Dam water and ground quality and its suitability for drinking and agricultural use in the Tonk of Niwai Province, RAJASTHAN

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Abstract :

The Tonk in Rajasthan Province is an important agricultural area with a low population density. The widespread agricultural activities in the Tonk Basin started delugeirrigation techniques. Since then, the water sample plan was raised because of the absence of an efficient drainage system. This obstruction is a critical factors that sustainable socioeconomic development. Hydro-chemical investigations were conducted in the, Tonk Rajasthan, to determine the chemical composition of dam water. Seventy water samples were collected from different area dam and hand pumps water to monitor the water chemistry of a range of ions. The results of the chemical analysis indicate that the dam water and ground water in this region is usually neutral to slightly acidic and predominantlymainly contains Na^+ and Ca^{2+} cations as well as HCO_3^- and SO_4^{2-} anions. High positive correlations between HCO_3^-, Mg^{2+}, Ca^{2+}, SO_4^{2-}, Mg^{2+},Na^+, K^+, and Cl^-,F^-were obtained. The total dissolved solids (TDS) mostly depend on the concentration of major, ions such as HCO_3^-, SO_4^{2-},Ca^{2+}, Cl^-, Mg^{2+} and Na^+, K^+, F^-. The dominant hydro–chemical faces for water samples are Mg^{2+}, HCO_3^-, Ca^{2+}, SO_4^{2-}, Cl^-, Na^+, K^+, Cl^-,SO^{2-} , F^- , PO^{3-}, NO^-, As, Cd, Pb and Cu. The hydro–chemical processes are the main factors that determine the water quality of the water system. These processes include weathering dissolution, ion exchange, and to a lesser extent, evaporation, which seem to be more pronounced down gradient of the flow system. The saturation index (SI), which is calculated according to the ionic ratio plot, indicates that the gypsum–halite dissolution reactions occur during a certain degree of rock weathering. SI also indicates that evaporation is the dominant factor the major ionic composition in the study area. The assessment results of the water samples using various methods indicate that the water in the study area is generally hard, fresh to brackish, high to very high saline, and low alkaline in nature. The high total hardness and TDS, chloride and, F^- NO_3^- of the water sample in several places indicate the unsuitability of the water sample for drinking and irrigation. These are as necessitate particular thought, particularly in the creation of adequate drainage as well as in the introduction of a substitute salt tolerance cropping.

Keywords: Water quality, ground water, Hydrochemical process, Saturation index Sodium adsorption ratio.

1. Introduction

Water is a critical resource for sustainability and development of civilization. Waterand application in almost all spheres of life. In general, organized water uses can be generalized into municipal, industrial and agricultural water uses. The quantity and quality requirements depend on the intended use of water. Global water use assessments have been made with different degrees of comprehensiveness and reliability in many countries of the world. Various studies on the quantity and pattern of water use were conducted at different periods in various countries. Several basic factors such as socio-economic development level, population, and physiographic feature sand area of the territory determine the volume and structure of water use, its dynamics and future tendencies. Municipal water uses are apportioned among housing estates, domestic and public services and enterprises. The volume of public water use depends on population, the level

of services and the availability of resources. Climatic factors also play a crucial role in the nature and quantum of water use. Precipitate use of water varies from country to country and from region to region.

The water quality has become one of the most agriculturally prolific areas in Tonk region, Rajasthan, since then, the water table has been elevated as a result of the absence of an efficient drainage system (Li et al. 2008). Moreover, the water quality has been affected by irrigation (Brunner et al. 2008; Li et al. 2009). Hence, to use and protect valuable water resources effectively and top redact the changes in water environments, the evolution and hydro chemical characteristics of water under natural water circulation processes must be implicit (Banoeng-Yakubo et al. 2009; Cloutier et al.2008; Yamanaka et al. 2006).

This study aims to identify the processes that control the geochemical evolution of water quality and to characterize the water–rock interaction as well as its effects on water chemistry. Statistical method sand a hydro–chemical approaches were used to divide the territory into areas withdistinct water qualities. Finally, this study may supply to the expansion of more efficient alternative corrective measures to combat the corrosion of water quality and to aid the management and future development of water resources in the region

Study area Location

Niwai Tehsil (Tonk district), located in the south-east on of Rajasthan, India, has a semi- arid region (N 26°23', E 73°8') of Rajasthan, India, has a semi-arid climate and various kinds pressure conditions viz. low and unpredictable rainfall, (Govt. of Rajasthan 2005). Agriculture is the dominant land use and comprises mainly of sloped farmlands, orchards, crop fields, sparse, and residential land.Soil is generally sandy loam to loam and classified clayey loam to loam. The main crops grown are wheat corn, groundnut. Til, mustard, Barelyand, Johor. The total cropland area the total population in the study area is 360000.

