

CHAPTER - VIIIGROUNDWATER POTENTIAL AND CHEMICAL QUALITYGENERAL

Groundwater is a renewable resource, subjected to periodic replenishment primarily from precipitation. To have a measure of the quantum of periodic increment to any groundwater body it is essential to obtain precise information on the hydrogeological framework of the study area, the groundwater aquifer conditions and the factors governing the recharge to and discharge from the groundwater system.

GROUNDWATER POTENTIAL ASSESSMENT

It is an accepted concept that a balance exist between the quantity of water supplied to the basin and the quantity

of water stored or existing in any basin over a specific period. And in a budget all waters incoming and outgoing the basin are considered, in general form, the hydrologic equilibrium in general form, the hydrologic equilibrium will be :

$$\text{Change in storage} = (\text{inflow into basin} - \text{outflow from the basin})$$

Hence; the most important one is to determine the replenishable component of recharge on annual basis.

GROUNDWATER RECHARGE

By definition recharge means replacement of something which has been taken out of a system either by artificial or natural processes. Therefore in any particular location of a groundwater regime the study of recharge or replenishment may be measured in terms of the decrement from storage in a period of time provided, during that period the storage remained constant. The principal sources of natural recharge of groundwater in any given area are meteoric precipitation, stream flow and lakes, and those of artificial recharge are surplus water from irrigation seepage, from man made water storage on surface, e.g. artificially impounded reservoirs, flow in canals or water introduced into the groundwater storage.

The quantitative estimation of groundwater recharge in the hard rock terrains is relatively a more complex task compared with well defined groundwater basins having well defined and delimited storage rocks. The complexities arise out of diversity in the conditions of groundwater occurrence within a definite groundwater basin in the hard rock terrains. The difficulties which crop up in direct or indirect quantitative estimation of recharge in the hard rock terrain are primarily inherent in the geological environment and may be classified as follows:

- a) Variation in the geomorphic expression at relatively short intervals of areal extent of the basin necessitating changes in norms of average slope of the area for the purpose of run-off computation.
- b) Wide variations in precipitation characteristics within different sectors of a basin.
- c) Wide range of variation of permeability of rock types and their products of weathering.
- d) Variation of features of structural control in the weathered and unweathered rock masses for groundwater percolation and movement.
- e) wide variation in the depth and lateral extent of the zone of weathering.
- f) Frequent occurrence of sub-surface boundary conditions below the zone of saturation causing intra-basin

- separation of the groundwater reservoir, and
- g) Wide variation in the composition and extent of phreatophytes within a basin at different terrain conditions and elevations so that computation of transpiration losses is a complex system.

In general, recharge in unconfined aquifer occurs over a large area and via unsaturated zone. Recharge to semi-confined aquifer is generally restricted through a narrow strip of permeable formations located at a higher elevation and connected to the aquifer. The process of recharge through unsaturated zones occurs in three steps (i) infiltration (ii) storage in soil and (iii) movement to water table.

Several methods of evaluation of groundwater recharge are available. The two approaches currently in vogue are (i) the water balance approach, and (ii) water table fluctuation/Sp. yield approach. For calculating the recharge and draft the basin area is divided into two parts viz. upper part (i.e. upper and middle basin of geomorphic division) and lower part (i.e. lower basin of the geomorphic division). The aerial and percentile distribution of two lithologic units viz; consolidated and unconsolidated, have been taken as the basis for this break-up. The basinwise lithologic distribution is as under:

(i)	Upper Heran basin	1037 sq.km.	
	consolidated rocks	827 sq.km	(80%)
	unconsolidated rocks	210 sq.km.	(20%)
(ii)	Lower Heran basin	208 sq.km.	
	consolidated rocks	99 sq.km.	(34%)
	unconsolidated rocks	189 sq.km.	(66%)
(iii)	Entire Heran basin	1325 sq.km *	
	consolidated rocks	928 sq.km.	(70%)
	unconsolidated rocks	397 sq.km.	(30%)

*As the surface water divide in the lower basin area does not follow groundwater divide, all aquifers in the lower basin shows isotrophy in their continuity upto river Orsang. Hence, for calculating recharge and potential, the basin area limit has been extended by including 116 sq.km. area in the lower reaches of the basin).

(I) Recharge From Rainfall

I.1. Groundwater Over Exploration Committee's Approach

Recharge to the groundwater has been calculated on the guidelines set by the Groundwater Over Exploration Committee (1979). The norms, known as New Norms for Groundwater Evaluation and Development (ARDC III) suggests "Recharge From Rainfall" in -

(i) Alluvial Areas

In sandy areas : 20 to 25 % of Normal Rainfall

- In area which
 have larger clay content : 15 to 20% of Normal Rainfall
 (ii) Hard Rock areas : 10 to 15 % of Normal Rainfall.

