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SURFACE AND GROUND WATER QUALITY EVALUATION IN PARTS OF UDHAMPUR DISTRICT (J&K)

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PREFACE

Water forms the most vital component of the earth's environment. Human existence is impossible without water and air. The issue of water quantity has always been a subject of concern since ancient times as per the then needs. During recent years, the issue of water quality has also been considered as important for a healthy ecosystem and finally of the living organisms, which may directly or indirectly be affected by poor quality of water. In hilly areas, a chunk of population is facing the both problems of water i.e., the quantitative and qualitative. In Udhampur District of Jammu & Kashmir, a protected water supply is a far cry for the villages. About 30% village have been covered under potable water supply schemes of State Public Health Engineering Department. Only a negligible percentage of village population use dug wells as their source of water supply. The majority of villages still depend on springs, streams and rainfall tanks. Therefore, it is important to monitor various sources of water and consequently their water quality for various uses.

The Regional Co-ordination Committee of the WHRC (NIH) Centre recommended to conduct this study under the work program of the Center during 1999-2000. Various physico-chemical parameters of water quality for both the surface and ground water sources have been determined. Trace elements (Cu, Mn, Zn, Co, Fe, Ni, Cd, Cr and Pb) analysis has also been performed. In the report, water quality evaluation was performed for drinking and irrigation purposes on the basis of the standard norms. The classification of surface and ground water was also carried out on the basis of popular methods e.g., Piper, Stiff, Schoeller and USSL Staff Classifications.

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(K.S. Ramasastri)

Director

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Water sources are polluted by four kinds of substances, i.e., traditional organic waste, waste generated from industrial processes, chemical agents of fertilizers and pesticides used for crop production and silt from degraded catchment. In Udhampur district, only a negligible percentage of village population use dug wells as their source of water supply. The majority of villages still depend on springs, streams and rainfall tanks. In the present study, surface and ground water quality monitoring has been undertaken in order to evaluate its quality for domestic and agricultural purposes. Accordingly, water samples from nine wells, eleven springs and five streams were collected during June 1999 and October 1999 in parts of Udhampur District (J&K).

The water quality parameters have been grouped in accordance with the standards of drinking purposes. The suitability of water for irrigation purposes has been determined based on various parameters like salinity (EC), permeability (Doneen's Permeability Index), toxicity due to chloride and sodium (SAR), parameters causing miscellaneous problems to soil-water-plant relationships (bicarbonate, RSC, sulphate) and USSL Staff Classification. The classification of water has been done on the basis of Piper, Stiff, Schoeller and USSL Staff Classification.

The values of pH show alkaline nature of water. The concentration of magnesium exceeded the permissible limits at about 32% sites during pre-monsoon and at 44% during post-monsoon periods. A higher concentration of Fe and Cr, has been observed in 67% and 33% water samples. Mn exceeded the tolerance limit (0.5 mg/l) at one location representing 7 % of site. The Concentration of Cd, which is a highly toxic element, has been observed below detection limits all sites except at one site where its concentration equaled tolerance limit (0.01 mg/l). The SAR values show water under the excellent category for irrigation purposes. Almost all sites fall under the Ca^{2+}, Mg^{2+}, HCO_3- hydro-chemical facie during both sampling periods as per the Piper's classification. In the study, 52% of water samples belonged to C3-S1 (high salinity- low SAR) class and 48% under C2-S1 (medium salinity- low SAR) category during June 1999. In another sampling carried out during October 1999, 35% water samples belonged to C3-S1 category and remaining 65% under C2-S1 category. However, the higher concentration effect of bicarbonate in irrigation water has shown all samples lying under "Increasing Problem" zone (bicarbonate, 1.5-8.5 me/l) in the present study.

1.0 INTRODUCTION

Environmental resources like the atmosphere and water may be regarded as global public goods. Their preservation not only benefits the local population but also the fauna and flora of the region. The survival and well being of a nation depend on sustainable development. With the population explosion, rapid industrialization without adequate treatment facilities and agricultural revolution promoting use of chemical fertilizers and pesticides for growing food and forage from high yielding varieties have left adverse effects on the sources of water and, hence, on its quality.

Water pollution in India has now reached to a crisis point. As assessed by the National Environmental Engineering Research Institute (NEERI), Nagpur, nearly 70% of water in India is polluted. Water is polluted by four kinds of substances: traditional organic waste, waste generated from industrial processes, chemical agents of fertilizers and pesticides used for crop protection and silt from degraded catchment. While, it is estimated that three-fourth volume of the waste water is generated from the municipal sources, industrial wastes contribute over one half of the total pollutant loads, and major portion of this is coming from large and medium industries. There has been a steady increase in the amount of waste water produced from urban communities and industries. At many places, this waste water is discharged into drains and rivers causing serious water pollution.