Climate

The Tonk has a semiarid very hot climate, with an annual precipitation of 45 mm and a mean annual evaporation of up to 90 mm. The mean annual temperature is 34.5 °C. The coldest month is January, which has an average temperature o 10 °C, whereas the hottest month is Aug, which has an average temperature of 34.9 °C. The relative humidity ranges from 36.7% (Dec) to 73.7% (Aug).

Materials and methods

Water, samples were collected from different villages of Niwai Tehsil Rajasthan mixed, and a total of 70 water samples were collected from different sources such as tube well, well, deep tube well, ponds, and hand-pumps were stored in area from(July2015 to Dec2015) (Fig1) Tarson polypropylene Carboys bottles. The chemical compositions were analyzed at the Banasthali Vidyapith Lab Tonk for major ions such as Na^+,K^+, Mg^{2+},Ca^{2+},$SO4^{2-}$,Cl^-, COD, NO_3^-,PO_4^-,CD,Pb, As,Cu,Cr, Mn.The water temperature, electric conductivity (EC), and pH were measured in situ. The major anions, namely, were analyzedSO_4^{2-} by spectrophotometer.Chloride and, COD were analyzed with titration method, whereas the cations, namely, Na^+, K^+, Mg^{2+} and Ca^{2+}were analyzed using inductively AAs. The total hardness (TH) in terms of CaCO3andHCO_3 concentrations was analyzed using titration. The TDS concentration was calculated using the results of the chemical analyses. All 70 samples were analyzed for their internal consistency using the Aqua chemical program. All samples collected from the Tonk exhibited chemical imbalances not exceeding 5 %. The parameters were then tests for normality.



Fig. 1 Location map of Tonk.

Result and discussion

Major ions are chemistry of dam and ground water.

The hydro–chemical properties of water samples collected from the Tonk are shown in Table

1. The groundwater and dam water pH ranges from 6.5 to 10.5 with an average of 7.215 and a standard deviation of 0.666. These values indicate that the waters are generally neutral to slightly acidic. The groundwater EC in the area ranges from 0.859to 6.589 µS/cm, with an average of 2.661µS/cm (Table 1). The TDS of water sample ranges from 196 to 3,600 mg/l, with an average of 1554.504 mg/l (Table 1). The TH (as $CaCO_3$) ranges from 440 to 1600mg/l, with an average of 720mg/l. The cation concentrations and ratios are symptomatic of water–rock interactions such as cation exchange, dissolution, and mineral weathering (Han *et al.* 2009). In the Tonk, the Na concentrations in water quality range from 26 to 300mg/l and from 1.08 to 67.5 mg/l, respectively, and the mean values are 246.68 and 9.78 mg/l, respectively the mean values are246.68 and 6.78 mg/l, respectively (Table 1). The high sodium concentrations are credited to the cation exchange of the water minerals. The Ca^{2+} concentrations in water quality range from 16 to 289 mg/l, with an average of 59.05 mg/l. This result is attributed to calcium-rich minerals such as amphiboles, pyroxenes, and feldspars. Meanwhile, the $Mg_2^{++}$and K concentrations in water quality range from 30 to 250 mg/l, with an average of 144.5 mg/l. This result is due to the ion exchange of minerals in the surrounding rocks and soils (Table 1). The carbonate (CO^-) and bicarbonate (HCO^-) concentrations in ground and damwater are derived from carbon weathering as well as from the dissolution of carbonicacid in the aquifers (Kumar et al. 2006; Eq.1).

