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Geochemistry of Ground Water Resources of Bikaner District, Rajasthan

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ABSTRACT: Geochemistry is the science that uses the tools and principles of chemistry to explain the mechanisms behind major geological systems such as the Earth's crust and its oceans.^{[1]:1} The realm of geochemistry extends beyond the Earth, encompassing the entire Solar System,^[2] and has made important contributions to the understanding of a number of processes including mantle convection, the formation of planets and the origins of granite and basalt.^{[1]:1} It is an integrated field of chemistry and geology. The term geochemistry was first used by the Swiss-German chemist Christian Friedrich Schönbein in 1838: "a comparative geochemistry ought to be launched, before geognosy can become geology, and before the mystery of the genesis of our planets and their inorganic matter may be revealed."^[3] However, for the rest of the century the more common term was "chemical geology", and there was little contact between geologists and chemists.^[3]

Geochemistry emerged as a separate discipline after major laboratories were established, starting with the United States Geological Survey (USGS) in 1884, which began systematic surveys of the chemistry of rocks and minerals. The chief USGS chemist, Frank Wigglesworth Clarke, noted that the elements generally decrease in abundance as their atomic weights increase, and summarized the work on elemental abundance in *The Data of Geochemistry*.^{[3][4]:2}

The composition of meteorites was investigated and compared to terrestrial rocks as early as 1850. In 1901, Oliver C. Farrington hypothesised that, although there were differences, the relative abundances should still be the same.^[3] This was the beginnings of the field of cosmochemistry and has contributed much of what we know about the formation of the Earth and the Solar System.^[5]

In the early 20th century, Max von Laue and William L. Bragg showed that X-ray scattering could be used to determine the structures of crystals. In the 1920s and 1930s, Victor Goldschmidt and associates at the University of Oslo applied these methods to many common minerals and formulated a set of rules for how elements are grouped. Goldschmidt published this work in the series *Geochemische Verteilungsgesetze der Elemente* [Geochemical Laws of the Distribution of Elements].^{[4]:2[6]}

The research of Manfred Schidlowski from the 1960s to around the year 2002 was concerned with the biochemistry of the Early Earth with a focus on isotope-biogeochimistry and the evidence of the earliest life processes in Precambrian.^{[7][8]}

KEYWORDS-geochemistry,groundwater,Bikaner,Rajasthan,geology

I. INTRODUCTION

The region of Bikaner, stretching across northern Rajasthan State in India, was earlier known as Jangladesh. It included the present-day districts of Bikaner, Churu, Ganganagar, and Hanumangarh. It is bounded on the south by Marwar and Jaisalmer regions, on the east by Ajmer-Merwara region.

Bikaner state was a princely state that was founded in the 15th century in this region. After becoming a British protectorate in 1818, it persisted until shortly after India's Independence in 1947.[1,2,3]

Prior to the mid 15th century, the region that is now Bikaner was a barren wilderness called Jangladesh.^[1] Rao Bika established the city of Bikaner in 1488. He was the son of Rao Jodha of the Rathor Rajput clan, the founder of Jodhpur and conquered the largely arid area in the north of Rajasthan. Provoked by a stray comment by his father, Bika left Marwar (Jodhpur) with his uncle Kandhmal to create his own kingdom. During his journey, Bika stopped at Deshnok where he consulted the mystic Karni Mata for her blessings and get prophesied that he would be successful. Encouraged by her support, Bika took advantage of the internal rivalries of the Jat clans to carve out his own territory

in the "Jangladesh" region of Rajasthan. Though it was in the Thar Desert, Bikaner was considered an oasis on the trade route between Central Asia and the Gujarat coast as it had adequate spring water. Bika's name was attached to the city he built and to the state of Bikaner ("the settlement of Bika") that he established. Bika built a fort in 1478, which is now in ruins, and a hundred years later a new fort was built about 1.5 km from the city centre, known as the Junagarh Fort.^{[2][3][4]}