Based on the field observations and overall rainfall pattern, the author has adopted lower limits of New Norms for recharge calculations. The recharge from rainfall in :

(i) Upper Basin

$$\text{Rainfall} = 0.969 \text{ m} \text{ ----- (from Chapter -V)}$$

$$\text{Recharge (I)} = \text{Rainfall} \times \text{Infiltration} \times \text{Total Area}$$

$$\begin{aligned} \text{Inconsolidated formation} &= 0.969 \times 0.10 \times 827 \times 10^6 \\ &= 80.13 \times 10^6 \text{ (80.13 Mm}^3\text{)} \end{aligned}$$

In unconsolidated formations

$$\begin{aligned} &= 0.969 \times 0.15 \times (210 \times 10^6) \\ &= 30.52 \times 10^6 \text{ (30.52 Mm}^3\text{)} \end{aligned}$$

$$\begin{aligned} \text{Total recharge} &= 80.13 + 30.52 \\ &= 110.65 \text{ Mm}^3 \quad \dots\dots\dots (A_1) \end{aligned}$$

(ii) Lower Basin

$$\text{Rainfall} = 1.026 \text{ m}$$

$$\text{Recharge (I)} = \text{Rainfall} \times \text{infiltration} \times \text{area}$$

In consolidated formations

$$\begin{aligned} &= 1.026 \times 0.10 \times (99 \times 10^6) \\ &= 10.15 \times 10^6 \text{ (10.15 Mm}^3\text{)} \end{aligned}$$

In unconsolidated formations

$$\begin{aligned} &= 1.026 \times 0.15 \times (189 \times 10^6) \\ &= 29.08 \times 10^6 \text{ (29.08 Mm}^3\text{)} \end{aligned}$$

$$\begin{aligned} \text{Total recharge} &= 10.15 + 29.08 \\ &= 39.23 \text{ Mm}^3 \quad \dots\dots \quad \dots\dots (B_1) \end{aligned}$$

(iii) Entire Heran Basin

In Consolidated formations

$$0.974 \times 0.10 \times (928 \times 10^6) \\ = 90.30 \times 10^6 \text{ (90.38 Mm}^3\text{)}$$

In unconsolidated formations

$$0.974 \times 0.15 \times (397 \times 10^6) \\ = 58.0 \times 10^6 \text{ (58.0 Mm}^3\text{)}$$

$$\text{Total recharge} = 90.38 + 58 = 148.38 \text{ Mm}^3 \text{(C}_1\text{)}$$

I.2 Sukhiya's Approach

Sukhiya (1972) has carried out extensive study on groundwater recharge for his doctoral thesis "Evaluation of Groundwater Recharge in Semi-arid Region of India; Using Environmental Tritium".

The entire study was based on actual field observations at six different stations in Gujarat. Author, has applied his findings for the computation of recharge in the Heran basin. As per Sukhiya's derived values, the recharge from rainfall in

Consolidated formations : 3% of Normal Rainfall

Unconsolidated formations: 8% of Normal Rainfall

(i) Upper Basin

$$\text{Rainfall} = 0.969 \text{ m}$$

Recharge in consolidated formations

$$= 0.969 \times .03 \times (827 \times 10^6) \\ = 24.04 \times 10^6 \text{ (24.04 Mm}^3\text{)}$$

$$\begin{aligned} \text{In unconsolidated formations} &= 0.969 \times 0.08 \times (210 \times 10^6) \\ &= 16.27 \times 10^6 (16.27 \text{ Mm}^3) \end{aligned}$$

$$\begin{aligned} \text{Total recharge} &= 24.04 + 16.27 \\ &= 40.31 \text{ Mm}^3 \quad \dots \quad \dots \quad \dots (A_2) \end{aligned}$$

(ii) Lower Basin

$$\begin{aligned} \text{In Consolidated formations} &= 1.026 \times 0.03 (99 \times 10^6) \\ &= 3.04 \times 10^6 (3.04 \text{ Mm}^3) \end{aligned}$$

$$\begin{aligned} \text{In unconsolidated formations} &= 1.026 \times 0.08 \times (189 \times 10^6) \\ &= 15.51 \times 10^6 (15.51 \text{ Mm}^3) \end{aligned}$$

$$\begin{aligned} \text{Total Recharge} &= 3.04 + 15.51 \\ &= 18.55 \text{ Mm}^3 \quad \dots \quad \dots \quad \dots (B_2) \end{aligned}$$

(iii) Entire Heran Basin

In consolidated formations

$$\begin{aligned} &0.974 \times 0.03 \times (928 \times 10^6) \\ &= 27.11 \times 10^6 (27.11 \text{ Mm}^3) \end{aligned}$$

In unconsolidated formations

$$\begin{aligned} &= 0.974 \times 0.08 \times (397 \times 10^6) \\ &= 30.93 \times 10^6 (30.93 \text{ Mm}^3) \end{aligned}$$

$$\text{Total Recharge} = 27.11 + 30.93 = 58.04 \text{ Mm}^3 \quad \dots \quad \dots (C_2)$$

I.3 Water Table Fluctuation/Specific Yield Approach

Groundwater levels rise due to rainfall or any other source of recharge. The rise during the monsoon period is, by and large, attributable to the increment to the groundwater body due to rainfall. Thus, the magnitude of the rise is in a

way a measure of the recharge to the groundwater; which amongst other things is dependent on the specific yield of the formation materials, comprising the zone of saturation.