$$CaCO_3+CO_2+H_2O \longrightarrow Ca^{++}+2HCO_3^-$$

$$CO2 + H2O \longrightarrow H^+ +HCO_3^-$$

The HCO_3^- concentration in the study area ranges from120 to 332 mg/l, with an average of 300.75 12 mg/l. The sulphate (SO_4^{2-}) concentration varies from 25 to 200 mg/l, with an average of 89 mg/l. Meanwhile, the chloride (Cl^-) concentration ranges from 255 to 3000 mg/l an average of (543.44 mg/) and increases from the recharge area to the discharge area. Figure 4 shows that Na^+ and Ca^{2+} are generally dominant, with medians (in milligram per litre) of 83 and 47 % of all cations, respectively. The magnesium ions chase exhibiting a median of 27 % of the totalcations. On the other hand, thepotassium ion content of Dam water and, groundwater is insignificant, with a median of only 2 % of the total cation.Meanwhile, of the major anions, $HCO3^-$ and $SO4^-$are generally dominant, with medians of 12% and 3 %of the total anions, respectively, followed by the Cl^- ions, which represent approximately 85 % of the total aions.

Pearson's correlation matrices (Swan et al. 1995) were used to determine the relationships between two or more variables. Table 2 shows the correlation coefficients of the major ions in groundwater and dam. A high positive correlation (>0.75) and a significance level of P<0.05 were obtained for $HCO_3^-Ca^{2,+,}$ $SO4^-$, Mg^{2+}, SO_4^-, Na^+, K^+,Mg^{+2},an

Table 1 Summary statistics of the analytical data dam water and groundwater samples of the study area exceeding the permissible limits prescribed by WHO for drinking the purpose

EC electrical conductivity, SAR sodium adsorption ratio, CAI index, TDS total , EC, EC ,dissolved solids, , TH total hardness, As, Pb , Nitrate, Cu, COD, SO_4 SD standard

Parameters	Units	Minimum	Maximum	Mean	SD	WHO International standard (2002)	Most desirable limits	Maximum allowable limits
pH		6.5	10.5	7.4	0.893		7–8.5	9.20
TDS	mg/L	196	3,600	1599.4	1025.5	500.00		1,500.00
Ca	mg/L	16	289	154.1	50.4	75.00		200.00
Mg	mg/L	30	259	109.4	62.5	50.00	150	
Ca	mg/L	16	289	154.1	50.4	75.00		200.00
Mg	mg/L	30	259	109.4	62.5	50.00	150	
Na	mg/L	26	300	18.4	6.05	–	–	200
K	Mg/L	0.856	1.86	1.15	1.02	–	–	–
CO_3	Mg/L	118	280			-	–	–
SO_4	Mg/L	8	100	39.9	21.99		200	400
Cl	Mg/L	147	3050	1280	88.99		200	600
TH	Mg/L	300	1600	814.9	460.7		100	500
As	Mg/L	0.1067	0.357	0.1445	0.0097		0. 5	–
Cu	Mg/L	0.1999	0.3548	1.6	0.854		0.5	–
Pb	Mg/L	0.1089	0.5426	0.3489	0.1429		0.5	–
CD	Mg/L	0.01965	0.5545	0.21474	0.13183		0.5	-
COD	Mg/L	3.9	25	12.2988	5.349		10	-
CAI	Mg/L	-0.39	25.1	15				
Nitrate	Mg/L	25	55	37.38	10.19	10	45	-
Fluoride	Mg/L	0.284	8			1.5	0.6	1.5

CAI index, TDS total , EC, EC ,dissolved solids, , TH total hardness, As, Pb , Nitrate, Cu, COD, SO_4 SD standard dervation

Na+,k+ Meanwhile, TDS mainly depends on the concentrationof major ions such as HCO3Ca^{2+},Mg^{2+},andNa+K+SO4-,Cl,