Around a century after Rao Bika founded Bikaner, the state's fortunes flourished under the sixth Raja, Rai Singhji, who ruled from 1571 to 1611. During the Mughal Empire's rule in the country, Raja Rai Singh accepted the suzerainty of the Mughals and held a high rank as an army general at the court of the Emperor Akbar and his son the Emperor Jahangir. Rai Singh's successful military exploits, which involved winning half of Mewar kingdom for the Empire, won him accolades and rewards from the Mughal emperors. He was given the jagirs (lands) of Gujarat and Burhanpur. With the large revenue earned from these jagirs, he built the Chintamani Durg (Junagarh fort) on a plain which has an average elevation of 760 feet (230 m). He was an expert in arts and architecture, and the knowledge he acquired during his visits abroad is amply reflected in the numerous monuments he built at the Junagarh fort.^{[2][4][5]}

Maharaja Karan Singh, who ruled from 1631 to 1669, under the suzerainty of the Mughals, built the Karan Mahal palace. Later rulers added more floors and decorations to this Mahal. Anup Singh, who ruled from 1669 to 1698, made substantial additions to the fort complex, with new palaces and the Zenana quarter, a royal dwelling for women and children. He refurbished the Karan Mahal with a Diwan-i-Am (public audience hall) and called it the Anup Mahal. Maharaja Gaj Singh, who ruled from 1746 to 1787 refurbished the Chandra Mahal (the Moon palace).

During the 18th century, there was an internecine war between the rulers of Bikaner and Jodhpur and also amongst other thakurs, which was put down by British troops in the 19th century.^[4]

Following Maharaja Gaj Singh, Maharaja Surat Singh ruled from 1787 to 1828 and lavishly decorated the audience hall (see illustration) with glass and lively paintwork. Under a treaty of paramountcy signed in 1818, during Maharaja Surat Singh's reign, Bikaner came under the suzerainty of the British, after which the Maharajas of Bikaner invested heavily in refurbishing Junagarh fort.^[6]



Left: Lalgarh Palace, built (Indo-Saracenic style) for Maharaja Ganga Singh and named after his father, presently a heritage hotel and also a residence of the Bikaner Royal Family. Right: Ganga Singh as a member of the Imperial War Cabinet at No. 10 Downing Street, 1917.

Dungar Singh, who reigned from 1872 to 1887, built the Badal Mahal, the 'weather palace', so named in view of a painting of clouds and falling rain, a rare event in arid Bikaner.^[5,8,7]

General Maharaja Ganga Singh, who ruled from 1887 to 1943, was the best-known of the Rajasthan princes and was a favourite of the British Viceroy of India. He was appointed a Knight Commander of the Order of the Star of India, served as a member of the Imperial War Cabinet, represented India at the Imperial Conferences during the First World War and the British Empire at the Versailles Peace Conference. His contribution to the building activity in Junagarh involved separate halls for public and private audiences in the Ganga Mahal and a durbar hall for formal functions. He also built the Ganga Niwas Palace, which has towers at the entrance patio. This palace was designed by Sir Samuel

Swinton Jacob, the third of the new palaces built in Bikaner. He named the building Lalgarh Palace in honour of his father and moved his main residence there from Junagarh Fort in 1902. The hall where he held his Golden Jubilee (in 1938) as Bikaner's ruler is now a museum.^{[4][6][7]}

Ganga Singh's son, Lieutenant-General Sir Sadul Singh, the Yuvaraja of Bikaner, succeeded his father as Maharaja in 1943, but acceded his state to the Union of India in 1949. Maharaja Sadul Singh died in 1950, being succeeded in the title by his son, Karni Singh (1924-1988).^[3] The Royal Family still lives in a suite in Lalgarh Palace, which they have converted into a heritage hotel.^{[4][6]}

The rise of Rao Bika

About 1465 Rao Bika, a Rathore Rajput, and an elder son of Rao Jodha, king of Marwar, provoked by a stray comment by his father, left Marwar (Jodhpur) with a small contingent of Rathore and Rajpurohit warriors (500 soldier and 100 cavalymen) to create his own kingdom. He was accompanied by his uncle, Rawat Kandhal, his brother Rao Bida and his chief advisor Vikramji Rajpurohit, who provided politico-strategic advice.

