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Physico-Chemical Comparative Study of under Ground Water and Surface Water of Baran District of Rajasthan

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ABSTRACT: Baran district is a district in the [Indian](#) state of [Rajasthan](#). The headquarters of the district are located at the city of [Baran](#). Baran is located at 25.1°N 76.52°E. It has an average elevation of 262 metres (859 feet). Located in the Kota Plateau of [Vindhya range](#), district is the location of famous [Ramgarh crater](#) made from the meteorite strike. The City has a dry climate except in the monsoon seasons. The winter season runs from mid of November to February and summer season runs from March to mid of June. The period from mid of June to September is the monsoon season followed by the months October to mid of November constitute the post monsoon or the retreating monsoon. The average rainfall in the district is 895.2mm. January is the coldest month with the average daily maximum temperature of 24.3°C and the average daily minimum temperature of 10.6°C. The present study is based on physico-chemical comparative study of under ground water and surface water of Baran district of Rajasthan.

KEYWORDS: Baran, physico-chemical, under ground water, surface water, Rajasthan, comparative

I.INTRODUCTION

At present Water Source for Baran is Heekar Deh with 1.5 m height anicut on river Parbati. About 6 mld water is supplied from Heekar Deh intake arrangement on the river Parbati 13 km, South-East of Baran town. Another 1 mld water is supplied from Majawatan Deh intake arrangement on the river Parbati located 16 km on North-East of Baran town which is likely to increase up to 3MLD after strengthening of existing 10 kilometer 250mm dia AC pipe line from Kalyan pura to head works (Work is under implementation with RIICO). [1,2]

Moreover there are 11 tube wells in the town. Discharge of tube wells is less than 10000 lph.[1,2] Presently, eleven (11) tube-wells supply ground water to the tune of 1.00 MLD. Total 8 mld water is now available to fulfill the present situation. Water is transmitted through transmission mains of 300 dia of CI and 350 dia. AC pipe line from Heekar Deh for the Baran town and 400mm dia DI & 250 mm dia AC pipeline from Majawatan Deh. As the old CI 300mm dia rising line is very old about 35 years and not in good condition, also 350mm dia AC pipe line is also leaking and require replacement. Total availability of surface water from Heekar deh and Mazawatan deh are 6.69 mcum and 2.15 mcum respectively. River Parbati is not a perennial river. There is a continuous flow for an average 65 days in a year and for balance 300 days storage water can be used. So an equivalent quantity of 29.47 mld can be drawn from there throughout the year. This arrangement can cater demand up to future. After that water demand will be fulfilled by construction of another annicut at the downstream of Mazawatan deh.[3,4]

Baran District receives the most rainfall in Rajasthan and is relatively well provided with surface water as a result. All of the rivers and streams are part of the Chambal system, which is the only perennial river in the state. All of the rivers and streams are full and swiftly flowing in the monsoon, but most are dry throughout the rest of the year. There is no

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water quality monitoring station at Baran and Chhabra. It is expected that during monsoon season the water quality will be deteriorated by large volume suspended solid. There are number of National Hydrographic monitoring stations of Central Ground Water Board in and around Baran. In most of the cases ground water table ranged between 2 - 10 m bgl. The Initial Environmental Examination (IEE) has been prepared for the Baran Water Supply Subproject as part of RUSDIP Phase II – Tranche 3. The subproject covers (i) improvement in the existing distribution system; (ii) provision of a new network, clear water reservoirs (CWR) with pumping stations, additional pumping stations, overhead storage reservoirs (OHSR) and ground level reservoir (GLSR); and (iii) construction of 2 water treatment plants (WTPs) including intake well, pumping mains, rising main from tube wells to CWRs and distribution pipelines.[5,6]

Soil of the region falls within low rainfall zone of 650- 1000 mm. The soils are black of alluvial origin, clay loam and groundwater salinity is reported. Nutrient level in the Baran soil includes area coverage of saline and sodic soil. The nutrient status of the Baran soil is graded as medium to high level. There are number of National Hydrographic monitoring stations of Central Ground Water Board in and around Baran. In most of the cases ground water table ranged between 2 - 10 m bgl.[7,8]

