CHAPTER X

GROUNDWATER QUALITY

GROUNDWATER QUALITY

INTRODUCTION

The evaluation of water quality forms an important aspect in groundwater assessment studies of any region. Groundwater resources development and utilisation can be planned scientifically when the chemical character of groundwater is fully known. In this chapter an appraisal of overall groundwater quality of the Upper Luni and Kantli watersheds is discussed.

The study area displays large scale variation in groundwater chemistry and quality, attributed to the lithological environment of the area. The groundwater circulating in these lithologic units generally develop a chemical character that is conformable to the constituent minerals comprising the rock formations. In addition to the lithologic factor, many other variables such as the hydroclimatic conditions have affected the chemical quality of the groundwater in the region.

Owing to adverse climatic conditions and inadequate recharge the groundwater in major parts of the study area is saline to brackish. However, good quality potable groundwater is available nearby the stream channels, pediment plains and the areas underlain by alluvium. The

groundwater quality of the study area has been assessed by evaluating various quality parameters *viz.*, Total Dissolved Solids, Electrical Conductivity, Sodium and Chloride contents, etc.

DATA COLLECTION

Central Groundwater Board (CGWB) and Rajasthan State Groundwater Department (RSGWD) have carried out extensive long term seasonal monitoring of groundwater quality. The author had collected the available district wise records of the period between 1970-1988 for evaluation of groundwater of the study area. In addition to this, the author has carried out detailed chemical analysis of the groundwater samples collected from different locations distributed within the study area. The groundwater chemistry for different years were scrutinized and the latest available data (1984-88) of 64 locations and author's primary data of 19 locations distributed within the study area were selected for detailed evaluation of hydrogeochemistry. The details on the groundwater chemistry based on the water sample analysis collected from different locations representing the study area are given in Tables 10.1 & 2 for the upper Luni and Kantli blocks respectively.

CHEMICAL PARAMETERS

pH

The pH values of the groundwater in the study area range between 7.08 and 9. All the samples show a just above neutral to alkaline nature. The lowest pH value was observed in the groundwater sample at Prithipura in the extreme southwestern part of the study area, along the Luni channel, whereas the highest pH value of the groundwater sample was at Fatehpur in the northeastern part in the Kantli basin. In about 38% of the samples, the pH is found to be in the range of 7.1 to 8.0, whereas remaining 55% of the samples it is between 8.1 and 9.0.

Table 10.1. Hydrogeochemical data of groundwater samples from Upper Luni Block (September 1992)

Sr. No	Location	Aquifer	SWL (m)	pH	EC µmho/cm at 25°C	TDS (mg/L)	T.H. as $CaCO_3$	Chemical Constituents (mg/L)									SAR
								Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	
1	Alniyawas	Alluv.	30	8.46	1416	908	170	16	32	159	02	16	174	213	Nil	-	5.28
2	Anandpura	Alluv.	17	8.16	1395	894	158	12	29	276	02	Nil	586	142	170	1.20	9.83
3	Badauli	Alluv.	06	8.30	660	423	228	15	19	57	04	Tr	220	85	48	0.80	2.31
4	Banthri	Lst.	48	8.09	7955	5099	378	56	56	126	66	Nil	708	1418	600	1.40	2.85
5	Barr	Sch.	10	7.58	1070	686	300	60	36	115	23	Nil	439	121	47	-	2.90
6	Basi	Alluv.	06	7.50	1570	1006	430	92	49	126	07	Nil	317	312	13	-	2.64
7	Bhakliawas	Sst.	36	7.73	3090	1981	400	73	73	552	14	Nil	427	596	411	1.20	12.01
8	Bhakrod	Sst.	46	8.19	1520	974	600	112	78	140	28	Nil	939	99	30	1.20	2.49
9	Bilara	Lst.	12	8.09	3752	2405	210	16	41	693	02	48	322	682	Tr	-	20.89
10	Birlokha	Alluv.	66	8.30	1115	715	200	28	32	154	10	Tr	232	149	142	0.42	4.73
11	Budsu	Alluv.	39	7.95	12170	7801	3310	272	639	874	46	Nil	1318	1879	1478	0.80	6.62
12	Chandawal	Sch.	10	7.98	785	503	100	24	10	140	06	Nil	427	43	03	-	6.06
13	Chosli	Alluv.	40	8.27	4315	2766	740	84	129	690	06	72	195	943	612	0.90	11.04
14	Choti Khatu	Lst.	40	8.12	1274	817	312	27	59	81	05	20	204	116	Nil	-	2.00
15	Dangiyawas	Alluv.	10	8.38	10620	6808	170	08	37	1980	05	180	748	1605	202	-	65.74
16	Daulatpura	Alluv.	28	7.43	7235	4638	260	16	53	1241	07	Nil	1476	957	393	4.30	33.66
17	Degana	Alluv.	26	7.66	17490	11212	518	36	102	2483	25	Nil	1427	319	261	4.90	47.90
18	Didwana	Sch.	20	7.98	3140	2013	940	96	170	326	17	Nil	598	411	517	-	4.63
19	Ganwardi	Alluv.	13	7.95	11350	7276	930	96	168	1632	32	Nil	573	2482	530	-	23.29
20	Gorav	Sst.	20	8 04	6797	4357	1076	148	172	724	08	28	236	1306	Nil	-	9.61
21	Gurha	Sst.	62	7 23	21210	13596	4650	38	899	2989	15	Nil	268	6382	1872	0 30	21 14

Sr. No	Location	Aquifer	SWL (m)	pH	EC µmho/cm at 25°C	TDS (mg/L)	T.H. as $CaCO_3$	Chemical Constituents (mg/L)									SAR
								Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	
22	Harsor	Sch.	10	8.05	2350	1506	550	112	66	133	219	Nil	403	262	402	-	2.46
23	Indawar	Alluv.	35	7.47	10730	6878	520	84	75	1793	14	Nil	1013	2021	729	5.60	34.27
24	Jaswantpura	P.C.H.R.	26	8.91	4106	2632	360	08	83	555	03	232	650	511	221	-	12.72
25	Jayal	Sst.	32	8.30	1295	830	600	84	95	66	10	Nil	476	78	246	0.40	1.17
26	Jawa	Alluv.	30	8.46	5239	3358	170	12	34	1060	05	184	840	710	86	-	35.40
27	Jodhpur	Sst.	12	8.05	3540	2269	480	82	67	140	154	40	423	373	125	-	2.78
28	Kekind	Alluv.	15	7.90	1225	785	200	36	27	119	27	Nil	403	149	82	0.70	3.66
29	Khimsar	Lst.	38	7.57	2520	1615	390	68	53	354	109	Nil	378	503	269	0.70	7.82
30	Kolia	Lst.	20	8.25	2005	1285	240	24	44	354	13	Nil	610	191	247	2.40	9.92
31	Kuchaman	Alluv.	29	8.04	1520	974	350	24	70	209	06	Nil	439	149	233	3.70	4.88
32	Kuchera	Alluv.	36	8.06	2270	1455	720	140	98	193	07	Nil	195	347	479	0.40	6.07
33	Ladnun	Sst.	21	7.94	3260	2090	140	24	32	694	04	Nil	878	511	246	15.80	21.83
34	Luni	Alluv.	05	7.73	6514	4176	360	60	51	404	04	170	355	1065	34	-	9.27
35	Makrana	Mrb.	26	8.22	1515	971	50	04	18	336	02	Nil	774	71	70	6.50	15.94
36	Manasir	Sst.	25	7.31	17708	11351	1600	140	304	3127	23	Nil	793	4006	2045	4.00	34.03
37	Manglana	W.Gr.	07	8.48	6700	4295	150	16	27	1058	02	288	769	922	41	9.20	37.50
38	Maulasar	Alluv.	45	8.30	2185	1407	486	60	88	262	06	Tr	354	220	448	0.40	5.04
39	Merta City	Alluv.	12	7.90	4110	2635	509	56	87	578	05	Nil	244	1125	184	0 40	11.28
40	Nimaj	Alluv.	10	7 70	2020	1295	270	24	51	299	06	Nil	573	319	08	-	7.93
41	Parbatsar	Alluv.	16	8 49	15155	9715	1740	89	372	2298	82	240	476	2304	2694	3.30	23.98
42	Pharod	Alluv.	32	8 29	1695	1087	460	48	83	149	17	Nil	281	291	160	0.60	3.02
43	Pichak	Lst.	12	8 23	4106	2632	190	38	23	592	02	30	593	550	110	-	18.70