Encouraged by the mystic Karni Mata, whom he had met early in his travels, he took advantage of the internal rivalries of the Jat clans so that by 1485 he was able to establish his own territory and build a small fort called Rati Ghati at the city which still bears his name. In 1488 he began the building of the city itself. In the beginning, the neighboring Bhati chiefs were suspicious of the new growing power in their vicinity. Karni Mata, who had become the kuladevi of Rao Bika brought the rivalry between the Rathore & Bhatias to an end by inspiring Rao Shekha – the powerful Bhati chief of Pugal, to give the hand of his daughter in marriage to Rao Bika. This consolidated Rao Bika's power in the region and proved to be a milestone in the history of the state.

Upon Rao Jodha's death in 1488 Rao Bika stormed Mehrangarh Fort,^[8] an event that was to lead to 200 years of intermittent wars between Marwar and Bikaner.

Remains of the original small fortress Rao Bika built can still be seen around the walled city, near Lakshminath ji temple. The royal family of Bikaner lived there, till Raja Rai Singh Ji built a new fort called "Chintamani" (now Junagarh) between 1589 and 1594 AD.

According to legend Bika Lunkaran consulted a holy man called Jas Nathji, who foretold that Bika's line would reign for 450 years. While Bika was pleased with this prediction, his brother Gharsiji when he heard of the prediction thought a longer period of power should have been prophesied. He confronted the holy man while he was in a deep trance and roused him by thrusting burning incense under his nose.^[8] Jas Nathji told him 'All right take 50 years more or less but of trial and tribulation'.^[9]

Rao Bika died in 1504. His successors benefited from the weak rule of Suraj Mal of Marwar and the disruption caused by Babur's invasion of India to consolidate and extend their possessions^[10] until by the 17th century all the Jat clans (including the powerful Godara clan) had accepted the suzerainty of the rulers of Bikaner.^[11]

One of the most successful earlier rulers was Jaitasi Singh (1526–41) until he was killed by the forces of Rao Maldev of Marwar. He was succeeded by his son Kalyan Mal (1541–74) who under pressure from the Marwar forces retreated to the Punjab where he joined with Sher Shah Suri who expelled the Mughal ruler Humayun in 1540. With Sher Shah Suri's support, Kalyan Mal was able by 1545 to recover his lost territories from Rao Maldev, causing death of Kishandas Ji Rajpurohit in action, whose son has been provided with jagiri of Kishnasar in Nokha Tehsil in Bikaner, which has given rise to Kanot Rajpurohit clan as a major warlords in upcoming battles, and winning 12 villages as a gift jagiri from the state including Hiyadesar, Desalsar, Rasisar,^[12] Dheerdesar, Aadsar, Kalyanpura, Sawai bari, Kotri,^[13] Hirajsar, Saajansar, Deha, Kuntalsar.^[9,10,11]

Mughal era



Raja Karan Singh of Bikaner, Aurazzeb's ally and enemy

The return of Humayun to power meant that Bikaner due to its involvement with Sher Shah Suri came into conflict with the Mughals again. However Kalyan Mal by using all the advantages of the harsh desert environment around Bikaner was able to defeat any invading Mughal army.^[9] The coming of Akbar to power saw the Mughal empire turn to diplomacy instead of force to bring the individual Rajput states into the empire. As a result, Raja Rai Singh, the sixth ruler of Bikaner was among the first Rajput Chiefs to make an alliance with the Mughal Empire. As a result, during the reign of the Mughal emperor Akbar the rulers of Bikaner were esteemed among the most loyal adherents of the empire and held high ranks as Mansabdars of special order in the imperial court. They served as military commanders in various Mughal campaigns all over the Indiasub-continent.