Polluted and non-potable water has been creating many health hazards to the living beings and often causes different water born diseases in the country. Pollution of water bodies, is also adversely affecting the growth of aquatic fauna and flora. Water quality study is, therefore, regarded as one of the thrust areas in the water resources sector as envisaged in the National Water Policy that "Both surface and ground water should be regularly monitored. A phased program should be undertaken for improvements of water quality".

In the present study, surface and ground water quality monitoring and evaluation in parts of the Udhampur District has been carried out. About 30% village have been covered under potable water supply schemes of the State Public Health Engineering

Department. Only a negligible percentage of village people use dug wells as their source of water supply in Udhampur district. The majority of villages still depend on springs, streams, nallas, and rainfall tanks. Therefore, it is necessary to monitor various water sources in the District, and their suitability in terms of water quality for various uses.

Various physico-chemical parameters of water quality have been determined for the samples drawn from rivers, springs and wells, during Pre-monsoon (June, 1999) and Post-monsoon (October, 1999) periods. Trace elements (Cu, Mn, Zn, Co, Fe, Ni, Cd, Cr and Pb) analysis has also been carried out on the water samples. The surface and ground water quality evaluation has been performed for drinking and irrigation purposes.

2.0 REVIEW

Pollution of water is the natural, physical, and chemical changes due to human activity, so that the water is no longer fit for a use for which it had previously been suited (Todd, 1980). The problem of pollution in ground water is much less than that of surface water, even though this problem is nowadays becoming a severe threat to public health (Pitchaiah, 1995). Due to urbanization and industrialization, water is increasingly laced with pollutants from industries, municipal sewers and agricultural fields that are treated with fertilizers and pesticides. As a result, water has become a cocktail of various pollutants like fluorides, nitrates, chlorides, heavy metals, pesticides etc. The kind and quality of various pollutants depend upon the sources for recharge of the ground water and the strata through which it flows. Handa (1994) studied ground water pollution in many parts of India and opinioned that the systematic efforts are needed to identify sources causing migration of pollutants in unsaturated zone, behaviour of pollutants and their potential for polluting ground water.

In J & K state, the establishment of hydrograph stations was initiated by the erstwhile ground water wing of Geological Survey of India in 1969 and later continued by the northern regional office of Central Ground Water Board (CGWB) located at Lucknow from 1972 onwards. These stations were passed over to North -Western Region, Chandigarh in 1974 (Bhatnagar et. al., 1986). Presently, ground water quality and quantity survey works are carried out by Central Ground Water Board, North

Western Himalayan Region, Jammu. Sangra (1987) carried out hydrogeological investigations in Jammu District, J & K State, during 1974 -78 & 1983, and observed that the concentration of chemicals in ground water of shallow aquifer is comparatively higher than the deeper aquifers. Srivastava and Singh (1998) reported trends of the change in water levels and the ground water quality over the last decade in Jammu region.

Kaushik (1989) has performed hydrogeological surveys in parts of Udhampur and Doda Districts. Dulloo (1994) has reported the groundwater in the Udhampur District is under unconfined condition in alluvium medium, and which is available mainly in the form of Springs. Further, it has also been mentioned in the report that the ground water quality in the area is good and fit for human consumption as well. Srivastava and Singh (1998) have also reported trends of the change in water levels and the ground water quality over the last decade in the Jammu region.

In addition, many workers have carried out various investigations on the limnological and geo-morphological aspects of the lakes in J & K (Zutshi et al., 1972, 1980; Zutshi and Khan, 1978 Zutshi & Vass, 1971, 1977, 1978; Kant & Kachroo, 1974, 1977; Kaul, 1977). Zutshi and Khan (1977) have carried out comparative study of the morphometric, physico-chemical and biological parameters of the Mansar and Surinsar lake. According to the studies, using radioactive Carbon isotope (^{14}C), production rates of the Surinsar lake is much higher than that of Mansar lake in Jammu region. However, recent studies reveal that the trophic level in the Mansar lake is rapidly advancing during last few years (Zutshi, 1985, 1989; Chandra Mohan, 1992; Gupta, 1992). Durani (1993) carried out the chemical and pollution studies of some springs and lakes of J & K State. The phytoplankton study of the Mansar lake has also been conducted (Kant & Anand, 1976, 1978).