Sr. No	Location	Aquifer	SWL (m)	pH	EC µmho/cm at 25°C	TDS (mg/L)	T.H. as $CaCO_3$	Chemical Constituents (mg/L)									SAR
								Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	
44	Pipar Road	Alluv.	15	7.96	9204	5900	500	62	84	490	208	75	263	1367	264	-	9.53
45	Prithipura	Alluv.	20	7.08	3845	2465	630	80	104	667	27	Nil	1147	667	225	-	11.59
46	Pushkar	Alluv.	09	7.95	581	372	190	32	27	11	16	Nil	132	497	Nil	-	0.35
47	Ren	Alluv.	38	8.20	1770	1135	250	28	44	276	04	72	220	248	197	0.20	7.59
48	Rohina	Alluv.	36	8.24	7434	4765	656	79	112	1020	04	20	294	1434	142	-	17.31
49	Rol	Lst.	29	8.50	1285	824	450	76	63	87	17	96	220	135	126	1.10	1.79
50	Run	Sst.	37	8.70	1445	926	90	24	07	68	06	12	759	21	62	6.10	3.15
51	Sanward	Alluv.	23	8.30	1850	1186	260	32	44	368	14	Tr	610	298	152	4.20	9.90
52	Singhana (N)	Gr.	25	7.90	12070	9255	1370	96	275	1839	59	Nil	134	2659	1465	0.16	21.63
53	Tosina	Lst.	40	8.27	6230	3994	1036	80	204	617	06	08	268	781	Nil	-	8.34

Alluv. Alluvium
Qtzite Quartzite
Sch. Schist
SWL Static Water Level

TDS Total Dissolved Solids
T.H. Total Hardness
SAR Sodium Absorption Ratio
EC Electrical Conductivity

Table 10.2. Hydrogeochemical data of groundwater samples from Kantli Block (September 1992)

Sr. No	Location	Aquifer	SWL (m)	pH	EC µmho/cm at 25°C	TDS (mg/L)	T.H. as $CaCO_3$	Chemical Constituents (mg/L)									SAR
								Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	
1	Alsisar	Alluv.	28	8.40	6250	4006	320	24	63	1587	30	192	1635	893	316	7.20	38.69
2	Babai	Qtzite	42	8.10	1380	885	520	144	39	108	9	Nil	476	149	98	1.20	2.06
3	Badagaon	Alluv.	32	8.60	1940	1244	330	24	66	328	4	48	220	340	110	0.30	7.84
4	Bagar	Alluv.	45	8.50	960	615	90	16	12	166	2	36	207	128	22	0.80	7.65
5	Bisanpura	Alluv.	40	8.13	963	617	248	16	5	163	2	Nil	248	70	Nil	-	9.12
6	Bissau	Alluv.	34	8.00	2120	1359	480	32	97	316	5	Nil	537	227	64	1.00	6.29
7	Chandgoti	Alluv.	40	8.35	3115	1997	168	21	28	640	2	24	492	412	Nil	-	21.54
8	Chirawa	Alluv.	42	8.96	2690	1724	60	13	7	475	2	100	634	227	42	-	26.44
9	Dadhia	Alluv.	43	8.60	820	526	160	24	24	212	Tr	48	195	106	15	0.16	7.32
10	D.Ramgarh	Alluv.	12	8.70	1200	769	210	44	24	193	3	48	232	156	37	1.90	5.81
11	Dhod	Alluv.	40	8.50	1170	750	170	32	22	189	4	24	244	191	90	0.34	6.30
12	Dighal	Alluv.	44	8.90	1700	1090	70	8	12	414	Tr	120	598	128	9	4.50	21.67
13	Fatehpur	Alluv.	35	9.00	2720	1744	240	16	49	656	2	156	842	135	295	0.70	18.37
14	Golyana	Alluv.	25	8.00	520	333	180	44	17	58	2	Nil	268	35	10	0.34	1.88
15	Govindhi	Alluv.	10	8.26	14160	9077	1068	69	218	1988	33	48	584	2954	326	-	26.47
16	Kanwat	Alluv.	3	8.30	1165	747	-	104	32	71	8	Nil	354	121	92	-	1.56
17	Khetri	Qtzite	10	7.70	1410	904	670	164	63	85	5	Nil	378	177	260	0.22	1.43
18	Khur	Alluv.	43	7.95	1300	833	210	52	19	209	5	Nil	366	206	10	-	6.30
19	Laxmangarh	Alluv.	35	7 85	6100	3910	470	64	153	989	297	Nil	3184	496	10	1.50	15.33
20	Mandawar	Alluv.	44	8.35	1610	1032	50	8	7	414	3	120	720	35	17	7.20	25.46
21	Maroth	Sch/Qtzite	36	7.95	3700	2372	636	140	80	806	7	Nil	500	830	20	0 80	13.44

Sr. No	Location	Aquifer	SWL (m)	pH	EC µmho/cm at 25°C	TDS (mg/L)	T.H. as $CaCO_3$	Chemical Constituents (mg/L)									SAR
								Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	
22	Mukandgarh	Alluv.	42	8.65	2890	1853	210	24	37	644	6	84	854	469	45	1.60	19.25
23	Neemka Thana	Alluv.	16	8.00	680	436	200	24	34	81	Tr	Nil	268	50	Tr	1.02	2.49
24	Pachlagi	Alluv.	12	8.37	765	490	84	21	8	93	2	Nil	252	31	Nil	-	4.37
25	Palsana	Alluv.	21	8.25	530	340	190	36	24	47	3	Tr	232	35	Tr	0.46	1 49
26	Pilani	Alluv.	49	8.90	1670	1070	100	12	17	331	2	72	305	248	14	1.60	14.43
27	Posana	Alluv.	35	8.50	730	468	190	28	29	87	3	24	159	57	23	0.04	2 75
28	Reengus	Alluv.	12	7.50	2995	1920	790	100	131	368	4	Nil	546	447	496	0.52	5.70
29	Sikar	Alluv.	30	7.65	830	532	190	32	27	196	3	6	155	135	95	1.40	6.17
30	Singhana	Alluv.	14	7.90	2340	1500	1020	168	146	223	6	Nil	390	383	590	0.90	3.04

Alluv. Alluvium
Qtzite Quartzite
Sch. Schist
SWL Static Water Level

TDS Total Dissolved Solids
T.H. Total Hardness
SAR Sodium Absorption Ratio
EC Electrical Conductivity

SPECIFIC CONDUCTANCE

Specific Conductance or Electrical Conductivity of water is dependent upon the ionic concentration and the ionic mobility of the mineral content in solution, and generally is an index of the degree to which water is mineralised.

The electrical conductivity of groundwater in the area shows a wide range between 520 μmhos/cm (at Golyana in the Kantli basin) and 21210 μmhos/cm (at Gurha in the Luni basin). It is observed that the electrical conductivity of groundwater in the Kantli watershed is generally lower than that in the Upper Luni basin; which is indicative of the availability of fresh groundwater in the Kantli watershed. Average range of electrical conductivity in the Kantli basin is 500-6000 μmhos/cm at 25° C, whereas in the Upper Luni basin, it ranges between 2000-15000 μmhos/cm at 25° C.

TOTAL DISSOLVED SOLIDS (TDS)

The concentration of Total Dissolved Solids in the groundwater of the study area shows increasing trend from the Kantli basin in the northeastern/eastern parts towards the Luni basin in the southwestern/western parts. In general the TDS values range from minimum 333 mg/L (at Golyana) to maximum 13596 mg/L (at Gurha). However, the highest TDS values are observed in the groundwaters of the alluvial areas of Luni basin and the lowest values in the pediplains as well as rocky terrains in the eastern, northeastern and southeastern parts of the study area. The Iso-TDS contour map (Fig. 10.1) has been drawn to obtain the pattern of variation of TDS in the region and thereby the regions of maximum concentration. It could be seen from the figure that there are six maxima in the region showing high TDS values *viz.*, 13596 mg/L at Gurha, 11212 mg/L at Degana, 9715 mg/L at Parbatsar, 9285 mg/L at Singhana, 6808 mg/L at Dangiyawas and 4006 mg/L at Alsisar.