Early and middle 19th century

By the middle of the 19th century the years of internal strife together with the financial and military demands put on Bikaner by the British had put the kingdom in debt. A sharp turnaround in the fortunes of the kingdom occurred in 1842 when Maharaja Ratan Singh took advantage of a shortage of pack animals to supply Bikaner's renowned camels at considerable profit to the British for their Afghan expedition. The turnaround was such that by 1844 he was able to reduce the dues on goods passing through Bikaner. He also gave assistance in both Sikh campaigns to the British.

Ganga Singh



Ganga Singh with his son in 1914

The reign of Maharaja Ganga Singh was notable for great socio-political and economic development in every sphere of life, namely, education, health, sanitation, water supply, power generation and electricity, irrigation, post and telegraph, roads and railways, trade and commerce, etc.

Drought is a common occurrence, and the region faced the most severe famine in 1899–1900 which was so severely felt that by 1901 it reduced the population to 584,627, a decrease of 30%.

When Maharaja Ganga Singh died in 1943, he was succeeded by Maharaja Sadul Singh. he was the colonel of the Regiment of 2nd lancers.

Accession to India

With the departure of the British in 1947, the subsidiary alliance of 1818 came to an end and Bikaner was left as an independent state, with the choice falling to Maharaja Sadul Singh of acceding to one of the new dominions, India or Pakistan. In the event, Sadul Singh was one of the first rulers of a princely state to sign an Instrument of Accession, on 7 August 1947, choosing India. Bikaner became part of the state of Rajputana, which was later renamed Rajasthan.[12,13,15]

House of Rathore at Bikaner

Name	Reign Began	Reign Ended
1 Rao Bika	1472	1504
2 Rao Narayan Singh	1504	1505
3 Rao Luna Karana Lon-Karan	1505	1526
4 Rao Jait Singh Jetasi	1526	1541
5 Rao Kalyan Mal – Acknowledged the suzerainty of Emperor Akbar at Nagaur in November 1570	1541	1574
6 Rao Rai Singh I Rai Rai Singh – Important General in the Mughal army Similar to Raja Man Singh I of Amber.	1574	1612
7 Rai Dalpat Singh Dalip	1612	1613
8 Rai Surat Singh Bhuratiya	1613	1631
9 Rao Karan Singh Jangalpat Badhshah – Deposed by Emperor Aurangzeb for dereliction of duty at Attock, 11 January 1667. Exiled to his betel gardens at Karanpura, in the Deccan	1631	1667
10 Maharaja Rao Anup Singh – To be the first to be granted the title 'Maharaja' by Emperor Aurangzeb. Served in the Deccan campaign at Salher in 1672, Bijapur in 1675, and the siege of Golconda in 1687. He was administrator of Aurangabad 1677–1678, Hakim of Adoni, 1678, Intiazgarh, Adoni 1689–1693, and of Nusratabad, Sukkar 1693–1698.	1669	1698
11 Maharaja Rao Sarup Singh – He died from smallpox, at Adoni, in the Deccan, 15 December 1700.	1698	1700
12 Maharaja Rao Sujan Singh – Ordered to attend Emperor Aurangzeb in the Deccan, where he remained for ten years. Faced invasions from Maharaja Abhai Singh of Jodhpur and Maharaja Bakht Singh of Nagaur, but successfully repulsed both.	1700	1735
13 Maharaja Rao Zorawar Singh	1735	1746
14 Maharaja Rao Gaj Singh – the first of his line granted permission to mint his own coinage by Emperor Alamgir II	1746	1787
15 Maharaja Rao Rai Singh II Raj Singh	1787	1787
16 Maharaja Rao Pratap Singh – Reigned under the Regency of his uncle Surat Singh who poisoned him to assume the throne	1787	1787
17 Maharaja Rao Surat Singh – He incurred huge debts due to his military adventures which had reduced his state to near anarchy. Entered the protection of the East India Company with a subsidiary alliance on 9 March 1818.	1787	1828
18 Narendra Maharaja Rao Ratan Singh – received the hereditary title of Narendra Maharaja from Emperor Akbar Shah II and assisted the British by furnishing them with supplies during the First Afghan War of 1841.	1828	1851
19 Narendra Maharaja Rao Sardar Singh – Assisted the British during the Indian Uprising of 1857 and served in person during many of the battles. Removed the name of the Mughal Emperor from his coinage, replacing the words with "Aurang Arya Hind wa Queen Victoria".	1851	1872
20 Narendra Maharaja Rao Dungar Singh – Assisted the British during the Second Afghan War.	1872	1887