Western Himalayan Regional Centre of NIH also performed water quality investigations in Jammu region. Detailed investigation of the chemical quality of ground water in district Jammu was carried out by analysing 47 water samples to see the suitability of water for various (Jain et al., 1994-95; Jain, et al., 1997). Later, ground water quality monitoring and evaluation programme was undertaken in Jammu and Kathua districts to study the spatial and temporal variation in ground water quality. Under these studies, in a particular year, sampling was done for pre-monsoon and post-monsoon periods. Water quality parameters were compared with the water quality standards for drinking purposes. These studies have shown higher values of certain parameters at certain locations indicate the contamination in ground water and make the water unsuitable for various applications at few locations. The salinity problem was also observed in parts of Jammu and Kathua Districts (Omkar et al., 1995-96, 1996-97, 1997-98, 1998-99, Kumar and Omkar, 1998-99).

Some studies of Lakes in Jammu region has also been conducted by Western Himalayan Regional Centre (NIH), Jammu. Based on the physico chemical analysis of Surinsar lake waer during 1994-95, it has showed that the lake water could be satisfactory used for irrigation purposes. In the Surinsar lake, various physico chemical parameters of water quality were found to be within the limits specified by Bureau of Indian Standards for drinking purposes under Class-A (Omkar & Sharma, 1994-95). In the Mansar lake, the water samples from different locations at the surface and from three zones (viz. Epilimnion, metalimnion and hypolimnion) were collected during 1996-97, 1997-98, 1998-99. A detailed physico chemical analysis was performed coupled with trace element analysis also at certain locations (Rai et al., 1996-97, 1997-98; 1998-99, Jain et al., 1999). The study of the Mansar lake reveals that the water is good for drinking and irrigation purposes. The temperature data indicated that in the winter, the lake becomes mixed and remains stratified from March to November. The concentration of phosphorous was observed to be more than 0.03 mg/l, which is the characteristic of a eutrophic lake. In other study, five sediment cores have been collected from the Mansar lake for study of sedimentation rate and life. A bathymetric survey of the Mansar lake was also performed.

3.0 STUDY AREA

3.1 Location

Udhampur district is situated in the south-eastern part of the J & K State and is bounded in the West by Rajouri district, in the North by Anantnag district, in the North-

East by Doda district, in the South-East by Kathua district and in the South-West by Jammu district. Geographically, it lies between latitudes 32^0 39′ 0″ to 33^0 31′ 20″N and longitudes 74^0 35′ 20″ to 75^0 40′ 30″E. The area of the district falls under four (43 K, 43 O, 43 L, 43 P) Survey of India toposheets on 1:250,000 scale.

The district covers a total area of 4550 sq. km, which constitutes about 2.05% of the total area of J&K State. There are in all 624 villages in the district. They are administered under five tehsils viz; Ramnagar, Udhampur, Reasi, Chenani and Gool Gulab Garh. Udhampur, which is also the district headquarters, is the biggest tehsil of the district and situated at a distance of 66 kms from Jammu on the Jammu-Srinagar National Highway. According to 1981 Census, the district had a total population of 4.54 lakhs comprising 2.38 lakh males and 2.16 lakh females (Anonymous, 1988-89). This shows a growth rate of 30% in population over a period of 10 years or 3% growth rate/ year.

For this study, the area selected comprised south-eastern and south-western region of the Udhampur district, with only two locations on the northern edge, namely at Kud and Chenani on the Jammu-Srinagar National Highway (Figure 1). The other regions of the district were difficult to work due to militancy problems. The water samples were collected from rivers, wells and springs in the study area. The latitudes and longitudes of sample locations are given in Table-1.

3.2 Physiography and Drainage

The district has a varied topography. It is interwoven with several hill ranges and mountains. There are a number of intermountain valleys in the area. The altitude variation in the district ranges from approx. 600m to 3000m. A major chunk of the area is occupied by Murrees and Shiwalik formations. Limestones and Panjal traps are other geological formations in the area, but they occupy only a small portion. Three terraces- lower, middle and upper are well developed in the area. These terraces are characterized distinctly by topography, land elevation and depositions. The average thickness of the upper terrace is 40 to 50 m, but at places, i.e. at Panthal, it attains a thickness of about 120m. The thickness of middle and lower terrace is relatively less.

Fig. 1: Location map showing sampling sites.

The district is drained by four major rivers namely, Chenab, Tawi, Basantar, and Ujh. River Chenab occupies the largest area, followed by the rivers Tawi, Ujh and Basantar. A lake namely, Mansar lake, is also situated in the district. The drainage network of Udhampur district mainly belongs to dendritic, dichotomic and trellis patterns (Figure 2).