CATIONS

(i) **Sodium (Na^+)**: In majority of the groundwaters sodium ions dominate over the other cations. The concentration of sodium ranges between 11 mg/L at Pushkar and 3127 mg/L at

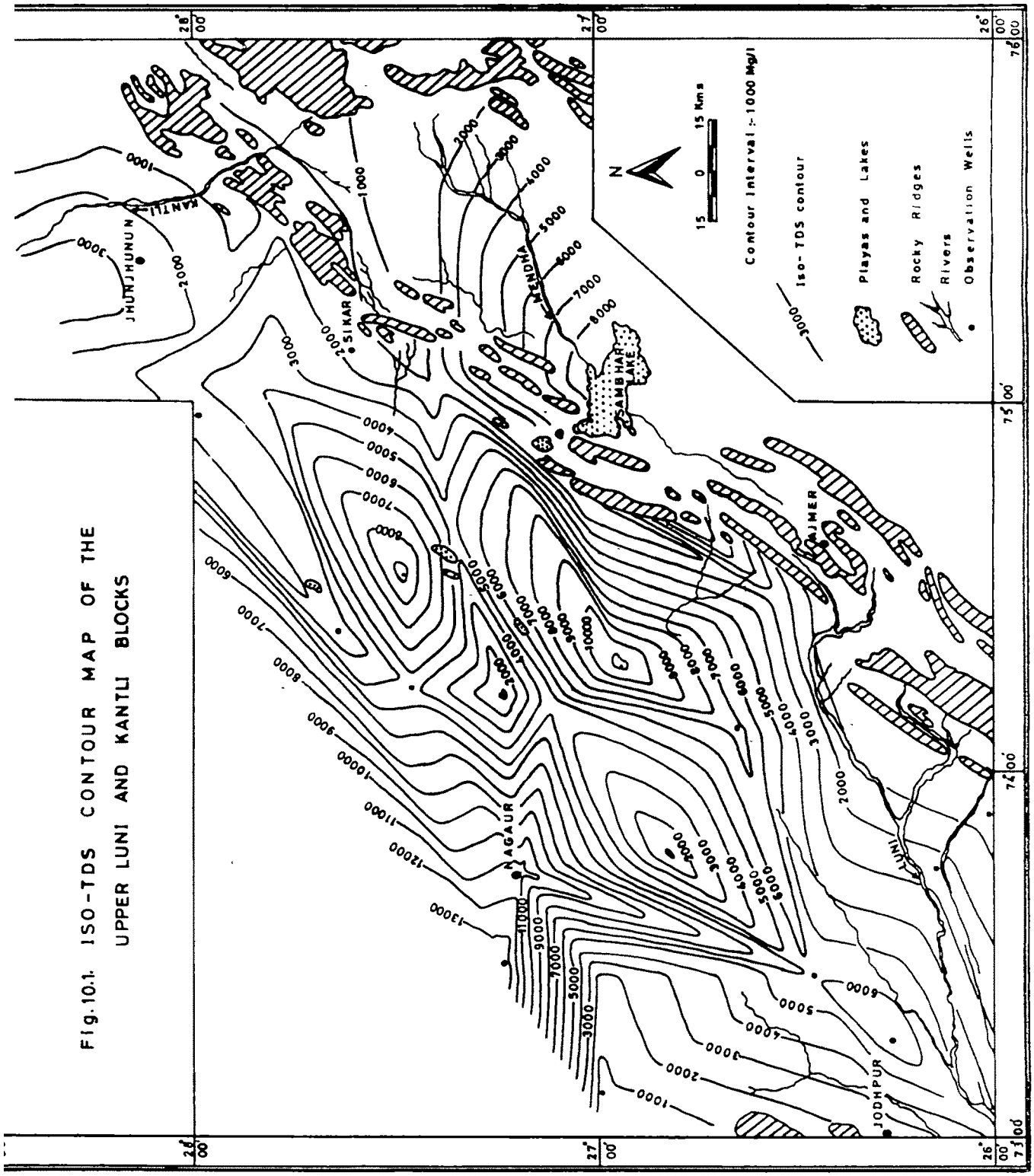

Fig.10.1. ISO-TDS CONTOUR MAP OF THE UPPER LUNI AND KANTLI BLOCKS

Manasir. Localities of high sodium content in the Luni basin are: Manglana (1058 mg/L), Daulatpura (1241 mg/L), Degana (2483 mg/L), Ganwardi (1632 mg/L), Gurha (2989 mg/L), Indawar (1793 mg/L), Parbatsar (2298 mg/L), Singhana (1839 mg/L), Dangiyawas (1980 mg/L), Jawa (1060 mg/L) and Rohina (1020 mg/L). In the Kantli basin, majority of the samples show comparatively low sodium concentrations ranging between 47 mg/L (Palsana) and 656 mg/L (Fatehpur). However, high concentrations are seen at Laxmangarh (989 mg/L), Alsisar (1589 mg/L) and Govindhi (1989 mg/L).

It is observed that the groundwaters in hard rock terrain are characterised by low sodium contents than the alluvial areas. This is possibly attributed to high rate of flushing in hard rock areas and highly porous nature of aquifers in the alluvial areas.

(ii) **Potassium (K^+)**: In the study area potassium forms only a minor constituent in groundwater. The general range is between 2 and 20 mg/L. The lowest concentrations are observed in the groundwaters of alluvial aquifers. High concentrations occur in the areas around Banthri (66 mg/L), Bursu (46 mg/L), Khimsar (109 mg/L), Harsor (219 mg/L), Parbatsar (82 mg/L), Singhana (59 mg/L), Laxmangarh (297 mg/L), Jodhpur (154 mg/L), Pipar Road (208 mg/L) and Ganwardi (32 mg/L).

(iii) **Calcium (Ca^{2+})**: The concentration of calcium ranges between 4 mg/L (Makrana) and 272 mg/L (Bursu) and shows anomalous distribution in the area. High values of calcium are observed at Khetri (164 mg/L), Babai (144 mg/L), Ringus (100 mg/L), Manasir, Kuchera and Maroth (140 mg/L), Harsor (112 mg/L) and Kanwat (104 mg/L). It is observed that the groundwaters in the Kantli basin in general show higher values of calcium, the abundance being more prominent in groundwater occurring in the aquifers constituted by blown sands, alluvium, amphibolites, calc-gneisses and quartzites.

(iv) **Magnesium (Mg^{2+})**: The distribution of magnesium ions in the groundwater of the study area does not show any significant pattern. The magnesium concentration ranges between 5 mg/L at Bisanpura and 899 mg/L at Gurha. Magnesium content is high in the groundwater samples at Manasir (304 mg/L), Bursu (639 mg/L), Chosli (129 mg/L), Didwana (170 mg/L),

Ganwardi (168 mg/L), Parbatsar (372 mg/L), Singhana-Nagaur (275 mg/L), Prithipura (104 mg/L), Laxmangarh (153 mg/L), Ringus (131 mg/L), Singhana-Jhunjhunun (146 mg/L), Gorav (172 mg/L), Tosina (204 mg/L) and Govindhi (218 mg/L). The groundwater in the Upper Luni block generally shows higher concentration of magnesium than in the Kantli block.

ANIONS

(i) **Chloride (Cl^-)**: The chloride content in groundwaters in the area ranges between 21 mg/L at Run and 6382 mg/L at Gurha. The concentration of chloride ions also shows increasing trend from eastern to western parts of the study area. The Iso-chloride map of the area (Fig. 10.2) shows seven maxima, corresponding to high levels of chloride concentrations. These are Dangiyawas (1605 mg/L), Gurha (6383 mg/L), Manasir (4006 mg/L), Ganwardi (2482 mg/L), Bursu (1879 mg/L), and Singhana-Nagaur (2659 mg/L) in the Upper Luni block and at Govindhi (2954 mg/L) in the Kantli block.