21	General Narendra Maharaja Sir Rao Ganga Singh – served in the First World War in France and Flanders 1914–1915. Member of the Imperial War Cabinet and served the British Royal Family in many other official capacities. Signed the Treaty of Versailles on behalf of India on 28 June 1919. Indian representative at the Imperial Conferences and at the League of Nations.	1887	1943
22	Lieutenant-General Narendra Maharaja Sir Rao Sadul Singh – Signed the instrument of accession to the Dominion of India on 7 August 1947. Merged his state into the present state of Rajasthan, India on 30 March 1949.	1943	1950
23	Rao Karni Singh – Member of Parliament (Lok Sabha) for Bikaner, 1952–1977. On 28 December 1971, India amended its Constitution to remove the position of the rulers of princely states and their right to receive privy-purse payments, thus making him the last ruler of Bikaner.	1950	1971

Head of House of Rathore clan in Bikaner

Name	Assumed Headship of family	Died
1 Maharaja Karni Singh	1971	1988
2 Maharaja Narendra Singh	1988	2003
3 Maharaja Ravi Raj Singh	2003	2022

Of all the natural resources, water is unarguably the most essential and precious. It is a universal solvent and as a solvent. It provides the ionic balance and nutrients that support all forms of life. In India, the major source of water used to meet the domestic, agricultural and industrial needs is the ground water. In recent years, the growth of industry, technology, population, chemical fertilizers, uses of pesticides and some other problems like sewer leakage etc. degraded the ground water quality. The Bikaner district lies in arid zone of western Rajasthan and is a part of Thar Desert. It covers an area of about 27, 244 sq Km and lies between North Latitudes 27o 11’ to 29o 03’ and East Longitudes 71o 54’ to 74o 12’. The present research work covers an area around village Raisar and falls between North Latitude 27o 50’ to 28o 05’ and East Latitude 73o 30’ to 73o 45’. The ground water quality assessment on the heavy metal helps to getting better information result. It is evident that in the present study the highest concentration of Fe and Mn is 0.1 mg/L and 0.079 mg/L, respectively. The concentration of these metals is below the recommended limit for drinking and irrigation purposes. However the highest concentration of Cu is 0.25 mg/L. The result shows that 85% of samples are above the maximum desirable limit (0.05 mg/L) for drinking & 8.33% samples were far above the maximum recommended limit (0.2 mg/L) for irrigation purposes. The highest concentration of Zn in samples is 5.8 mg/L. The result shows that 20% samples are above the maximum desirable limit (5.0 mg/L) for drinking and 95% samples are above the maximum recommended limit (2 mg/L) for irrigation purpose. In many sample sites Na concentration is also very high for drinking and irrigation. The result shows that K concentration is in the range for drinking and irrigation purpose. Even though, the condition is not very bad at present, there may be problems if the same continues in future and the ground water sources will be completely polluted and become unfit for drinking and other purpose. Hence this is high time to preserve and protect these precious resources in Bikaner.[15,17,18]