Table-1 Location Details of Sampling Sites in Udhampur District

S No	Site	Code	Latitude (^{0}N)	Longitude (^{0}E)
1.	Chenab	R-1	33.08	74.82
2.	Banganga	R-2	32.99	74.93
3.	Tawi (d/s at Udh.)	R-3	32.85	75.15
	Tawi (u/s at Udh.)	R-4	32.93	75.13
4.	Jhajjar River	R-5	32.89	74.9
5.	Juni River	R-6	32.39	74.26
6.	Agharjitto	S-1	33.01	74.91
7.	Katra	S-2	32.99	74.93
8.	Chamba	S-3	32.98	74.96
9.	Chiryai	S-4	32.99	75.03
10.	Kakrai	S-5	32.78	75.16
11.	Nauzi (Ramnagar)	S-6	32.83	75.30
12.	Khu Nalla	S-7	32.85	75.17
13.	Udhampur	S-8	32.93	75.13
14.	Chenani	S-9	32.04	75.26
15.	Kud	S-10	33.05	75.27
16.	Tikeri	S-11	32.94	74.98
17.	Reasi	W-1	33.09	74.83
18.	Talwara	W-2	33.1	74.77
19.	Talwara	W-3	33.1	74.77
20.	Chani	W-4	32.68	75.17
21.	Paldai	W-5	32.69	75.23
22.	Chinal	W-6	32.68	75.24
23.	Manwal	W-7	32.76	75.13
24.	Dehari	W-8	32.78	75.27
25.	Ramnagar	W-9	32.83	75.30