Higher concentrations of chloride are generally observed in the groundwaters of the Upper Luni block. The chloride content in Kantli basin ranges between 30 mg/L and 500 mg/L. Chloride concentrations of more than 1000 mg/L occur in the groundwaters at Gorav, Rohina, Pipar Road, Luni Junction, Parbatsar, Indawar, Merta city and Banthri. Higher concentrations of chloride are seen in the groundwater occurring in alluvial aquifers. However, at Gurha, where high chloride concentration is recorded, the Palaeozoic sandstones constitute the aquifers.

(ii) **Bicarbonate (HCO_3^-)**: The bicarbonates also share a major percentage of the ions along with chlorides. Bicarbonate content in the groundwater ranges between 132 mg/L (Pushkar) and 3184 mg/L (Laxmangarh). Interestingly, the bicarbonate content in the groundwaters in the Kantli basin is higher than in the Upper Luni basin. The lowest concentration of bicarbonate in the Kantli block is observed at Posana (159 mg/L) and the highest concentration is observed at Laxmangarh (3184 mg/L). In the Upper Luni block it ranges between 130 and 1475 mg/L. Lithology wise, the bicarbonate concentration shows wide range, *viz.*, alluvium (100-1500 mg/L), Palaeozoic Sandstones and Limestones (350-650 mg/L), Precambrian Metamorphics (350-800 mg/L).

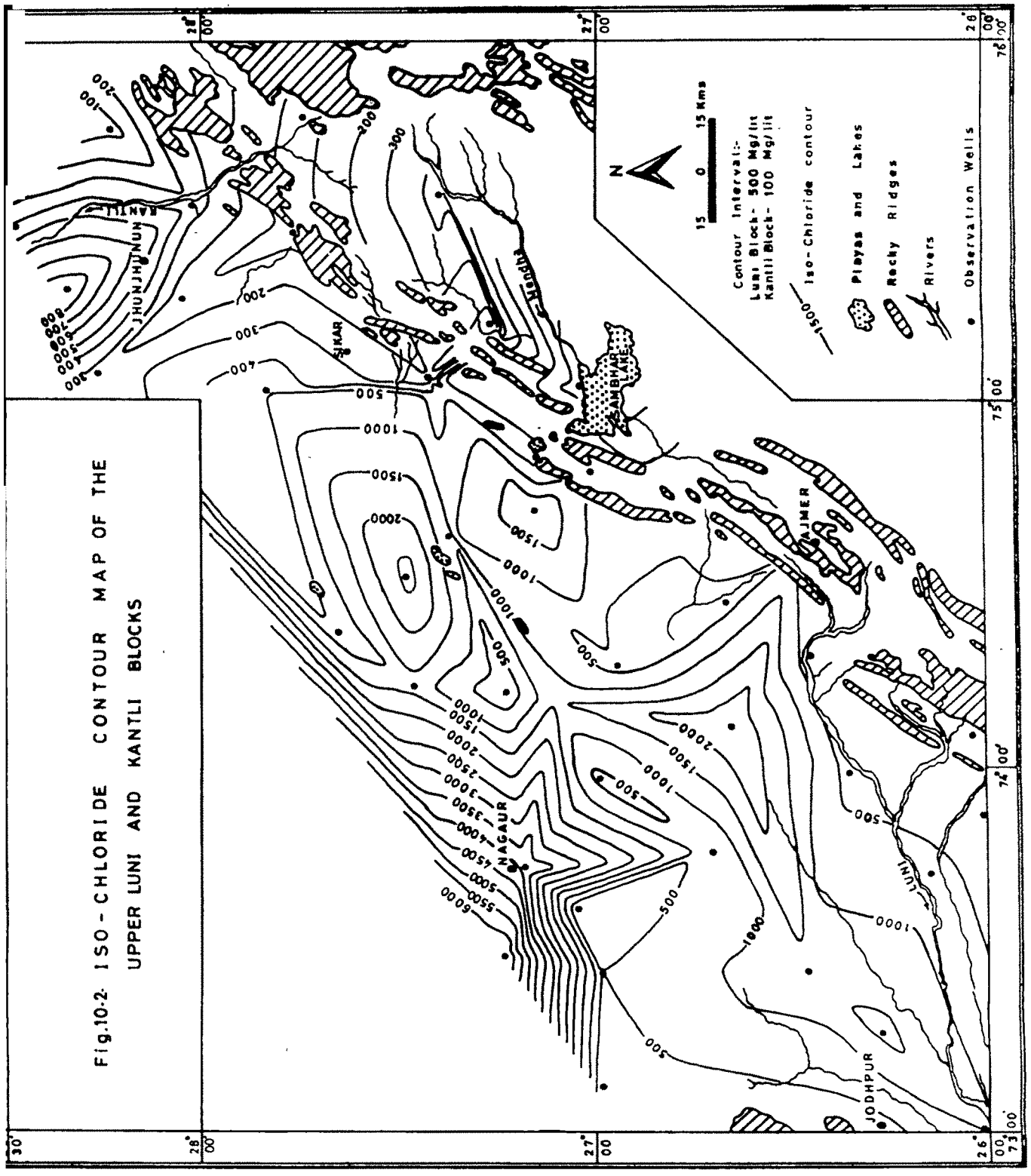

Fig.10.2 ISO-CHLORIDE CONTOUR MAP OF THE UPPER LUNI AND KANTLI BLOCKS

(iii) **Carbonates** (CO_3^{2-}) : Most of the groundwaters are devoid of carbonates. Fifty three percent of the samples in the Kantli block show the presence of carbonates which range between 6 mg/L (Sikar) and 192 mg/L (Alsisar). Only 36% of the samples in the Upper Luni block depict carbonate concentrations that range between 8 mg/L (Tosina) and 288 mg/L (Manglana). Lithology wise, carbonates in the groundwaters of alluvial aquifers range between 6 mg/L and 192 mg/L, in the sandstone and limestone aquifers between 8 mg/L and 96 mg/L and in the Precambrian hardrock aquifers it is more than 200 mg/L.

(iv) **Sulphates** (SO_4^{2-}): Sulphate concentration is generally low in the groundwaters of the Kantli basin, ranging between traces (Neem ka Thana, Palsana) to 590 mg/L (Singhana). The concentration of sulphate was found to be uniformly low in the groundwaters occurring in alluvial aquifers. In the Upper Luni block, sulphate concentration ranges between 3 mg/L (Chandawal) and 2694 mg/L (Parbatsar). This highest concentration was recorded in a well located in alluvium aquifer. High concentrations of sulphate also occur at Manasir (2045 mg/L), Budsu (1478 mg/L), Gurha (1872 mg/L), Singhana-Nagaur (1465 mg/L), Banthri (600 mg/L), Chosli (612 mg/L), Didwana (517 mg/L), Ganwardi (530 mg/L), Indawar (729 mg/L), Singhana-Jhunjhunun (590 mg/L), etc.

In order to evaluate an overall chemistry of groundwater and its classification, the chemical contents have been plotted on Piper Trilinear Plot (Piper, 1944). The Piper Trilinear diagram for the Upper Luni block (Fig. 10.3) illustrates that the groundwater samples dominantly fall in the field 7, indicating high order of primary salinity. The groundwaters are dominantly of Na-K-Ca-Mg : $Cl\text{-}SO_4\text{-}HCO_3\text{-}CO_3$ type and thus the water quality in the Upper Luni block is mainly influenced by the abundance of sodium chloride and bicarbonates.

Piper Trilinear plots of the Kantli block (Fig. 10.4) display inconsistency in its chemical content, the plots occurring in a scattered manner. However, large number of samples indicate neutral type i.e., field 9. Few samples falling in the field 7 show primary salinity. By and large the groundwaters in Kantli basin are Na-K-Ca-Mg : $HCO_3\text{-}CO_3\text{-}Cl\text{-}SO_4$ type, the chemical quality dominantly influenced by bicarbonates of sodium, calcium and magnesium.

