), Nitrate (NO^{3-}), Fluoride (F^{-}) and Uranium were determined in the laboratory. District wise collection of samples during May, 2022 is given in **Table- 6.1**.

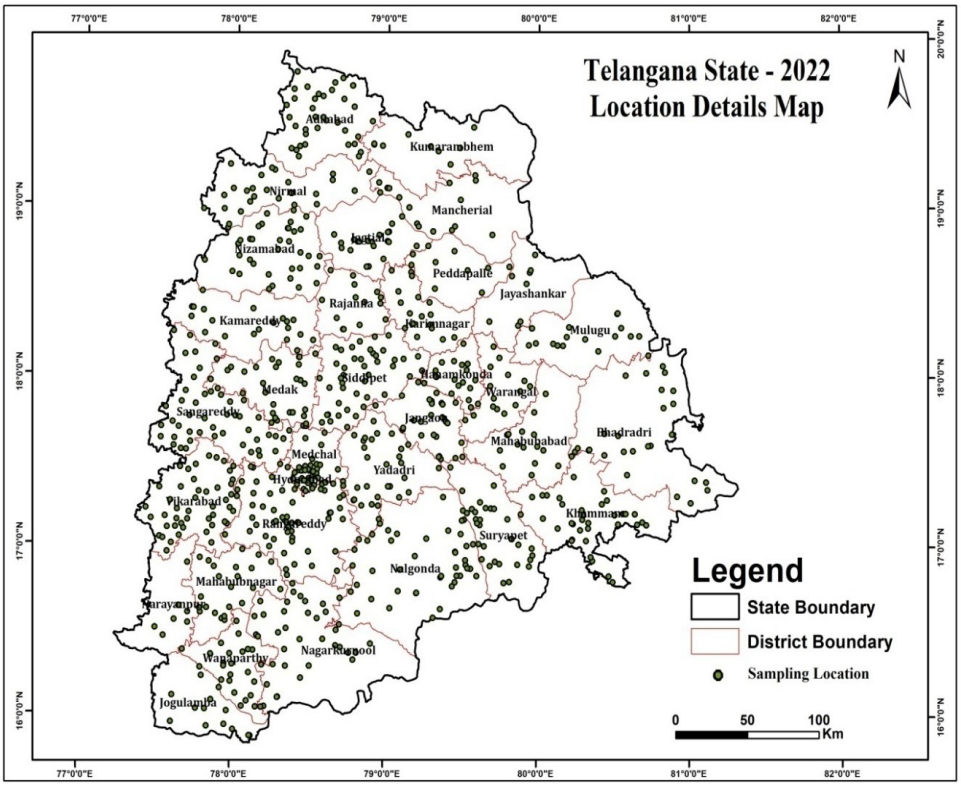


Fig.6.1: Location of Ground water sample sites (2022) in Telangana State

Table-6.1: District wise collection of samples (May, 2022)

Sr. No	Districts	No. of Samples collected (NHS 2022-23)	Sr. No	Districts	No. of Samples collected (NHS 2022-23)
1	Adilabad	40	18	Mulugu	19
2	Bhadradri	38	19	Nagarkurnool	35
3	Hanamkonda	13	20	Nalgonda	47
4	Hyderabad	23	21	Narayanpur	8
5	Jagtial	23	22	Nirmal	28
6	jangaon	27	23	Nizamabad	39
7	Jayashankar	9	24	Peddapalle	10
8	Jogulamba	15	25	Rajanna	10
9	Kamareddy	20	26	Rangareddy	66
10	Karimnagar	23	27	Sangareddy	47
11	Khammam	38	28	Siddipet	46
12	Komarambhim	8	29	Suryapet	31
13	Mahabubabad	13	30	Vikarabad	49
14	Mahabubnagar	27	31	Wanaparthy	22
15	Mancherial	16	32	Warangal	20
16	Medak	33	33	Yadadri	35
17	Medchal	14			
	Total	892			

The ground water samples collected from NHS monitoring stations analyzed for all the major inorganic parameters. Based on the results, it is found that ground water of the state is of calcium bicarbonate (Ca-HCO_3) type when the total dissolved solids of water is below 500 mg/L (corresponding to electrical conductance of 750 µS/cm at 25^0C).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 3000µS/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,and nitrate have been observed in Telangana states.

In the state out of 892 samples it has been observed that the chloride content is less than 250 mg/L in about 82.3% of the sample analyzed and 1.23% showed more than 1000mg/L. The Fluoride content is less than 1.5mg/L in about 81.4% of the sample analyzed and about 18.6% of the sample shows more than 1.5 mg/L. The Nitrate content is less than 45mg/L in about 60.6 % of the sample analyzed and and 39.3 % of sample shows more than 45mg/L (**Table-6.2**).

Table - 6.2. Summarized result of groundwater quality ranges of Telangana, (May 2022)

Sl. No	Parameters	Category	Range	No. of samples	Percentage
1	Electrical Conductivity µS/cm at 25°C	Fresh	< 750	185	20.7
		Moderate	751- 2250	624	69.9
		Slightly mineralized	2251- 3000	52	5.8
		Highly mineralized	> 3000	31	3.47
2	Chloride in mg/L	Desirable limit	< 250	734	82.3
		Permissible limit	251-1000	147	16.5
		Beyond permissible limit	> 1000	11	1.23
3	Fluoride in mg/L	Desirable limit	< 1.00	580	65
		Permissible limit	1.01- 1.50	146	16.4
		Beyond permissible limit	>1.50	166	18.6
4	Nitrate in mg/L	Permissible limit	<45	541	60.6
		Beyond permissible limit	> 45	351	39.3

7.0 GROUND WATER QUALITY HOT SPOTS IN SHALLOW AQUIFERS OF TELANGANA

Unconfined aquifers are extensively tapped for water supply across the country 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 state have been prepared depicting 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.

- Electrical Conductivity
- Chloride (> 1000 mg/L)
- Fluoride (>1.5 mg/L)
- Nitrate (>45mg/L)
- Uranium (>0.03 mg/L)
- Total Hardness (>600 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 /cm at 25^0C) in case of no alternate source. Water having TDS more than 2000 mg/L is not suitable for drinking purpose. **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.

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

Sr. No	Districts	No. of Samples collected (NHS 2022-23)	No. of Samples (EC>3000 µS/cm)	(%) Samples (EC >3000µS/cm)
1	Adilabad	40	0	0
2	Bhadradri	38	1	2.63
3	Hanamkonda	13	0	0
4	Hyderabad	23	0	0
5	Jagtial	23	0	0
6	jangaon	27	0	0
7	Jayashankar	9	0	0
8	Jogulamba	15	3	20
9	Kamareddy	20	1	5
10	Karimnagar	23	0	0
11	Khammam	38	4	10.7
12	Komarambhim	8	0	0
13	Mahabubabad	13	0	0
14	Mahabubnagar	27	1	3.7
15	Mancherial	16	0	45
16	Medak	33	1	3.03
17	Medchal	14	0	0
18	Mulugu	19	0	0
19	Nagarkurnool	35	2	5.71
20	Nalgonda	47	5	10.63
21	Narayanpur	8	1	12.5
22	Nirmal	28	0	0
23	Nizamabad	39	1	2.56
24	Peddapalle	10	0	0
25	Rajanna	10	0	0
26	Rangareddy	66	1	1.51
27	Sangareddy	47	2	4.25
28	Siddipet	46	0	0
29	Suryapet	31	2	6.45
30	Vikarabad	49	0	0
31	Wanaparthy	22	0	0
32	Warangal	20	1	5
33	Yadadri	35	5	14.28

In **Fig 7.1.1** The EC values (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.

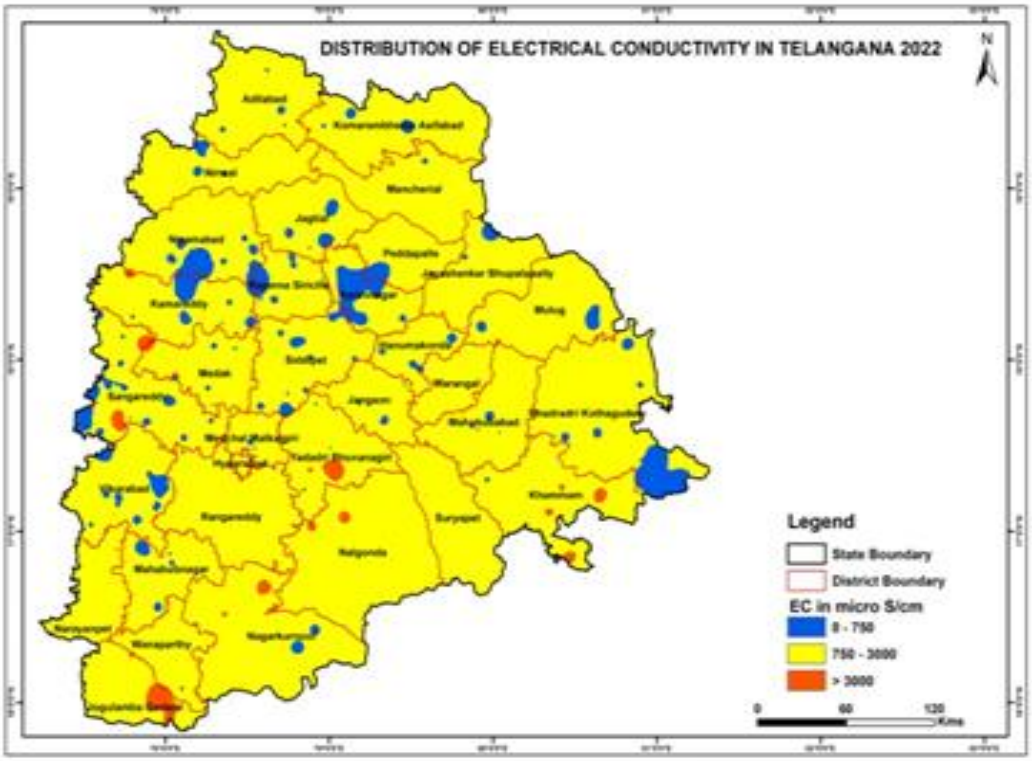
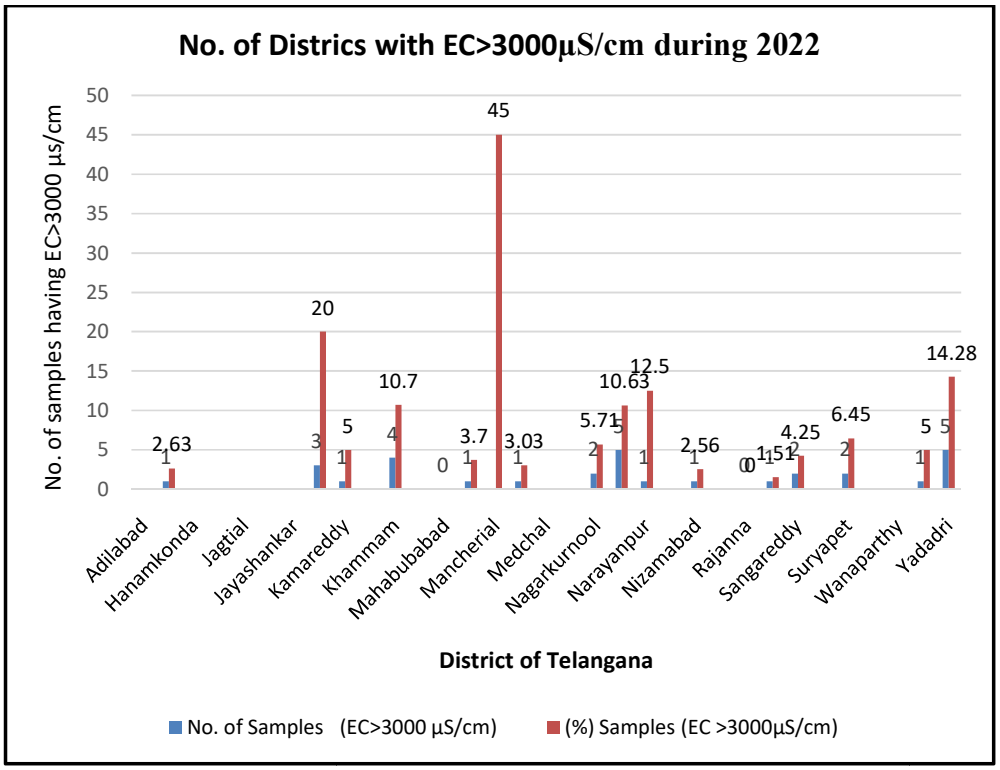


Fig 7.1.1 Spatial distribution of Electrical Conductivity during May 2022.

In general, the ground water quality of the state is fresh in about 20.7% of the Ground Water Monitoring wells as indicated by the EC value less than 750 µS/cm at 25^0C. In about 69.9% of the Ground Water Monitoring wells, the EC varies between 751 -2250 µS/cm at 25^0C and 5.8% of Ground Water Monitoring wells are between 2251-3000 µS/cm at 25^0C indicating that the ground water is slightly mineralized and about 3.47% of Ground Water Monitoring wells the EC is more than 3000 µS/cm at 25^0C indicating that the ground water ishighly mineralized. The highest value 16500 µS/cm at 25^0C was observed in Boravalle in Jogulamba district. District-wise percentage of wells having EC >3000 µS/cm is shown as a bar diagram in **Fig 7.1.2** the percentage groundwater samples in various EC range is also illustrated in **Fig 7.1.3.**and locations details are given in Annexure-I. The **Table7.1.2** shows the parts of taluks in different districts of Telangana having EC>3000µS/cm.



7.1.2 District wise percentage of wells having EC>3000 µS/cm May 2022.

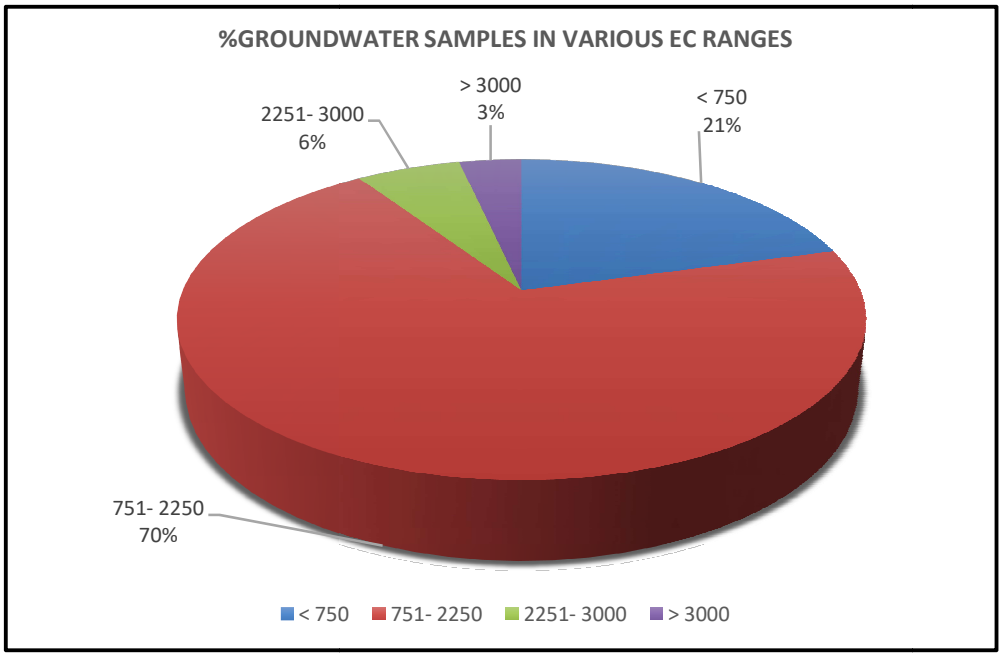


Fig 7.1.3 Percentage groundwater samples in various EC range of Telangana

Table 7.1.2: Mandals Affected by High EC groundwater in Telangana

Sl. No.	Districts	Different Parts of Taluks having EC >3000µS/cm.
1.	**Bhadradri**	Kukkunur
2.	**Jogulamba**	Undavelli, Manopadu, Gadwal
3.	**Kamareddy**	Birkoor
4.	**Khammam**	Thallada, Wyra, Penuballi, Yerrupalem
5.	**Mahabubnagar**	Kodair
6.	**Medak**	Narayankhed
7.	**Nagarkurnool**	Charakonda, Tadoor
8.	**Nalgonda**	Munugode, Nidamanur, Vemulapalle, Marriguda
9.	**Narayanpur**	Kosgi
10.	**Nizamabad**	Bodhan
11.	**Rangareddy**	Kothur
12.	**Sangareddy**	Kohir
13.	**Suryapet**	Munagala, Suryapet
14.	**Warangal**	Wardhannapet
15.	**Yadadri**	Valigonda, Pochampalle

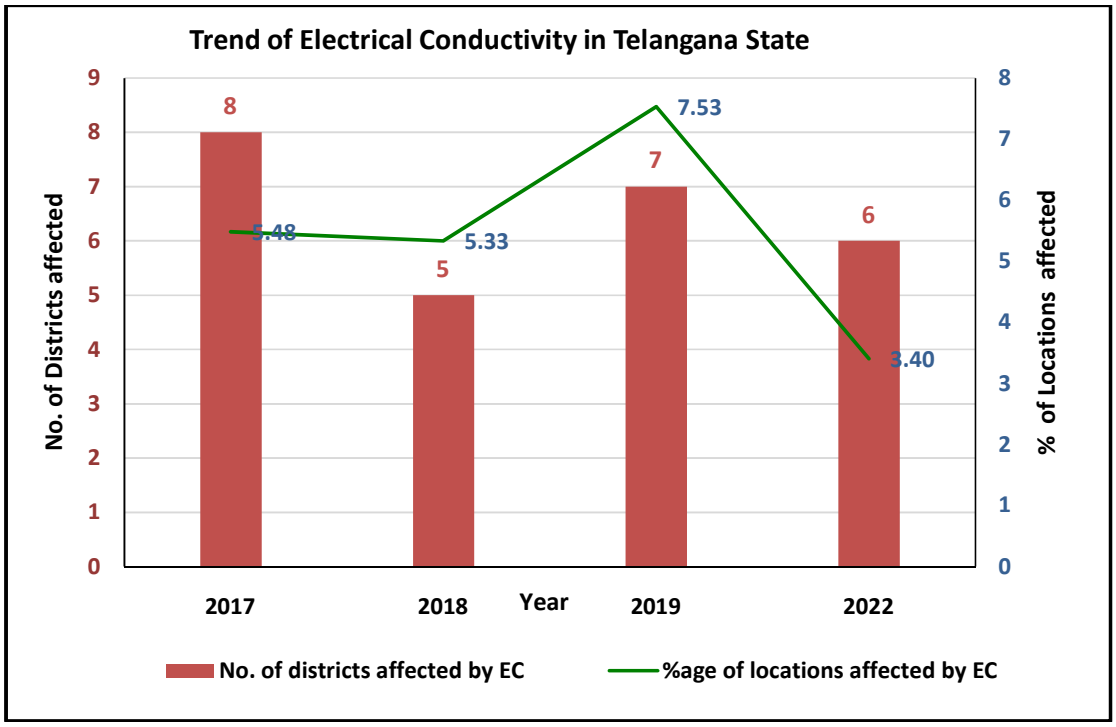


Fig 7.1.4 Trend of EC in Telangana State

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 groundwater from observation wells have been used to show distribution patterns of chloride in different ranges of suitability. The chloride content is less than 250 mg/L in about 82.3% of the sample analyzed and 16.5% of the sampleare between 251-1000 mg/L and 1.23% shows more than 1000mg/L which are from the districts of Jogulamba, Khammam, Medak, Nalgonda, Sangareddy, Suryapet and Yadadri.

Water with chloride ranging between 250 and 1000 mg/L falling under 'permissible' range are confined mostly to districts of Bhadadri, Hanamkonda, Jagtial, Jangaon, Jayashankar, Jogulamba, kamareddy, Karimnagar, Khammam, Mahabubnagar, Medak, Nagarkurnool, Nalgonda, Rangareddy, Sangareddy, Siddipet, Suryapet, Vikarabad, Wanaparthy, Warangal, Yadadri.

Relatively high values of Chloride (>1000 mg/L) are observed in the districts of. **Table 7.2.1** shows the District wise number of samples affected by high chloride water (>1000 mg/L) and these areas are water quality hotspots from high chloride point of view.

The occurrence 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 (>1000mg/L) is shown as a bar diagram in **Fig7.2.2** and also given location details in Annexure-II. The **Table 7.2.2** shows the parts of taluks in different districts of Telangana having Chloride (>1000mg/L).