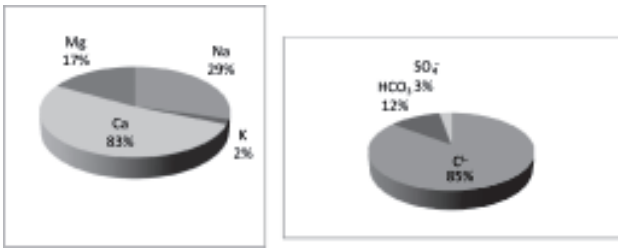


FIG -3 pie digaram major ions

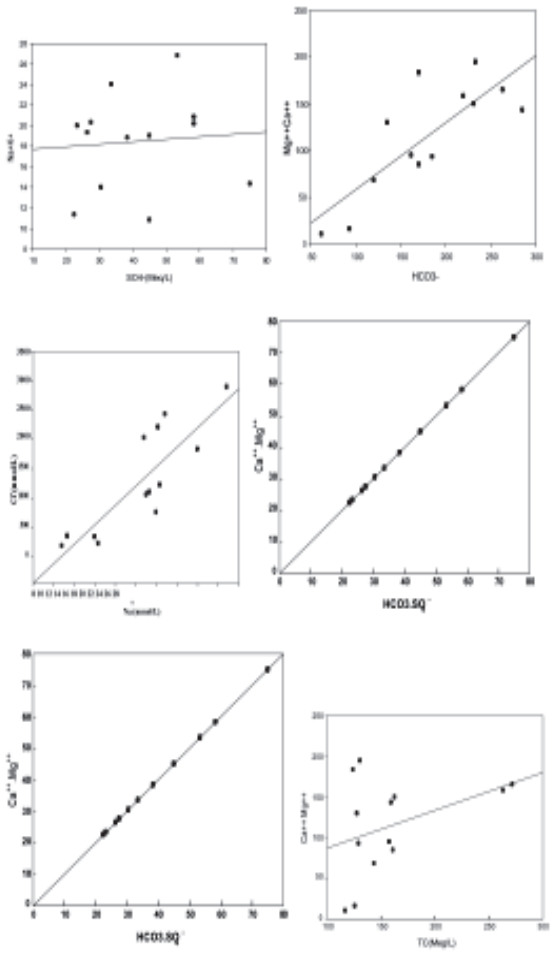
Hydro chemical evolution-The results of the chemical analyses were used to recognize the Dam water and groundwater evolution mechanism as well as the geochemical processes in the Tonk. The$Cl^{"}$ concentrations usually reflect the input conditions at the time of recharge and may be subsequently modified by inputs from forming waters or from evaporation (Anupam et al. 2012). Increases in the $Cl^{"}$ and Na^{+} concentrations were observed along the flow pathof the majority of the dam water and groundwater samples.

In arid regions, the Na+–$Cl^{"}$ affiliation is generallyused to determine the mechanism of salinityacquisition and saline intrusions (Ravikumar et al. 2010). In general, if the evaporation process is dominant and no mineral species are precipitated in ground-water, the Na+/Cl" molar ratio is constant (Cloutier et al. 2008), and the plot of Na+/Cl" versus Cl" gives a horizontal line (Fig. 3). In this study, the Na+/Cl"as in generally range from 0.61 to 3.94, with a mean Na ratios for the dam water, and groundwater samples from the tonk generally range from 0.61 to 3.94, with a When the Na+ concentration is plotted against that of Cl", most of the water samples meanlie slightly above the 1:1 trend line (Fig. 3). The highNa+/Cl" ratios are probably due to water–rock inter- actions (Adomako et al. 2011) . The plot of Ca_2^{+} + Mg_2^{+} versus $HCO3^{"}$ + $SO4^{-}$ will be close to the 1:1 line if the dissolution of calcite, dolomite, and gypsum are the dominant reactions in a system (Anupam et al. 2012). The plot of Ca2+ + $Mg2^{++}$ SO4 versus HCO3 shows that most of the ground-water dam water water samples fall below the 1:1 trend, which shows the requirement for cations from the weathering of silicate rocks (Fig. 3c). Therefore, the excess positive charge of $HCO3^{-}$and $SO4^{-}$ mustbalanced alkalis (Na^{+} + K^{+}). A high Na+ concentration is an indicator of ion exchange in the dam water groundwater..