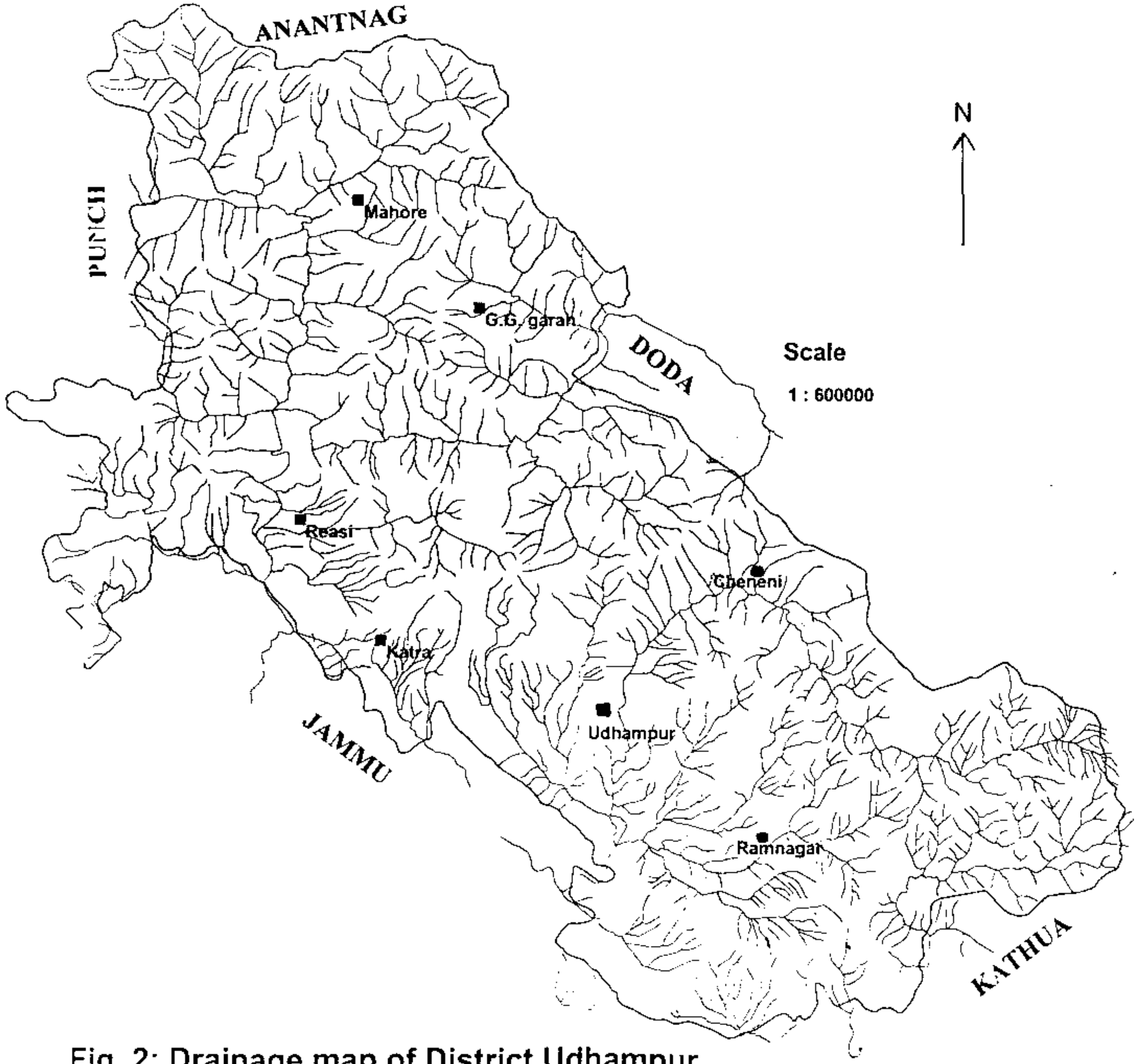


Fig. 2: Drainage map of District Udhampur

Chenab river is one of the main constituent rivers of the great Indus river system. In the State of Jammu & Kashmir, the Chenab basin lies in its southern part of covering the districts of Doda, Udhampur, Rajouri and Jammu. The Chenab basin, thus, falls in the Jammu region draining the areas partly between outer and central Himalayas and partly between Siwaliks and outer Himalayas. In the upper and middle reaches, Chenab cuts through the formations of phyllites, quartzite gneisses, schists and dogra slates with gypsum and crystalline limestone bands. In the lower reaches, it traverses through the formations belonging to Sirban limestones, eocenes and lower murrees (Sharma, 1994).

After entering Jammu & Kashmir at Paddar area of Doda district, the Chenab flows in a north-west direction in this reach for a distance of 61 km when it is joined on the right by its biggest tributary, the Marsudhar at Bhandalkot. Further down stream, the river flows in a southerly direction for a distance of 32 km, upto Thathri and the takes a west ward course. In this reach about 15 km downstream of Thathri, Niru Nala joins on its left bank. Chenab thereafter flows generally in a north west direction for another 41 km till it receives a tributary Bichleri on the right bank. Afterwards, the river traverses in a westerly direction for a distance of about 64 km. In this reach, a number of small streams join in, namely, Chineni, Talsuen, Yabu, Ans on the right bank; and Katu Nalla, Mandial and Painthal Khad on the left bank. Downstream of Ans river confluence, the river changes its direction and flows in southerly course for about 55 km upto Akhnoor before entering into Pakistan (CWC, 1988).

Tawi river is a major left bank tributary of river Chenab. Total catchment of this river within India is about 2780 Km^2. The river originates from the lapse of Kali Kundi glacier and adjoining area south-west of Bhadarwah in Doda district (J&K), at an elevation of about 4000m. Initially, it flows in westerly direction course for about 16 km then turns towards north-western direction for a distance of about 27 km near Sudh Mahadev. Then it follows a westerly course for about 5 km upto Chenani, and further down a south-westerly course upto Udhampur, after which it takes a southerly course for about 24 km. In the lower part of this reach, a number of small streams or nallahs join with it. The river then takes south-westerly direction for about 8 km and then north-westerly direction for about 12 km where Jhajjar nallah joins it on the right bank. From this point, the river takes a south-westerly direction for about 24 km upto Jammu city.

Tawi river originates from the Kaplas granite Dom and cuts across Panjal, Murree, Muran and Krishanpur Thrusts throughout the course upto Jammu. The main tributaries of Tawi, namely, Duddar Khad, Ramnagar Wali Khad, Salam, Naddal, Biruni, Baramani, Juni, Balin, Bamir Khad, Jhajjar, Gamhi, Dhamal Khad, Saro, Sulok, follow strike direction and are controlled by geological structures.The control of structures on the streams is generally evident from the drainage pattern (Singh, 1990).

Ujh river is a tributary of river Ravi, with its origin in the Bhadarwah hills of Doda district. The Ujh catchment comprises hilly and rugged terrain. In the state of J&K, this river has main tributaries as Bhini, Sutar, Dunarki, Bein and Talin. Only a small portion of the district is drained by Ujh river in the south-eastern part. An even smaller area in the southern part is drained by Salia river, a tributary of Basantar river.

3.3 Climate and Rainfall

The climate in Udhampur district is of mountain type, with monsoon having sufficient influence. It is characterized by the relative influence of winter and summer precipitation. Whereas in the northern, north-eastern, and eastern areas, the "westerlies" dominate in winter, the outer Himalayan ridges are heavily influenced by the monsoon rains in summer. The south-west monsoon is active during June to September, and is pronounced in July and August.

Wide climate variations prevail from place to place and from year to year. Most of the rainfall takes place during July, August and September in summer. The study area receives an average annual precipitation of about 1630mm. The Pir Panjal range experience heavy snowfall during winter months. The temperature in the snowfall zone varies between sub-zero to about 35^0 C, whereas non-snowfall areas experience temperature variation between 3^0 C during winter to about 40^0 C during peak summer. The average monthly rainfall at Udhampur, Katra, Ramnagar and Chenani has been shown Figs. 3 to 6 (Goyal V.C.- Personal Communication, 2000). As seen in these figures, about 46-63% of the annual rainfall is received during the monsoon months of July, August and September. Katra receives highest average annual rainfall of 2234 mm, followed by Ramnagar (1689 mm), Chenani (1338 mm) and Udhampur (1264 mm).