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

Sl.No.	District	No. of Samples Collected (NHS 2022-23)	No.of Samples (Cl >1000mg/l)	(%) Samples (Cl>1000 mg/l)
1	Adilabad	40	0	0
2	Bhadradri	38	0	0
3	Hanamkonda	13	0	0
4	Hyderabad	23	0	0
5	Jagtial	23	0	0
6	jangaon	27	0	0
7	Jayashankar	9	0	0
8	Jogulamba	15	1	6.66
9	Kamareddy	20	0	0
10	Karimnagar	23	0	0
11	Khammam	38	2	5.26
12	Komarambhim	8	0	0
13	Mahabubabad	13	0	0
14	Mahabubnagar	27	0	0
15	Mancherial	16	0	0
16	Medak	33	1	3.03
17	Medchal	14	0	0
18	Mulugu	19	0	0
19	Nagarkurnool	35	0	0
20	Nalgonda	47	2	4.25
21	Narayanpur	8	0	0
22	Nirmal	28	0	0
23	Nizamabad	39	0	0
24	Peddapalle	10	0	0
25	Rajanna	10	0	0
26	Rangareddy	66	0	0
27	Sangareddy	47	2	4.25
28	Siddipet	46	0	0
29	Suryapet	31	1	3.22
30	Vikarabad	49	0	0
31	Wanaparthy	22	0	0
32	Warangal	20	0	0
33	Yadadri	35	2	5.71

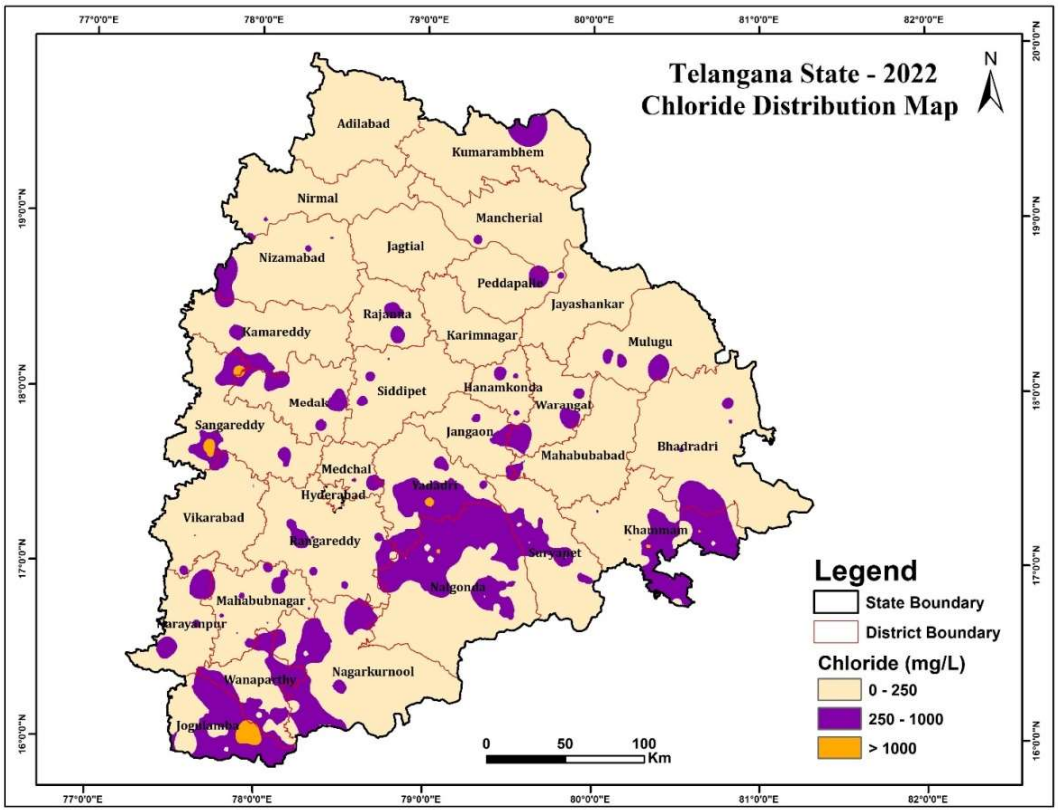


Fig 7.2.1 Spatial Distribution of Chloride in shallow aquifer of Telangana, May2022

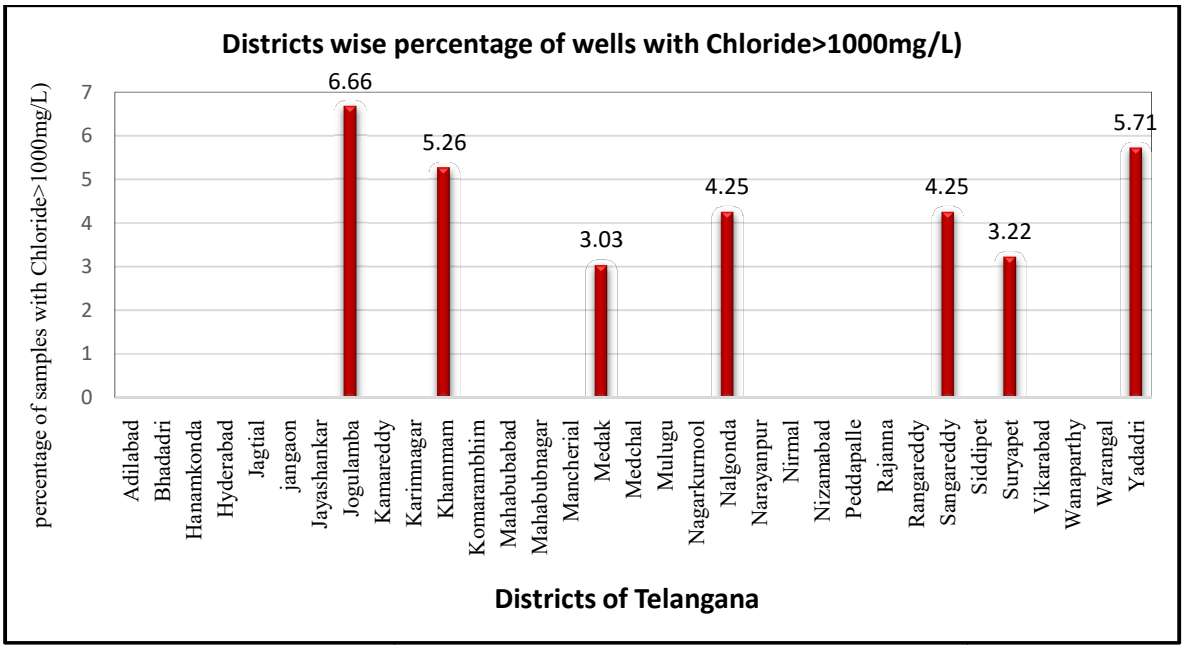


Fig 7.2.2 District-wise percentage of wells having Chloride > 1000 mg/L

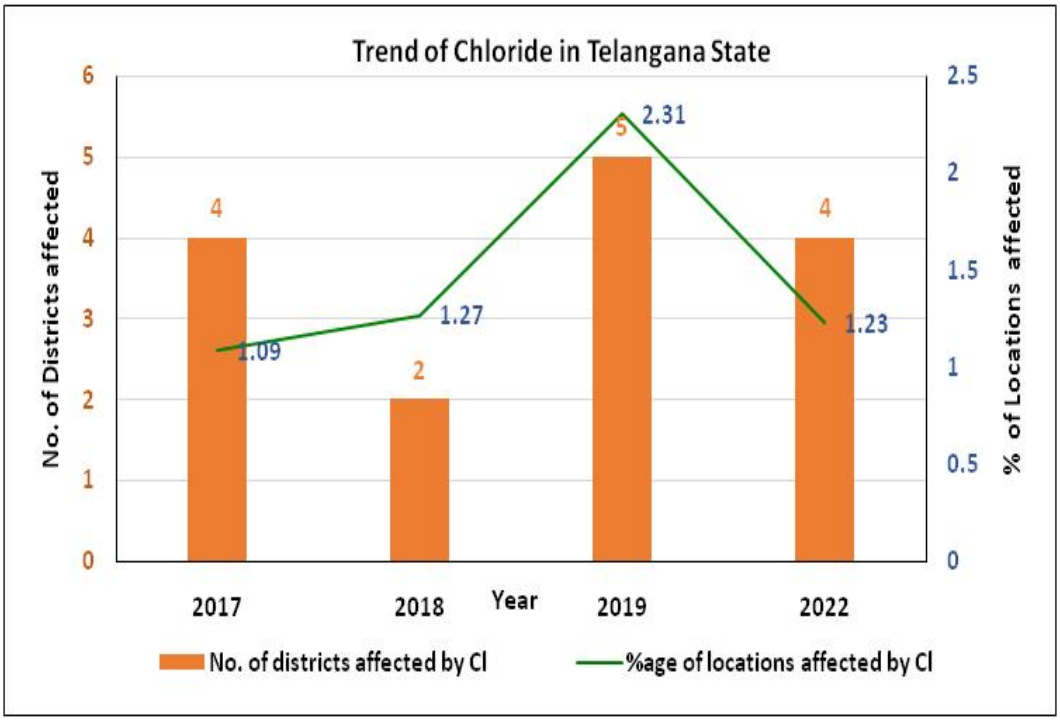


Fig 7.2.3 Trend of Chlorides in Telangana State

Table-7.2.2: Taluks having Chloride concentration (more than 1000 mg/L) in Telangana (NHS 2022-23)

Sr. No	Districts	Parts of Mandals having Chloride>1000mg/L
1.	Jogulamba	Manopadu
2.	Khammam	Wyra, Penuballi
3.	Medak	Narayankhed
4.	Nalgonda	Munugode, Marriguda
5.	Sangareddy	Kohir
6.	Suryapet	Suryapet
7.	Yadadri	Valigonda

Techniques Available for Removal of Salinity

Traditionally, distillation has been the method used for desalting water for human consumption or other use. Membrane methods have emerged through the last 50 years and now predominate among the desalination practices. The following describes each of the various methods used for water

desalination treatment.

1. **Distillation Methods**

There are several variations in distillation technology used in desalination. They are all based on the vapourization of liquid water when brought to its boiling point. The nearly pure water vapour produced is condensed and collected for use, while dissolved salts remain behind in the remaining liquid feed water. Some of the methods by which distillation is practiced are as follows:

- Multi-stage flash;
- Multiple effect;
- Vapour compression;
- Membrane distillation; and
- Solar humidification.

2. **Membrane Technologies**

Membrane processes involve passing of impaired feed water through a semi-permeable material which can filter out unwanted dissolved or un-dissolved constituents, depending on the size and treatment of the openings. Membrane technologies identified include:

- Reverse Osmosis;
- Microfiltration/ Ultra filtration/Nano filtration;
- Electro dialysis Reversal; and
- Forward Osmosis.

3. **Hybrid Technology:**

A method of reducing overall costs of desalination can be the use of hybrid systems using both RO and distillation processes. Such a system could provide a more suitable match between power and water development needs.

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 hydro geological 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. Waters having fluoride concentration of more than 1.5 mg/L are not suitable for drinking purposes.

The Fluoride content is less than 1.5 mg/L in about 81.4 % of the sample analyzed and about 18.6% of the sample shows more than1.5mg/L,which are from the districts of Adilabad, Bhadadri, Hanamkonda, Hyderabad, Jagtial, Jangaon, Jayashankar, Jogulamba, Karimnagar, Khammam, Mahabubabad, Mahabubnagar, Mancherial, Medak, Medchal, Nagarkurnool, Mulugu, Nalgonda, Narayanpur, Nirmal, Nizamabad, Peddapalle, Rajanna, Rangareddy, Sangareddy, Siddipet, Suryapet, Vikarabad, Warangal andYadadri. Most of the disctricts of Telangana found to be having fluoride more than permissible limit. The list 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**. The Table **7.3.2** shows the parts of taluks in different districts of Telangana having Fluoride >1.5 mg/L. The details of locations where fluoride concentration more than 1.5 mg/l is given in Annexure III.

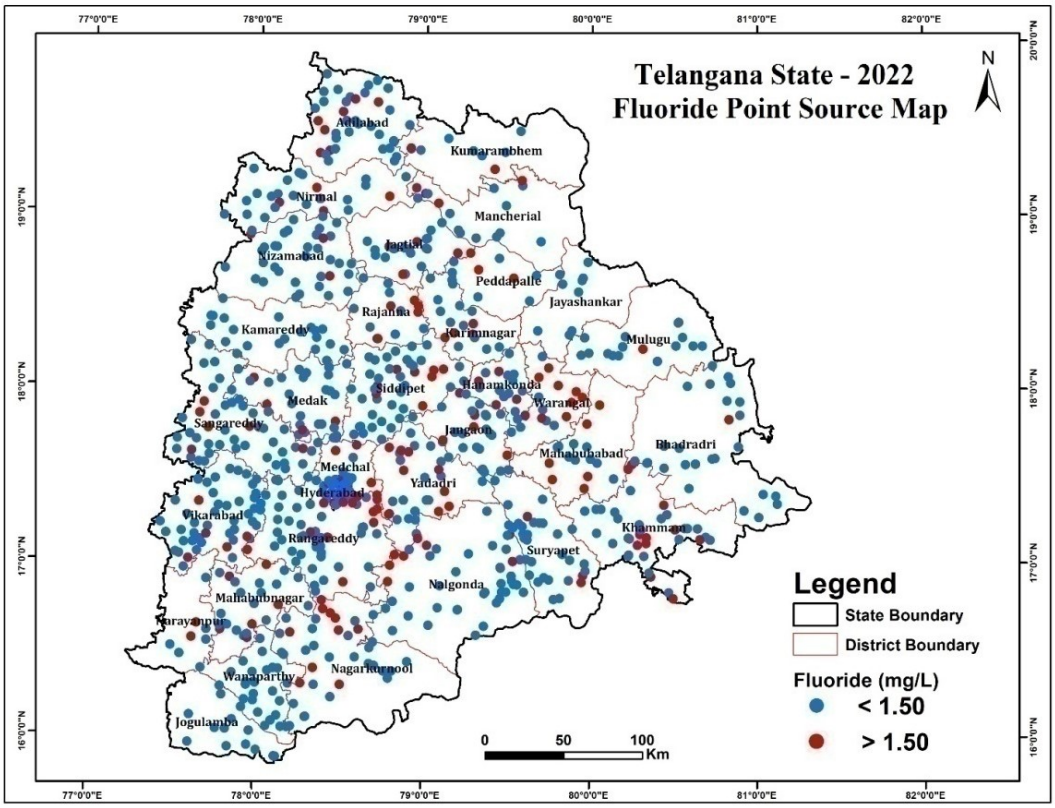


Fig 7.3.1 Distribution of Fluoride in shallow aquifers of Telangana, May 2022.

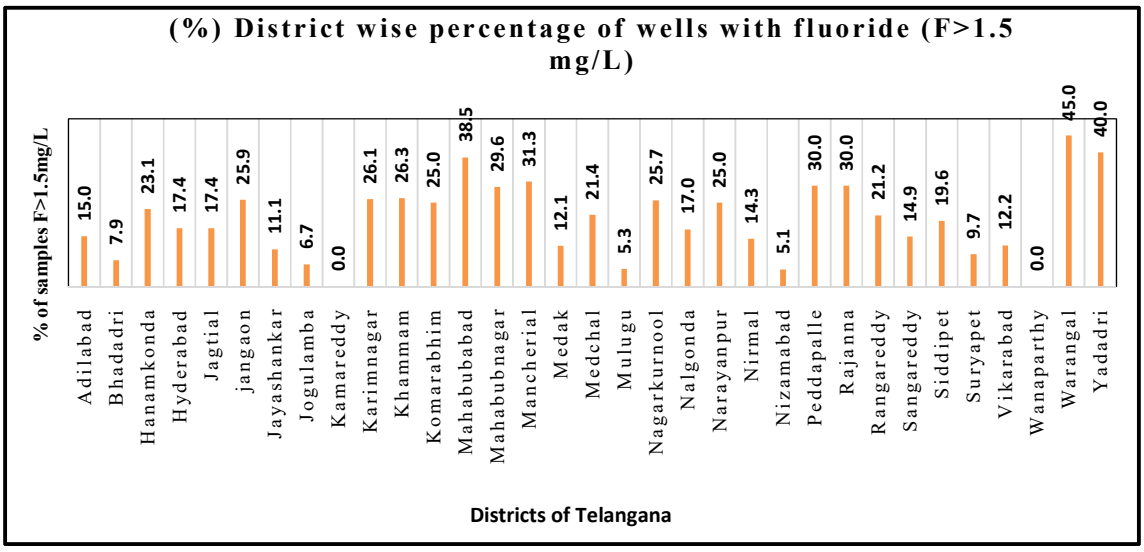


Fig 7.3.2 District-wise percentage of wells having fluoride >1.5 mg/L

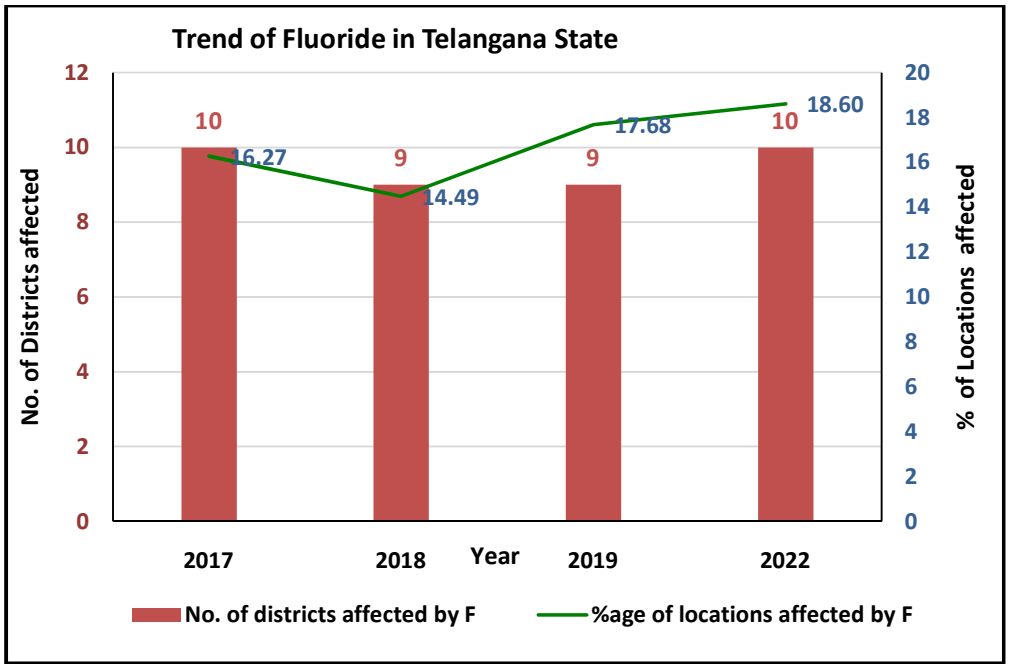


Fig 7.3.3 Trend of Fluoride in Telangana State.

Table7.3.1 District-wise percentage of wells having Fluoride>1.5 mg/L

Sl. No.	District	No. of Samples collected (NHS 2022-23)	No. of Samples (F>1.5mg/L)	(%) Samples (F>1.5mg/L)
1	Adilabad	40	6	**15.0**
2	Bhadradri	38	3	**7.9**
3	Hanamkonda	13	3	**23.1**
4	Hyderabad	23	4	**17.4**
5	Jagtial	23	4	**17.4**
6	Jangaon	27	7	**25.9**
7	Jayashankar	9	1	**11.1**
8	Jogulamba	15	1	**6.7**
9	Kamareddy	20	0	**0.0**
10	Karimnagar	23	6	**26.1**
11	Khammam	38	10	**26.3**
12	Komarabhim	8	2	**25.0**
13	Mahabubabad	13	5	**38.5**
14	Mahabubnagar	27	8	**29.6**
15	Mancherial	16	5	**31.3**
16	Medak	33	4	**12.1**
17	Medchal	14	3	**21.4**
18	Mulugu	19	1	**5.3**
19	Nagarkurnool	35	9	**25.7**
20	Nalgonda	47	8	**17.0**
21	Narayanpur	8	2	**25.0**
22	Nirmal	28	4	**14.3**
23	Nizamabad	39	2	**5.1**
24	Peddapalle	10	3	**30.0**
25	Rajanna	10	3	**30.0**
26	Rangareddy	66	14	**21.2**
27	Sangareddy	47	7	**14.9**
28	Siddipet	46	9	**19.6**
29	Suryapet	31	3	**9.7**
30	Vikarabad	49	6	**12.2**
31	Wanaparthy	22	0	**0.0**
32	Warangal	20	9	**45.0**
33	**Yadadri**	**35**	**14**	**40.0**

Table 7.3.2: Taluks having Fluoride concentration (> 1.5 mg/L) in Telangana

Sr. No	Districts	Parts of Mandals having Fluoride >1.5mg/L
1.	Adilabad	Boath, Neradigonda, Nizamabad_South, Adilabad Bazar Hatnoor, Bela
2.	Bhadradri	Chintur, Aswapuram, Yellandu
3.	Hanamkonda	Bhimdevraopalli, Wardhannapeta, Hanamkonda
4.	Hyderabad	Bandlaguda, Tirumalgiri, Khairatabad
5.	Jagtial	Velgatur, Korutla, Jagitial Rural, Kodimial
6.	Jangaon	Pedda Pendyal, Ghanpur, Palakurthy, Ghanpur Tharigoppula, Jangaon, Raghunathpalle
7.	Jayashankar	Chittial
8	Jogulamba	Manopad
9	Karimnagar	Shankarapatnam, Yelakaturthy, Manakondur, Thimmapur, Konaraopet
10	Khammam	Singareni, Madhira, Enkuru, Wyra, Thallada, Bonakal Konijerla, Yerupalem, Penuballi
11	Komarambhem	Rebbana, Sirpur
12	Mahabubabad	Gudur, Kothaguda, Maripeda, Danthalapalle, Kuravi
13	Mahabubnagar	Devarkadara, Jadcherla, Addakal, Musapet, Addakal Nawabpet, Kodair, Gandeed
14	Mancherial	Jannaram, Bheemini, Vemanpalle
15	Medak	Shankarampet_A, Toopran, Narsapur, Uppal
16	Medchal	Ghatkesar, Medchel, Shamirpet
17	Mulugu	Tadvai
18	Nagarkurnool	Vangoor, Urkonda, Kalwakurthy, Nagar_Kurnool Lingal, Bijinapalle, Kalaawakurthy, Gurrampod
19	Nalgonda	Gadiguda, Munugode, Kethepalle, Vemulapalle Chinthapalle, Marriguda
20	Narayanpur	Makthal
21	Nirmal	Ranjal, Soan, Lokeswaram, Kaddampeddur
22	Nizamabad	Balkonda, Bheemgel
23	Peddapalle	Ramagiri, Munjampalli, Peddapalli
24	Rajanna	Boinpalli
25	Rangareddy	Amangal, Kulkacharle, Rajendranagar, Serilingampally, Ibrahimpatnam, Saroornagar, Abdullapurmet, Manchal, Maheshwaram
26	Sangareddy	Jharasangam, Naykal, Pulkal, Andhole, Jinnaram
27	Siddipet	Koheda, Siddipet Urban, Cherial, Thoguta, Nanganur
28	Suryapet	Kodad, Atmakur
29	Vikarabad	Bomraspet, Doultabad, Peddemul, Zahirabad, Parigi Doma
30	Warangal	Damera, Narsampet, Shayampet, Khanapur, Duggondi, Chennaraopet, Sangem, Nellikudur
31	Yadadri	Srikonda, Turkapalle, Bhongiri, Choutuppal, Ramannapeta, Narayanapur, Yadagirigutta, Valigonda, Mootakondur

Remedial Measures for Fluoride

The fluoride remedial measures broadly adopted are ex-situ techniques. They can be classified into three major categories.