To study the pattern and the behaviour of the groundwater regime with time, the author has constructed hydrographs for the period of six years. The water table fluctuations in the upper part of the basin have been studied for the period between postmonsoon (1976) to premonsoon (1982) and (1983-85), in the lower basin between premonsoon (1979) and premonsoon (1985). Selected numbers of observation wells have been taken for the long term fluctuation studies and their blockwise weighted area were calculated by employing theissen's polygon method. For the calculation of recharge from rainfall, six years lowest premonsoon and highest postmonsoon levels were considered. Formations specific yield values for - Metamorphics (3 %) Sandstone (2.5%), Basalt (2.5%) and alluvium (10-12%) were adopted.

Recharge due to rainfall has been worked out from the general relation.

$$R = A \times S_y \times (h_1 - h_2) \text{ where}$$

R = Recharge due to rainfall, A = Area under evaluation

S_y = Specific yield of the aquifer, h₁ = monsoon ground water level, and h₂ = premonsoon groundwater level.

The arrived recharge values are -

- (i) Upper Basin = 121.37 Mm³ (A₃)
 (ii) Lower Basin = 60.18 Mm³ (B₃)
 (iii) Entire Heran Basin = 181.55 Mm³ (C₃)

The detailed account of recharge is given in Annexure VIII.1.

II. Recharge from Water Balance Approach

The recharge from this approach can be expressed as

$$I = (P - (R + ET))$$

where : I = infiltration (recharge)

P = Precipitation

R = Run off

ET = Evapotranspiration

From Chapter V

(i) Upper Basin

$$P = 0.969 \text{ m}, R = 0.475 \text{ M}, ET = 0.427 \text{ m}$$

$$I = (0.969 - (0.475 + 0.427))$$

$$\text{i.e. } 0.969 - 0.902 = 0.067 \text{ m}$$

$$\text{Gross Recharge} = I \times A \text{ (area)}$$

$$\text{i.e. } 0.067 \times 1037 \times 10^6$$

$$= 69.47 \times 10^6 = 69.47 \text{ Mm}^3 \dots\dots\dots (A_4)$$

(ii) Lower Basin

$$P = 1.026 \text{ M}, R = 0.323 \text{ n}, ET = 0.503 \text{ m}$$

$$I = (1.026 - (0.323 + 0.503))$$

$$\text{i.e. } 1.026 - 0.826 = 0.20 \text{ m}$$

$$\begin{aligned}
 \text{Gross Recharge} &= I \times A \\
 \text{i.e. } &0.20 \times 288 \times 10^6 \\
 &= 57.6 \times 10^6 = 57.6 \text{ Mm}^3 \quad \dots\dots\dots (B_4)
 \end{aligned}$$

(iii) Entire Heran Basin

$$\begin{aligned}
 P &= 0.974 \text{ m, } R = 0.427 \text{ m, } ET = 0.424 \text{ m} \\
 I &= (0.974 - (0.427 + 0.424)) \\
 \text{i.e. } &0.974 - 0.851 = 0.123 \text{ m} \\
 \text{Gross Recharge} &= I \times A \\
 \text{i.e. } &0.123 \times 1325 \times 10^6 \\
 &= 162.97 \times 10^6 = 162.97 \text{ Mm}^3 \quad \dots\dots\dots (C_4)
 \end{aligned}$$

Mean Recharge

For the purpose of groundwater potential assessment, the mean recharge value from various approaches has been considered. It could be seen from the computed values that except B.S. Sukhija's approach, all arrived recharge values varies between 11 to 22 % with each other. The very low values i.e. 58.04 Mm³ arrived by Sukhija's approach though it is very less but still applicable to the present study area, particularly in the upper and middle part (here upper basin) of the basin. Almost 20-30% of the total calculated recharge for upper basin goes as run-off to lower reaches. The main reasons which could be accounted for it are

- (i) The dynamic flow of groundwater
- (ii) affluent nature of river bed
- (iii) significant quantum of discharge through springs.

The canal irrigation from Rajwasana Wier in the lower basin is totally dependent on this water, particularly in the post monsoon period. Therefore, by considering all above cited factors the author, has adopted mean value of all the four approaches to consider as mean annual recharge in the Heran river basin .