Construction activities will be conducted on drains flowing to nallahs, although dried up during the summer period, has significant amount of silt materials. Mobilization of settled silt materials, run-off from stockpiled materials, and chemical contamination from fuels and lubricants during construction works can contaminate downstream surface water quality. These potential impacts are temporary and short-term duration only and to ensure these are mitigated, construction contractor will be required to Avoid stockpiling of earth fill especially during the monsoon season unless covered by tarpaulins or plastic sheets; (ii) Prioritize re-use of excess spoils and materials in the construction works. If spoils will be disposed, consult with IPIU/DSC on designated disposal areas; (iii) Install temporary silt traps or sedimentation basins along the drainage leading to the water bodies; (iv) Place storage areas for fuels and lubricants away from any drainage leading to water bodies; (v) Dispose any wastes generated by construction activities in designated sites; and (vi) Conduct surface quality inspection according to the Environmental Management Plan (EMP).[9,10]

Geology of an area plays an important role in occurrence and movement of ground water in it. The ground water potential depends upon these aquifers present in the area. Therefore, it is necessary to consider the nature of the geological formations present in Baran district. The sandstone, limestone and shale of Bhandar group of Vindhyan Super Group constitute the basement overlain by Deccan Trap basalt. At places a thin Alluvial cover is also found. General stratigraphic succession Era Group Sub-group Lithology Recent --- --- Alluvium and soil Upper Cretaceous to Palaeocene --- Deccan traps Basaltic flows with intertrappean beds Lower Bhandar sandstone Sandstone with shale intercalation Upper Vindhyan Bhandar group Bhandar limestone Impure argillaceous stromatolitic limestone Ganurgarh shale Variegated shale Southern part of Baran district is occupied by basaltic flows and constitutes about 16% area of the district covering parts of Chhabra & Chhipabarod blocks. Sandstone, limestone & shale of lower Bhandar group occupy 84% of the area in north and northeastern parts of Anta, Atru, Baran, Kishanganj & Shahbad blocks. The rock formations exposed in Baran district are the meta-sedimentaries belonging to Vindhyan Super Group, overlain by Deccan basalt and Quaternary alluvium.[11,12]

The availability, occurrence and movement of ground water depends upon the rock formations present in the area. In Baran district, alluvium, limestone, sandstone, shale and inter trappeans are the main hydroolith units. Among these formations, alluvium is the most potential among different hydrogeological formations. The ground water in these formations occurs under water table conditions. At places, semi-confined conditions also exist. Ground water in hard rocks viz. Vindhyan limestone, sandstone, shale and Deccan basalt occurs in secondary porosity developed by weathering and/ or fracturing. The ground water potential of these rocks depends upon the intensity of joints and fracture systems and their interconnection. These formations are known to be waterbearing down to more than 100 mbgl. These deeper zones are tapped by bored wells mostly for irrigation purpose. Exploratory drilling in the district has revealed that the hard rock forms the main aquifer over large parts of the district. Depth of tubewells ranges from 20m to 150m. Yield of tube wells ranges from meagre to 2000 lpm[13,14]