(a) Adsorption and ion exchange

This technique functions on the adsorption of fluoride ions onto the surface of an active agent such as activated alumina, red mud, bone char, brick pieces column, mud pot and natural adsorbents where fluoride is removed by ion exchange or surface chemical reaction with the solid bed matrix.

Activated alumina: Activated alumina is a highly porous aluminum oxide exhibiting high surface area. Alumina has a high preference for fluoride compared to other anionic species, and hence is an attractive adsorbent. The crystal structure of alumina contains cation lattice discontinuities giving rise to localized areas of positive charge which makes it attract various anionic species. It also does not shrink, swell, soften nor disintegrate when immersed in water. The maximum absorption capacity of activated alumina for fluoride is found to be 3.6 mg F/g of alumina.

Ion-Exchange resins: Synthetic chemicals, namely, anion and cation exchange resins have been used for fluoride removal. Some of these are Polyanion (NCL), Tul-sion A - 27, Deacedite FF (IP), Amberllte IRA 400, LewatitMIH - 59, and AmberliteXE - 75. These resins have been used in chloride and hydroxy form. The fluoride exchange capacity of these resins depends upon the ratio of fluoride to total anions in water.

(b) Coagulation-precipitation

Precipitation methods are based on the addition of chemicals (coagulants and coagulant aids) and the subsequent precipitation of a sparingly soluble fluoride salt as insoluble. Fluoride removal is accomplished with separation of solids from liquid. Aluminium salts (eg. Alum), lime, Poly Aluminium Chloride, Poly Aluminium Hydroxy sulfate and Brushite are some of the frequently used materials in defluoridation by precipitation technique. The best example for this technique is the famous Nalgonda technique.

Nalgonda Technique

Nalgonda technique involves addition of Aluminium salts, lime and bleaching powder followed by rapid mixing, flocculation, sedimentation, filtration and disinfection. It is opined that this technique is preferable at all levels because of the low price and ease of handling, is highly versatile and can be

used in various scales from household level to community scale water supply.

The Nalgonda technique can be used for raw water having fluoride concentration between 1.5 and 20 mg/L and the total dissolved solids should be <1500 mg/L, and total hardness < 600 mg/L. The alkalinity of the water to be treated must be sufficient to ensure complete hydrolysis of alum added to it and to retain a minimum residual alkalinity of 1 - 2 meq/L in the treated water to achieve a pH of 6.5 - 8.5 in treated water. Several researchers have attempted to improve the technique by increasing the removal efficiency of fluoride using Poly Aluminium Chloride (PAC) and Poly Aluminium Hydroxy Sulphate (PAHS).

(c) Membrane techniques

Reverse osmosis, nanofiltration, dialysis and electrodialysis are physical methods that have been tested for defluoridation of water. Though they are effective in removing fluoride salts from water, however, there are certain procedural disadvantages that limit their usage on a large scale.

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 hydro geological 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.

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 theform 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 de-nitrification 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 Methaemoglobinaemia 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 Nitrate content is less than 45mg/L in about 60.6% of the sample analyzed and 39.3% of samples shows more than 45 mg/L in Telangana state. The highest value of 1128mg/Lwas observed in Jupally, Nagarkurnool district.

The occurrences of Nitrate in ground water beyond permissible limit (45mg/L) have been shown on the map as a point source **Fig 7.4.1** and also given in Annexure-IV. **Table-7.4.1** shows the district wise percentage of wells having nitrate >45mg/L in ground water. District-wise percentage of wells having nitrate >45mg/L is also shown as a bar diagram in **Fig 7.4.2**. The Table **7.4.2** shows the parts of taluks in different districts of Telangana having Nitrate >45mg/L.

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

Sl. No	District	No.of Samples collected (NHS 2022-23)	No. of Samples (NO3 >45 mg/L)	(%)Samples (NO3>45mg/L)
1	Adilabad	40	25	62.5
2	Bhadradri	38	6	15.8
3	Hanamkonda	13	4	30.8
4	Hyderabad	23	3	13.0
5	Jagtial	23	6	26.1
6	jangaon	27	8	29.6
7	Jayashankar	9	3	33.3
8	Jogulamba	15	4	26.7
9	Kamareddy	20	9	45.0
10	Karimnagar	23	8	34.8
11	Khammam	38	12	31.6
12	Komarabhim	8	3	37.5
13	Mahabubabad	13	6	46.2
14	Mahabubnagar	27	7	25.9
15	Mancherial	16	7	43.8
16	Medak	33	12	36.4
17	Medchal	14	3	21.4
18	Mulugu	19	2	10.5
19	Nagarkurnool	35	11	31.4
20	Nalgonda	47	29	61.7
21	Narayanpur	8	3	37.5
22	Nirmal	28	15	53.6
23	Nizamabad	39	14	35.9
24	Peddapalle	10	3	30.0
25	Rajanna	10	3	30.0

26	Rangareddy	66	33	50.0
27	Sangareddy	47	22	46.8
28	Siddipet	46	23	50.0
29	Suryapet	31	10	32.3
30	Vikarabad	49	23	46.9
31	Wanaparthy	22	3	13.6
32	Warangal	20	9	45.0
33	Yadadri	35	22	62.9

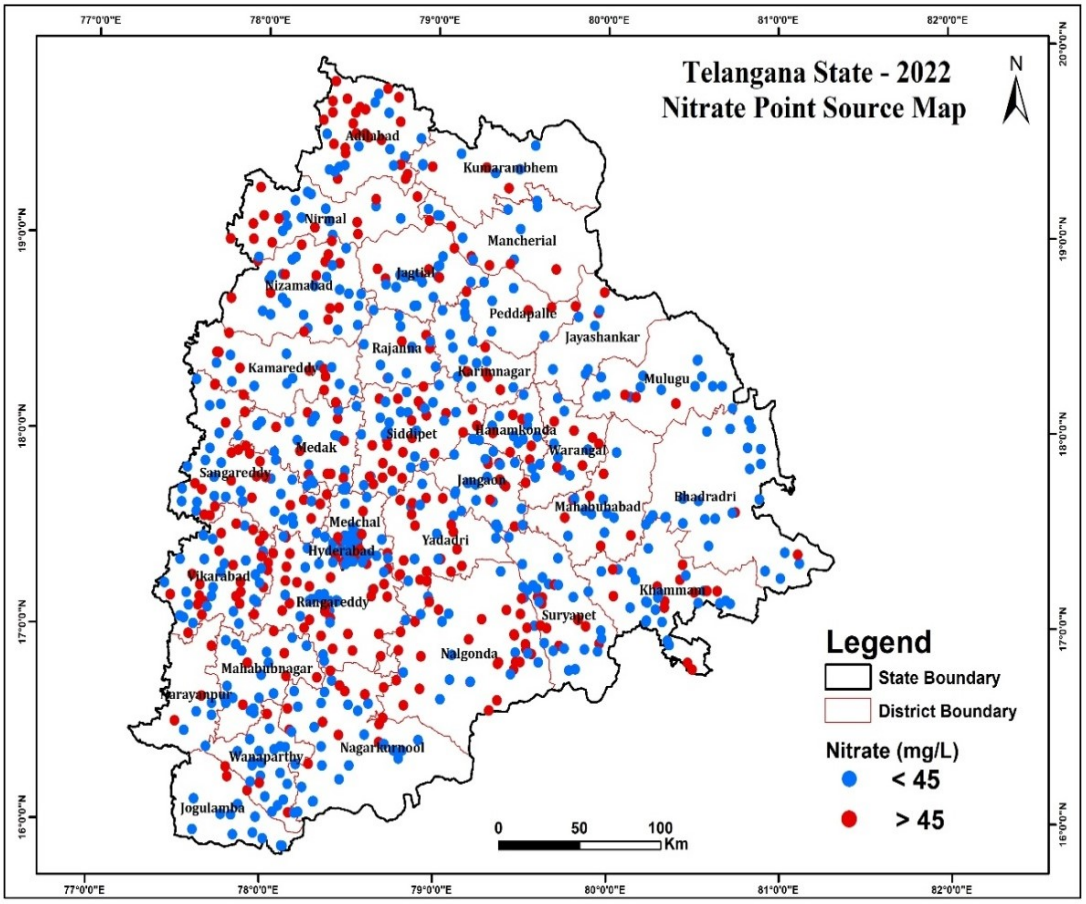


Fig 7.4.1 Distribution of Nitrate in shallow aquifers of Telangana, May 2022.

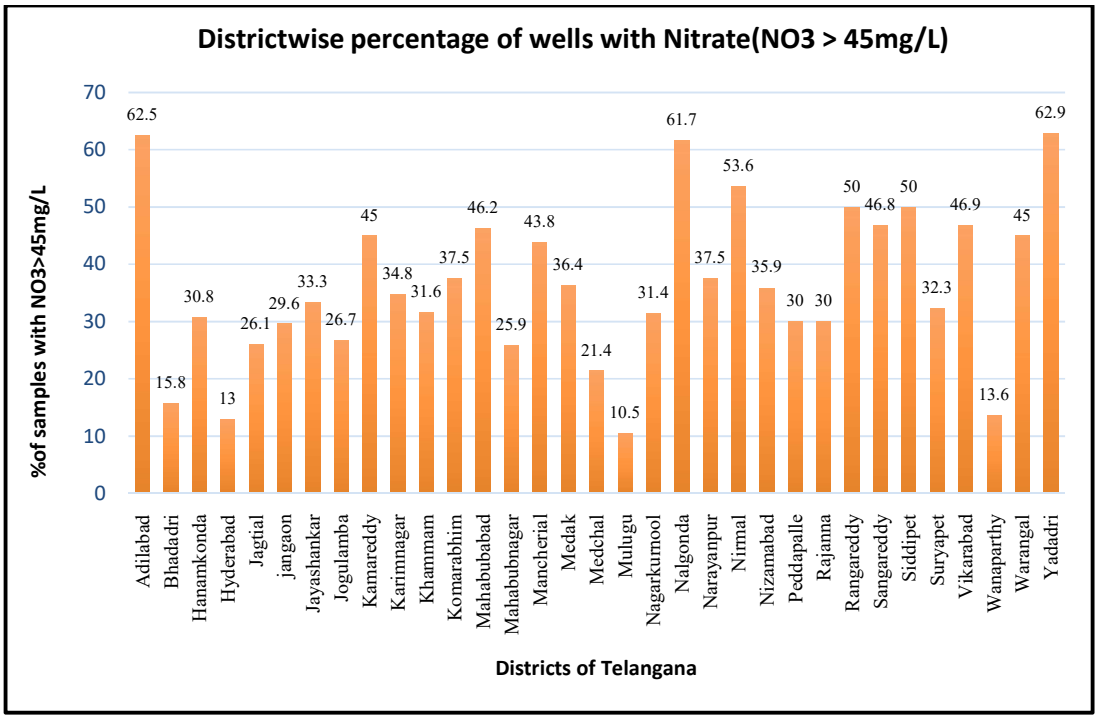


Fig 7.4.2: District-wise percentage of wells having Nitrate >45mg/L

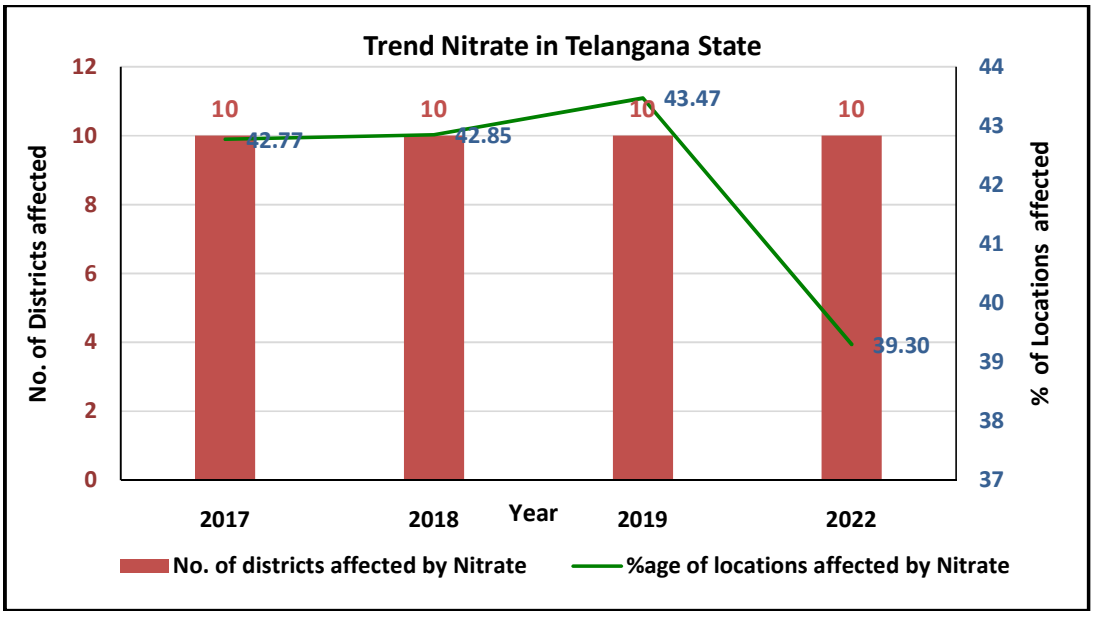


Fig 7.4.3: Trend of Nitrate in Telangana State

Table 7.4.: Taluks having Nitrate concentration (> 1.5 mg/L) in Telangana

Sr. No.	Districts	Parts of Mandals having Fluoride >1.5mg/L
1.	Adilabad	Gudihathnur, Wankdi, Bela, Neradigonda, Utnur, Ichoda, Inderavelly, Mavala, Adilabad Rural, Adilabad, Bheempur, Ichoda, Jainad, Talamadugu Tamsi, Utnur, Sirpur, Bazar Hatnoor, Narnoor
2	Bhadradri	Chintur, Palawancha, Nellipaka, Aswaraopeta, Kukkunur, Munagala
3	Hanamkonda	Inavole, Hanamkonda, Velair, Hasanparthy
4	Hyderabad	Bandlaguda, Ammerpet, Khairatabad
5	Jagtial	Dharmapuri, Metpalli, Jagityal, Jagitial Rural, Gollapalli, Korutla
6	Jangaon	Pedda Pendyal, Ghanpur, Palakurthy, Devruppula, Kodakandla
7	Jayashankar	Mahadevpur, Kataram, Tadvai
8	Jogulamba	Gadwal, Itikyal, Watpalle
9	Kamareddy	Bichkunda, Pitlam, Kamareddy, Gambhiraopeta, Birkoor, Bhiknur
10	Karimnagar	Shankarapatnam, Mustabad, Yelakaturthy, Manakondur, Thimmapur, Huzurabad, ,Konaraopet
11	Khammam	Yerrupalem, Enkuru, Konijerla, Thallada, Wyra, Penuballi, Mudigonda, Kallur, Thirumalayapalem
12	Komarambhem	Asifabad, Rebbana, Kerameri
13	Mahabubabad	Garla, Gudur, Kesamudram, Maripeda
14	Mahabubnagar	Jadcherla, Midjil, Hanwada, Devarakadra, Nawabpet, Rajapur, Kodair
15	Mancherial	Gollapalle, Hajipur, Jannaram, Bheemini, Luxettipet, Mancherial
16	Medak	Kowdipalle, Papannapet, Narayankhed, Narsapur, Narsingi, Manoharabad, Haveli Ghanpur, Sivampet, Chegunta, Chandi, Uppal
17	Medchal	Shamirpet, Uppal, Kapra
18	Mulugu	Govindaraopet
19	Nagarkurnool	Urkonda, Charakonda, Kalwakurthy, Tadoor,Telkapalle, Bijinapalle, Achampet, Uppunuthala
20	Nalgonda	Nalgonda, Nidamanur, Devarakonda, Miryalaguda, Nakrekal, Nampalle, Kangal, Madugulapally, Gundlapalle, Huzurnagar, Peddavura, Vemulapalle, Munugode, Thipparthi, Marriguda, Kethepalle, Chinthapalle, Thripuraram, Chandampet, Peddavura
21	Narayanpur	Kosgi, Dhanwada, Makthal
22	Nirmal	Nizamabad_South, Pembi, Mamda, Ranjal, Mudhole, Bhainsa, Sarangapur, Kaddampeddur, Lokeshwaram, Kubeer, Dilawarpur, Tanoor
23	Nizamabad	Nandipet, Balkonda, Indalwai, Armur, Uppal, Bodhan, Mortad, Bheemgel, Dharpalli, Mupkal, Indralwai, Maklur
24	Peddapalle	Manthani, Ramagiri
25	Rajanna	Boinpalli, Mustabad
26	Rangareddy	Farooqnagar, Kadthal, Keshampeta, Talakondapalle, Madgul, Amangal, Kulkacharle, Abdullapurmet, Shankarpalle, Chevella, Shamshabad, Hayathnagar, Manchal, Saroornagar, Balanagar, Chevella, Shabad, Maheshwaram, Kandukur, Serilingampally, Ibrahimpatnam, Kothur, Yacharam
27	Sangareddy	Zahirabad, Kohir, Gummadidala, Watpalle, Narayankhed, Hathanoora, Munipalli, Kangti, Andhole, Watpalle, Patancheruvu, Sangareddy, Pulkal, Sadasivpet, Manoor, Kalher, Jinnaram
28	Siddipet	Koheda, Husnabad, Akkannapet, Chinnakodur, Gajwel,Dubbak, Jagadevpur, Thoguta, Kondapak, Daulatabad, G.P. Ponnala, Siddipet Wargal, Nanganur, Markook and Jagadevpur, Mulugu, Cherial
29	Suryapet	Munagala, Suryapet, Penpahad, Kodad, Garidepalle, Chivvemla, Atmakur.
30	Vikarabad	Bomraspeta, Doulatabad, Kodangal, Vikarabad, Mominpet, Peddemul, Kotepally, Pudur, Tandur, Yelal, Doma, Pargi, Dharur, Nawabpet, Marpalle

31	Wanaparthy	Pebbair, Chinnambavi, Ghanpur
32	Warangal	Alair, Damera, Khanapur, Narsampet, Duggondi, Chennaraopet, Sangem, Nellikudur, Wardhannapet
33	Yadadri	Srikonda, Pochampalle, Choutuppal, Turkapalle, Bhongiri, Valigonda, Ramannapeta, Yadagirigutta, Narayanapur, Mootakondur

Remedial Measures for Nitrate

For removal of nitrate both non-treatment techniques like blending and treatment processes suchas ion-exchange, reverse osmosis, biological de-nitrification and chemical reduction are useful. The most important thing is that neither of these methods is completely effective in removing all the nitrogen from the water.

a) Methods involving no treatment:

In order to use any of these options the nitrate problem mustbe local-scale. Common methods are –

- Raw water source substitution
- Blending with low nitrate waters

This greatly reduces expenses and helps to provide safer drinking water to larger numbers of people.

b) Methods involving Treatment:

They are as follows

- Adsorption/Ion Exchange
- Reverse Osmosis
- Electro dialysis
- Bio-chemical De-nitrification **(**By using denitrifying bacteria and microbes)
- Catalytic Reduction/De-nitrification (using hydrogen gas)

The mechanism of nitrate pollution in subsurface porous unconfined/confined aquifer is governed by complex biogeochemical processes. Apart from recharge conditions, groundwater chemistry may be impacted by the mineral kinetics of water-rock interactions. Consequently, suitable nitrateremoval technologies should be selected. Nitrate is a very soluble ion with limited potential for co-precipitation or adsorption. This makes it difficult such as chemical coagulation, lime softening and filtration which are commonly used for removing most of the chemical pollutants such as fluoride, arsenic and heavy metals. According to King et al., 2012 nitrate treatment technologies can be

classified in two categories in two categories, i.e. nitrate reduction and nitrate removal options. Nitrate removal technologies involve physical processes that do not necessarily involve any alteration of the chemical state of nitrate ions. Bio-chemical reduction options aim to reduce nitrate ions to other states of nitrogen, e.g. ammonia, or a more innocuous form as nitrogen gas. In-situ bioremediation is also effectively used in used in nitrate treatment of contaminated groundwater. Reverse Osmosis, catalytic reduction and blending are effective methods for nitrate removal from groundwater. For nitrate removal, operating trans-membrane pressure of RO unit generally ranges from 20 to 100 bar.