Mean Recharge

(i) Upper Basin

$$\frac{A_1 + A_2 + A_3 + A_4}{4}$$

$$\text{i.e. } \frac{110.65 + 40.31 + 121.37 + 69.47}{4}$$

$$= 85.45 \text{ Mm}^3$$

(ii) Lower Basin

$$\frac{B_1 + B_2 + B_3 + B_4}{4}$$

$$\text{i.e. } \frac{39.23 + 18.55 + 60.18 + 57.6}{4}$$

$$= 43.90 \text{ Mm}^3$$

(iii) Entire Heran Basin

$$\frac{C_1 + C_2 + C_3 + C_4}{4}$$

$$\text{i.e. } \frac{148.38 + 58.04 + 181.55 + 162.97}{4}$$

$$= 137.73 \text{ Mm}^3$$

III. Recharge Due to Seepage from Canals & Irrigation

In the study area a small irrigation canal system from Rajwasana Wier irrigate about 25 sq.km area in the lower basin. The recharge due to seepage from canal and irrigation could not be computed. Therefore, the author has adopted GWRDC's computed values for his evaluation of recharge purpose. The estimated seepage both from canal as well as irrigation water has been taken as 2.59 Mm³.

GROUNDWATER DRAFT (EXTRACTION)

Groundwater in the study area exploited through out the year. The amount of the groundwater (Q) extracted from the basin area has been calculated on norms adopted by "Groundwater Estimation Committee" Adayalkar & Kittu (1983) and GWRDC (for dug wells with pump sets). The values adopted are -

- (i) Dugwell without pump = 5000 m³/year
@ rate of 8.3 m³/hr, 8 hrs/day, 75 days/year
- (ii) Dugwell with pump sets = 12,000 m³/year (upper basin)
18450 m³/year (lower basin)*
* (After GWRDC)
@ rate of 20 m³/hr & 30.75 m³ /hr respectively for
8 hrs/day, 75 days/ year
- (iii) Public tube wells = 3,00,000 m³/year (Upper basin)
4,00,000 m³/year(Lower basin)

Thus, the gross extraction can be calculated as -

$$Q = \text{Number of wells} \times \text{Annual draft}$$

Gross Extraction

Area	Well Type	Total Nos.	Annual Dis-charge	Annual Extra-ction	Gross Extraction
Upper Basin	Dugwell with -out pump	845	5000 M ³	4.22	15.82 Mm ³
	Dugwell with pump	720	2000 M ³	8.60	
	Public tube wells	10	300000 m ³	3.00	
Lower Basin	Dugwell with -out pump	415	5000 m ³	2.07	18.67 Mm ³
	Dugwell with pump	510	18450 m ³	9.40	
	Public tube well	18	400000 m ³	7.20	
Total Entire Heran Basin	Dugwell with -out pump	1260	-	6.29	34.49 Mm ³
	Dugwell with pump	1230	-	18.00	
	Public tube wells	28	-	10.20	

Net Extraction

70 % of the Gross extraction :

(i) Upper Basin	11.07 Mm ³
(ii) Lower Basin	13.07 Mm ³
(iii) Entire Basin	24.14 Mm ³

NET-GROUNDWATER POTENTIAL

(Mean Recharge + Recharge due to Canal Seepage - Net Extraction)

(i) Entire Heran Basin

$$\begin{aligned} \text{i.e. } & (137.73 + 2.59 - 24.14) \\ & = 116.18 \text{ Mm}^3 \end{aligned}$$

(ii) Upper Heran Basin

$$\begin{aligned} \text{i.e. } & (85.45 - 11.07) \\ & = 74.38 \text{ Mm}^3 \end{aligned}$$

(iii) Lower Heran Basin

$$\begin{aligned} & (43.90 + 2.59 - 13.07) \\ & = 33.42 \text{ Mm}^3 \end{aligned}$$

A comprehensive account of groundwater potential in the study area is given in Table 8.1.

For Heran River Basin

$$\begin{aligned} \text{(i) Stage of development} & = \frac{(\text{Net extraction})}{*(\text{Net recoverable recharge})} \times 100 \\ \text{expressed as percentage} & \\ & = \frac{24.14}{81.32} \times 100 = 29.68 \% \end{aligned}$$

(* Net recoverable recharge = 70% of the Gross recharge)

$$\begin{aligned} \text{(ii) Stage of Groundwater} & \frac{\text{Net yearly draft}}{\text{Net yearly Recharge}} \times 100 \\ \text{development} & \\ & = \frac{24.14}{116.18} \times 100 = 20.77 \% \end{aligned}$$

CHEMICAL QUALITY OF GROUNDWATER

In groundwater resource evaluation, the quality of groundwater is of nearly equal importance to quantity. Development and utilisation of the groundwater resources could be planned scientifically only, when the chemical character of groundwater is fully known.