3.4 Hydrogeology and Occurrence of Ground Water

Geologically, the area can be divided into four zones: (i) The Pir-Panjal zone, (ii) The Murree zone, (iii) The Riasi Limestone Inlier, and (iv) The Siwalik belt. These four stratigraphic zones are distinct from one another in their constituent rock formations and in their tectonics and intensity of metamorphism. The general geological succession of the area is given in Table-2 (GSI, 1977; Dulloo, 1994).

Groundwater in the area is present under unconfirmed conditions in the alluvial formations and under confined conditions in the underlying rocks of the Shiwaliks. Perennial springs of good discharge are numerous in the whole area and form the principal source of water supply. Murree sand stones, though porous, are hard and steep dipping and, therefore, cannot retain water. The system of joints, cracks and faults allow the stored water to come out in the form of springs. The Shiwalik sandstones are good permeable formations, but relatively bad retainers of water. Sirban and Numulitic limestones are not only good water bearing rocks but also contain good quality water, rich in calcium.

The movement of water is controlled by joints and bedding planes of the hard rocks. These joints and bedding plains render the groundwater liable to seep to greater depth. The depth of water in the area ranges between 0.10 to 11. 50 m below ground level. In the greater part the water level is found between 2 to 4.50 m bgl. Deep groundwater levels are observed in the valley of Ramnagar wali khad and ranges between 6.30 to 11.50 m bgl. The shallow water levels lying between 0.10 to 0.32m bgl are observed in Udhampur and Kud valleys. The gradient of groundwater flow is towards river Tawi, and its tributaries (Dulloo, 1994).

Fig. 3 Average Monthly Rainfall at Udhampur

(1961-72, 81-89,97-98, Compiled by NIH-WHRC/2k)