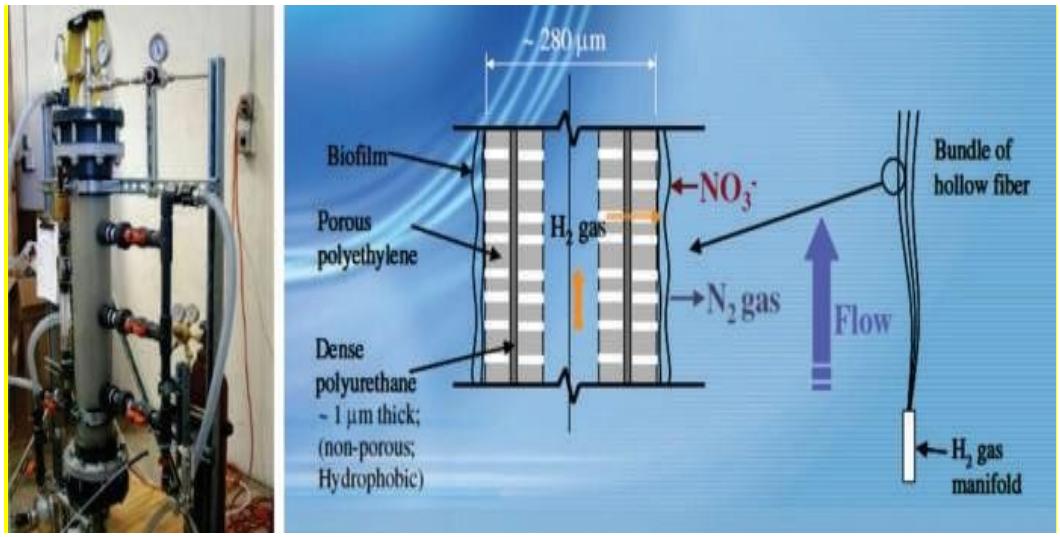


Fig. 7.4.4: Advanced Nitrate Reduction Hollow Fiber Membrane Reactor (Source: Hand Book for Drinking Water Treatment, JJM, Ministry of Jal Shakti, Govt. of India)

7.5 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 normallylow, but in circumstances in which uranium is present in a drinking water source, the majority ofintake can be through drinking water.

Water with uranium concentration above the recommended maximum permissible concentrationof 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 levelof 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 7.5.1: 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 7.5.2: 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) along with other basic parameters in Telangana state during Pre-monsoon monitoring (May, 2022). The groundwater samples were collected in plastic bottles for basic parameters and uranium analyses. Uranium (U) was analysed by BARC method, using LED Fluorimeter.

The occurrences of Uranium in ground water beyond permissible limit (>30 µg/l) have been given in Annexure-V. **Table-7.5.3** shows the District-wise percentage of wells having Uranium > 30 µg/l in groundwater. District-wise percentage of wells having uranium 30 µg/l is shown as a bar diagram in **Fig 7.5.1**. The Table **7.5.4** shows the parts of taluks in different districts of Telangana having Uranium > 30 µg/l in groundwater.

Uranium concentration in ground water of Telangana state varied from 0.02 to 1250 µg/l during Pre-monsoon monitoring (May, 2022), indicating that uranium concentrations in groundwater widely vary by several orders of magnitude. Large variations seen in Uranium concentrations could be due to the hydro-geochemical characteristics of groundwater. The uranium concentration was above permissible limit in districts of Hyderabad, Mahabubnagar, Medak, Nagarkurnool, Nalgonda, Rangareddy, Siddipet, Wanaparthy and Yadadri. The highest concentration of 1250 µg/l was recorded in Rajendranagar of Rangareddy district.

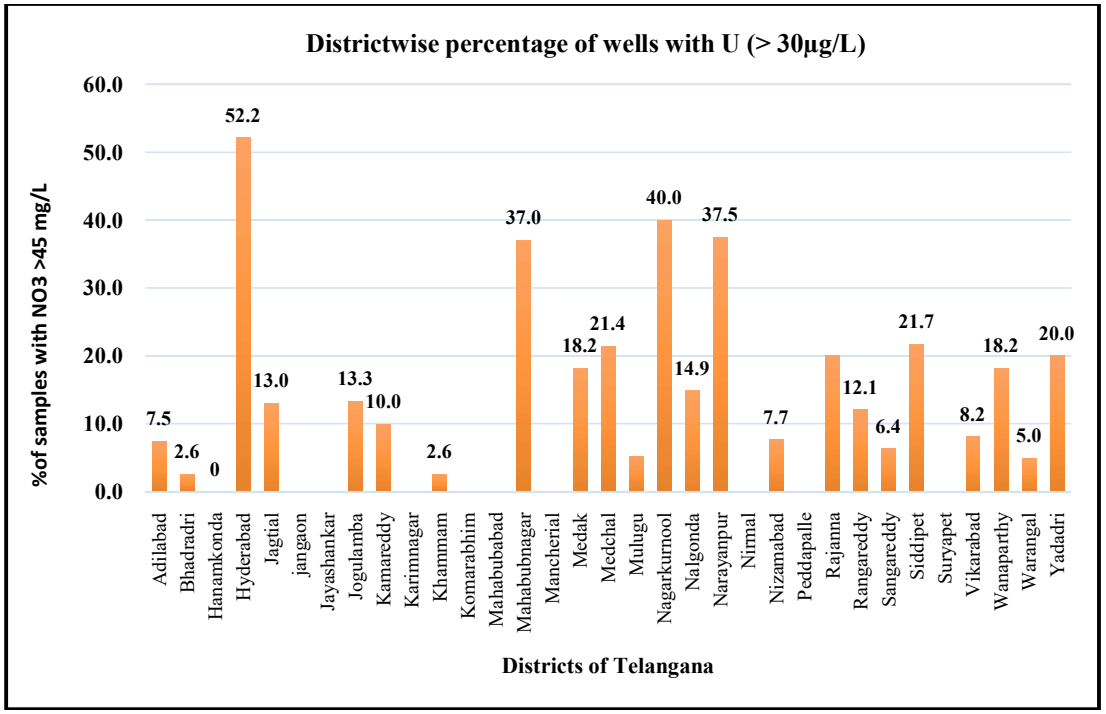


Fig. 7.5.1: District-wise samples exceeding Uranium concentration >30 µg/L (NHS 2022-23)

Table 7.5.3: District-wise percentage of wells having Uranium > 30 µg/L

Sr. No.	Districts	No. of Samples collected (NHS 2022-23)	No. Of Samples (U >30 ppb)	(%) Samples (U >30 ppb)
1	Adilabad	40	3	7.5
2	Bhadradri	38	1	2.6
3	Hanamkonda	13	0	0.0
4	Hyderabad	23	12	52.2
5	Jagtial	23	3	13.0
6	jangaon	27	0	0.0
7	Jayashankar	9	0	0.0
8	Jogulamba	15	2	13.3
9	Kamareddy	20	2	10.0
10	Karimnagar	23	0	0.0
11	Khammam	38	1	2.6
12	Komarabhim	8	0	0.0
13	Mahabubabad	13	0	0.0
14	Mahabubnagar	27	10	37.0
15	Mancherial	16	0	0.0
16	Medak	33	6	18.2
17	Medchal	14	3	21.4
18	Mulugu	19	1	5.3
19	Nagarkurnool	35	14	40.0
20	Nalgonda	47	7	14.9
21	Narayanpur	8	3	37.5
22	Nirmal	28	0	0.0
23	Nizamabad	39	3	7.7
24	Peddapalle	10	0	0.0
25	Rajanna	10	2	20.0
26	Rangareddy	66	8	12.1
27	Sangareddy	47	3	6.4
28	Siddipet	46	10	21.7
29	Suryapet	31	0	0.0
30	Vikarabad	49	4	8.2
31	Wanaparthy	22	4	18.2
32	Warangal	20	1	5.0
33	Yadadri	35	7	20.0

Table 7.5.4: Taluks having Uranium >30 µg/L in different districts of Telangana

Sr. No.	District	Parts of taluks having Uranium > 30 µg/L
1	Adilabad	Talamadugu, Bazar Hatnoor, Ichoda
2	Bhadadri	Kukkunur
3	Hanamkonda	Nil
4	Hyderabad	Golkonda, Shaikpet, Nampally, Bandlaguda, Himayatnagar, Khairatabad, Ammerpet,Asifnagar Tirumalgiri
5	Jagtial	Metpalli, Kodimial, Chinna Kodur
6	jangaon	Nil
7	Jayashankar	Nil
8	Jogulamba	Gadwal
9	Kamareddy	Pitlam, Birkoor
10	Karimnagar	Nil
11	Khammam	Wyra
12	Komarabhim	Nil
13	Mahabubabad	Nil
14	Mahabubnagar	Balanagar, Jadcherla, Midjil, Hanwada, Addakal, Devarakadra, Rajapur, Kodair, Gandeed
15	Mancherial	Nil
16	Medak	Narayankhed, Shankarampet, Papannapet, Toopran, Sivampet, Chegunta
17	Medchal	Ghatkesar, Kapra, Shamirpet
18	Mulugu	Govindaraopet
19	Nagarkurnool	Vangoor, Urkonda, Charakonda, Kalwakurthy, Tadoor, Mahabubnagar, Lingal, Bijinapalle, Achampet, Kalaawakurthy
20	Nalgonda	Nampalle, Gundlapalle, Munugode, Marriguda, Thripuraram
21	Narayanpur	Dhanwada, Makthal
22	Nirmal	Nil
23	Nizamabad	Bodhan, Maklur, Ergatla
24	Peddapalle	Nil
25	Rajanna	Vemulawada, Rudrangi
26	Rangareddy	Madgul, Kulkacharle, Serilingampally, Rajendranagar, Saroornagar, Maheshwaram, Kandukur, Kothur
27	Sangareddy	Patancheruvu, Jinnaram, Sirgapoor
28	Siddipet	Koheda, Thoguta, Komuravelli, Chinnakodur, Gajwel, Siddipet, Nanganur, Chinna Kodur
29	Suryapet	Nil
30	Vikarabad	Doulatabad, Kodangal, Parigi
31	Wanaparthy	Kothakota, Pebbair, Ghanpur, Gopalpeta
32	Warangal	Wardhannapet
33	Yadadri	Srikonda, Valigonda, Narayanapur, Pochampalle, Valigonda

REMEDIAL MEASURES

Finding a remedy for the uranium contaminated groundwater effectively and thoroughly, has become need of day. Remediation technologies can be classified into physical, chemical and biological methods. Bioremediation is divided into plant and microorganism methods. Each method consists of both advantages and disadvantages and the appropriate mitigation techniques should be need based.

Adsorption has a high removal efficiency, but costs are also higher. The coagulation process is simple and comparatively economical, but the standard effluent concentration is hard to reach, so there is a need for follow-up treatment. Combined with adsorption, coagulation can remove 99% of U. The extraction process can remove effluent U concentrations of less than 0.05mg / L, but it will produce a lot of sludge. Reverse osmosis is referred as a best technology, but due to its high cost it cannot be used on community scale. The evaporation method is simple and effective, the removal rate is high, but there are high costs and sludge needs that must be dealt with. A review of various treatment technologies for Uranium removal from water and their technical achievability as reported by various researchers are given below in Table **7.5.5**

Table 7.5.5: Comparison of treatment methods for removal of Uranium.

Treatment Method	**Technical Achievability (%)**
Coagulation/filtration at high pH (10+)	> 95
Lime softening	85-99
Anion exchange	99
Reverse osmosis	>95
Activated alumina	90
Coagulation/filtration	80-89

(Source: Hand Book for Drinking Water Treatment, JJM, Ministry of Jal Shakti, Gov. of India).

7.6 Total hardness

Total hardness is predominantly caused by cations such as calcium and magnesium and anion such as bicarbonate and sulphate. Total hardness is defined as the sum of calcium and magnesium both expressed as $CaCO_3$ in mg/L. Hardness represents the soap-consuming capacity of water. Species that form insoluble compounds with soap Ca, Mg, Organic compounds etc. Total

hardness is sum of Ca and Mg and expresses as $CaCO_3$ mg/l. EDTA titration. The two kind of hardness observed in water.

- Temporary hardness is due to Carbonate.
- Permanent hardness is due to Sulphate, Chloride or Nitrate.

The hardness in water is derived largely from contact with the soil and rock formations. Rain water as it falls upon the earth is in capable of dissolving the tremendous amount of solids found in many natural waters. People with kidney and bladder stones should avoid high content of calcium and magnesium in water (K. R. Karanth, 1997). The BIS permissible limit of hardness is200 – 600 mg/L.

The total hardness in ground water was observed in a many parts of Telangana state. The Total hardness exceeds the BIS permissible limit of 600 mg/L in 8.63% of the samples in the state. The number of locations where total hardness concentration is more than 600 mg/L in various districs of the state is given in **Table 7.6.1**. Mandals having total hardness more than permissible limit is given in **Table 7.6.2**.

Fig 7.6.1 District-wise percentage of wells having Total hardness > 600 mg/L as $CaCO_3$

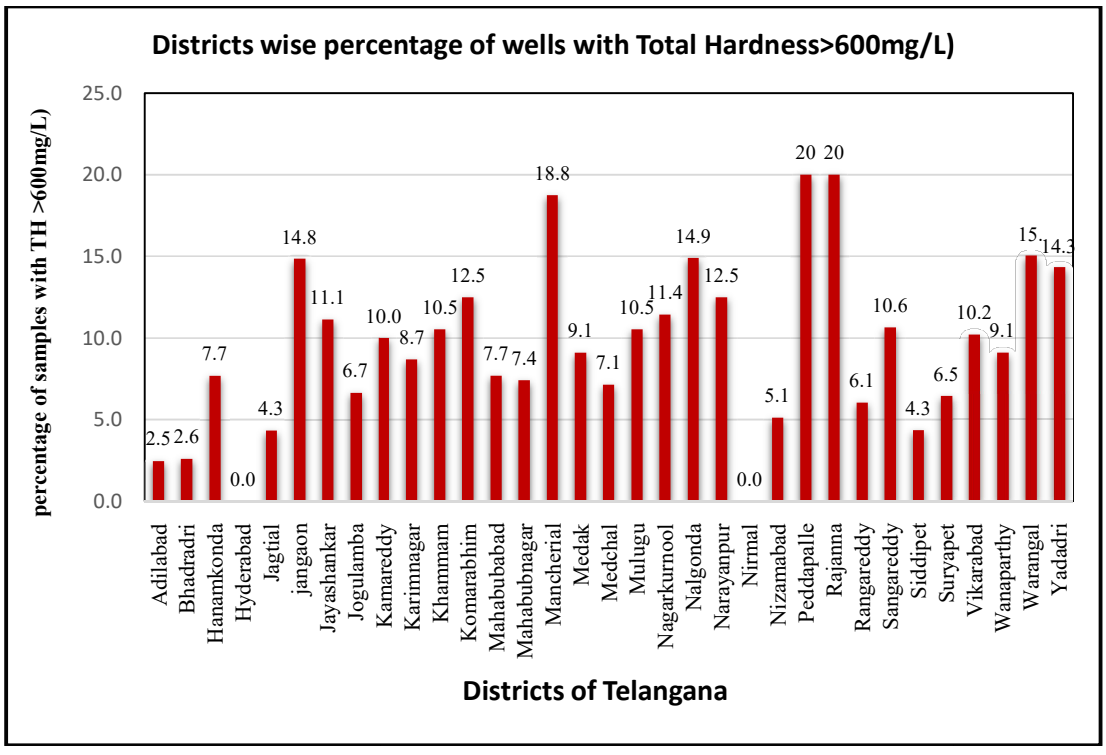


Table 7.6.1 Districts-wise percentage of samples having Total hardness >600 mg/L

Sr. No.	Districts	No. of Samples collected (NHS 2022-23)	No. of Locations Having TH>600mg/L	(%) Samples (TH >600 mg/L)
1	Adilabad	40	1	2.5
2	Bhadradri	38	1	2.6
3	Hanamkonda	13	1	7.7
4	Hyderabad	23	0	0.0
5	Jagtial	23	1	4.3
6	jangaon	27	4	14.8
7	Jayashankar	9	1	11.1
8	Jogulamba	15	1	6.7
9	Kamareddy	20	2	10.0
10	Karimnagar	23	2	8.7
11	Khammam	38	4	10.5
12	Komarabhim	8	1	12.5
13	Mahabubabad	13	1	7.7
14	Mahabubnagar	27	2	7.4
15	Mancherial	16	3	18.8
16	Medak	33	3	9.1
17	Medchal	14	1	7.1
18	Mulugu	19	2	10.5
19	Nagarkurnool	35	4	11.4
20	Nalgonda	47	7	14.9
21	Narayanpur	8	1	12.5
22	Nirmal	28	0	0.0
23	Nizamabad	39	2	5.1
24	Peddapalle	10	2	20.0
25	Rajanna	10	2	20.0
26	Rangareddy	66	4	6.1
27	Sangareddy	47	5	10.6
28	Siddipet	46	2	4.3
29	Suryapet	31	2	6.5
30	Vikarabad	49	5	10.2
31	Wanaparthy	22	2	9.1
32	Warangal	20	3	15.0
33	Yadadri	35	5	14.3

Table : 7.6.2 Taluks having total hardness > 600 mg/L in Ground Water in Different Parts of Telangana state

Sr. No	Districts	Mandals Having Total Hardness >600mg/L in Ground Water
1	Adilabad	Neradigonda
2	Bhadradri	Kukkunur
3	Hanamkonda	Inavole
4	Hyderabad	Nil
5	Jagtial	Chinna Kodur
6	jangaon	Pedda Pendyal, Ghanpur, Palakurthy, Kodakandla
7	Jayashankar	Tadvai
8	Jogulamba	Manopadu
9	Kamareddy	Pitlam, Birkoor
10	Karimnagar	Yelakaturthy, Konaraopet
11	Khammam	Yerrupalem, Wyra, Penuballi, Thirumalayapalem
12	Komarambhim	Sirpur
13	Mahabubabad	Garla
14	Mahabubnagar	Midjil, Rajapur
15	Mancherial	Hajipur, Jannaram
16	Medak	Narayankhed, Papannapet, Chegunta
17	Medchal	Ghatkesar
18	Mulugu	Govindaraopet
19	Nagarkurnool	Charakonda, Tadoor, Bijinapalle
20	Nalgonda	Munugode, Vemulapalle, Marriguda, Marriguda Kethepalle, Thripuraram
21	Narayanpur	Kosgi
22	Nirmal	Nil
23	Nizamabad	Armur, Bodhan
24	Peddapalle	Manthani
25	Rajanna	Vemulawada, Thangallapalli
26	Rangareddy	Keshampeta, Kothur, Manchal, Maheshwaram
27	Sangareddy	Watpalle, Narayankhed, Kohir, Sangareddy
28	Siddipet	Daulatabad, Siddipet
29	Suryapet	Munagala, Kodad
30	Vikarabad	Kodangal, Doulatabad, Nawabpet, Marpalle
31	Wanaparthy	Pebbair, Ghanpur
32	Warangal	Wardhannapet, Chennaraopet
33	Yadadri	Pochampalle, Valigonda, Pochampalle, Valigonda

Removal of total hardness

A few methods to remove hardness from water are,

- Chemical Process of Boiling Hard Water.
- Adding Slaked Lime (Clark's Process)
- Adding Washing Soda.
- Calgon Process.
- Ion Exchange Process.
- Using Ion Exchange Resins.

CARBONATE (TEMPORARY) HARDNESS also known as Ca Bicarbonate

Ca $(HCO_3)_2$ + Mg Bicarbonate $Mg(HCO_3)_2$. Removal by Boiling or adding Lime

NON-CARBONATE (PERMANENT) HARDNESS

Calcium Sulfate $CaSO_4$ + Magnesium Sulfate $MgSO_4$ & Calcium Chloride $CaCl_2$ + MagnesiumChloride $MgCl_2$

Removal by Lime-soda, Zeolite or Demineralization Processes

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. Excessiveconcentrations 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 irrigationwater 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 levelsare 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 hasrecommended 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:

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

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 matterto 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.

The computed SAR values ranges from 0.09 to 45.41. The maximum SAR value has been found at munugodu of Nalgonda district. It is apparent from **Fig. 8.1** that 97.73% samples belong to excellent category (S1), 1.91% water samples are associated with Medium sodium category (S2), 0.30% water samples are associated with High sodium category (S3) and 0.06% water samples are associated with Very high sodium category (S4).

According to SAR classification, 100% of water samples from Hanamkonda, Hyderabad, Jangaon, Jayashankar, Kamareddy, Karimnagar, Komarambhem, Mahabubabad, Mancherial, Medak, Medchal, Mulugu, Nagarkurnool, Narayanpur, Nirmal, Peddapalle, Rajanna, Rangareddy, Sangareddy, Siddipet, Vikarabad, Wanaparthy, Warangal fall in excellent category (S1) given in bar diagram **Fig. 8.2**. The Summary of irrigation quality of the groundwater samples in Telangana based on SAR classifications is given in **Table 8.1**.

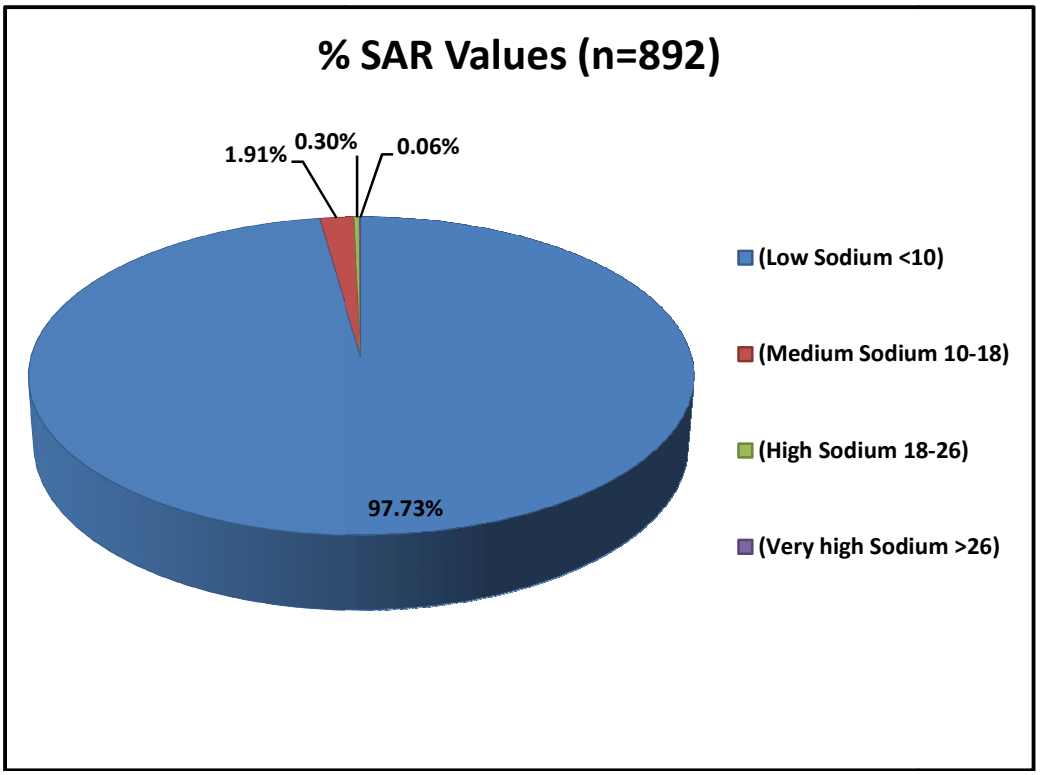


Fig. 8.1: Percentage of groundwater samples according to SAR classifications (n=892).