Theplot of Ca^{2+} Mg^{2}+versus $HCO3^{"}$ (Fig. 6d) versus HCO_3 shows upper limit of$HCO_3^{"}$ input from wreathingof carbonates (Yidana et al. 2011). The Ca_2^{+} and Mg_2^{+} sources in dam water and groundwater can be deter- mined from the (Ca^{2+} + $Mg^{2+)/}HCO3^{-}$ ratio . if $Mg^{++}$and Ca^{2+} originate from the dissolution of carbonates in the aquifer materials as well as from the weathering of accessory pyroxene or amphibole minerals, this ratio would be approximately 0.5 (Sami 1992). The" (Fig. 5)shows plot of Ca2+ + Mg2+ versus HCO3 5showsthat most of the data fall below the 1:1 trend line even though a number of points approach this line. The low ratio (<0.5) may be due to either Ca2+ + Mg2+/HCO3,Ca_2^{+} Mg^{2+} depletion by cation exchange or HCO3enrichmentHowever, high ratios cannot be attributed" depletion because under the existing alka- to HCO3" does not form carbonic acid line conditions, H2CO3) (Spears 1986). The high ratios indicate that an excess of alkalinity in these waters is balanced by the alkalis Na+ and K+. The higher Ca2+ + Mg2+oncentrations compared with those of HCO3ral samples indicate the existence of an additional Ca2+ and Mg2+ source. These excess concentrations are balanced by Cl" and SO4Meanwhile, the plot of Ca2+ + Mg2+ versus the totaltions (Fig. 6e) shows that the chemical compositions of the samples are far below the theoretical line (1:1;This result indicates an increasing Na+ andK+ contribution as TDS increases (Subba Rao 2008). Figure 6f shows that the increases in acid concen-K+ contributionas TDS increases (Subba Rao 2008).In the first group, the positions of the data points in the Piper diagrams represent ca++mg ++, HcO3,2", Mg2+–Ca2+–Na+– HCO3,Ca++.mg++, SO_4-The TDS concentration inthe majority of the groundwater samples is <500 mg/l, indicating that the dam water groundwater samples are freshwater. $HCO3^{-}$ andSO_4^{-} are the major anion in the dam water and ground waterwhereas Mg2+

and Ca2+ are the major cations. The relative concentrations of the ions areranked in the following order: Mg2+ > Ca2+ > Na+ +2 > Cl" (Fig. 5). These types of water are generally found in the2 > Cl" (Fig. 9). These types of water are generally found in theseThese types of water are generally found in thetonk areas of the rajasthan, where the groundwater recharge areas are located. This water type may be found during rapid flow-through times, which result in low ionic concentrations during the high recharge period in shallow zones. This phenomenon is currently the major factor that determines the chemical charac teristics of the surface waters in the groundwater.

In the second group, the positions of the data points in the Piper diagrams represent the Ca^{2+},Mg^{2+}– Cl"$SO4^{-}$, mg^{++}, ca^{++},$SO4^{-}Cl^{-}$,mg,Mg,Na^{++}Most of the groundwater and dam waterter samples are greater than 500 mg/l, indicating that the groundwater is fresh, slightly saline, or moderately and Cl" are the major anions, saline water. $SO4^{-}$ whereas Na^{+} and Ca2+ are the major cations. The relative concentrations of the ions are ranked in the

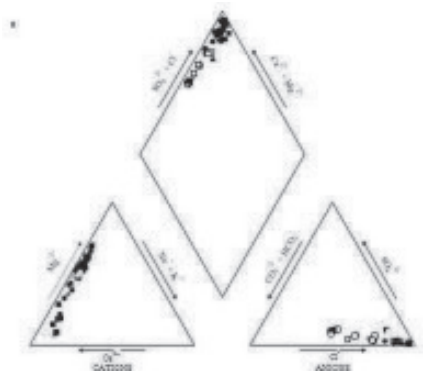


for groundwater in the study area (The solid line denotes1:1)

Table 2 Correlation coefficient s between major ions in groundwater and Dam water

	TDS	Ca++	Mg++	Na+	K^{+}	$So4^{-2}$	$NO3^{-}$	Cl^{-}	F^{-}	$HCO3^{-}$	$CO3^{-}$
TDS	1										
Ca++	0.739	1									
Mg++	0.547	0.426	1								
Na+	1	0.516	0.786	1							
K^{+}	0.724	0.686	0.585	0.788	1						
$So4^{-}$	0.624	0.4	0.12	0.54	0.583	1					
NO3	0.57	0.444	0.745	0.688	0.62	0.179	1				
Cl^{-}	0.957	0.767	0.561	0.611	0.688	0.252	0.48	1			
F^{-}	0.862	0.656	0.769	0.715	0.0705	0.769	0.761	0.634	1		
HCO3	0.486	0.205	0.523	0.248	0.578	0.102	0.358	0.716	-0.21		
CO3	-0.63	0.305	0.373	0.426	0.348	0.22	0.423	0.128	0.321	1	0.365