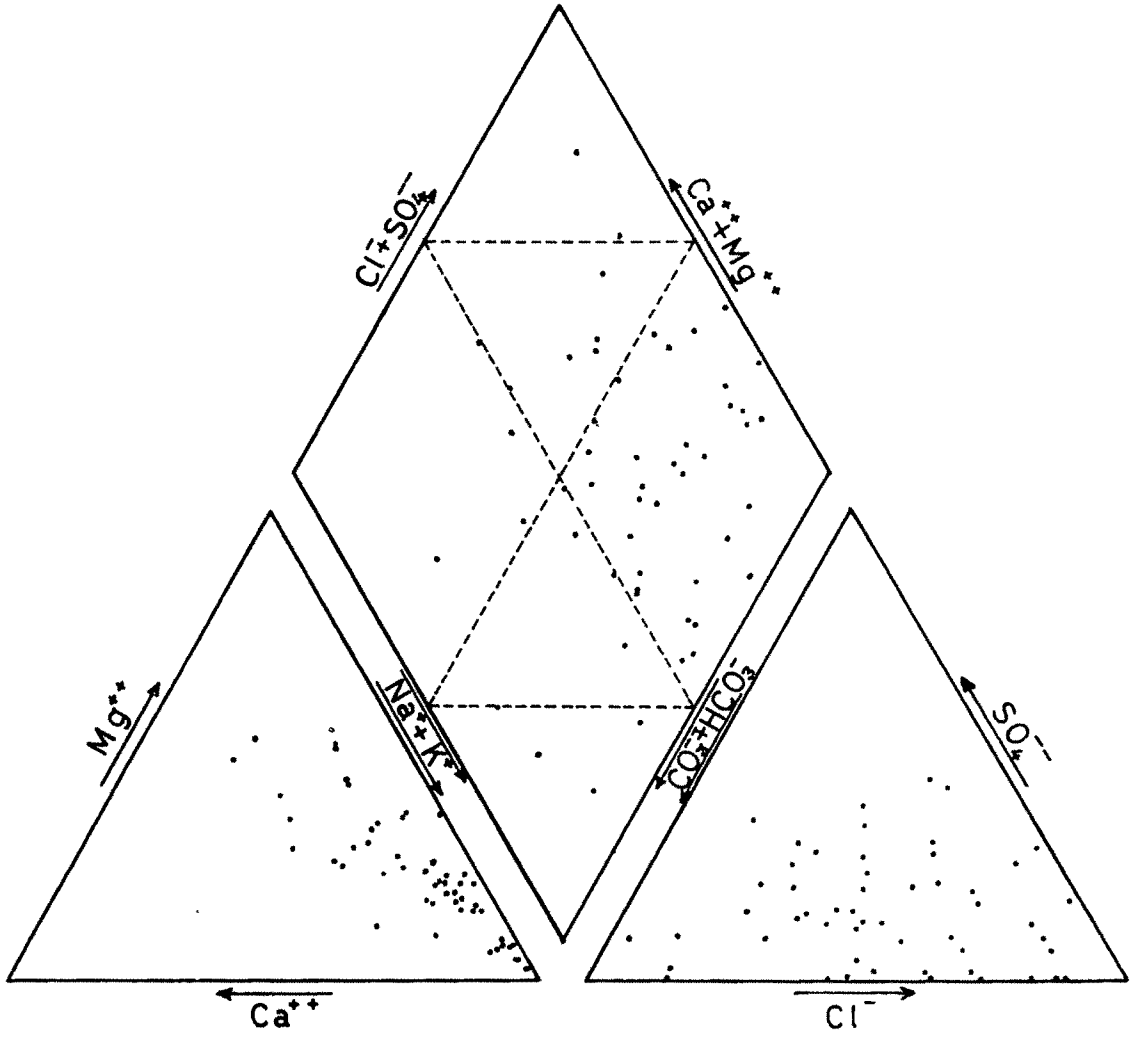

Fig. 10.3. Piper's Diagram showing the Chemical Quality of Groundwater in the Upper-Luni River Basin.

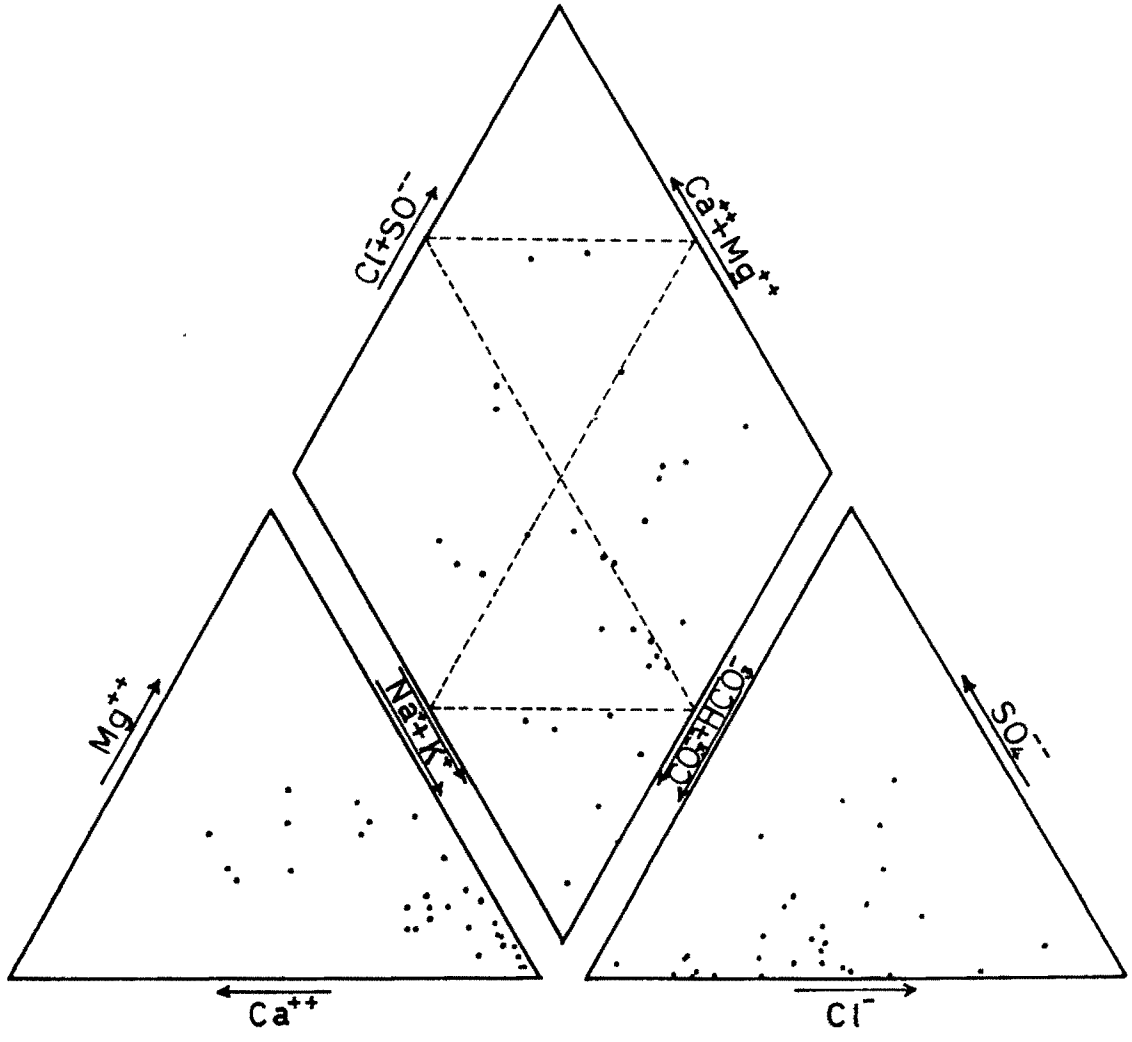

Fig.10·4. Piper's Diagram showing the Chemical Quality of Groundwater in the Kantli River Basin.