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II.DISCUSSION

The depth to water level varies widely depending upon topography, drainage and bedrock configuration etc. During pre-monsoon depth to water level in the district was found to vary between 3.2 and 11.55 mbgl. In major part of the district, the depth to water level varied from 5 to 10 mbgl. Water level in the range of 2 to 5 mbgl was recorded in 11.11% of the monitoring stations, 5 to 10 mbgl in 66.67% of the monitoring stations and 10 to 20 mbgl in only 22.22% of the monitoring stations. Deep water levels beyond 20 m have not been observed in the district. Shallow water levels in the range of 2 to 5 m have been observed in parts of Anta, Kishanganj and Shahbad blocks. Water levels in the range of 10 to 20 m have been observed in parts of Anta, Baran Atru, Chhipa Barod and Shahbad blocks. During post-monsoon period, the depth to water level in the district varied from 1.75 to 17.32 mbgl. In major part of the district, depth to water level was recorded in the range of 2 to 5 m covering [parts of Chhipa Barod, Atru, Shahbad, Kishanganj and Anta blocks].[15,16] It was observed that depth to water level varied from 0 to 2 m in 16.67 % of the wells monitored, 2 to 5 m in 44.44 % of wells, (NHS), 5 to 10 m in 27.78% of wells and between 10 and 20 m in the remaining 11.11% of wells monitored. Water levels in the range of 10 – 20 m have been observed in localized pockets in Anta, Baran, Atru and Chhabra blocks. Analysis of pre- and post-monsoon water level indicates that there has been exceptionally rise in water levels in the entire district. Perusal of the fluctuation data indicates that major part of the district has recorded rise in water level of more than 7.83 m whereas no decline in water levels has been observed in the district due to high rainfall. Around 44.4% of the wells monitored have registered rise in the range of 2-5 m in water level, 22.2% wells have registered rise of 5-10 m and 33.3% of the wells have shown rise of 10 to 20 m. Analysis of decadal pre-monsoon water level data, indicates that there has been rising trend of ground water levels over a major part of the district.[15]

The rising trend in water levels varies from 0 to 25 cm/year. [17,18] Declining trend of upto 25 cm/year has been observed in northeastern, northern, southwestern and southeastern parts of the district falling in Anta, Kishanganj, Shahbad, Atru, Chhipa Barod and Chhabra blocks. Shallow ground water of dug well zone is alkaline in nature with pH ranging from 7.1 to 7.9. The Chloride content in ground water has been found to vary from 35 to 710 mg/l. The specific conductance (EC) of ground water in the district is within 3550 $\mu\text{S}/\text{cm}$ at 25°C. Quality of ground water is generally fresh with EC below 3000 $\mu\text{S}/\text{cm}$ at 25°C in major parts of the district. EC above 3000 $\mu\text{S}/\text{cm}$ at 25°C has been observed in localised pockets in Anta and Baran blocks. The fluoride content in all the ground water samples has been found to vary from 0 to 0.5 mg/l and is well within the desirable limit of 1 mg/l (BIS prescribed limit for drinking water) in the entire district. The concentration of iron varies from 0.04 to 0.1 mg/l. Iron content in ground water has been found to be well within the desirable limit of 0.3 mg/l as prescribed by BIS in drinking water. [16,17,18] The concentration of Nitrate ranges from 2 to 280 mg/l. Nitrate values in major part of the district are within 45 mg/l. Nitrate in excess of 45 mg/l (maximum permissible limit prescribed by BIS for drinking water) has been observed in parts of Shabad and Anta blocks.[19,20]

Rainfall in the district is the main source of ground water recharge. Due to less rainfall and increased ground water withdrawals, the groundwater levels are declining in some parts of the district. Irrigation in the area is mainly done by ground water i.e. dug wells and tube wells. The stage of ground water development for the district as a whole has reached 96.18 %. Out of 7 blocks, two blocks viz. Atru and Baran fall under over-exploited category, one block each viz. Chhipa Barod and Anta fall under critical and semi-critical categories respectively. The remaining three blocks viz. Chhabra, Kishanganj and Shahbad fall under safe category. There is practically no scope left for further ground water development in over-exploited blocks. Caution needs to be exercised in critical and semicritical blocks so as to prevent over-exploitation of ground water. Scope for further development of ground water resources is available in Chhabra, Kishnaganj and Shahbad blocks.[21,22]

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III.RESULTS

Stage of ground water development in two out of seven blocks in the district has exceeded 100%, which indicates that the scope of ground water development is already exhausted in these blocks and the blocks have been categorized as "Overexploited". There is no scope for further development of ground water in these blocks for irrigation or industrial use.