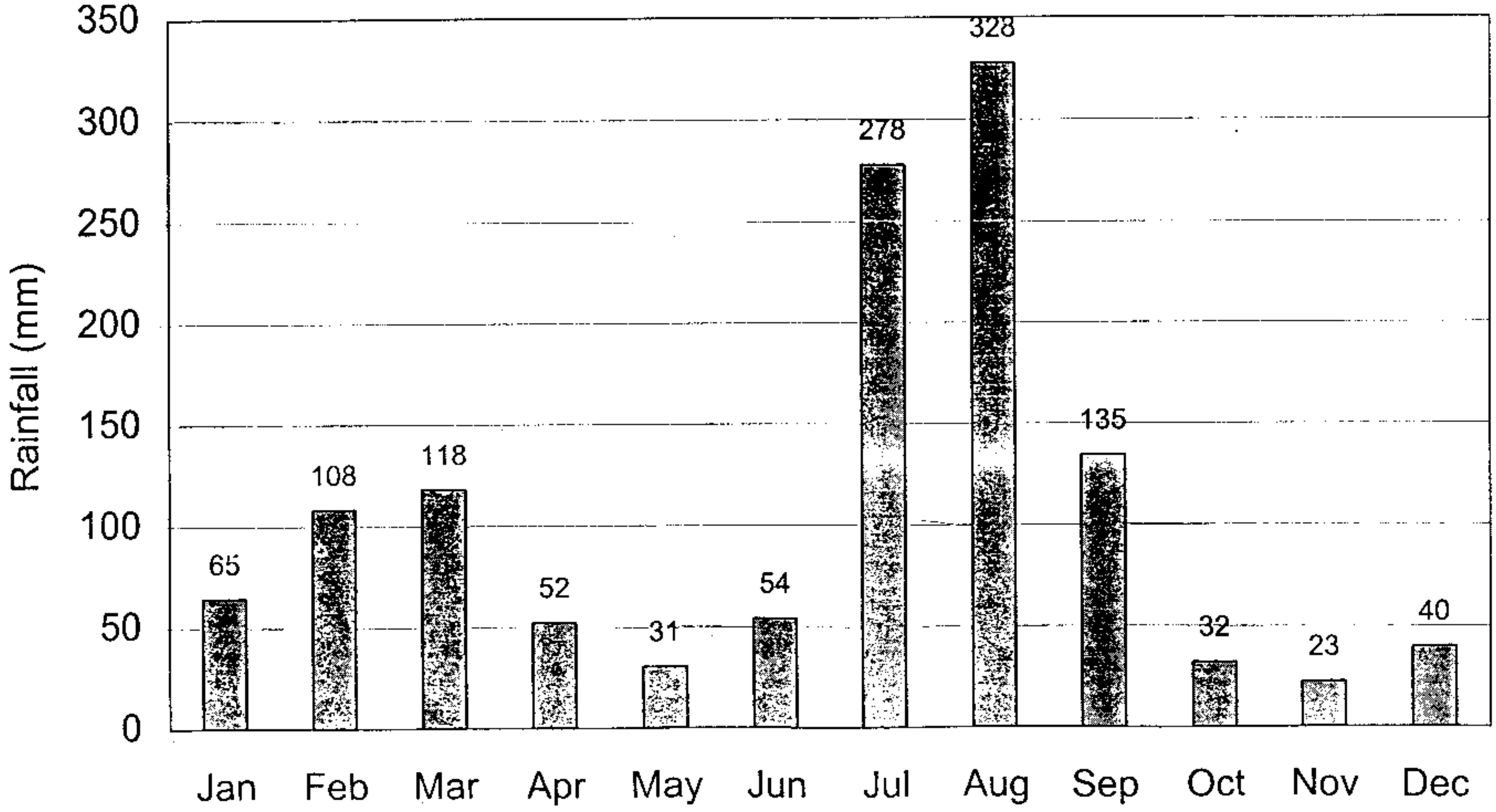


Fig.4 Average Monthly Rainfall at Katra

(1980-95; Source: IMD, Compiled by NIH-WHRC)