From the comparison of the Trilinear Diagrams of the two river basins it can be inferred that good quality, fresh groundwater of potable nature occurs in the Kantli basin rather than in the Upper Luni basin.

The groundwater facies in the Luni and Kantli blocks have been prepared for the various aquifer units based on the relative percentage abundance of cations and anions (Table 10.3). A perusal of the groundwater facies of the two river basins shows that in the Upper Luni block, the Na-K-Mg-Ca : Cl-HCO_3-SO_4 type of groundwater is predominant, i.e. the groundwater is dominantly influenced by the abundance of chlorides and bicarbonates of sodium and magnesium. On the other hand, within the Kantli block, the Na-K-Ca-Mg : HCO_3-CO_3-Cl-SO_4 type of groundwater is abundant, pointing to the occurrence of fresh, potable groundwater in this region, dominantly influenced by sodium, calcium and magnesium bicarbonates.

The groundwater facies of Luni basin has revealed the predominance of Na and Mg ions, while in the case of Kantli it is Na and Ca. This enrichment of Na, Mg and Ca is attributed to the chemical weathering of feldspars, amphiboles and lime bearing rocks, *viz.*, granites, gneisses, amphibolites, calc-gneisses, limestones, marbles, etc., which form the major rock types of the region. Similarly, the high anionic content of HCO_3 and Cl is also attributed to the chemical weathering of the above listed minerals reflecting alkaline environment.

SODIUM ADSORPTION RATIO (SAR)

The Sodium Adsorption Ratio (SAR) values are widely used for the classification of irrigation water, as recommended by U.S. Salinity Laboratory. High SAR values in irrigation waters lead to the development of sodium hazards in soils.

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

Table 10.3 Groundwater facies in the Upper Luni and Kantli Blocks

Block	Locality	Aquifer Type	Groundwater Facies
LUNI	Maulasar, Merat city, Anandpura, Badauli, Kuchera, Birlokha, Bursu, Chosli, Daulatpura, Degana, Ganwardi, Kuchaman, Indawar, Kekind, Parbatsar, Pharod, Ren, Sanward, Nimaj, Basi, Prithipura, Dangiyawas, Luni, Pipar Road, Pushkar, Jawa, Alniyawas, Rohina	Quaternary Alluvium	Na-Mg-Ca-K:HCO_3:Cl:SO_4
	Ladnun, Manasir, Bhakliawas, Bhakrod, Gurha, Jayal, Run, Jodhpur, Gorav	Palaeozoic Sandstones	Na-Mg-Ca-K:Cl-HCO_3-SO_4
	Banthri, Khimsar, Kolia, Rol, Bilara, Pichak, Tosina, Choti Khatu	Limestone	Na-Mg-Ca-K:HCO_3-Cl-SO_4-CO_3
	Makrana, Didwana, Harsore, Barr, Chandawal, Jaswantpura	Precambrian Hardrocks	Na-Mg-Ca-K:HCO_3-Cl-SO_4
	Manglana, Singhana	Intrusive granites	Na-Mg-Ca-K:Cl-HCO_3-SO_4
KANTLI	Sikar, Dadhia, Danta Ramgarh, Dhod, Fatehpur, Kanwat, Khur, Lachhmangarh, Nim ka Thana, Palsana, Ringus, Alsisar, Badagaon, Bagar, Bissau, Dighal, Golyana(Udaipurwati), Mandawar, Mukandgarh, Posana, Pilani, Singhana, Chandgoti, Chirawa, Govindhi, Pachlagi, Bisanpura	Quaternary Alluvium	Na-Ca-Mg-K:HCO_3-Cl-SO_4-CO_3
	Babai, Khetri, Maroth	Precambrian Hardrocks	Ca-Na-Mg-K:HCO_3-Cl-SO_4

Wilcox (1955) divides water into four classes, with the following limits of conductivity:

0-250	(C_1 - low salinity hazard)
250-750	(C_2 - medium salinity hazard)
750-2250	(C_3 - high salinity hazard)
Over 2250	(C_4 - very high salinity hazard)

All other factors being equal, the suitability of water for irrigation purpose decreases with increasing salinity. Similarly, with respect to sodium hazard, water is rated in four classes as follows:

SAR	0-10	(S_1 - low sodium hazard)	Excellent water
SAR	10-18	(S_2 - medium sodium hazard)	Good water
SAR	18-26	(S_3 - high sodium hazard)	Fair water
SAR	over 26	(S_4 - very sodium hazard)	Poor water

About 60% of the total number of samples in the study area show SAR values below 10 indicating no sodium hazards in soil, thereby excellent water for irrigation purposes, 13% of samples show values ranging between 10 - 18 (Good water), 13% show values between 18 - 26 (Fair water) and about 13% show values over 26 (Poor water). Relatively good percentage of samples showing greater than 10 SAR values indicates that sodium hazards of the order of medium to very high exist in the soils in parts of the study area, especially at Manasir, Manglana, Daulatpura, Degana, Ganwardi, Gurha, Indawar, Parbatsar, Singhana, Bilara, Jodhpur, Dangiyawas and Jawa in the Luni block and at Govindhi, Chirawa, Chandgoti, Mukandgarh, Mandawar, Dighal, Alsisar, Fatehpur, etc. in Kantli basin.

The plots of U.S. Salinity diagram for salinity hazard (specific conductivity) against sodium alkali hazard (SAR) for the groundwater samples of the Upper Luni and Kantli blocks are given in Figs. 10.5 & 6 respectively. It is observed that a major portion of the samples of the Upper Luni block group under Class III and Class IV (35.5%), *viz.*, bad and intolerable waters, encompassing C_3-S_4, C_4-S_4 and C_5-S_4 categories. Few samples plot in the C_2-S_1, C_3-S_1 and