However, exploratory drilling can be taken up in unexplored area for estimation of aquifer parameters. There is need to control and regulate ground water development in over-exploited blocks in the district. In critical and semi-critical blocks, caution needs to be exercised so as not to further deplete the resource. Precious Groundwater resources have to be conserved for sustainable availability. There is need to reduce/ avoid wastage of water in various uses. Ground water should be used judiciously taking into account modern agriculture water management techniques by cultivating crops needing less watering and use of sprinkler system & drip irrigation should be encouraged. [23,24] Alluvial aquifer is the principal aquifer in the district, which supports maximum ground water extraction through dug wells, dug cum bore wells and tube wells. Overexploitation of ground water resources has led to declining trend in ground water levels. It is recommended that increasing number of ground water structures should not be encouraged and artificial ground water recharge schemes like check dams, bunds, anicuts etc., should be constructed at appropriate hydrogeological locations.

Surface water reservoirs like ponds/ tanks etc. should be constructed, which would serve dual purpose of supply of water during lean period and recharge to the ground water body. Also water shed development projects and soil conservation project should be encouraged. Sandstone is the next important aquifer in the district. Extraction of ground water in this aquifer is through large diameter dug wells and dug cum bore wells and tube wells. The draft is mainly for agriculture, which is more than 80% of the total draft in most of the area. The stage of ground water development in this aquifer varies from 81.88 to 156.46%. Ground water storage capacity in this hard rock aquifer is very less hence during summer season, dug wells either go dry or yield is reduced. Therefore, it is recommended that deepening of the dug wells should be carried out to have good storage during pumping so that these don't go dry during lean period. Also the number of ground water structures in Shahbad block may be increased.[25,26]

Only very restricted and planned ground water development can be taken up in critical and semi-critical areas to avoid becoming overexploited. Ground water should be used judiciously taking into account modern agriculture water management techniques by cultivating crops that need less watering. Use of sprinkler system & drip irrigation should be encouraged. Small farmers in the area should be encouraged to use common ground water structures for optimum use of ground water resources for irrigation 13 purposes. Cultivators should also be made aware and encouraged to adopt suitable cropping pattern using modern techniques by extension services for getting maximum agriculture production through minimum withdrawal. Suitable artificial recharge structures like subsurface barriers across the river beds should be constructed so that the ground water runoff can be arrested and impounded in the subsurface reservoir for meeting various sectoral demands. There is need for regulation of ground water development in overexploited areas. Awareness about the consequences in the near future caused by the impact of sharply declining water levels and need and ways of judicious use of water and rain water harvesting and artificial recharge needs to be created among the users.[26]

IV.IMPLICATIONS

In general the groundwater quality in shallow aquifers is suitable for use for different purposes, except for a few areas in which a high concentration of some of the constituents are reported. The quality of the deeper aquifers varies from place to place, and exploration work is going on to assess the suitability of their water for various uses.

A high incidence of constituents such as fluoride and nitrate has been reported from some of the areas, which has mostly been attributed to geogenic causes. Similarly salinity, both in the inland and coastal areas, has been reported from various parts of the country. Nitrate, fluoride and heavy metals are the important constituents, the high concentration of which poses severe health problems, which may be attributed to anthropogenic activities. The