Table 8.1: Summary of irrigation quality of the groundwater samples in Telangana state based on SAR classifications

Sl.No.	District	% of samples in various SAR range			
		(Low Sodium <10)	(Medium Sodium 10-18)	(High Sodium 18-26)	(Very high Sodium >26)
1	Adilabad	39	1	0	0
2	Bhadradri	35	3	0	0
3	Hanamkonda	13	0	0	0
4	Hyderabad	23	0	0	0
5	Jagtial	22	0	1	0
6	Jangaon	27	0	0	0
7	Jayashankar	9	0	0	0
8	Jogulamba	12	3	0	0
9	Kamareddy	20	0	0	0
10	Karimnagar	23	0	0	0
11	Khammam	34	4	0	0
12	Komarambhem	8	0	0	0
13	Mahabubabad	13	0	0	0
14	Mahabubnagar	26	1	0	0
15	Mancherial	16	0	0	0
16	Medak	33	0	0	0
17	Medchal	14	0	0	0
18	Mulugu	19	0	0	0
19	Nagarkurnool	35	0	0	0
20	Nalgonda	43	3	0	1
21	Narayanpur	8	0	0	0
22	Nirmal	28	0	0	0
23	Nizamabad	38	1	0	0
24	Peddapalle	10	0	0	0
25	Rajanna	10	0	0	0
26	Rangareddy	66	0	0	0
27	Sangareddy	47	0	0	0
28	Siddipet	46	0	0	0
29	Suryapet	29	2	0	0
30	Vikarabad	49	0	0	0
31	Wanaparthy	22	0	0	0
32	Warangal	20	0	0	0
33	Yadadri	32	1	2	0

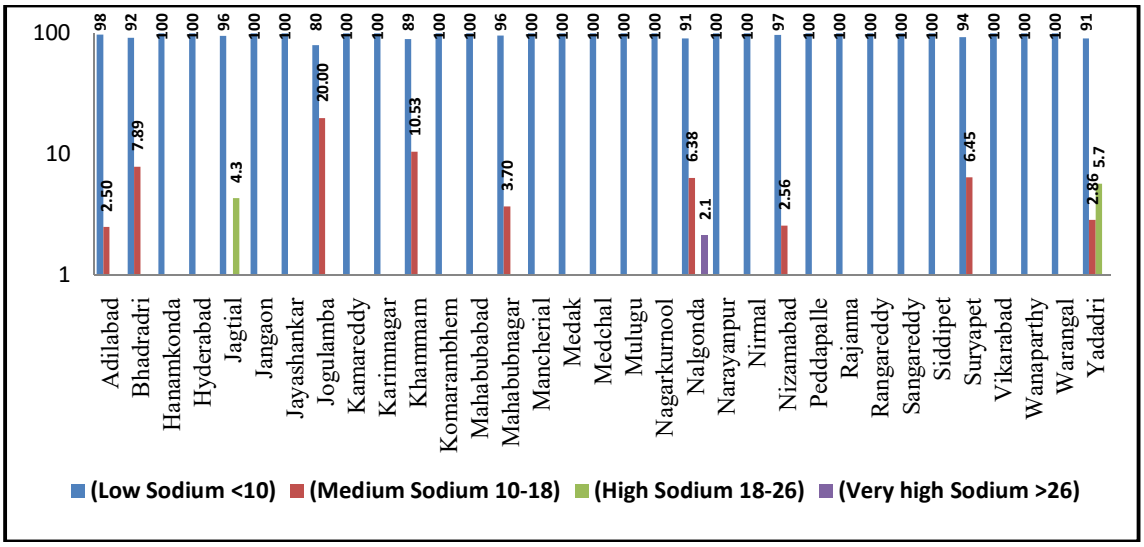


Fig. 8.2: P ercentage of ground water samples with respect to SAR values in Telangana

Residual Sodium Carbonate (RSC)

If the enriched carbonate (residual) concentration becomes relatively high, carbonates gettogether 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 alkalineearths 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;

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

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. 8.3** it can be seen that in Telangana 79.92% of collected water samples are associated with RSC values less than 1.25 and are safe for use in irrigation practices. 8.63% of water samples falling in the range of between 1.25-2.5 are marginally accepted for irrigation purpose. 11.44% 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 8.2** summarizes the irrigation quality of the groundwater samples in various districts of

Telangana based on RSC values. Four districts- Hyderabad, Medchal, Nirmal, Hanamkonda, Adilabad and Kamareddy in Telangana are found to be having 96%, 93%, 93%, 92%, 90% and 90% RSC values (<1.25 RSC –Very safe) respectively.

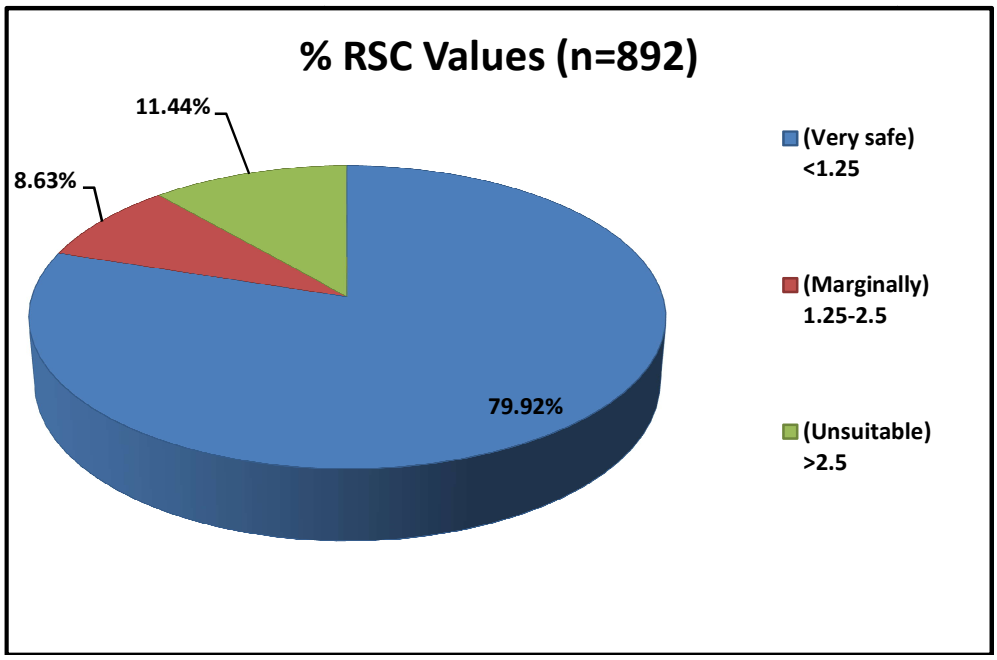


Fig. 8.3: Percentage of groundwater samples according to RSC classifications (n=892)

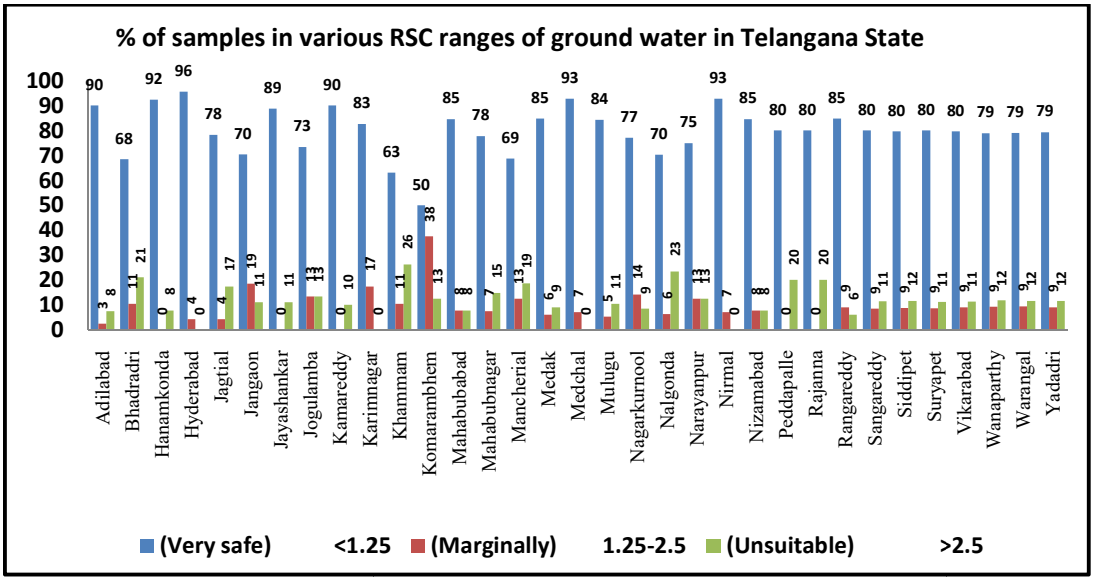


Fig. 8.4: Percentage of groundwater samples in various categories according to RSC classifications (n=892) (Wilcox et al.,1954)

Table 8.2: Summary of irrigation quality of the groundwater samples in Telangana based on RSC values

Sl. No.	District	%. of samples in various RSC range		
		<1.25	1.25-2.5	>2.5
		(Very safe)	(Marginally safe)	Unsuitable
1	Adilabad	36	1	3
2	Bhadradri	26	4	8
3	Hanamkonda	12	0	1
4	Hyderabad	22	1	0
5	Jagtial	18	1	4
6	Jangaon	19	5	3
7	Jayashankar	8	0	1
8	Jogulamba	11	2	2
9	Kamareddy	18	0	2
10	Karimnagar	19	4	0
11	Khammam	24	4	10
12	Komarambhem	4	3	1
13	Mahabubabad	11	1	1
14	Mahabubnagar	21	2	4
15	Mancherial	11	2	3
16	Medak	28	2	3
17	Medchal	13	1	0
18	Mulugu	16	1	2
19	Nagarkurnool	27	5	3
20	Nalgonda	33	3	11
21	Narayanpur	6	1	1
22	Nirmal	26	2	0
23	Nizamabad	33	3	3
24	Peddapalle	8	0	2
25	Rajanna	8	0	2
26	Rangareddy	56	6	4
27	Sangareddy	45	2	0
28	Siddipet	41	2	3
29	Suryapet	22	3	6
30	Vikarabad	47	0	2
31	Wanaparthy	19	3	0
32	Warangal	17	2	1
33	Yadadri	28	4	3

9.0 WILCOX DIAGRAM

EC and SAR are very important in classifying irrigation water. The Wilcox diagram (Wilcox 1948) relating EC and SAR shows **(Fig. 9**). The samples collected from the monitoring wells in Telangana fall in to 9 classes as described below.

C_1S_1: Low salinity and low sodium waters are good for irrigation and can be used with most of the crops with no restriction on use on most of the soils.

C_2S_1: Medium salinity and low sodium water can be used for irrigation on almost all soils with little danger of Na problem/hazard, if a moderate amount of leaching occurs. Crops can be grown without any special consideration for salinity control.

C_3S_1: The high salinity and low sodium waters require good drainage. Crops with good salt tolerance should be selected.

C_3S_2: Thehigh salinity and medium sodium waters require good drainage and can be used on coarse textured or organic soils having good permeability.

C_3S_3: These high salinity and high sodium waters require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendments make feasible the use of these waters.

C_4S_1: Very high salinity and low sodium waters are not suitable for irrigation unless the soil must be permeable and drainage must be adequate. Irrigation waters must be applied in excess to provide considerable leaching. Salt tolerant crops must be selected.

C_4S_2: Very high salinity and medium sodium waters are not suitable for irrigation on fine textured soils and low leaching conditions and can be used for irrigation on coarse textured or organic soils having good permeability.

C_4S_3: Very high salinity and high sodium waters produce harmful levels of exchangeable sodium in

most soils and will require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendment makes feasible the use of these waters.

C_4S_4: Very high salinity and very high sodium waters are generally unsuitable for irrigation purpose. These are sodium chloride type of waters and can cause sodium hazard. It can be used on coarse textured soils with very good drainage for very high salt tolerant crops. Gypsum amendments make feasible the use of these waters.

The figure shows US Salinity Laboratory diagram of deeper aquifer water samples of the state. It is observed that 56% of water samples are falling in C_3S_1 class, 27% in C_2S_1 class, 7.5% in C_3S_2 class, 4.8 % in C_4S_2 , 1.6 % in C_4S_3 ,about 1% each ofthe samples falling in C_1S_1, C_3S_3, C_4S_1classes.

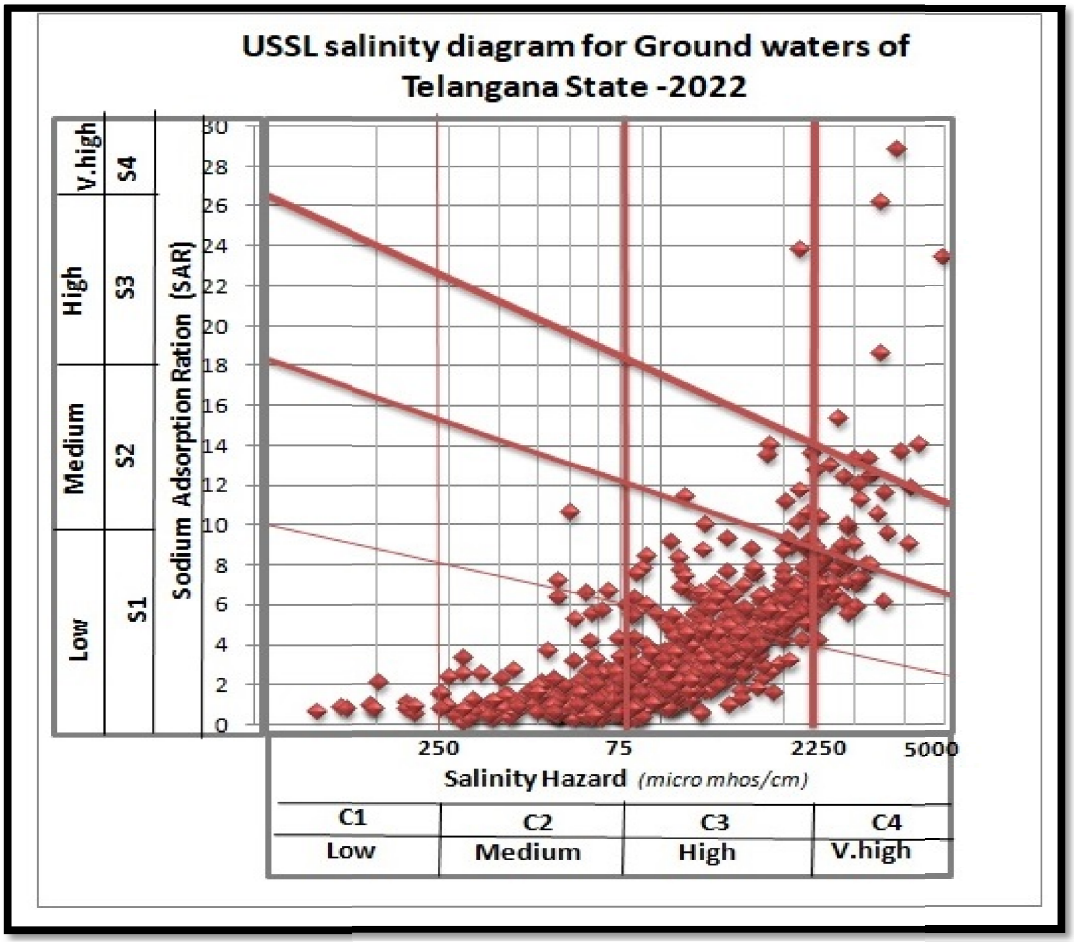


Fig: 9 USSL salinity Diagram of Telangana State

9.1 Piper diagram

Piper diagram (Piper 1944) describes the process responsible for the evolution of hydro geochemical parameter in groundwater. Based on the major Cation and major anion contentin the water samples and plotting them in the trilinear diagram, hydro chemical 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 hydro geological controls. Hydro chemical facies are delineated by plotting percentage reacting value of major ions on tri-linear diagrams know as Piper Diagram.

For identification of different water faecies of groundwater, Piper diagram is widely used as it gives best graphical representation (Hill, 1940; Piper 1944) for finding out type of water. Groundwater can be grouped broadly into 5 types (**Fig: 9.1**). Shallow ground water from the state is mainly of Ca-Mg-Cl and Ca-Mg-HCO_3 type followed by Mixed Types like Na-Mg- HCO_3-Cl, Ca-Na- HCO_3-Cl and Mg-Ca-Na- HCO_3-Cl type.

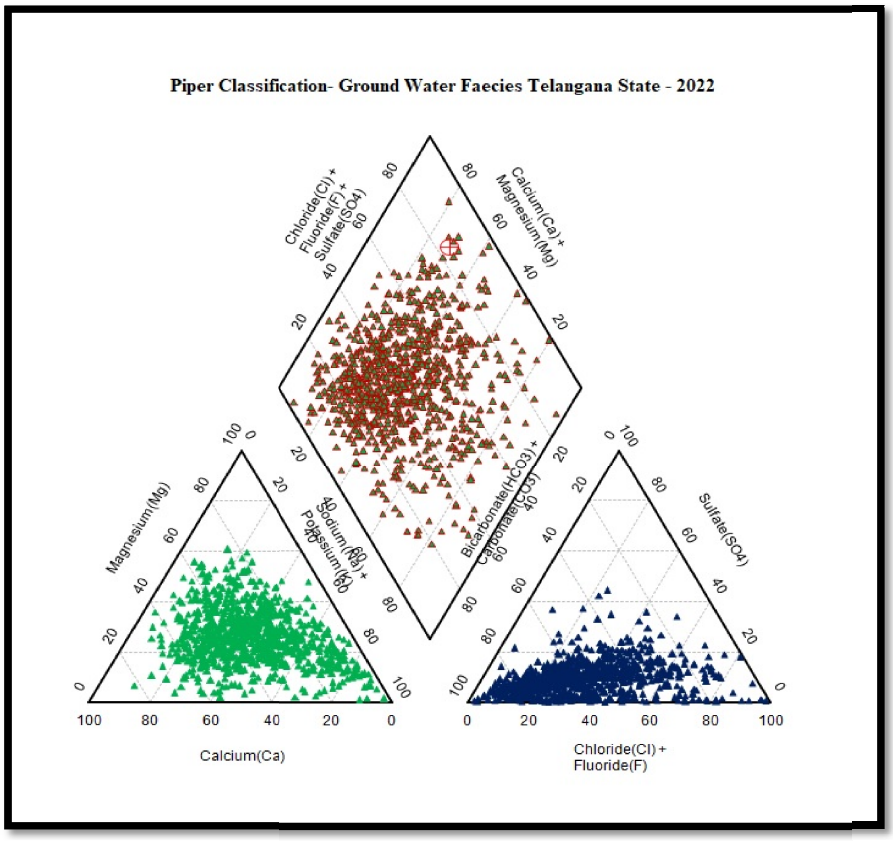


Fig. 9.1: Piper diagram of groundwater of Telangana

9.2 X-Y Plots:

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 Telangana most 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 Telangana, **65.58**% 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).

$$2Na+ - clay + Ca2+ = Ca2+ - clay + Na +$$

The observed Na+/Cl-< 1, may be attributed to groundwater interaction with connate seawater in coastal areas and Cl- enrichment from anthropogenic sources such as irrigation return flows or domestic waste disposal in another areas.

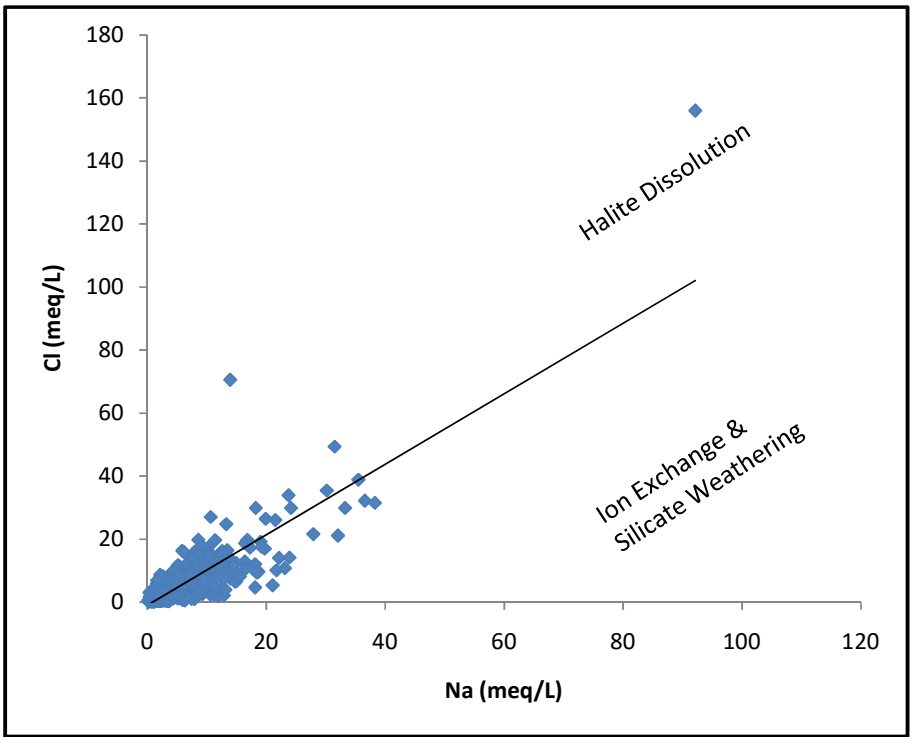


Fig. 9.2:The plot for Na versus Cl in groundwater samples of Telangana.