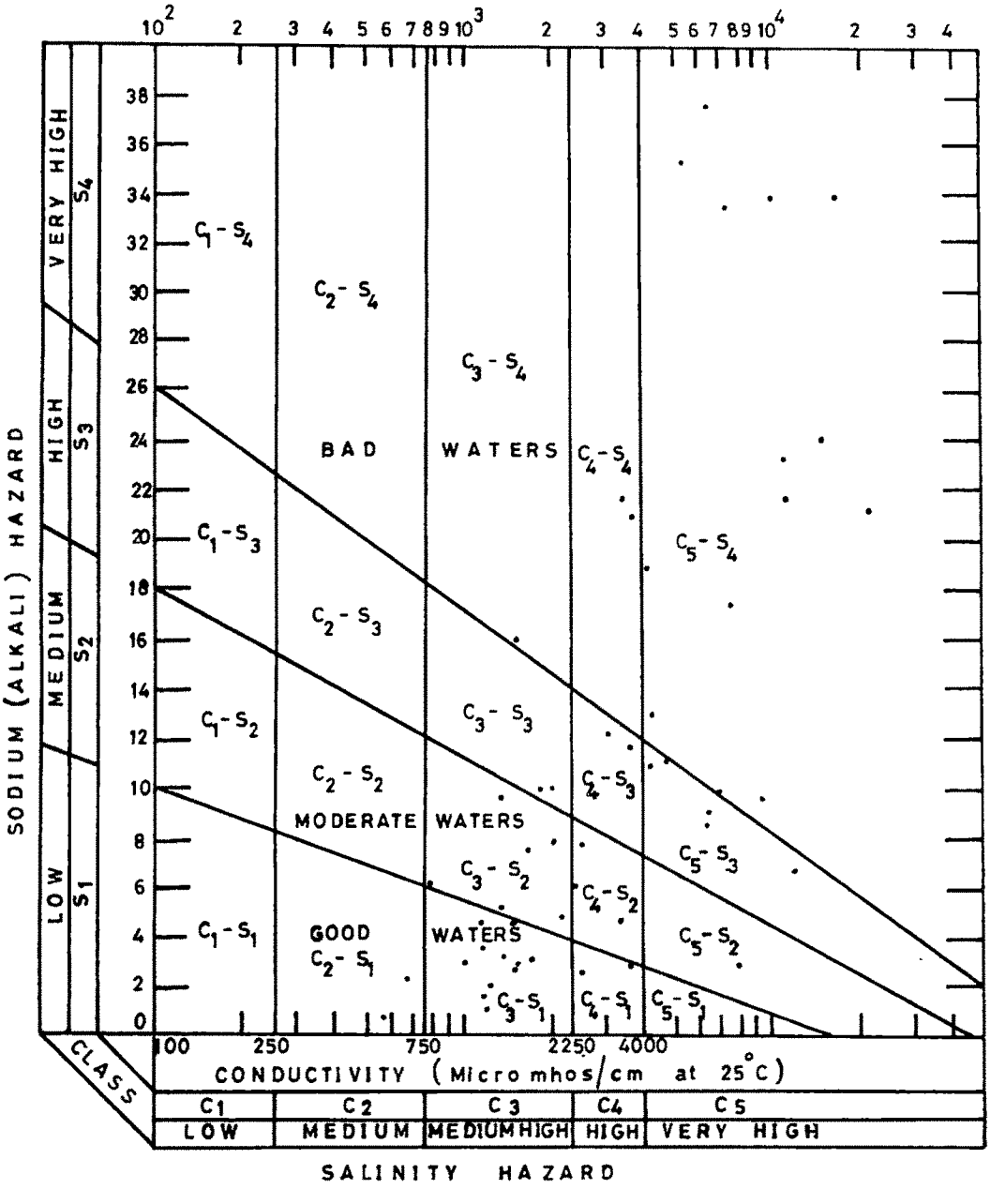

Fig.10.5. U.S. Salinity Diagram for the Classification of groundwater in the Upper Luni River Basin for Irrigation Purpose

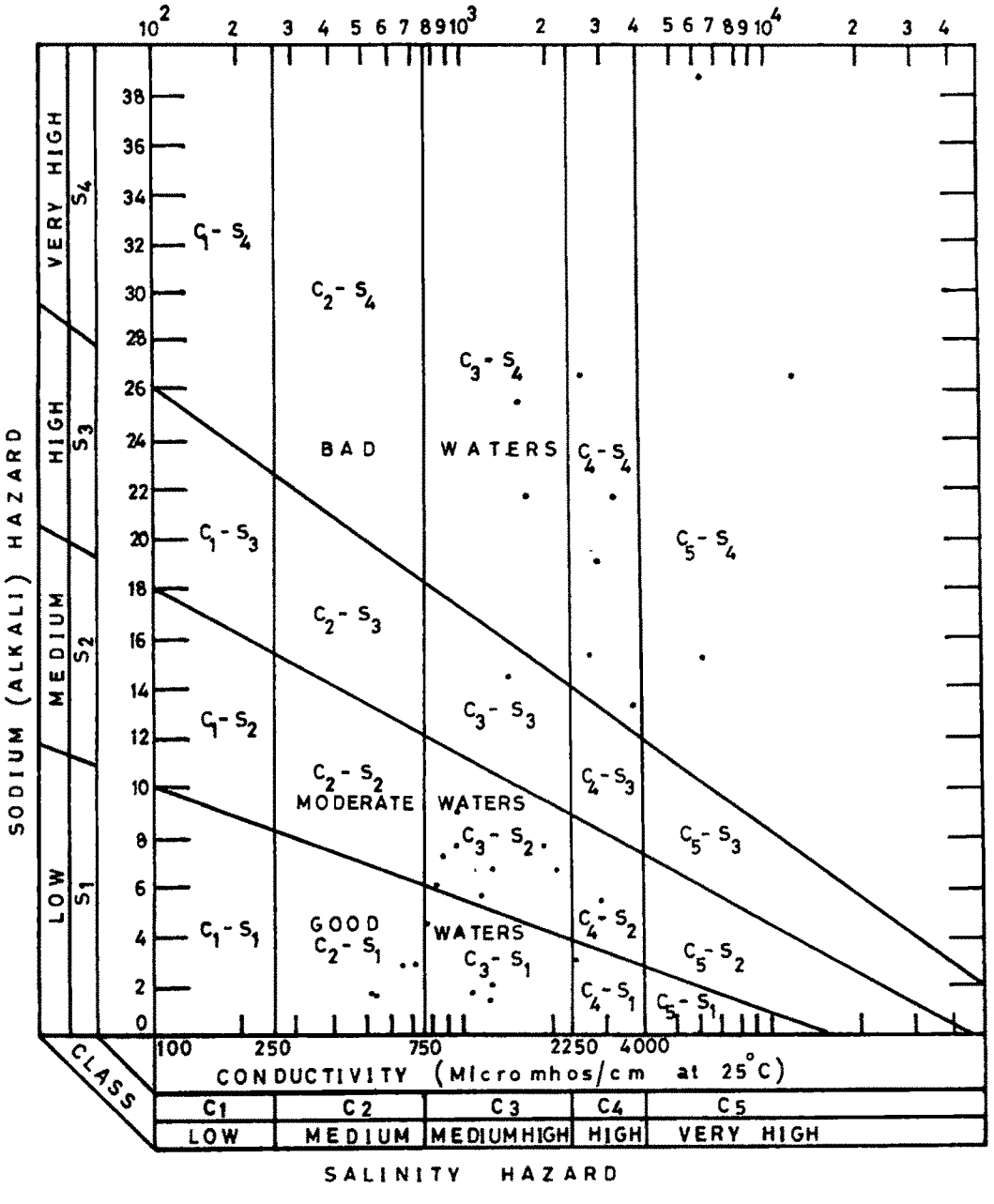

Fig. 10.6. U.S. Salinity Diagram for the Classification of groundwater in the Kantli River Basin for Irrigation Purpose

C_4-S_1 categories indicating good waters (Class I, 28.1%) and some fall under C_3-S_2, C_4-S_2, C_3-S_3 and C_4-S_3 categories showing moderate waters (Class II, 35.7%). This shows that the general quality of water for irrigation purposes in the Upper Luni block is moderate to bad.

The scenario is far better in the Kantli basin. A major portion of the groundwater samples in this basin fall under the Class I (29.9%) and Class II (36.9%), *viz.*, good and moderate waters. Class III, bad waters is represented by 33.4% of samples, indicating the occurrence of salinity hazardous waters.

The groundwaters of the study area have been categorised based on the classification of saline groundwater (after Caroll, 1962), by taking the TDS parameter (Table 10.4). It could be seen from the Table that brackish water is more abundant in the Upper Luni basin, whereas, fresh water and brackish water are distributed equally within the Kantli basin.

The hardness classification of water as $CaCO_3$ (after Sawyer and McCarty, 1967) has been utilised to categorise the groundwaters of the study area, based on the total hardness of the water (Table 10.5). The data clearly shows that moderately hard to very hard waters exist in both the Upper Luni and Kantli basins, however, soft water is also present in good quantities in the Kantli basin.

FLUORIDE

Fluoride is a very important constituent in determining the suitability of water for drinking purposes. High concentration of fluoride in drinking water causes mottling of teeth enamel. Regular intake of water with high concentration of fluoride may cause fluorosis. The Indian Council of Medical Research (ICMR) has recommended 1.0 mg/L of fluoride as an acceptable limit and 2.0 mg/L as maximum permissible limit in drinking water. In the study area, high concentration of fluoride in groundwater is observed in the areas of Pali, Nagaur and Sikar districts. High concentration of fluoride in tube well water is found at Jaitaran, Kekindra (6.0 mg/L) in the extreme southwestern parts of the study area, falling within the Luni basin. In Fatehpur, Laxmangarh and Sikar tehsils of Sikar district, the fluoride concentration in large

Table 10.4 Classification of saline groundwater in the study area (after Carroll, 1962)

Water Class	TDS (mg/L)	Upper Luni Block		Kantli Block	
		No. of samples	Percentage	No. of samples	Percentage
Fresh water	0-1000	13	24.53	15	50
Brackish water	1000-10000	37	69.81	15	50
Saline water	10000-100000	03	5.66	nil	-
Brine	> 100000	nil	-	nil	-

Table 10.5 Classification of hardness of groundwater in the study area (after Sawyer and McCarty, 1967)

Hardness (mg CaCO3/L)	Water Class	Upper Luni Block		Kantli Block	
		No. of samples	Percentage	No. of samples	Percentage
0-75	Soft	01	1.89	02	6.67
75-150	Moderately Hard	04	7.55	02	6.67
150-300	Hard	19	35.85	13	43.33
Over 300	Very Hard	29	54.71	12	40.00

areas exceeds 2 mg/L to about 10 mg/L. In the Nagaur district, a longitudinal belt of high concentration fluoride (>4 mg/L) extends from Manasir in Nagaur block to Indawar in Merta block. The fluoride content is also much above 4 mg/L in and around the areas of Parbatsar and Makrana. The source of fluoride in the groundwater in Pali district has been attributed to the presence of fluoride bearing minerals in granites, gneisses, etc, which occur in abundance in these parts.