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predominant cations and anions in the groundwater are in the following order: $\text{NO}_3^- > \text{Na}^+ > \text{Ca}^{2+} + \text{Mg}^{2+} > \text{Cl}^- > \text{HCO}_3^- > \text{F}^- > \text{CO}_3^{2-} > \text{K}^+$, respectively during the sampling time. The samples are analyzed for the major cations, anions, physico-chemical parameters and water quality index for evaluating the groundwater's quality and its suitability for various uses [21,22] An examination of the major ion concentration data reveals that Na^+ and Cl^- are the major cations and anions respectively, irrespective of the nature of the source [23,24] The Na concentration observed in the hand pump water ranged between 1.5 to 67.3 meq L⁻¹ and between 4.2 to 14.8 meq L⁻¹ in the tube well water. The calcium plus magnesium (2.3 - 32.0 meqL⁻¹), potassium (0.01 - 0.70 meqL⁻¹), CO_3^{2-} (0-1 - 1.1 meqL⁻¹), HCO_3^- (2.0 - 8.3 meq L⁻¹), Cl^- (1.9-31.0 meq L⁻¹) values[25]of the water samples are well within the highest desirable or maximum permissible limits set by Food and Agriculture Organization (FAO), [24,25] Bureau of Indian Standards (BIS) and World Health Organization (WHO). Nitrate was found above the permissible limits (>45 mg L⁻¹) in 6% of the samples. The observed NO_3^- values in the tube well water ranged from 0.01 to 158.8 mg L⁻¹, while the NO_3^- values in the hand pump water ranged between 0.01 to 210.4 mg L⁻¹. Nitrogenous materials are rare in the geological record; therefore, the occurrence of nitrate in groundwater is an anthropogenic pollutant contributed by nitrogenous fertilizers, industrial effluents, and human and animal waste through the biochemical activity of nitrifying bacteria, such as *Nitrosomonas* and *Nitrobacter*. [26] All the sources of nitrogen are potential sources of nitrate. In water, especially groundwater, these sources include decaying plant or animal material, agricultural fertilizers, manure, domestic sewage, industrial wastewater, precipitation, or geological formations containing soluble nitrogen compounds. The nitrate concentration in groundwater was generally low for all the samples except for 6% of the samples, which were higher than the permissible limits (> 45 mg L⁻¹), but could reach high levels in agricultural runoff or from contamination by human or animal waste. The nitrate levels in the districts of Baran, Rajasthan are generally less than 45 mg L⁻¹ except for 6% of the samples of the water, a though the groundwater levels are often higher. The observed fluoride value range in the tube well water was 0.6 to 5.8 mg L⁻¹ and 0.33 to 9.89 mg L⁻¹ in the hand pump. A high fluoride concentration contamination (>1.5 mg L⁻¹) exists in 49 % of the samples. High fluoride (> 1.5 mg L⁻¹) may cause various types of fluorosis. [24,25] An abnormal level of fluoride in water is common in fractured hard rock zones with pegmatite veins [22,23]The veins are composed of minerals such as topaz, fluorite, fluor-apatite, villuamite, cryolite, and fluoride replaceable hydroxyl ions in ferro-magnesium silicates. Fluoride ions from these minerals leach into the groundwater and contribute to high fluoride concentrations [21,22]Occasionally, the mica group of minerals such as muscovite and biotite, also contribute to water's fluoride content. Again, it is evident from the chemical analysis of the groundwater samples that the pH value of the groundwater in the affected area varies from 7.3 to 8.1, indicating a saline condition in nature, which favors the solubility of fluorine-bearing minerals. In an acidic medium (acidic pH), fluoride is adsorbed in clay; however, in a saline medium, it is desorbed, thus a saline pH is more favorable for fluoride dissolution activity. [25]

Fluoride has a unique chemical behavior towards most of the anions and can be easily replaced even under normal temperature and pressure conditions. Generally, a high concentration of sodium will increase the solubility of fluoride-bearing minerals in water. This is the reason for the higher levels of fluoride in the groundwater of the area studied. Under the prevailing semi-arid climatic conditions, i.e., during the weathering of granite gneissic rocks, fluorine is released from apatite and biotite to the circulating alkaline groundwater (Karanath, 1987). Richards (1954) categorized the groundwater on the basis of SAR values (26 as poor quality). The data revealed that the different administrative subdivisions of the district of Baran, Rajasthan, have groundwater with SAR values less than 10.0. It has been also delineated that 13% of the samples from the region indicated excellent groundwater quality. The observed RSC values overall ranged between -28.2 to 5.1 meq L⁻¹. [20,21]A negative RSC indicates that a sodium build up is unlikely, since the sufficient calcium and magnesium are in excess of what could be precipitated as carbonates. The water quality index was measured by the WQI calculator using NO_3^- , the pH and the temperature. The WQI for the sixty groundwater samples ranged from 35.03 to 67.47, and the water quality rating was close to medium (70%) for drinking purposes. The low value of the WQI at various locations may be ascribed to higher values of TDS, NO_3^- , Na^+ , $\text{Ca}^{2+} + \text{Mg}^{2+}$, Cl^- , and F^- in the groundwater. A further 30% of the water samples were found to be of bad quality, implying that the groundwater should not be directly used for drinking purposes. The pH of water is a measurement of the concentration of hydrogen ions (H^+) in a solution. In the hand pump water, the pH shows a significant positive