The Heran basin comprise variety of geological formations with equally large number of rock units of various origin. These have given rise to a variety of rock formations having different chemical composition. Groundwater circulating in these lithologies develops a chemical character conformable to the constituent minerals comprising the rock formations. Indeed, there are many variables in the environment that effect the chemical quality of groundwater. The groundwater quality in the study area has been assessed by evaluating seasonal i.e. post and pre-monsoon quality parameters viz. Total Dissolved Solids (TDS), Hydrogen Ion Concentration (pH), Electrical Conductivity (EC) and Chloride (Cl) content.

DATA EVALUATION

As pointed out in the preceding chapter on Groundwater Hydrology, Soil Survey Department and GWRDC has carried out long term seasonal monitoring of observation wells for various project studies, particularly in the middle and lower

part of the basin. The available records from 1976-1982 have been collected by the author for the evaluation of groundwater chemistry of the study area. Fifteen numbers of tube well records from GWRDC has provided detail chemical analysis of groundwater of the alluvium area. The author has collected seven samples from the basaltic terrain and carried out detailed chemical analysis.

CONSTITUENTS

The following chemical constituents of groundwater samples have been evaluated.

Total Dissolved Solids (TDS)

The concentration of Total Dissolved Solids in the groundwater in the study area shows increasing trend from east to west. The highest TDS values have been observed in the alluvium area and lowest in the Deccan trap area of upper and middle basins. The highest T.D.S. 2048 ppm has been observed in the area around village Kunvad and the lowest 220 ppm at Kawant. The ISO - TDS contour map (Fig.8.1) has been drawn to obtain the maximum concentrations of dissolved solids. It could be seen from the figure that, there are two maxima showing maximum values 2000 ppm & 1200 ppm in the area around Kunvad - Bortalav and Sinhadra - Navagam respectively.

Anions

(i) Chloride Content (Cl^{-1}): Like TDS the concentration of chloride ions also shows increasing trend from east to west. The Iso-chloride contour map superimposed on TDS contours (Fig. 8.1) shows three maximas. Two maxima shows more than 400 ppm values in the area around Gundicha and Kankuva villages. Interestingly both these locations are located in the proximity of Precambrian metamorphics. A third maxima of 300 ppm could be seen near village Bihora. The minimum value 35 ppm has been observed in the observation well no. 25.

(ii) Bicarbonates (HCO_3^{-1}) : Among anions bicarbonates share major percentage (by weight). In the study area almost all the samples show more than 70% concentration (Table 8.2). The maximum 90.83% has been recorded from the tube well sample of Ratanpur village, and the minimum 63.78 % at Wanta.

(iii) Carbonates (CO_3^{-2}) : About 4.74 % (24 ppm) has been reported from the village Sitpur, which is situated in the proximity of the Heran Basin in the extreme west.

(iv) Sulphates (SO_4^{-2}) : The presence of sulphate ions in groundwater is very less and ranges between 2.3 % to 6.12%.