II. DISCUSSION

An investigation was undertaken with the objective to determine the quality of underground waters of non-command area of Bikaner district, their effect on soil properties and to categorize them for their suitability for irrigation. A total of 173 water samples were collected from Nokha, Kolayat, Loonkaransar and Bikaner tehsils. The waters are mostly Na-Mg-Ca type with dominance of chlorides followed by carbonates + bicarbonates. EC of soil was significantly and positively correlated with EC of irrigation water. Rajasthan's Bikaner District, part of the Thar Desert, is experiencing problems with falling groundwater levels, high salinity, fluoride and nitrate concentrations. Therefore, groundwater quality studies are underway to determine the suitability of groundwater for drinking purposes in the Bikaner district. Quality analysis is performed using parameters such as Conductivity (EC), Total Dissolved Solids (TDS), pH, Calcium, Potassium, Sodium, Nitrate, Sulfate, Chloride, Fluoride, magnesium, total hardness (TH) and Bicarbonate. Conductivity, TDS and TH increases were observed in the post-monsoon period. No such changes were observed in the sulphate, nitrate and fluoride concentrations after the rains. Most of the study areas have high salinity and are therefore unsuitable for consumption. However, all other chemical parameters are within the maximum

allowable limits according to the BIS standard. Unconventional energy use desalination of groundwater is proposed to provide sustainable drinking water. Various industrial and mining man-made recharge structures (Pits with Bore-hole Technique) near the villages, resulting in higher groundwater levels and improved quality in neighboring areas. Success stories can be replicated in similar geographic environments. Large-scale artificial rainwater harvesting/storage/replenishment of potential aquifers is another management alternative, which can improve the chemical quality of groundwater. [19,20,21]

The samples were collected from villages of different regions namely Nokha Mandi(1), Dasarsar(2), Palana(3), Gajner(4), Shri Kolayat(5), Jajhu(6), Nokhra(7), Pubasar(8), Dantour(9), Pugal(10), Karmisar(11), Motigarh(12), Kumbhana(13), Lun karansar(14), Kapurisar(15), Kalu(16), Mundsar(17), Ghatu(18), Jamsar(19), Sobhasar (20), all in Bikaner. Perusal of results of chemical analysis shows that the Electrical conductivity in groundwater is ranging from 1840 to 6550 $\mu\text{m}/\text{cm}$ and only 16.66% of total samples (i.e. only 1 out of 6 samples) is within maximum permissible limit. TDS values are ranging from 982 to 3838 mg/L and only 16.66% of the total samples are within maximum permissible limit. Values of pH are within maximum permissible limit in all the 06 samples. Calcium values are ranging from 3.30 to 325 mg/L and 50% of total samples are within maximum permissible limit. Values of Potassium are ranging from 0.08 to 5mg/L and no sample falls in more than maximum permissible limit. Sodium contents are ranging from 273 to 1113 mg/L and no sample falls within maximum permissible limit. Nitrate value is 00 and none of the samples is having value more than maximum permissible limit. Sulphate values are ranging from 00 to 19mg/L, all samples fall within maximum permissible limit. Chloride content is ranging from 11.0 to 2099mg/L and 50% of total samples are within the maximum permissible limit. Fluoride contents were ranging from 00 to 1.36mg/L and no sample is in more than maximum permissible limit. Magnesium is ranging from 2.50 to 114 mg/L and in 33.32% of total samples, it is more than maximum permissible limit. The TH of samples are ranging from 290 to 1250 mg/L and 50% of total sample are within maximum permissible limit. HCO_3 content is ranging from 5.40 to 500mg/L and all the samples falls within Maximum Permissible Limit. [21,22]