Figure 10.7 shows the fluoride concentration distribution in the groundwaters of the Upper Luni and Kantli river basins. It can be clearly observed that fluoride concentration is alarmingly high in most parts of the area. An abnormally high concentration of 15.8 mg/L is observed at Ladnu and a NE-SW linear belt (locally known as Banka Patti) of greater than 6 mg/L concentration occurs to the southwest of Gorav up to west of Fatehpur. In the Upper Luni basin a major portion comprises of more than 2 mg/L fluoride concentration especially around Pipar Road, Indawar, Jaitaran, Basi, Kekind, Ren, Kuchera, Chosli, Makrana, Daulatpura, Didwana, etc. High concentration of fluoride in groundwater of Kantli basin occur around Mandawar, Alsisar, Mukandgarh, Dighal, etc.

GROUNDWATER QUALITY CRITERIA FOR DOMESTIC USE

A comparative summary of the hydrochemical constituents of the study area with the World Health Organisation (WHO) standards and Indian Drinking Water Quality Standards is given in Table 10.6. A general assessment and deduction of the acceptability of groundwater of the Upper Luni and Kantli river basins has been made based on this comparative analysis.

When compared with the WHO and Indian Drinking Water standards, the groundwater in the Upper Luni and Kantli river basins can be considered to be of inferior quality as far as drinking water standards are considered. Lack of fresh groundwater availability, the torrid climatic conditions and inconsistent rainfall; people in this part of the Thar desert are forced to utilise such inferior quality water for domestic as well as irrigation purposes. But the situation is slightly better in the Kantli river basin and in the catchment areas and drainage divides of the

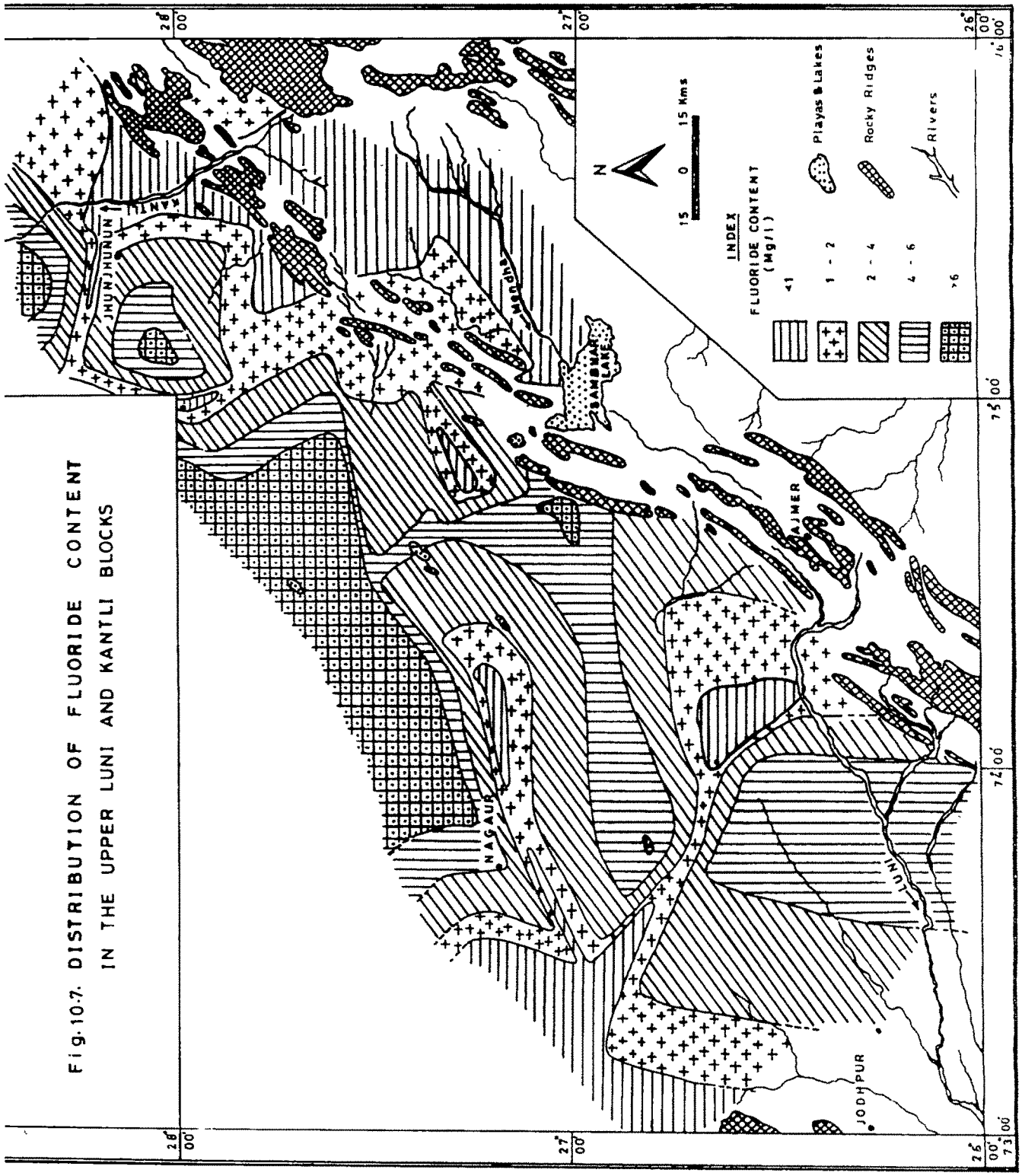

Fig.10.7. DISTRIBUTION OF FLUORIDE CONTENT IN THE UPPER LUNI AND KANTLI BLOCKS

Table 10.6 Comparative assessment of groundwater quality criteria in the study area for domestic use

Constituents	WHO (1972)		Indian Drinking Water Standards		In study area
	Highest Desirable	Maximum permissible	Highest Desirable	Maximum permissible	
TDS (mg/L)	500	1500	500	1500	333-13596
pH	7.0-8.5	6.5-9.2	7.0-8.5	6.5-9.2	7.08-9.0
Total Hardness (mg $CaCO_3$/L)	-	-	300	600	50-4650
Calcium (mg/L)	75	200	75	200	04-272
Magnesium (mg/L)	30	250	50-100	100	05-899
Chloride (mg/L)	200	600	200	1000	21-6382
Sulphate (mg/L)	200	400	200	400	Traces to 2694
Fluoride (mg/L)	0.6-0.9	0.8-1.7	1.0	1.5	0.04-15.8

Luni river in Ajmer district. In general, the quality of groundwater is suitable for domestic and irrigation purposes.

Some of the important facts about the presence of good quality groundwater in the study area are as follows:

- The quality of groundwater in the areas underlain by the alluvium and blown sands is invariably good.
- The groundwater quality is good in the interstream areas.
- The quality is generally the best along the drainage divides of the Luni and Kantli rivers.
- The groundwater in the Kantli block is of better quality than that of the Luni block.
- The chemical quality of groundwater in northern parts of Luni block is generally brackish to saline with few fresh water pockets.

Owing to the diversity in lithology and geomorphology of the study area and on account of irregular variation in hydrochemistry of the groundwater from aquifer to aquifer, it could not be possible to categorise the aquifers of varying lithologies in the study area.