ANNEXURE-I:

S. No	Latitude	Longitude	Districts	Mandal	Location	E C in µS/cm
1	17.5939	81.0867	Bhadradri	Kukkunur	Chirevalli	3007
2	15.9147	78.0183	Jogulamba	Undavelli	Alampur X crossroad-Aq-I	3080
3	16.0254	77.976	Jogulamba	Manopadu	Boravalle	16500
4	16.28	77.7996	Jogulamba	Gadwal	Kothapalle	3260
5	18.4985	77.7843	Kamareddy	Birkoor	Bairangaidi	3550
6	16.8333	80.4722	Khammam	Yerrupalem	Yerupalem	4110
7	17.2603	80.4261	Khammam	Thallada	Annarugudem	3890
8	17.1167	80.3369	Khammam	Wyra	Rebbavaram	4946
9	17.2008	80.6431	Khammam	Penuballi	Sitarampuram	5400
10	16.3005	78.2794	Mahabubnagar	Kodair	Janumpalle	3100
11	18.0953	77.8839	Medak	Narayankhed	Nizampet	6640
12	16.6592	78.6031	Nagarkurnool	Charakonda	Jupally- Aq-I	5780
13	16.5158	78.3597	Nagarkurnool	Tadoor	Thaduru- Aq-I	3430
14	17.0773	79.0837	Nalgonda	Munugode	Munugodu-Pz	4320
15	16.8306	79.375	Nalgonda	Nidamanur	Nidamanuru- Pz	3630
16	17.0097	79.5389	Nalgonda	Vemulapalle	Mangapur	3040
17	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-I	4150
18	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	4320
19	16.8958	77.7103	Narayanpur	Kosgi	Gundimal	3150
20	18.6787	77.7944	Nizamabad	Bodhan	Khazipur	3035
21	17.1358	78.2742	Rangareddy	Kothur	Kothur-Pz	3070
22	17.61	77.7172	Sangareddy	Kohir	Kohir	5100
23	17.6628	77.7133	Sangareddy	Kohir	Pz of Aq-I, At-Digwal	7684
24	17.0528	79.8336	Suryapet	Munagala	Munagala	3206
25	17.2097	79.5944	Suryapet	Suryapet	Balwemla	3480
26	17.7516	79.525	Warangal	Wardhannapet	Dammannapet	3310
27	17.3575	79.0339	Yadadri	Valigonda	Nagaram	5590
28	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-I	3290
29	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-II	3560
30	17.3569	79.02	Yadadri	Valigonda	Nagaram- Aq-I	3500
31	17.3569	79.02	Yadadri	Valigonda	Nagaram-Aq-II	3840

ANNEXURE-II:

Sl No	Latitude	longitude	District	Mandal	Location	Cl > 1000 mg/L
1	16.0254	77.976	Jogulamba	Manopadu	Boravalle	5530
2	17.1167	80.3369	Khammam	Wyra	Rebbavaram	1377
3	17.2008	80.6431	Khammam	Penuballi	Sitarampuram	1117
4	18.0953	77.8839	Medak	Narayankhed	Nizampet	1750
5	17.0773	79.0837	Nalgonda	Munugode	Munugodu-Pz	1140
6	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	1057
7	17.61	77.7172	Sangareddy	Kohir	Kohir	1200
8	17.6628	77.7133	Sangareddy	Kohir	Pz of Aq-I, At-Digwal	2500
9	17.2097	79.5944	Suryapet	Suryapet	Balwemla	1059
10	17.3575	79.0339	Yadadri	Valigonda	Nagaram	1256
11	17.3569	79.02	Yadadri	Valigonda	Nagaram-Aq-II	1057

ANNEXURE-III:

Sl No	Latitude	longitude	Districts	Mandal	Location	F>1.5mg/ L
1	19.3441	78.3579	Adilabad	Boath	Boath-PZ	7.29
2	19.3579	78.4147	Adilabad	Neradigonda	Kumari	3.29
3	19.1434	78.3389	Adilabad	Nizamabad_South	Chincholi (bk)	1.51
4	19.6541	78.5656	Adilabad	Adilabad	Kachkanti	1.68
5	19.5261	78.3403	Adilabad	Bazar hatnoor	Morkhandi	9.08
6	19.6393	78.7049	Adilabad	Bela	Toyaguda	1.63
7	17.7544	81.1714	Bhadradri	Chintur	Edugarallapalli	1.96
8	17.8292	80.8306	Bhadradri	Aswapuram	Ashwapuram	3.44
9	17.5692	80.2486	Bhadradri	Yellandu	Mukundapuram	2.73
10	18.0427	79.3266	Hanamkonda	Bhimdevraopalli	Kothakonda Pz	1.87
11	17.8493	79.6074	Hanamkonda	Wardhannapeta	Panthini	3.16
12	17.9413	79.5572	Hanamkonda	Hanamkonda	Ammavaripeta	2.67
13	17.3345	78.4682	Hyderabad	Bandlaguda	Falaknama2	1.8
14	17.4753	78.5109	Hyderabad	Tirumalgiri	Tirumalgiri-PZ	1.9
15	17.4458	78.4361	Hyderabad	Khairatabad	Erragadda-PZ	2.48
16	17.4518	78.4957	Hyderabad	Tirumalgiri	Picket-1-PZ	1.55
17	18.7780	79.195308	Jagtial	Velgatur	Kothapet	2.44
18	18.8096	78.7802	Jagtial	Korutla	Mohanraopet1	1.92
19	18.8390	78.947	Jagtial	Jagitial Rural	Polosa	2.33
20	18.6514	78.8647	Jagtial	Kodimial	Thirumalapur	1.7
21	17.9078	79.4342	Jangaon	Pedda Pendyal	Pedda Pendyal	1.83
22	17.863	79.3025	Jangaon	Ghanpur	Thatikonda Pz	1.88
23	17.62	79.5025	Jangaon	Palakurthy	Vavillala Pz	1.82
24	17.848	79.3047	Jangaon	Ghanpur	Kothapalli	1.97
25	17.9733	79.2146	Jangaon	Tharigoppula	Bontagattu Nagaram	1.9
26	17.7033	79.1162	Jangaon	Jangaon	Yellamala	1.56
27	17.7806	79.3003	Jangaon	Raghunathpalle	Komalla	1.53
28	18.3344	79.6797	Jayashankar	Chittial	Chityal2	2
29	16.6592	78.6031	Jogulamba	Manopad	Jellapur-Aq-I	1.62
30	18.312265	79.289406	Karimnagar	Shankarapatnam	Tadikal	1.53
31	18.09961	79.4493	Karimnagar	Yelakaturthy	Yelakaturthy-Pz	2.95
32	18.37322	79.2911	Karimnagar	Manakondur	Kondapalakal	1.83
33	18.291083	79.123624	Karimnagar	Thimmapur	Renukunta Pz	2.41
34	18.31864	79.177989	Karimnagar	Thimmapur	Nusthulpur Pz	1.69
35	18.4697	78.7952	Karimnagar	Konaraopet	Suddala	1.96
36	17.5428	80.2264	Khammam	Singareni	Madharam-Pz	1.9
37	16.9244	80.3644	Khammam	Madhira	Madira1	1.56
38	17.3367	80.4419	Khammam	Enkuru	Enkur - Pz	1.64
39	17.1167	80.3369	Khammam	Wyra	Rebbavaram	2.48
40	17.1944	80.5089	Khammam	Thallada	Rangam Banjar Malsur Tanda	1.58
41	17.1483	80.3375	Khammam	Wyra	Thatipudi	2.27

42	17.1056	80.2847	Khammam	Bonakal	Thutikuntla	3.09
43	17.1675	80.2981	Khammam	Konijerla	Peddamunagala	1.61
44	16.7996	80.4979	Khammam	Yerupalem	Remidicherla	1.78
45	17.14	80.6585	Khammam	Penuballi	K.M Banjara (Telagavaram)	1.62
46	19.2596	79.4147	Komarambhem	Rebbana	Rebbenna1	2
47	19.3768	78.9066	Komarambhem	Sirpur_U	Jainoor- PZ	6.56
48	17.801	79.9796	Mahabubabad	Gudur	Gudur2	1.98
49	17.9104	80.0547	Mahabubabad	Kothaguda	Kothaguda	2
50	17.4311	79.9652	Mahabubabad	Maripeda	Edjarla Pz	1.66
51	17.4816	79.7737	Mahabubabad	Danthalapalle	Beerishettigudem	1.58
52	17.5001	79.9851	Mahabubabad	Kuravi	Ayyagaripalle	1.52
53	16.605	77.7983	Mahabubnagar	Devarkadara	Bandrapal (Banderpalli)	1.8
54	16.7475	78.1447	Mahabubnagar	Jadcherla	Jedcherla-Pz	1.9
55	16.5567	77.96	Mahabubnagar	Addakal	Kandur-Aq-I	2.09
56	16.6339	77.9894	Mahabubnagar	Musapet	Janampet-Aq-I	1.52
57	16.5567	77.96	Mahabubnagar	Addakal	Tarnikal-Aq-Ii	2.8
58	16.9764	78.0708	Mahabubnagar	Nawabpet	Chowdoor	1.78
59	16.3005	78.2794	Mahabubnagar	Kodair	Janumpalle	2.26
60	16.9066	77.8504	Mahabubnagar	Gandeed	Nacharla	1.9
61	19.0626	79.0766	Mancherial	Jannaram	Tapalpur	1.93
62	19.117	78.997	Mancherial	Jannaram	Jannaram	3.06
63	19.1959	79.5802	Mancherial	Bheemini	Bhimini -PZ-1	4.5
64	19.1959	79.5802	Mancherial	Vemanpalle	Bhimini-PZ- 2	2.64
65	19.1498	78.9424	Mancherial	Jannaram	Indanpally	2.9
66	18.0486	77.9794	Medak	Shankarampet_A	Bodagattu	1.71
67	17.8035	78.4709	Medak	Toopran	Toopran	1.97
68	17.7524	78.2746	Medak	Narsapur	Narsapur	2.08
69	17.4312	78.55	Medak	Uppal	Nacharam	3.4
70	17.4539	78.6906	Medchal	Ghatkesar	Ghatkesar2	1.65
71	17.6355	78.4754	Medchal	Medchel	Medchal1	1.73
72	17.669	78.5996	Medchal	Shamirpet	Thurakapalli	2.31
73	18.2329	80.3128	Mulugu	Tadvai	Tadvai-New	1.61
74	16.6131	78.6211	Nagarkurnool	Vangoor	Vangur-Pz	3.42
75	16.7281	78.4089	Nagarkurnool	Urkonda	Urukonda-Middle	2.31
76	16.7783	78.4006	Nagarkurnool	Urkonda	Bommaraju Palli	2.11
77	16.6742	78.4858	Nagarkurnool	Kalwakurthy	Kalwakurthy-Aq-I	1.61
78	16.3897	78.3522	Nagarkurnool	Nagar_Kurnool	Pedda Mudnur - Aq-I	1.64
79	16.295	78.5133	Nagarkurnool	Lingal	Lingala - Aq-I	3.04
80	16.5914	78.2158	Nagarkurnool	Bijinapalle	Vatem- Aq-I	2.15
81	16.7034	78.4551	Nagarkurnool	Kalaawakurthy	Marchala	3.4
82	16.6053	78.5053	Nagarkurnool	Gurrampod	Masangi	1.8
83	19.6375	79.0356	Nalgonda	Gadiguda	Chennamnen Palli	1.84
84	17.0981	79.0244	Nalgonda	Munugode	Chikatimamidi	2.1
85	17.1636	79.5211	Nalgonda	Kethepalle	Chikatguda	3.98
86	17.0097	79.5389	Nalgonda	Vemulapalle	Mangapur	1.96

87	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-I	4.95
88	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	2.6
89	16.8869	78.7947	Nalgonda	Chinthapalle	Kurumapalli, Aq-I	2.62
90	16.9823	78.8047	Nalgonda	Marriguda	Ajilapuram	1.71
91	16.6411	77.6564	Narayanpur	Dhanwada	Dhanwada-Pz	1.74
92	16.5583	77.6268	Narayanpur	Makthal	Jawlapur	1.55
93	18.8722	77.9451	Nirmal	Ranjal	Basar - PZ	4.37
94	19.0091	78.3815	Nirmal	Soan	Soan	1.59
95	19.0557	78.1143	Nirmal	Lokeswaram	Manmad	2.83
96	19.0982	78.7809	Nirmal	Kaddampeddur	Kadem	1.6
97	18.8534	78.3826	Nizamabad	Balkonda	Vennel Bashirabad	2.32
98	18.6374	78.425	Nizamabad	Bheemgel	Gangoppala	1.82
99	18.6363	79.534076	Peddapalle	Ramagiri	Kalwacherla	2.78
100	18.7780	79.27177	Peddapalle	Munjampalli	Munjampalli Pz (maredupalli)	1.6
101	18.6820	79.3215	Peddapalle	Peddapalli	Palthem	1.66
102	18.50307	78.93644	Rajanna	Boinpalli	Boinpally Pz	2.53
103	18.435578	78.95896	Rajanna	Boinpalli	Venkatraopalli Pz	2.07
104	18.47167	78.9614	Rajanna	Boinpalli	Vilasagar	1.58
105	16.8822	78.5283	Rangareddy	Amangal	Vithayapalli-Aq-I	2.78
106	17.0602	77.956	Rangareddy	Kulkacharle	Kistampalli	2.56
107	17.3831	78.7247	Rangareddy	Abdullapurmet	Chinna Raviral	2.8
108	17.3029	78.7283	Rangareddy	Abdullapurmet	Bata Singaram	2.56
109	17.3334	78.409	Rangareddy	Rajendranagar	Rajendranagar1	3.3
110	17.3357	78.58	Rangareddy	Saroornagar	Vanasthalipuram -Pz	1.68
111	17.1656	78.3305	Rangareddy	Serilingampally	Muchinthal	3.4
112	17.2261	78.7068	Rangareddy	Ibrahimpatnam	Polkampalli	2.24
113	17.3403	78.5248	Rangareddy	Saroornagar	Karmanghat	2.47
114	17.3769	78.61	Rangareddy	Abdullapurmet	Marripally	1.83
115	17.2878	78.7053	Rangareddy	Abdulapurmet	Guntapally	3.05
116	17.0424	78.8338	Rangareddy	Manchal	Loyapalli	5.85
117	17.3582	78.7269	Rangareddy	Manchal	Manchal	2.34
118	17.1356	78.4367	Rangareddy	Maheshwaram	Maheshwaram	5.89
119	17.7614	77.7103	Sangareddy	Jharasangam	Jharasangam-Pz	1.81
120	17.9086	77.6833	Sangareddy	Naykal	Chalki	2.03
121	17.7683	77.9572	Sangareddy	Pulkal	Pz of Aq-I, At-Peddareddypet	2.03
122	17.8947	78.0581	Sangareddy	Andhole	Pz of Aq-I, At-Rollapadu	1.64
123	17.6442	78.2797	Sangareddy	Jinnaram	Pz of Aq-II, At-Solakapalli	1.6
124	17.8458	77.657	Sangareddy	Nayalkal	Nayalkal	6
125	17.6326	78.3303	Sangareddy	Jinnaram	Jinnaram	1.62
126	18.103101	79.056496	Siddipet	Koheda	Buswapuram1	1.75

127	18.11000	79.115328	Siddipet	Koheda	Samudrala Pz	1.73
128	18.1058	78.8356	Siddipet	Siddipet_Urban	Siddipet-Pz	2.08
129	18.2806	78.7181	Siddipet	Cherial	Dommata	1.56
130	17.9643	78.714	Siddipet	Thoguta	Kistapur	2.01
131	18.0093	78.7203	Siddipet	Thoguta	Thoguta	2.21
132	18.0665	79.0461	Siddipet	Nanganur	Nanganur	2.24
133	18.0917	78.9435	Siddipet	Nanganur	Rajgopalpet	1.56
134	17.8986	78.9933	Siddipet	Cherial	Mutsyala-Pz	1.67
135	16.9306	79.9583	Suryapet	Kodad	Kodad-Pz	1.95
136	17.2675	79.6258	Suryapet	Atmakur_S	Kandagatla Pz-2	1.96
137	16.89	79.9492	Suryapet	Kodad	Yerravaram, Aq-I	1.97
138	17.1511	77.7055	Vikarabad	Bomraspet	Kothur EW	1.68
139	17.0105	77.6008	Vikarabad	Doultabad	Yamki EW	4.31
140	17.3391	77.6605	Vikarabad	Peddemul	Peddamul	1.52
141	17.63	77.6133	Vikarabad	Zahirabad	Indur-Pz	3.36
142	17.1361	77.9521	Vikarabad	Parigi	Rapole	1.53
143	17.0729	77.8341	Vikarabad	Doma	Pallepalli	1.53
144	18.0683	79.6899	Warangal	Damera	Urugonda	1.66
145	17.9238	79.8865	Warangal	Narsampet	Narsampet	2.77
146	18.1211	79.7476	Warangal	Shayampet	Sayampeta-Pz	2.06
147	17.954	79.951	Warangal	Khanapur	Ashok Nagar	1.86
148	17.986	79.9135	Warangal	Narsampet	Akulatanda	2.21
149	18.0217	79.8063	Warangal	Duggondi	Duggondi	1.71
150	17.8433	79.8564	Warangal	Chennaraopet	Jhalli	2.06
151	17.8328	79.7077	Warangal	Sangem	Theegarajupalli	2.56
152	17.5752	79.7544	Warangal	Nellikudur	Nellikuduru	1.71
153	17.3472	78.8197	Yadadri	Srikonda	Pochampalli	1.88
154	17.6569	78.7958	Yadadri	Turkapalle_M	M.Turkapalli-Pz	1.81
155	17.5272	78.8831	Yadadri	Bhongiri	Hasanabad	3.75
156	17.2739	78.7961	Yadadri	Choutuppal	Malkapuram	2.35
157	17.2933	79.0953	Yadadri	Ramannapeta	Ramannapet	2.06
158	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-I	3.48
159	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-II	3.43
160	17.6417	78.8664	Yadadri	Turkapalle_M	Venkatapuram	3.28
161	17.6339	78.9117	Yadadri	Yadagirigutta	Mallapuram	2.18
162	17.2764	78.8008	Yadadri	Choutuppal	Malkapur Aq-Ii	3.33
163	17.3569	79.02	Yadadri	Valigonda	Nagaram- Aq-I	3.02
164	17.4089	79.1297	Yadadri	Valigonda	Lingarajpalle	1.82
165	17.3231	79.1578	Yadadri	Ramannapeta	Munipampula	1.99
166	17.5336	79.0936	Yadadri	Mootakondur	Chandepalli	1.54

ANNEXURE-IV:

Sr. No.	Latitude	Longitude	District	Mandal	Location	NO3 (>45mg/L)
1	19.581	78.4937	Adilabad	Gudihathnur	Sitagondi	84
2	19.5304	78.5134	Adilabad	Gudihathnur	Gudihathur	54
3	19.6667	78.5333	Adilabad	Wankdi	Wakri (wankidi colony)	67
4	19.375	78.777	Adilabad	Bela	Utnoor	122
5	19.2979	78.4063	Adilabad	Neradigonda	Neredikonda1	63
6	19.7193	78.7624	Adilabad	Bela	Bela1	115
7	19.3263	78.818	Adilabad	Utnur	Dantalapally	151
8	19.4288	78.4507	Adilabad	Ichoda	Echoda-PZ	54
9	19.7186	78.7609	Adilabad	Bela	Bela-PZ	103
10	19.5004	78.6622	Adilabad	Inderavelly	Indravalli-PZ	105
11	19.3746	78.7769	Adilabad	Utnoor	Utnoor	83
12	19.6377	78.5083	Adilabad	Mavala	Mavala (adilabad)	142
13	19.5124	78.5853	Adilabad	Neradigonda	Danora - B	118
14	19.5977	78.3216	Adilabad	Adilabad Rural	Ratnapur kandili	91
15	19.6541	78.5656	Adilabad	Adilabad	Kachkanti	173
16	19.796	78.3914	Adilabad	Bheempur	Kamatwada	61
17	19.4555	78.4501	Adilabad	Ichoda	Gubba - Ramtek	137
18	19.7625	78.6974	Adilabad	Jainad	Karanji -khurd	112
19	19.6379	78.3726	Adilabad	Talamadugu	Dorli	129
20	19.6941	78.3721	Adilabad	Talamadugu	Lingi	133
21	19.7074	78.4579	Adilabad	Tamsi	Jamidi	175
22	19.3027	78.8061	Adilabad	Utnur	Balampur	135
23	19.3656	78.9649	Adilabad	Sirpur U	Devadapalle	89
24	19.4759	78.3818	Adilabad	Bazar Hatnoor	Dehgaon	59
25	18.72895	79.1709	Adilabad	Narnoor	Kothapally	69
26	17.7544	81.1714	Bhadradri	Chintur	Edugarallapalli	150
27	17.6056	80.7464	Bhadradri	Palawancha	Kesavapuram	97
28	17.7333	81.1	Bhadradri	Nellipaka	Lakshmipuram	96
29	17.3883	81.1111	Bhadradri	Aswaraopeta	Aspaka	64
30	17.5939	81.0867	Bhadradri	Kukkunur	Chirevalli	200
31	17.0192	79.8789	Bhadradri	Munagala	Mukundapuram	119
32	17.8706	79.548	Hanamkonda	Inavole	Inoli Pz	91
33	17.9413	79.5572	Hanamkonda	Hanamkonda	Ammavaripeta	56
34	18.0055	79.3322	Hanamkonda	Velair	Velair	121
35	18.0787	79.5012	Hanamkonda	Hasanparthy	Yellapur	60
36	17.3345	78.4682	Hyderabad	Bandlaguda	Falaknama2	58
37	17.445	78.452	Hyderabad	Ammerpet	Begumpet-PZ (Balkampet)	48
38	17.3622	78.4236	Hyderabad	Khairatabad	Attapur	76
39	18.95013	79.09741	Jagtial	Dharmapuri	Dharmapuri-New	158
40	18.83953	78.64767	Jagtial	Metpalli	Metpalli1 (Arepeta)	127
41	18.79752	78.90105	Jagtial	Jagityal	Jagityal-New	153
42	18.83905	78.9476	Jagtial	Jagitial Rural	Polosa	94
43	18.79953	79.01019	Jagtial	Gollapalli	Mallannapeta	170
44	18.78945	78.69432	Jagtial	Korutla	Yakeenpur	50