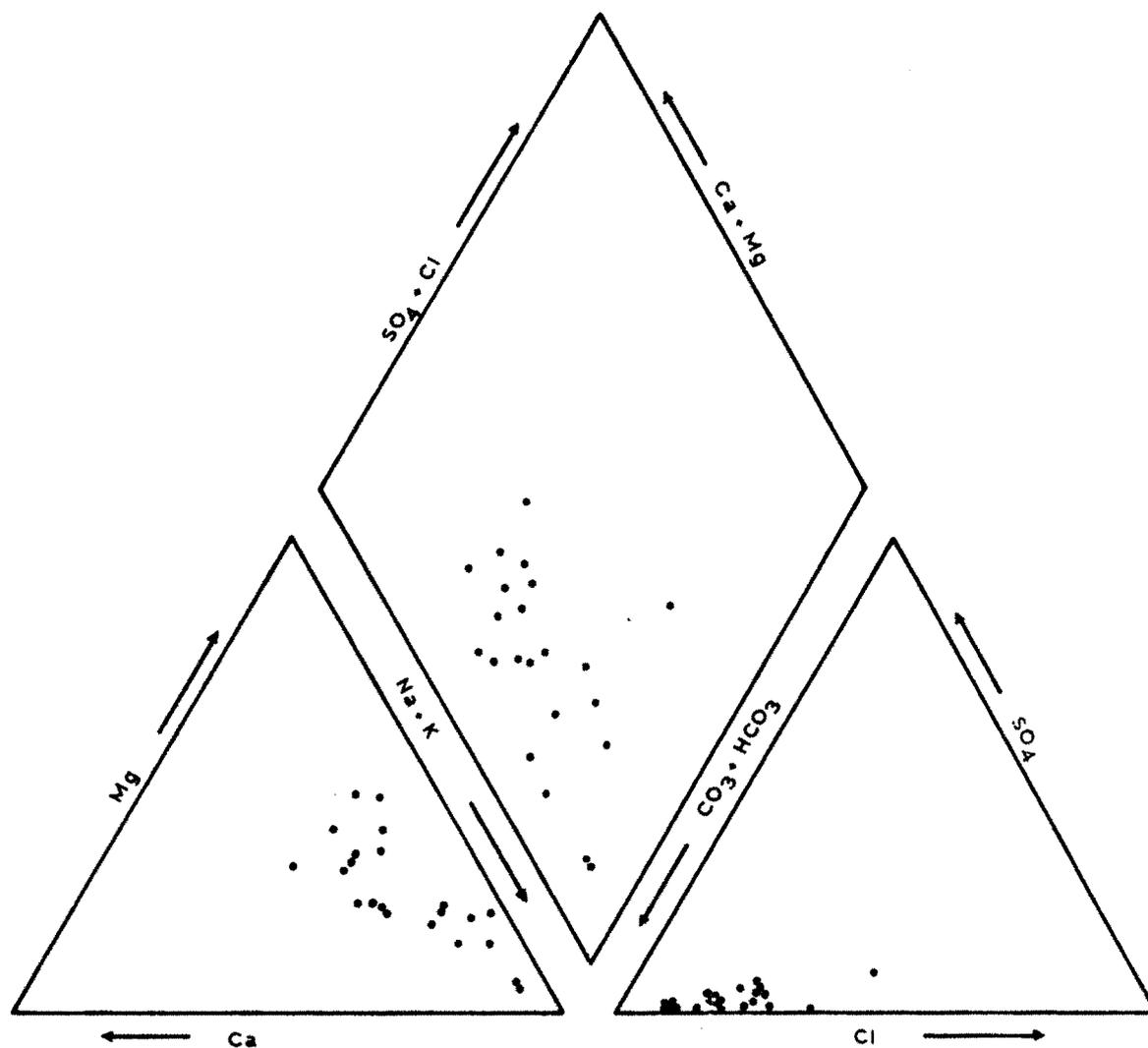
Cations

(i) Sodium (Na^+) : Among all analysed samples, the sodium ions share major percentage. The values between 45.85 % to 89.25% have been recorded in the alluvium area while in the hard rock area the values are between 38.66 % to 67.33 %.

(ii) Calcium (Ca^{++}) : The concentration of calcium ions show anomalous distribution in the study area. The maximum value 34.01% has been recorded at Diwalipura and minimum 3-4% at Patna and Karnet villages (all are located in the neighbouring basin).

(iii) Magnesium (Mg^{++}) : The distribution of magnesium ions in the groundwater can be considered as an intermediate group between Sodium (high) and calcium (low). The maximum value 45.27% has been obtained from Jharoi, and the minimum 5.01 % from Chanwada tubewell sample.

The Piper trilinear diagram (Fig. 8.2) has been plotted for the evaluation of their overall distribution and the general quality of groundwater in the study area. The diagram illustrates that the concentration of plots at the right hand side triangle are almost confined in carbonate and bicarbonate field. While in the left side triangle, the cation plots are distributed between sodium and magnesium fields, but more towards sodium side. The overall quality



PIPER'S DIAGRAM SHOWING THE CHEMICAL QUALITY OF GROUNDWATER IN THE HERAN RIVER BASIN

could be judged from the central diamond plot which suggests that the overall quality of groundwater is of intermediate category and dominantly influenced by the abundance of sodium bicarbonate.

Sodium Absorption Ratio (SAR)

The SAR values are widely used for the classification of irrigation water, recommended by U.S. Salinity Laboratory. High SAR values in irrigation water constitute to the development of excess sodium in soil. SAR values of 18 and above are considered high, between 10 and 18 medium and below 10 are low. All the obtained SAR values (Table 8.2) are below 10 and hence, cause no sodium hazards in soil.

The interpretation diagram (commonly known as U.S. Salinity diagram) based on Electrical Conductivity (EC) values and SAR values, enables quality rating of irrigation water.

Almost all water samples fall in C_2-S_1 category of groundwater rating for the irrigation suitability, which states ' C_2 ' medium salinity water, suitable for most crops with moderate leaching. ' S_1 ' low sodium water, suitable for almost all soils with less danger.

Quality Criteria for Domestic Use: Based on the World Health Organisation (WHO, 1972) classification, the groundwater could be considered as suitable for domestic

purposes, except the area around Kunvad which shows higher TDS values. The suggested maximum permissible and maximum desirable values (ppm) of chemical constituents are as under:

Constituents	WHO (1972)		Range in Heran River Basin (ppm)
	Max Desirable	Max Permissible	
Calcium	75	200	10 - 15
Magnesium	30	250	16 - 93
Chloride	200	600	35.5 - 440
Sulphate	200	400	20 - 90
TDS	500	1500	220 - 2500
pH	7.0-8.5	6.5-9.2	7 - 8

SEASONAL CHANGES IN SALINITY

Salinity records of selected observation wells for seven years show following details.