III. RESULTS

Studies carried out reveals that major parts of Bikaner district is having Electrical conductivity, TDS and Sulphate concentrations more than permission limits indicating high salinity in groundwater and therefore unsuitable for drinking as well as irrigation purposes. However, pH values, Potassium, Fluoride, Nitrate and Sulphate concentrations in groundwater are within maximum permissible limits in the larger areas of study in Bikaner. It is found that Electrical Conductivity, TDS and TH increase during premonsoon period. However, no such changes are recorded in Sulphate, Nitrate and Fluoride contents after rainfall. Salinity in groundwater is owing to prevailing as well as palaeo-aridity in the region especially salinity in alluvial geo-formations. Salinity in consolidated formations is mainly due to connate nature of groundwater entrapped during their origin. There is also increase in salinity because of rapid declining of water levels over the period of time due to overexploitation of groundwater resources in the study area. Enhancement in premonsoon – post-monsoon salinity is due to dissolution of salts by the rainwater through soils and zone of aeration during monsoon precipitations. Desalination of groundwater is recommended for sustainable drinking water supply so as to combat ill health effects among the common people in the study area. Possibilities of growing salt tolerant crops like wheat and gram may be explored and promoted especially in coarse textured soils in the study area.

Mass awareness, water literacy and community participation is needed for addressing various issues of concern effectively and efficiently which will be fruitful for improving local ecosystem, socio-economic scenario and contribution towards development of not only Bikaner District but other arid areas of the state of Rajasthan.

- Awareness program to teach about preservation of valuable ground water assets and preparing on water collecting will be advantageous to check decrease in water level and legitimized use.
- Ground water improvement in over-took advantage of, basic and semi-basic region ought not be energized.
- Utilization of water saving gadgets like sprinklers, close field dispersion channels and so on ought to be advanced.
- Current farming administration methods must be taken on for powerful and ideal use of the water assets. This can be accomplished by keeping up with water system through least siphoning hours according to least necessity of water by the harvest and furthermore choosing most appropriate practical yield design.

- High water necessity harvests to be deterred. Legitimate horticulture augmentation administrations ought to be given to the ranchers so they can go for substitute low water necessity prudent yields.
- Salt safe harvests can be planted in the space having harsh ground water.
- In Kolayat and Lunkaransar blocks, which fall under safe class, further ground water advancement is proposed.
- Customary water reaping structures like tankas, rooftop top downpour water capacity ought to be urged for meeting everyday prerequisites which will lessen ground water withdrawal.
- Enormous scope re-energize possibilities exist in drained springs. Execution of counterfeit re-energize in such regions through external surface water sources like lift channel from IGNP framework or floodwater during abundance stormy years be advanced.
- Conjunctive utilization of ground water and surface water ought to be empowered in trench order regions to forestall further water signing in the CCA. Hostile to water logging measures must be embraced in the trench order regions

III. CONCLUSIONS

Rajasthan's Bikaner District, part of the Thar Desert, is experiencing problems with falling groundwater levels, high salinity, fluoride and nitrate concentrations. Therefore, groundwater quality studies are underway to determine the suitability of groundwater for drinking purposes in the Bikaner district. Quality analysis is performed using parameters such as Conductivity (EC), Total Dissolved Solids (TDS), pH, Calcium, Potassium, Sodium, Nitrate, Sulfate, Chloride, Fluoride, magnesium, total hardness (TH) and Bicarbonate. Conductivity, TDS and TH increases were observed in the post-monsoon period. No such changes were observed in the sulphate, nitrate and fluoride concentrations after the rains. Most of the study areas have high salinity and are therefore unsuitable for consumption. However, all other chemical parameters are within the maximum allowable limits according to the BIS standard. Unconventional energy use desalination of groundwater is proposed to provide sustainable drinking water. Various industrial and mining man-made recharge structures (Pits with Borehole Technique) near the villages, resulting in higher groundwater levels and improved quality in neighboring areas. Success stories can be replicated in similar geographic environments. Large-scale artificial rainwater harvesting/storage/replenishment of potential aquifers is another management alternative, which can improve the chemical quality of groundwater. [20,21,22]

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