45	17.9078	79.4342	Jangaon	Pedda Pendyal	Pedda Pendyal	126
46	17.7679	79.3745	Jangaon	Ghanpur	Ippagudem	91
47	17.863	79.3025	Jangaon	Ghanpur	Thatikonda Pz	57
48	17.8507	79.3692	Jangaon	Ghanpur	Ghanpur Pz	57
49	17.848	79.3047	Jangaon	Ghanpur	Kothapalli	224
50	17.7341	79.4085	Jangaon	Palakurthy	Gudur Pz	95
51	17.6629	79.3193	Jangaon	Devruppula	Kolukonda Pz	73
52	17.5278	79.463	Jangaon	Kodakandla	Ramavaram	49
53	18.72976	79.97971	Jayashankar	Mahadevpur	Mahadevpur1	64
54	18.62549	79.94478	Jayashankar	Kataram	Garepalli	123
55	18.1623	80.4007	Jayashankar	Tadvai	Katapuram-2	280
56	16.23	77.8106	Jogulamba	Gadwal	Mitta Nandimala	57
57	16.1603	77.9286	Jogulamba	Itikyal	Beechapally	46
58	16.28	77.7996	Jogulamba	Gadwal	Kothapalle	74
59	17.9211	77.8933	Jogulamba	Watpalle	Medikonda	100
60	18.4005	77.7148	Kamareddy	Bichkunda	Bichkunda	160
61	18.7078	78.0229	Kamareddy	Pitlam	Janakampet	90
62	18.3206	77.8505	Kamareddy	Pitlam	Rampurkalan1	399
63	18.3129	78.2547	Kamareddy	Kamareddy	Tadvai-1	84
64	18.4001	77.7251	Kamareddy	Bichkunda	Bichkunda-Pz	153
65	18.3218	78.3436	Kamareddy	Gambhiraopeta	Kamareddy-2012pz	260
66	18.2833	78.352	Kamareddy	Kamareddy	Patarajampet	100
67	18.4985	77.7843	Kamareddy	Birkoor	Bairangaidi	190
68	18.2141	78.3453	Kamareddy	Bhiknur	Arepally	46
69	18.31227	79.28941	Karimnagar	Shankarapatnam	Tadikal	52
70	18.28167	78.71383	Karimnagar	Mustabad	Mustafabad	58
71	18.09962	79.44936	Karimnagar	Yelakaturthy	Yelakaturthy-Pz	64
72	18.44493	79.28341	Karimnagar	Manakondur	Lakshmipur Pz	73
73	18.31864	79.17799	Karimnagar	Thimmapur	Nusthulpur Pz	49
74	18.22689	79.37421	Karimnagar	Huzurabad	Tummanapalli	84
75	18.29346	79.30078	Karimnagar	Shankarapatnam	Kesawapatnam	236
76	18.4697	78.7952	Karimnagar	Konaraopet	Suddala	100
77	16.8333	80.4722	Khammam	Yerrupalem	Yerupalem	493
78	17.3367	80.4419	Khammam	Enkuru	Enkur - Pz	55
79	17.2233	80.2939	Khammam	Konijerla	Konijarla	53
80	17.2603	80.4261	Khammam	Thallada	Annarugudem	163
81	17.1167	80.3369	Khammam	Wyra	Rebbavaram	217
82	17.1944	80.5089	Khammam	Thallada	Rangam Banjar Malsur Tanda	130
83	17.1483	80.3375	Khammam	Wyra	Thatipudi	86
84	17.2008	80.6431	Khammam	Penuballi	Sitarampuram	52
85	17.1741	80.0402	Khammam	Mudigonda	Kattakur	60
86	16.7996	80.4979	Khammam	Yerupalem	Remidicherla	61
87	17.2032	80.5826	Khammam	Kallur	Bathulapally	66
88	17.3114	80.0365	Khammam	Thirumalayapalem	Thirumalayapalem	256
89	19.3656	79.2833	Komaram bhem	Asifabad	Asifabad	50
90	19.2596	79.4147	Komaram	Rebbana	Rebbenna1	69

			bhem			
91	19.5938	78.774	Komaram bhem	Kerameri	Sangvi	61
92	17.4867	80.1392	Mahabubabad	Garla	Garla	102
93	17.4867	80.1392	Mahabubabad	Garla	Gandhampally (Santulalpod)	196
94	17.801	79.9796	Mahabubabad	Gudur	Gudur2	63
95	17.6672	79.8018	Mahabubabad	Kesamudram	Ingurti	111
96	17.6865	79.9001	Mahabubabad	Kesamudram	Kesamudram	75
97	17.4311	79.9652	Mahabubabad	Maripeda	Edjarla Pz	67
98	16.7475	78.1447	Mahabubnagar	Jadcherla	Jedcherla-Pz	47
99	16.7436	78.3231	Mahabubnagar	Midjil	Midjil-Pz	167
100	16.8122	77.9194	Mahabubnagar	Hanwada	Hanwada	307
101	16.5978	77.8972	Mahabubnagar	Devarakadra	Baswaipalle	83
102	16.9764	78.0708	Mahabubnagar	Nawabpet	Chowdoor	51
103	16.8644	78.1332	Mahabubnagar	Rajapur	Chennavalli	270
104	16.3005	78.2794	Mahabubnagar	Kodair	Janumpalle	54
105	18.8462	79.6963	Mancherial	Gollapalle	Bhimavaram1	70
106	18.864	79.3039	Mancherial	Hajipur	Hajipur	282
107	19.0626	79.0766	Mancherial	Jannaram	Tapalpur	65
108	19.1959	79.5802	Mancherial	Bheemini	Bhimini -PZ-1	84
109	19.0897	78.9493	Mancherial	Jannaram	Kalamadugu	205
110	18.909	79.1973	Mancherial	Luxettipet	Lakshettipet-3	47
111	18.8721	79.4284	Mancherial	Mancherial	Old manchierala	55
112	17.9014	78.2078	Medak	Kowdipalle	Kaudipally-Pz	114
113	18.0211	78.0672	Medak	Papannapet	Narsingi	258
114	18.0953	77.8839	Medak	Narayankhed	Nizampet	361
115	17.78	78.2586	Medak	Narsapur	Pz of Aq-I, At-Reddypalli	48
116	18.0953	77.8839	Medak	Narayankhed	Nizampet	55
117	18.069	78.4261	Medak	Narsingi	Japtisivnoor	66
118	17.7658	78.4637	Medak	Manoharabad	Manoharabad	56
119	18.0981	78.2486	Medak	Haveli Ghanpur	Patigadda Tanda	80
120	17.7863	78.3697	Medak	Sivampet	Sivampet	102
121	17.9573	78.4649	Medak	Chegunta	Wadiyaram	100
122	17.7864	78.3902	Medak	Chandi	Chandi	80
123	17.4312	78.55	Medak	Uppal	Nacharam	196
124	17.5972	78.5792	Medchal	Shamirpet	Aliabad	119
125	17.4023	78.561	Medchal	Uppal	Uppal	60
126	17.4782	78.5736	Medchal	Kapra	Kushaiguda	95
127	18.2059	80.1021	Mulugu	Govindaraopet	Chelvai-2	85
128	18.1944	80.1666	Mulugu	Govindaraopet	Pasara	86
129	16.7783	78.4006	Nagarkurnool	Urkonda	Bommaraju Palli	95
130	16.6592	78.6031	Nagarkurnool	Charakonda	Jupally- Aq-I	1128
131	16.6742	78.4858	Nagarkurnool	Kalwakurthy	Kalwakurthy- Aq-I	95
132	16.6956	78.7108	Nagarkurnool	Charakonda	Charakonda- Aq-I	105
133	16.5158	78.3597	Nagarkurnool	Tadoor	Thaduru- Aq-I	62
134	16.4494	78.4517	Nagarkurnool	Telkapalle	Telkapalli- Aq-I	97
135	16.5822	78.1558	Nagarkurnool	Bijinapalle	Manganur- Aq-I	110
136	16.4733	78.1672	Nagarkurnool	Bijinapalle	Mamaipalli- Aq-I	66
137	16.4153	78.685	Nagarkurnool	Achampet	Nadimpalli- Aq-I	95

138	16.5067	78.6867	Nagarkurnool	Uppunuthala	Veltoor- Aq-I	73
139	16.7034	78.4551	Nagarkurnool	Kalaawakurthy	Marchala	53
140	17.0508	79.2758	Nalgonda	Nalgonda	Nalgonda-2	166
141	16.8228	79.3689	Nalgonda	Nidamanur	Nidamanuru	104
142	16.6911	78.9189	Nalgonda	Devarakonda	Devarakonda	162
143	16.8333	79.5	Nalgonda	Miryalaguda	Thungapadu	52
144	17.0994	79.4194	Nalgonda	Nakrekal	Nakrekal-Pz	85
145	16.8583	78.925	Nalgonda	Nampalle	Devarakonda	68
146	16.875	79.5653	Nalgonda	Miryalaguda	Miryalaguda- Pz	66
147	16.8306	79.375	Nalgonda	Nidamanur	Nidamanuru- Pz	205
148	16.9467	79.2017	Nalgonda	Kangal	Kanagal-Pz	54
149	16.975	79.4639	Nalgonda	Madugulapally	Madugula Palli-Pz	72
150	16.5403	78.7083	Nalgonda	Gundlapalle	G.Palli(Dindi)-Pz	124
151	16.8972	79.5333	Nalgonda	Huzurnagar	Huzurnagar-Pz	183
152	16.7289	79.2108	Nalgonda	Peddavura	Peddavoora	92
153	16.9253	79.5306	Nalgonda	Vemulapalle	Vemulapalli	55
154	16.5847	79.3214	Nalgonda	Peddavura	Nagarjunasagar Polygon	77
155	17.0981	79.0244	Nalgonda	Munugode	Chikatimamidi	95
156	17.0097	79.5389	Nalgonda	Vemulapalle	Mangapur	223
157	17.08	79.4997	Nalgonda	Thipparthi	Yellammagudem	48
158	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-I	242
159	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	93
160	17.1597	79.5081	Nalgonda	Kethepalle	Kethepalli	313
161	16.7944	79.4631	Nalgonda	Thripuraram	Satyanarayanapuram, Aq-I	441
162	16.8869	78.7947	Nalgonda	Chinthapalle	Kurumapalli, Aq-I	183
163	16.9823	78.8047	Nalgonda	Marriguda	Ajilapuram	438
164	16.8328	79.4742	Nalgonda	Thripuraram	Tripuraram	64
165	16.9697	79.4658	Nalgonda	Madugulapally	Magulapally	207
166	16.6053	78.8269	Nalgonda	Chandampet	Gagillapuram	103
167	16.6357	79.3684	Nalgonda	Peddavura	Godumadaka	183
168	16.7334	78.7831	Nalgonda	Devarkonda	Iddampalli	110
169	16.8958	77.7103	Narayanpur	Kosgi	Gundimal	353
170	16.6411	77.6564	Narayanpur	Dhanwada	Dhanwada-Pz	228
171	16.5106	77.5025	Narayanpur	Makthal	Makthal	87
172	19.0767	78.5253	Nirmal	Nizamabad_South	Mamda	77
173	19.195	78.6355	Nirmal	Pembi	Pembi	108
174	19.0154	78.5301	Nirmal	Mamda	Potaram	47
175	18.8722	77.9451	Nirmal	Ranjal	Basar - PZ	103
176	18.9837	77.92	Nirmal	Mudhole	Mudhol-PZ	144
177	19.061	77.9158	Nirmal	Bhainsa	Elegaon	46
178	19.5289	78.5667	Nirmal	Mudhole	Tocham	51
179	19.2122	78.8772	Nirmal	Sarangapur	Udampur	137
180	18.9821	77.7851	Nirmal	Kaddampeddur	Wadgaon	132
181	19.1029	77.9781	Nirmal	Bhainsa	Bhainsa	120
182	18.966	78.0283	Nirmal	Lokeshwaram	Kankapur	60
183	19.2477	77.9573	Nirmal	Kubeer	Rajura	87
184	19.0466	78.2771	Nirmal	Dilawarpur	Saghvi	288
185	19.088	78.0663	Nirmal	Bhainsa	Pendapalle	47

186	18.9821	77.7851	Nirmal	Tanoor	Wadgaon	130
187	18.9791	78.3778	Nizamabad	Nandipet	Dudgaon	96
188	18.8712	78.3399	Nizamabad	Balkonda	Balkonda1	50
189	18.5759	78.3618	Nizamabad	Indalwai	Dharpalli-Pz	48
190	18.7998	78.2886	Nizamabad	Armur	Armur-Pz	276
191	18.1524	78.4129	Nizamabad	Uppal	Baswapur	110
192	18.8719	78.345	Nizamabad	Balkonda	Balkonda 2012pz	66
193	18.6787	77.7944	Nizamabad	Bodhan	Khazipur	196
194	18.8649	78.4261	Nizamabad	Mortad	Dharmora	128
195	18.6374	78.425	Nizamabad	Bheemgel	Gangoppala	65
196	18.6338	78.3729	Nizamabad	Dharpalli	Dubbaka	62
197	18.9562	78.201	Nizamabad	Nandipet	Annaram	97
198	18.9096	78.358	Nizamabad	Mupkal	Mupkal	95
199	18.5118	78.2221	Nizamabad	Indralwai	Chandrainpally	67
200	18.8035	78.1058	Nizamabad	Maklur	Gotimukala	93
201	18.65771	79.81005	Peddapalle	Manthani	Venkatapur	50
202	18.63634	79.53408	Peddapalle	Ramagiri	Kalwacherla	88
203	18.65213	79.67011	Peddapalle	Manthani	Manthani	201
204	18.50307	78.93644	Rajanna	Boinpalli	Boinpally Pz	77
205	18.43558	78.95897	Rajanna	Boinpalli	Venkatraopalli Pz	53
206	18.28056	78.7185	Rajanna	Mustabad	Mustabad	72
207	17.0375	78.2753	Rangareddy	Farooqnagar	Weljorla	235
208	16.9681	78.5014	Rangareddy	Kadthal	Kadtal-Pz	50
209	16.9553	78.345	Rangareddy	Keshampeta	Kesampet-Pz	287
210	17.0828	78.1175	Rangareddy	Farooqnagar	Mogiligidda-Pz	52
211	16.995	78.2467	Rangareddy	Farooqnagar	Gantlavelli-Pz	54
212	16.8906	78.4133	Rangareddy	Talakondapalle	Talakondapalli-Pz	121
213	16.8558	78.6922	Rangareddy	Madgul	Madugula-Pz	80
214	16.8822	78.5283	Rangareddy	Amangal	Vithayapalli- Aq-I	140
215	17.0602	77.956	Rangareddy	Kulkacharle	Kistampalli	62
216	17.3831	78.7247	Rangareddy	Abdullapurmet	Chinna Raviral	350
217	17.3029	78.7283	Rangareddy	Abdullapurmet	Bata Singaram	76
218	17.4578	78.1324	Rangareddy	Shankarpalle	Shankarapally	101
219	17.3254	78.032	Rangareddy	Chevella	Antaram (C)	94
220	17.2561	78.3957	Rangareddy	Shamshabad	Shamshabad1	53
221	17.3292	78.6047	Rangareddy	Hayathnagar	Hayatnagar-1	82
222	17.1603	78.7269	Rangareddy	Manchal	Manchal	93
223	17.3582	78.5359	Rangareddy	Saroornagar	Saroornagar-Pz	57
224	17.4621	78.435	Rangareddy	Balanagar	Sanathnagar	55
225	17.3073	78.1391	Rangareddy	Chevella	Chevella-Pz	131
226	17.374	78.1582	Rangareddy	Chevella	Kammeta-Pz	107
227	17.2358	78.1335	Rangareddy	Shabad	Nagarguda-Pz	48
228	17.1516	78.3434	Rangareddy	Maheshwaram	Ameerpelli	81
229	17.0806	78.3665	Rangareddy	Maheshwaram	Kollapadkal	151
230	17.048	78.3967	Rangareddy	Kandukur	Chippalapally	111
231	17.4738	77.756	Rangareddy	Serilingampally	Peddapur	47
232	17.1203	78.1594	Rangareddy	Shabad	Salbathpur	53
233	17.2261	78.7068	Rangareddy	Ibrahimpatnam	Polkampalli	63
234	17.1986	78.6458	Rangareddy	Ibrahimpatnam	Ibrahimpatnam	74
235	17.3749	78.0604	Rangareddy	Chevella	Tangadpalli	70
236	17.2087	78.2739	Rangareddy	Kothur	Gudur	246

237	17.1629	78.6329	Rangareddy	Ibrahimpatnam	C-Patelgudem	54
238	16.9704	78.6793	Rangareddy	Yacharam	Kottapalli	159
239	17.1086	78.3701	Rangareddy	Maheshwaram	Dubbacherla	139
240	17.7261	77.5997	Sangareddy	Zahirabad	Didigi	98
241	17.5628	77.6908	Sangareddy	Kohir	Bilalpur(Pn)	48
242	17.6794	78.3686	Sangareddy	Gummadidala	Gumardalla1	79
243	17.9022	77.8497	Sangareddy	Watpalle	Ghatpalli	109
244	18.0389	77.7722	Sangareddy	Narayankhed	Narayankhed	72
245	17.6514	78.2353	Sangareddy	Hathanoora	Chintala Cheruvu-Pz	53
246	17.61	77.7172	Sangareddy	Kohir	Kohir	241
247	17.7444	77.8106	Sangareddy	Munipalli	Tatipally	210
248	18.2322	77.7058	Sangareddy	Kangti	Tadkal	125
249	17.8436	77.9761	Sangareddy	Andhole	Talelma	53
250	17.8836	77.9161	Sangareddy	Watpalle	Nagulapally	200
251	17.5567	78.2792	Sangareddy	Patancheruvu	Rameshwaram Banda	110
252	17.5656	77.6569	Sangareddy	Kohir	Badampet	90
253	17.6961	77.6403	Sangareddy	Zahirabad	Pastapur	67
254	17.6228	78.1569	Sangareddy	Sangareddy	Pz of Aq-I, At-Ismailkhanpet	183
255	17.7647	78.0119	Sangareddy	Pulkal	Pz of Aq-I, At-Mudimanikyam	65
256	17.6572	77.9322	Sangareddy	Sadasivpet	Pz of Aq-I, At-Atmakur	70
257	17.7683	77.9572	Sangareddy	Pulkal	Pz of Aq-I, At-Peddareddypet	120
258	17.8867	77.8094	Sangareddy	Manoor	Raipally	49
259	18.1836	77.8731	Sangareddy	Kalher	Masanpally	119
260	17.6326	78.3303	Sangareddy	Jinnaram	Jinnaram	121
261	17.6311	78.3309	Sangareddy	Jinnaram	Jinnaram	54
262	18.1031	79.0565	Siddipet	Koheda	Buswapuram1	52
263	18.126	79.21143	Siddipet	Husnabad	Husnabad-1	105
264	18.04234	79.23828	Siddipet	Akkannapet	Katkur Pz	91
265	18.0079	79.15772	Siddipet	Akkannapet	Gandipalli Pz	46
266	18.1397	78.9142	Siddipet	Chinnakodur	Ramanpatla	81
267	17.9341	78.7187	Siddipet	Gajwel	Ahimadepur	120
268	18.1617	78.8966	Siddipet	Chinnakodur	Chinnakodur	52
269	18.1743	78.6669	Siddipet	Dubbak	Dubbak	78
270	17.7687	78.8051	Siddipet	Jagadevpur	Jagadevpur	68
271	17.9643	78.714	Siddipet	Thoguta	Kistapur	46
272	17.9758	78.8614	Siddipet	Kondapak	Kondapak	173
273	17.9354	78.6293	Siddipet	Daulatabad	Raipole	326
274	18.2387	78.9236	Siddipet	Chinnakodur	Alipur	252
275	18.0641	78.8576	Siddipet	G.P. Ponnala	G.P. Ponnala	63
276	17.8438	78.6921	Siddipet	Gajwel	Gajwel	51
277	18.1758	78.7762	Siddipet	Siddipet	Raghavapuram	279
278	17.7739	78.6152	Siddipet	Wargal	Wargal	54
279	17.9022	78.8076	Siddipet	Kondapaka	Medinipur	49
280	18.0917	78.9435	Siddipet	Nanganur	Rajgopalpet	50
281	17.8048	78.748	Siddipet	M-Markook	Ganeshpalli	48
282	17.7708	78.6914	Siddipet	M-Markook	Pamulaparthi	72