Station - Kawant (OW.No.66)

Year	January			May			October		
	TDS	Cl	pH	TDS	Cl	pH	TDS	Cl	pH
1974	290	32	8.1	370	80	7.5	220	40	8.0
1975	370	24	7.4	420	33	7.8	240	80	7.8
1976	290	120	7.4	440	120	7.8	220	120	8.2
1977	410	60	7.6	300	80	7.6	430	80	7.7
1978	310	80	7.8	390	120	7.8	390	160	7.8
1979	350	80	7.4	800	80	7.0	288	40	6.5
1980	320	40	7.0	448	40	7.0	384	60	7.0

Station - Sankheda (OW.No.68)

Year	January			May			October		
	TDS	Cl	pH	TDS	Cl	pH	TDS	Cl	pH
1974	210	24	7.6	430	80	7.8	280	120	8.2
1975	560	32	7.6	580	32	7.6	480	40	7.8
1976	480	80	8.0	530	80	7.6	210	120	8.4
1977	581	80	7.5	440	120	7.6	490	240	8.4
1978	740	200	8.1	480	80	8.2	540	120	8.2
1979	440	120	8.2	630	160	7.6	640	80	7.5
1980	640	80	7.1	928	120	7.7	704	40	7.7

Based on the presence of chemical constituents in groundwater it could be possible to categorise the aquifers of various lithologies of the study area.

(i) Aquifers in Metamorphic Rocks

OW No.	Village	TDS (ppm)	Cl (ppm)	pH
61	Desan	768	140	7.1
56	Wasana	832	200	7.3
-	Malpur	731	120	8.0
-	Sargai	704	120	7.4

(ii) Aquifers in Sedimentary (Bagh) Rocks

OW No.	Village	TDS (ppm)	Cl (ppm)	pH
51	Parvata	950	200	7.0
-	Lachhras	1088	230	8.2
-	Lunadra	1152	220	7.6
53	Ghantoli	1440	250	8.2

(iii) Aquifers in Deccan Traps

OW No.	Village	TDS (ppm)	Cl (ppm)	pH
25	Mora Dungri	288	35.5	8.2
24	Nava Timberva	324	42.6	7.7
16	Rangpur	269	53.2	8.2
29	Bagaliya	609	71.0	7.9

(iv) Aquifers in Unconsolidated Formations

OW No.	Village	TDS (ppm)	Cl (ppm)	pH
Tube well	Bhilodiya	769	80	7.8
-do-	Kunvad	2048	460	7.9
-do-	Nagdol	1237	232	8.0
-do-	Bihora	1280	300	7.9

GEO-ENVIRONMENTAL ASPECTS OF THE HERAN BASIN

Water resources of the basin is one of the most important factor governing the Geo-environmental conditions of the basin. The surface and ground water resources have played predominant role in shaping the present state of environment system of the basin as a whole. This includes physical environments and the ecological environments.

So far as, the physical environments are concerned, the interaction of land and water are mainly responsible for the (dynamical) surficial weathering, erosion, transportation, and deposition etc. The major part of the basin area is subjected to slow but steady and prolonged effects of the mechanical weathering, resulting in residual landforms with a thin veneer of soil cover. This is due to several reasons in combination with the topography, rock types, short duration intense rainfall etc.

Due to insufficient thickness of regular mantle cover the surface retention of moisture is poor, which in turn provide inadequate support to vegetation and vis-avis the poor vegetation. The first weathering zone in rocks is also very shallow and rate of surface erosion is fast. The lesser thickness of weathering zone results in producing very limited sized aquifers for the groundwater storage.

In the upper reaches of the basin, there are no appreciable surface water storages, except the one small dam reservoir across Rami near Khandibaru. Further, the postmonsoon subsurface runoff is also of higher order which leaves the area dry in most of the part of the area. This adversely affects the ecological balance. The vegetation growth is being gradually reduced. The extremes of temperature, wind, velocity and variation in humidity enhance the rate of evapotranspiration, which in-turn further increases the conditions of dryness. Deforestation also help in this process. This can be termed as, an adverse phenomenon of natural degradation of the physical environment.

In the lower reaches, the greater thickness of alluvial cover providing the better conditions of subsurface water storage and the top fertile soil cover has produced relatively better environmental conditions for living. The use of groundwater for irrigation in post-monsoon season has also helped in improving the climatic conditions. The population growth is also reflected accordingly. However, the small pockets of groundwater aquifers providing sufficient water supply to inhabitants, and have supported the development of small towns and bigger villages like Kawant, Panvad, Chaktalav and Bakhatgarh etc. The alluvial filled river terrace provides levelled ground for inhabitation and the post-monsoon stream flow and related groundwater supply helps the overall requirement for domestic and irrigation purposes. However, such

conditions are restricted to exceptionally favourable hydrogeological locations viz. Chalamali, Wandha, Kosindra and Kashipura.