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correlation with CO_3^{2-} ($r=0.606^{**}$), RSC ($r=0.350^{**}$), F^- ($r=0.253^*$) and an insignificant negative correlation with pH, Na^+ , $\text{Ca}^{2+}+\text{Mg}^{2+}$ SAR and Cl^- . Further, for the tube well water, the pH shows a significant positive correlation with CO_3^{2-} ($r=0.899^{**}$), RSC ($r=0.726^{**}$), F^- ($r=0.561$) and an insignificant negative correlation with Na^+ , K^+ , $\text{Ca}^{2+}+\text{Mg}^{2+}$ NO_3^- and HCO_3^- [23,24] The electrical conductivity (EC) of water depends upon the concentration of ions and its nutrient load. The EC is a measure of the capacity of a substance or solution to conduct electricity. It is an excellent indicator of total dissolved solids, which is a measure of salinity that affects the taste of potable water. In the hand pump water, the EC shows a significant positive correlation with the total dissolved solids (TDS) ($r=1.00^{**}$), $\text{Ca}^{2+}+\text{Mg}^{2+}$ ($r=0.252^*$) and an insignificant negative correlation with F^- , Na^+ , SAR, RSC and HCO_3^- . For the tube well water, the EC shows a significant positive correlation with NO_3^- ($r=0.650^*$), TDS ($r=1.00^{**}$) and an insignificant negative correlation with K^+ , $\text{Ca}^{2+}+\text{Mg}^{2+}$, HCO_3^- and F^- [25] There is a significant relationship between the sodium adsorption ratio (SAR) of groundwater and the extent to which the sodium is absorbed by the soils. If the water used for irrigation is high in sodium and low in calcium content, then the exchangeable calcium in the soil may replace the sodium by the base exchange reaction in the water. This can destroy the soil structure owing to the dispersion of the clay particles. The SAR shows a significant positive correlation with Na^+ ($r=0.985^{**}$) and an insignificant negative correlation with NO_3^- , pH, EC, Cl^- , Ca^{2+} , Mg^{2+} and F^- in the hand pump water [24] The SAR shows a significant positive correlation with Na^+ ($r=0.927^{**}$), RSC ($r=0.612^*$) and a negative insignificant correlation with F^- , K^+ and $\text{Ca}^{2+}+\text{Mg}^{2+}$ in the tube well water. In addition to the RSC, the excess sum of carbonate and bicarbonate in groundwater over the sum of calcium and magnesium also influences the suitability of groundwater for irrigation. The continued use of high residual sodium carbonate water affects the yields of crops. RSC shows a significant positive correlation with the pH ($r=0.350^{**}$), HCO_3^- ($r=0.242^*$) and an insignificant negative correlation with the EC, Cl^- , $\text{Ca}^{2+}+\text{Mg}^{2+}$, K^+ , NO_3^- in the hand pump water [26] In the tube well water the RSC showed a significant positive correlation with pH ($r=0.726^{**}$), SAR ($r=0.612^{**}$) and an insignificant negative correlation with NO_3^- , $\text{Ca}^{2+}+\text{Mg}^{2+}$, K^+ and Cl^- in the tube well water. [26]

V.CONCLUSIONS

Gugor Gram Panchayat in Chhabra Block of Baran District in Rajasthan lies on the banks of river Parvati that joins Rajasthan and Madhya Pradesh. The village experiences heavy rain during the monsoons owing to which it remains flooded. Despite this, water crisis during the summer months is common as the river goes dry. To tackle water shortage, the district administration has constructed a 40,000 litre water storage tank that provides for the needs of the community. District officials also identified 127 acre land and conducted an anti-encroachment drive for afforestation. They will continue to actively work with the Gugor GP to create a large green cover in the land and across the village. Further, with a view to creating awareness on water conservation, a Kalash Yatra was organised. The village community joined together and pledged to save water and use water efficiently. [26]

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