Fig. 5–**Ion scatter diagramsfordiagram Dam watergroundwater in the study area (The solid linedenotes 1:1)**



1Ca^{+2}+Mg^{+2}+SO_4^-+Cl^-II Type Na^++K^++ Mg^{+2}+ Ca^{+2}IIIrd Type CO_3+2$_{+\ HCO3+IVTypeE}$

SO4-VCl$^-$

Drinking and irrigation water quality

The analytical results were evaluated to determine the suitability of the dam water and ground water for drink ing and agricultural uses. The drinking water quality was then compared with the condition set by the World Health Organization (WHO 2002). According to the WHO, a TDS of up to 500 mg/l is the optimum value, whereas a TDS of 1,500 mg/l is the maximum permissible concentration (Table 2).

Based on this classification, 90 % of the samples belong to the maximum permissible category, whereas the remaining samples exceed the maximum allowable limits. The dam water ,and ground water classification based on TH (Sawyer and McCarty 1967) shows that 50 % of the dam water and groundwater samples fall in the very hard-water class, whereas 35 % fall in the hard-water category (Table 3). The maximum allowable TH maximum value for drinking water is 500 mg/ l, and the optimal level is 100 mg/l as per the WHO international standard. Based on this classification, 22 % of the samples surpass the maxi- mum permissible limits. Water with TH above 80 mg/l cannot be used for domestic purposes because it coagulates soap lather. The development and maintenance of successful irrigation projects involve not only the supply of irri- gation water to the land but also the control of salt and alkali in the soil (Haritash et al. 2008). The suitability of dam water and groundwater for agricultural uses is determined by parameters such as the sodium absorption ratio, sodi- um percentage (%Na), residual sodium carbonate, and permeability index (PI) (Raju 2007).

EC is a measure of the degree in which water conducts electricity. Salty water conducts electricity more readily than pure water. Therefore, EC is habitually used to measure salinity. Based on this categorization, 46.67 % of the dam water and groundwater samples in the study areas belong to the good category, 45 % to the permissible category, 6.67 % to the doubtful category.

Conclusions

Hydro chemical analysis shows that the dam water groundwater in the TONK is generally neutral to slightly acidic, hard to very hard, and acidic in nature. The relative abundance of the major ions can be ranked as followed Na^+>Ca^{+2}> Mg^{+2}> $K^+$and HCO_3^->Cl^-. A high positive correlations n between the following ions was obtained HCO_3^- · Mg^{+2}, $SO4^-$, Na^+ and Na+, Cl^-· TDS mainly depend on concentration of major ions such as HCO_3^-·$SO4^{-2}$,Cl^-, Mg^{++} and Na^+. The Hyderochemical in the area can be classified the three major group. per liter (Eaton 1950).The classificationof irrigation water according to the RSC value indicatesthat water with an RSC of above 2.5 meq/l isnot suitable for irrigation, those with RSCs of 1.25to

2.5 meq/l are considered doubtful, and those withRSCs below 1.25 meq/l are good for irrigationwater as well as by the sodium, calcium,magnesium, and bicarbonate contents of.Ragunath (1987) developed a criterion for assessing the suitability of water for irrigation basewhere alionareex presseinmillie quivalenperlit(Ragunath 1987). The WHO (1997) uses a criterionfor assessing the suitability of water for irrigationbased on PI. According to this criterion, the dam water and ,groundwaterin the study area can be classified as class II (25to 75 %), whichindicates that the dam water , and groundwatersunsuitable for irrigation. However, 70 of the samplescan be classified as class I (>75

%).3ypes. Most of thgroundwater samples are above 1,000 mg/l, indicating that the groundwater is slightly saline ormoderately saline. These types of water are generally found in the Tonk region areas and occur in the intermediate zone of groundwater discharge areas dam water.Generally, This result may be attributed to evaporation.. The assessment of the water quality damusing the parametric values established bythe WHO indicates that most of the groundwater samples in the study area are chemically suitable for drinking use. The calculated SAR, %Na, andRSC show that the water is generally suitable for irrigation. However, the higher salinities and %Na at certain sites reduce the suitability of the dam water ground waterfor irrigation. This condition requires special management. The conclusions of this study should be measuredwhen developing strategies for the proper managementof dam water ,and groundwater resources in the Tonk region.

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