283	17.7368	78.6378	Siddipet	Mulugu	Mulugu	52
284	17.8986	78.9933	Siddipet	Cherial	Mutsyala-Pz	88
285	17.0528	79.8336	Suryapet	Munagala	Munagala	135
286	17.1333	79.6236	Suryapet	Suryapet	Suryapet-Pz	70
287	17.0083	79.6528	Suryapet	Penpahad	Penpahad-Pz	93
288	16.9306	79.9583	Suryapet	Kodad	Kodad-Pz	155
289	17.0517	79.8367	Suryapet	Munagala	Munagala-Pz	62
290	16.9169	79.7261	Suryapet	Garidepalle	Ponugudu	77
291	17.1669	79.5992	Suryapet	Suryapet	Pillalamarri	65
292	17.165	79.6272	Suryapet	Chivvemla	Kudakuda	68
293	17.2319	79.6964	Suryapet	Atmakur_S	S.Atmakur	226
294	17.0214	79.6178	Suryapet	Penpahad	Dospadu	50
295	17.1225	77.6678	Vikarabad	Bomraspeta	Ragidimailaram	197
296	16.9603	77.5736	Vikarabad	Doulatabad	Goka Paslabad	68
297	17.0539	77.6528	Vikarabad	Kodangal	Hasnabad	71
298	17.1072	77.6264	Vikarabad	Kodangal	Kodangal	112
299	17.1519	77.6347	Vikarabad	Bomraspeta	Enkapalli	100
300	17.3351	77.9014	Vikarabad	Vikarabad	Vikarabad	50
301	17.4654	78.0035	Vikarabad	Mominpet	Chimaldarri	67
302	17.3391	77.6605	Vikarabad	Peddemul	Peddamul	68
303	17.3824	77.7462	Vikarabad	Kotepally	Kotepally (New)	66
304	17.2275	78.2018	Vikarabad	Pudur	Hyatabad-Pz	51
305	17.2889	78.0306	Vikarabad	Pudur	Angadi Chittampalli	79
306	17.2617	77.591	Vikarabad	Tandur	Thandur	96
307	17.2102	77.6377	Vikarabad	Yelal	Yelal	60
308	17.3583	77.9915	Vikarabad	Vikarabad	Siddlur	109
309	17.1145	77.8709	Vikarabad	Doma	Bompalli	107
310	17.1994	78.0075	Vikarabad	Pudur	Kankal	108
311	17.225	77.8725	Vikarabad	Pargi	Naskal	126
312	17.3111	77.8285	Vikarabad	Dharur	Kerelli	62
313	17.4944	77.9416	Vikarabad	Mominpet	Yenkathala	56
314	17.437	77.9818	Vikarabad	Nawabpet	Vattiminapally	110
315	17.5231	77.8428	Vikarabad	Marpalle	Siripuram	159
316	17.1554	77.4671	Vikarabad	Marpalle	Marpally	198
317	17.1514	77.8482	Vikarabad	Parigi	Sultanpoor Thanda	64
318	16.1989	77.9975	Wanaparthy	Pebbair	Pebbair-Aq-I	209
319	16.0503	78.1644	Wanaparthy	Chinnambavi	Peddadaggada-Aq-I	50
320	16.5519	78.0385	Wanaparthy	Ghanpur	Khilla Ghanpur	276
321	17.6686	79.0431	Warangal	Alair	Aler	79
322	18.0683	79.6899	Warangal	Damera	Urugonda	55
323	17.954	79.951	Warangal	Khanapur	Ashok Nagar	84
324	17.986	79.9135	Warangal	Narsampet	Akulatanda	95
325	18.0217	79.8063	Warangal	Duggondi	Duggondi	62
326	17.8433	79.8564	Warangal	Chennaraopet	Jhalli	229
327	17.8328	79.7077	Warangal	Sangem	Theegarajupalli	150
328	17.5752	79.7544	Warangal	Nellikudur	Nellikuduru	82
329	17.7516	79.525	Warangal	Wardhannapet	Dammannapet	482
330	17.3472	78.8197	Yadadri	Srikonda	Pochampalli	140
331	17.3472	78.8197	Yadadri	Pochampalle	Pochampalli	131
332	17.25	78.9158	Yadadri	Choutuppal	Choutuppal-	263
333	17.6569	78.7958	Yadadri	Turkapalle_M	M.Turkapalli- Pz	91

334	17.5847	78.8625	Yadadri	Bhongiri	Yadagirigutta	59
335	17.3575	79.0339	Yadadri	Valigonda	Nagaram	326
336	17.5272	78.8831	Yadadri	Bhongiri	Hasanabad	68
337	17.2739	78.7961	Yadadri	Choutuppal	Malkapuram	53
338	17.2933	79.0953	Yadadri	Ramannapeta	Ramannapet	111
339	17.6692	78.9467	Yadadri	Yadagirigutta	Gouraipally	150
340	17.2431	78.9556	Yadadri	Choutuppal	Panthangi -Pz 1	88
341	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-I	93
342	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-II	93
343	17.6417	78.8664	Yadadri	Turkapalle_M	Venkatapuram	48
344	17.4969	79.1064	Yadadri	Mootakondur	Koratikal	105
345	17.2764	78.8008	Yadadri	Choutuppal	Malkapur Aq-Ii	78
346	17.2928	78.9531	Yadadri	Choutuppal	Salavari Aq-1 (swamiwari lingotam)	123
347	17.2928	78.9531	Yadadri	Choutuppal	Salavari Aq-II (swamyvaari lingotam)	108
348	17.4089	79.1297	Yadadri	Valigonda	Lingarajpalle	192
349	17.3231	79.1578	Yadadri	Ramannapeta	Munipampula	177
350	17.5336	79.0936	Yadadri	Mootakondur	Chandepalli	51
351	17.1746	77.8759	Yadadri	Narayanapur	Pargi-Pz	47

ANNEXURE-V:

S. No.	Latitude	Longitude	Districts	Mandal	Location	Uranium >30ppb
1	19.4168	78.799	Adilabad	Bazar hatnoor	Hasnapur	57
2	19.6941	78.3721	Adilabad	Talamadugu	Lingi	37.15
3	19.367	78.448	Adilabad	Ichoda	Mukra	37.2
4	17.5939	81.0867	Bhadradri	Kukkunur	Chirevalli	36.3
5	17.3949	78.3962	Hyderabad	Golkonda	Kutubshah tumbs	71.65
6	17.4305	78.4063	Hyderabad	Shaikpet	Jubili Hills-PZ	37.1
7	17.3759	78.4238	Hyderabad	Golkonda	Langar House-PZ	108.69
8	17.3981	78.4553	Hyderabad	Nampally	Shanti Nagar-PZ	425.72
9	17.3345	78.4682	Hyderabad	Bandlaguda	Falaknama2	65.22
10	17.4005	78.5001	Hyderabad	Himayatnagar	Bagh Lingampally-PZ	31.55
11	17.4458	78.4361	Hyderabad	Khairatabad	Erragadda-PZ	113.08
12	17.445	78.452	Hyderabad	Ammerpet	Begumpet-PZ (Balkampet)	71.69
13	17.3843	78.4846	Hyderabad	Nampally	Koti-PZ	118.36
14	17.3845	78	Hyderabad	Asifnagar	Gudimalkapur1	108.65
15	17.3622	78.4236	Hyderabad	Khairatabad	Attapur	580.73
16	17.4462	78.4741	Hyderabad	Tirumalgiri	Begumpet(IMD)	50.27
17	18.83953	78.64767	Jagtial	Metpalli	Metpalli1 (Arepeta)	34
18	18.6514	78.8647	Jagtial	Kodimial	Thirumalapur	47
19	17.1633	78.9631	Jagtial	Chinna Kodur	Medipalli	238
20	16.23	77.8106	Jogulamba	Gadwal	Mitta Nandimala	40.6
21	16.28	77.7996	Jogulamba	Gadwal	Kothapalle	76.9
22	18.7078	78.0229	Kamareddy	Pitlam	Janakampet	41.5
23	18.4985	77.7843	Kamareddy	Birkoor	Bairangaidi	76
24	17.1167	80.3369	Khammam	Wyra	Rebbavaram	33.7
25	16.9447	78.1778	Mahabubnagar	Balanagar	Balanagar-Pz	52
26	16.7475	78.1447	Mahabubnagar	Jadcherla	Jedcherla-Pz	58
27	16.7436	78.3231	Mahabubnagar	Midjil	Midjil-Pz	369.9
28	16.8122	77.9194	Mahabubnagar	Hanwada	Hanwada	43.6
29	16.5567	77.96	Mahabubnagar	Addakal	Kandur-Aq-I	49
30	16.5567	77.96	Mahabubnagar	Addakal	Tarnikal-Aq-Ii	62
31	16.5978	77.8972	Mahabubnagar	Devarakadra	Baswaipalle	46.3
32	16.8644	78.1332	Mahabubnagar	Rajapur	Chennavalli	89.3

33	16.3005	78.2794	Mahabubnagar	Kodair	Janumpalle	99.5
34	16.9066	77.8504	Mahabubnagar	Gandeed	Nacharla	82.14
35	18.0953	77.8839	Medak	Narayankhed	Nizampet	114
36	18.0486	77.9794	Medak	Shankarampet_A	Bodagattu	49
37	18.0492	78.1442	Medak	Papannapet	Yusuf Peta	97.9
38	17.8035	78.4709	Medak	Toopran	Toopran	119
39	17.7863	78.3697	Medak	Sivampet	Sivampet	34.6
40	17.9573	78.4649	Medak	Chegunta	Wadiyaram	58.1
41	17.4539	78.6906	Medchal	Ghatkesar	Ghatkesar2	31.56
42	17.4782	78.5736	Medchal	Kapra	Kushaiguda	62.39
43	17.669	78.5996	Medchal	Shamirpet	Thurakapalli	63.5
44	18.2464	80.1918	Mulugu	Govindaraopet	Projectnagar-1	30.93
45	16.6131	78.6211	Nagarkurnool	Vangoor	Vangur-Pz	37
46	16.7281	78.4089	Nagarkurnool	Urkonda	Urukonda-Middle	58.28
47	16.6592	78.6031	Nagarkurnool	Charakonda	Jupally- Aq-I	331
48	16.6742	78.4858	Nagarkurnool	Kalwakurthy	Kalwakurthy-Aq-I	38
49	16.6956	78.7108	Nagarkurnool	Charakonda	Charakonda-Aq-I	148
50	16.5158	78.3597	Nagarkurnool	Tadoor	Thaduru- Aq-I	91.7
51	16.6124	78.3492	Nagarkurnool	Mahabubnagar_Rural	Aitol- Aq-I	37.8
52	16.295	78.5133	Nagarkurnool	Lingal	Lingala - Aq-I	40
53	16.5822	78.1558	Nagarkurnool	Bijinapalle	Manganur- Aq-I	57
54	16.5914	78.2158	Nagarkurnool	Bijinapalle	Vatem- Aq-I	42.5
55	16.4733	78.1672	Nagarkurnool	Bijinapalle	Mamaipalli- Aq-I	115
56	16.4153	78.685	Nagarkurnool	Achampet	Nadimpalli- Aq-I	58.4
57	16.4052	78.715	Nagarkurnool	Achampet	Ainol- Aq-I	48.5
58	16.7034	78.4551	Nagarkurnool	Kalaawakurthy	Marchala	68
59	16.8583	78.925	Nalgonda	Nampalle	Devarakonda	82
60	16.5403	78.7083	Nalgonda	Gundlapalle	G.Palli(Dindi)-Pz	65
61	17.0981	79.0244	Nalgonda	Munugode	Chikatimamidi	103
62	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-I	169
63	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	128
64	16.7944	79.4631	Nalgonda	Thripuraram	Satyanarayanapuram, Aq-I	38
65	16.9823	78.8047	Nalgonda	Marriguda	Ajilapuram	80
66	16.6411	77.6564	Narayanpur	Dhanwada	Dhanwada-Pz	53.6
67	16.5106	77.5025	Narayanpur	Makthal	Makthal	46.6
68	16.4635	77.5572	Narayanpur	Makthal	Rudrasamudram	38.5
69	18.6787	77.7944	Nizamabad	Bodhan	Khazipur	39.5
70	18.9426	78.4612	Nizamabad	Ergatla	Tadpakal	36.6
71	18.8035	78.1058	Nizamabad	Maklur	Gotimukala	35.7
72	18.44271	78.85435	Rajanna	Vemulawada	Nampalli Pz	91.8
73	18.6281	78.6278	Rajanna	Rudrangi	Manala	102

74	16.8558	78.6922	Rangareddy	Madgul	Madugula-Pz	87.5
75	17.0602	77.956	Rangareddy	Kulkacharle	Kistampalli	62.6
76	17.4625	78.3597	Rangareddy	Serilingampally	Serilingampally	84.95
77	17.3334	78.409	Rangareddy	Rajendranagar	Rajendranagar1	1250
78	17.3357	78.58	Rangareddy	Saroornagar	Vanasthalipura m-Pz	93.56
79	17.1516	78.3434	Rangareddy	Maheshwaram	Ameerpelli	36.17
80	17.048	78.3967	Rangareddy	Kandukur	Chippalapally	67.84
81	17.2087	78.2739	Rangareddy	Kothur	Gudur	60.61
82	17.5567	78.2792	Sangareddy	Patancheruvu	Rameshwaram Banda	83.6
83	18.1256	77.6767	Sangareddy	Sirgapoor	Wangada	43.5
84	17.6326	78.3303	Sangareddy	Jinnaram	Jinnaram	37.2
85	18.11	79.11533	Siddipet	Koheda	Samudrala Pz	33.1
86	17.9643	78.714	Siddipet	Thoguta	Kistapur	52
87	17.88	78.8781	Siddipet	Komuravelli	Posanpalli	37.9
88	18.0093	78.7203	Siddipet	Thoguta	Thoguta	42.7
89	18.2387	78.9236	Siddipet	Chinnakodur	Alipur	54.4
90	17.8438	78.6921	Siddipet	Gajwel	Gajwel	30.9
91	18.1758	78.7762	Siddipet	Siddipet	Raghavapuram	37.3
92	18.0665	79.0461	Siddipet	Nanganur	Nanganur	46
93	17.9924	78.7041	Siddipet	Nanganur	Rampur (Section Office)	34.8
94	18.1276	78.9327	Siddipet	Chinna Kodur	Gonepalli	44
95	16.9603	77.5736	Vikarabad	Doulatabad	Goka Paslabad	38.5
96	17.1072	77.6264	Vikarabad	Kodangal	Kodangal	77.2
97	17.0105	77.6008	Vikarabad	Doulatabad	Yamki EW	127
98	17.1514	77.8482	Vikarabad	Parigi	Sultanpoor Thanda	62.43
99	16.4206	77.94	Wanaparthy	Kothakota	Palem-Aq-I	66.8
100	16.1989	77.9975	Wanaparthy	Pebbair	Pebbair-Aq-I	45.7
101	16.5519	78.0385	Wanaparthy	Ghanpur	Khilla Ghanpur	93
102	16.386	78.1164	Wanaparthy	Gopalpeta	Thadparthy	118
103	17.7516	79.525	Warangal	Wardhannapet	Dammannapet	175.62
104	17.3472	78.8197	Yadadri	Srikonda	Pochampalli	43.26
105	17.3575	79.0339	Yadadri	Valigonda	Nagaram	37
106	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-I	79
107	17.1375	78.9708	Yadadri	Narayanapur	Gujja -Pz-II	79
108	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-I	36
109	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-II	54
110	17.3569	79.02	Yadadri	Valigonda	Nagaram- Aq-I	43

ANNEXURE-VI:

Sl No	Latitude	Longitude	Districts	Mandal	Location	TH >600mg/L
1	19.3579	78.4147	Adilabad	Neradigonda	Kumari	650
2	17.5939	81.0867	Bhadradri	Kukkunur	Chirevalli	885
3	17.8706	79.548	Hanamkonda	Inavole	Inoli Pz	635
4	17.1633	78.9631	Jagtial	Chinna Kodur	Medipalli	670
5	17.9078	79.4342	Jangaon	Pedda Pendyal	Pedda Pendyal	675
6	17.848	79.3047	Jangaon	Ghanpur	Kothapalli	1075
7	17.7341	79.4085	Jangaon	Palakurthy	Gudur Pz	945
8	17.5354	79.5088	Jangaon	Kodakandla	Kodakandla	710
9	18.1623	80.4007	Jayashankar	Tadvai	Katapuram-2	610
10	16.0254	77.976	Jogulamba	Manopadu	Boravalle	3200
11	18.3206	77.8505	Kamareddy	Pitlam	Rampurkalan1	674
12	18.4985	77.7843	Kamareddy	Birkoor	Bairangaidi	675
13	18.09961	79.4493	Karimnagar	Yelakaturthy	Yelakaturthy-Pz	608
14	18.4697	78.7952	Karimnagar	Konaraopet	Suddala	601
15	16.8333	80.4722	Khammam	Yerrupalem	Yerupalem	830
16	17.1167	80.3369	Khammam	Wyra	Rebbavaram	653
17	17.2008	80.6431	Khammam	Penuballi	Sitarampuram	838
18	17.3114	80.0365	Khammam	Thirumalaya palem	Thirumalayapalem	628
19	19.4795	79.5703	Komarambhem	Sirpur_T	Sirpur	709
20	17.4867	80.1392	Mahabubabad	Garla	Gandhampally (Santulalpod)	606
21	16.7436	78.3231	Mahabubnagar	Midjil	Midjil-Pz	670
22	16.8644	78.1332	Mahabubnagar	Rajapur	Chennavalli	740
23	18.864	79.3039	Mancherial	Hajipur	Hajipur	660
24	19.0897	78.9493	Mancherial	Jannaram	Kalamadugu	715
25	19.1498	78.9424	Mancherial	Jannaram	Indanpally	717
26	18.0953	77.8839	Medak	Narayankhed	Nizampet	1731
27	18.0492	78.1442	Medak	Papannapet	Yusuf Peta	738
28	17.9573	78.4649	Medak	Chegunta	Wadiyaram	961
29	17.4539	78.6906	Medchal	Ghatkesar	Ghatkesar2	830
30	18.2059	80.1021	Mulugu	Govindaraopet	Chelvai-2	685
31	18.1944	80.1666	Mulugu	Govindaraopet	Pasara	770
32	16.6592	78.6031	Nagarkurnool	Charakonda	Jupally- Aq-I	1500
33	16.6956	78.7108	Nagarkurnool	Charakonda	Charakonda- Aq-I	640
34	16.5158	78.3597	Nagarkurnool	Tadoor	Thaduru- Aq-I	820
35	16.5822	78.1558	Nagarkurnool	Bijinapalle	Manganur- Aq-I	705
36	16.867	79.1041	Nalgonda	Munugode	Gurrampode	637
37	17.0097	79.5389	Nalgonda	Vemulapalle	Mangapur	889
38	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-I	1178
39	17.0361	78.8889	Nalgonda	Marriguda	Antampet-Pz-II	1066
40	17.1597	79.5081	Nalgonda	Kethepalle	Kethepalli	713
41	16.7944	79.4631	Nalgonda	Thripuraram	Satyanarayanapuram, Aq-I	1052
42	16.9823	78.8047	Nalgonda	Marriguda	Ajilapuram	795
43	16.8958	77.7103	Narayanpur	Kosgi	Gundimal	1070
44	18.7998	78.2886	Nizamabad	Armur	Armur-Pz	640

45	18.6787	77.7944	Nizamabad	Bodhan	Khazipur	875
46	18.65771	79.81005	Peddapalle	Manthani	Venkatapur	604
47	18.6521	79.67011	Peddapalle	Manthani	Manthani	658
48	18.44271	78.85434	Rajanna	Vemulawada	Nampalli Pz	817
49	18.30777	78.82272	Rajanna	Thangallapalli	Nerall Pz	622
50	16.9553	78.345	Rangareddy	Keshampeta	Kesampet-Pz	640
51	17.1358	78.2742	Rangareddy	Kothur	Kothur-Pz	1125
52	17.1603	78.7269	Rangareddy	Manchal	Manchal	640
53	17.1516	78.3434	Rangareddy	Maheshwaram	Ameerpelli	740
54	17.9022	77.8497	Sangareddy	Watpalle	Ghatpalli	626
55	18.0389	77.7722	Sangareddy	Narayankhed	Narayankhed	718
56	17.61	77.7172	Sangareddy	Kohir	Kohir	1274
57	17.6228	78.1569	Sangareddy	Sangareddy	Pz of Aq-I, At-Ismailkhanpet	637
58	17.6628	77.7133	Sangareddy	Kohir	Pz of Aq-I, At-Digwal	2958
59	17.9354	78.6293	Siddipet	Daulatabad	Raipole	750
60	18.1758	78.7762	Siddipet	Siddipet	Raghavapuram	667
61	17.0528	79.8336	Suryapet	Munagala	Munagala	1115
62	16.9306	79.9583	Suryapet	Kodad	Kodad-Pz	815
63	17.0472	77.5233	Vikarabad	Kodangal	Ravalpalle	625
64	16.9603	77.5736	Vikarabad	Doulatabad	Goka Paslabad	640
65	17.437	77.9818	Vikarabad	Nawabpet	Vattiminapally	860
66	17.5231	77.8428	Vikarabad	Marpalle	Siripuram	620
67	17.1554	77.4671	Vikarabad	Marpalle	Marpally	700
68	16.1989	77.9975	Wanaparthy	Pebbair	Pebbair-Aq-I	740
69	16.5519	78.0385	Wanaparthy	Ghanpur	Khilla Ghanpur	840
70	17.7814	79.5801	Warangal	Wardhannapet	Yellenda	815
71	17.8433	79.8564	Warangal	Chennaraopet	Jhalli	945
72	17.7516	79.525	Warangal	Wardhannapet	Dammannapet	980
73	17.3472	78.8197	Yadadri	Pochampalle	Pochampalli	653
74	17.3575	79.0339	Yadadri	Valigonda	Nagaram	755
75	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-I	1125
76	17.3561	78.8825	Yadadri	Pochampalle	Wankamamidi Aq-II	1074
77	17.4089	79.1297	Yadadri	Valigonda	Lingarajpalle	613

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