The overall environmental conditions have yet not suffered degradation. The basin has so far retained the natural amicable environmental situations for further growth and development, by improving the present conditions through proper strategy of harnessing the natural resources. The natural resources include the surface and ground water supplies, soil cover, the landforms and land-use pattern, afforestation and further growth. The area do not indicate any substantial mineral resources for the industrial development. Of course, fluorite mining, just in the southern vicinity of the upper basin has got a pocket of mining industry. The tailing of fluorite beneficiation is being drained in the stream meeting Rami river. But, the due treatment of the waste and alternative arrangement of the drinking water supply in the plant vicinity has so far not caused any remarkable effects of fluoride pollution in the drinking water (Plate VIII 1 & 2). However, proper monitoring system of fluoride contamination to the groundwater system is essential.

Agriculture is the main source of livelihood of the people in the area. Day by day, water requirement for

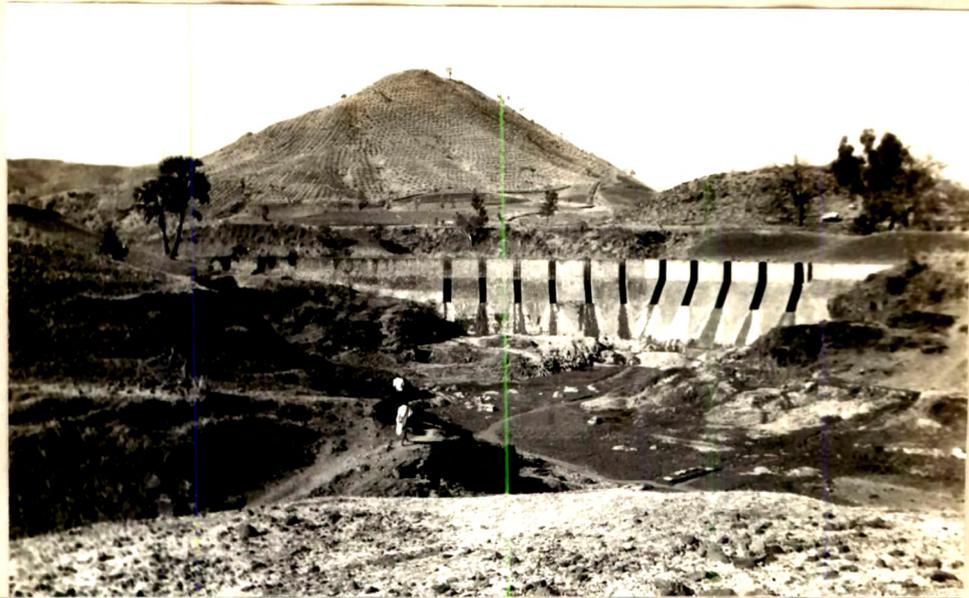


Plate VIII.1 Field photograph showing downstream and upstream view of the fluorite mine tail water settling tank. (Loc. Raisingpur).

irrigation is also increasing. In the lower reaches of the basin where groundwater potential is good and suitable, a large areas of land are also available for irrigation, more and more groundwater extraction is being done. The natural balance of average annual recharge and average annual draft is yet not disturbed, there is some more scope for further development of the groundwater resources. However, the capacity of storage reservoir being very limited, the over-draft situation will not last for long. It is therefore, further groundwater development will have to be planned in combination with appropriate recharge measures. The human interaction in the prevailing natural environmental conditions show a natural rate of reaching the line of natural balance. The area in the lower reaches, provides better natural conditions for augmenting the annual recharge by appropriate technique of artificial recharge. Advantage of such environmental conditions could be taken at an appropriate time before the large scale degradation has already taken place.

In the upper reaches of the basin also, the high surface run-off conditions, and similarly high subsurface run-off during immediate post-monsoon period generate sufficient surplus water, available for harnessing at very low cost schemes. This increases the subsurface storage. The unconfined phreatic aquifers, losing their storages

through springs could be retained by series of low height check dams. At Panvad, one such check dam has produced excellent results raising groundwater supply to a great extent. It support local supply for irrigation purpose (Plate VIII.3).

There is a proposal for reservoir dam across Heran near Lalpur, but due oppose of the local people for land submergence, the project has not been materialised. However, in view of the high potential of Heran, if not a single high level large storage at one place, there could be a series of low-level barriers, checking the post-monsoon flow, creating bank height storage in the river bed and raising the groundwater recharge to the adjoining areas. The geoenvironmental conditions offer very good conditions for the combined development of the subsurface water and surface water supplies.



Plate VIII.2 Field photograph showing Narmada water is being supplied through pipe line to the local inhabitants residing in the vicinity of Ambadongar Fluorite mine, Kadipani (Loc. Village Bujetha).



Plate VIII.3 Field photograph showing check dam providing potential recharge site to the aquifers in granitic terrain, ensure perennial supply of domestic and agriculture purposes (Loc. Near Panvad).