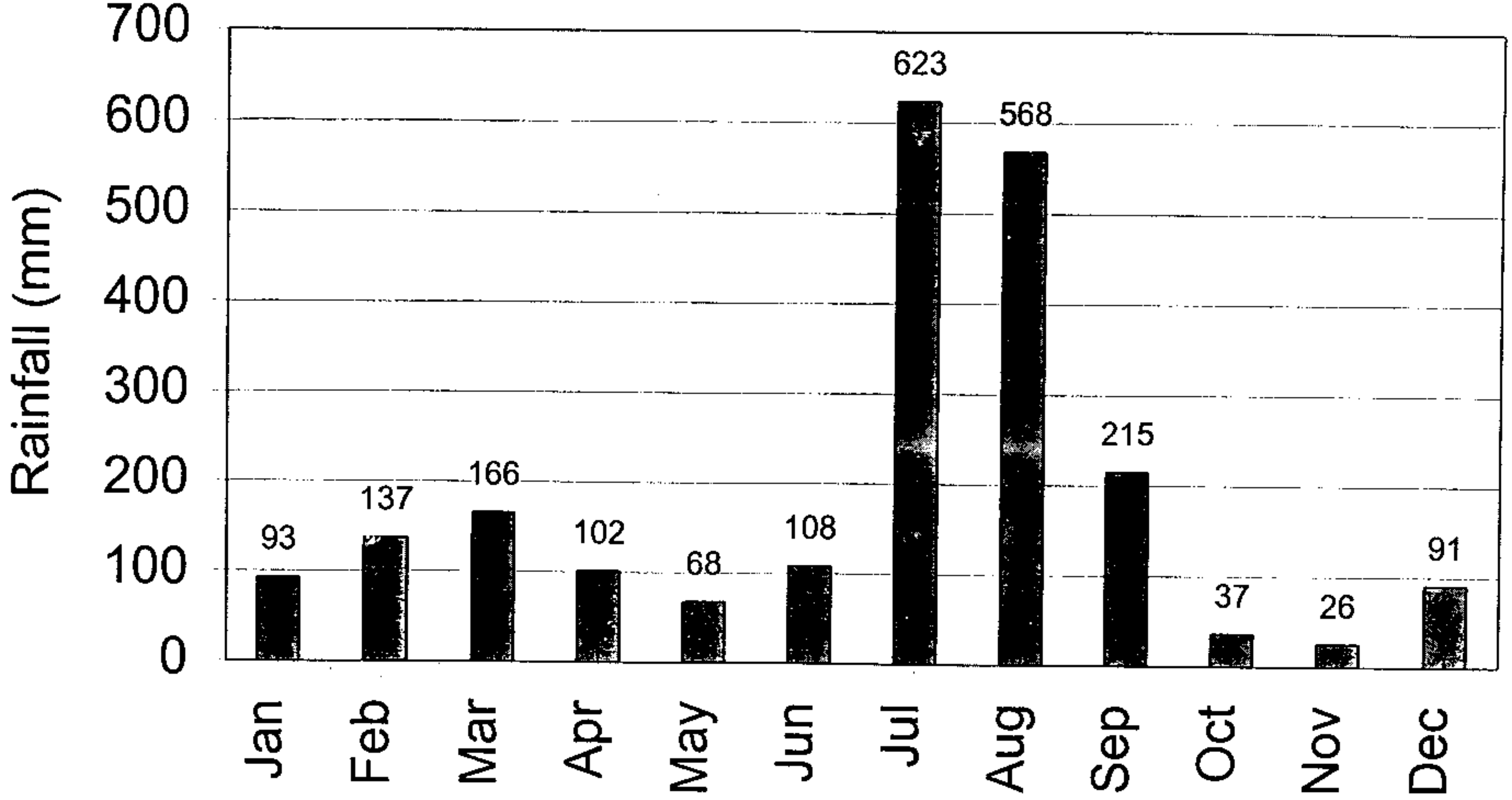


Fig. 5 Average Monthly Rainfall at Ramnagar
(1961-85, 97-98, Compiled by NIH-WHRC/2k)

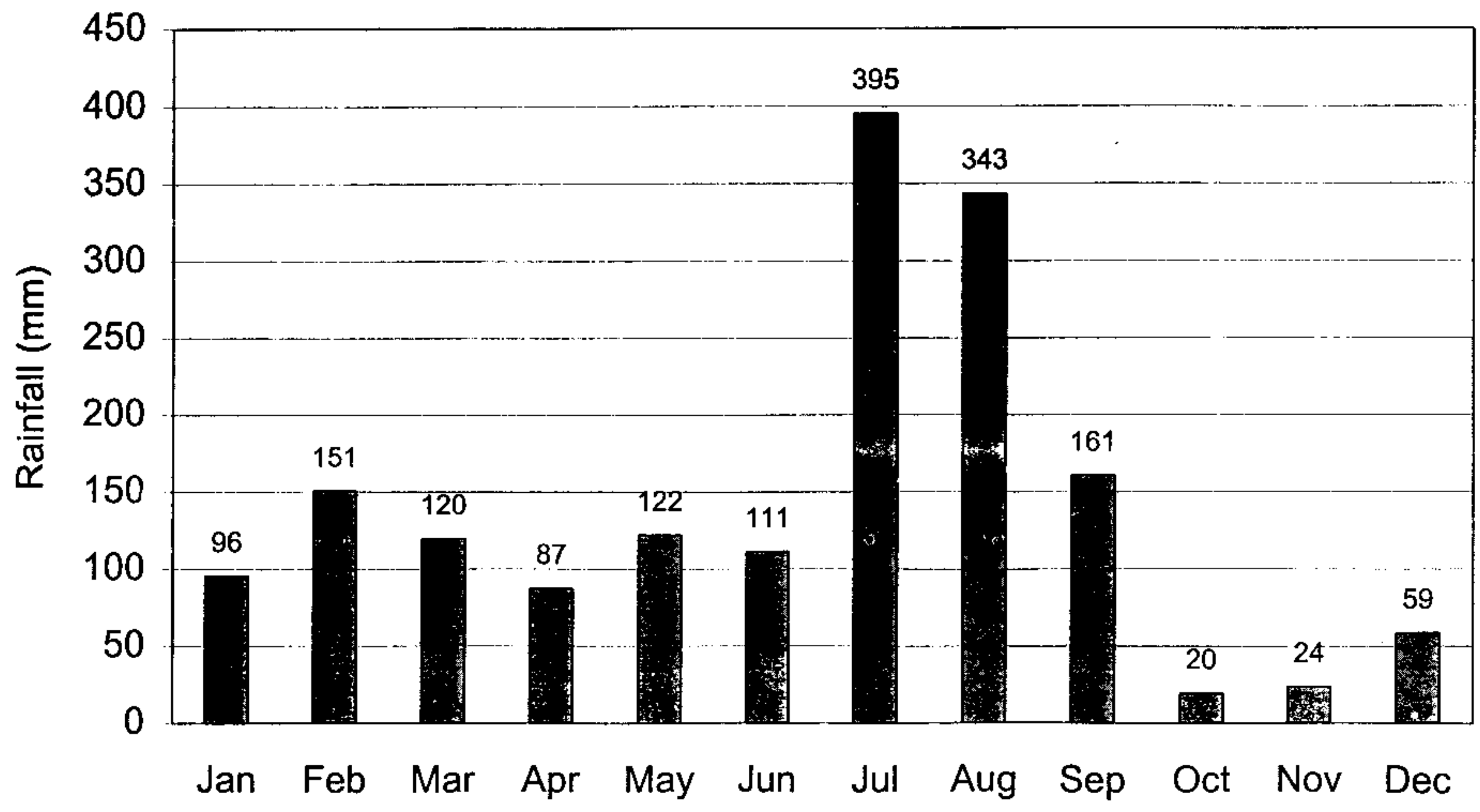


Fig. 6 Average Monthly Rainfall at Chenani

(1963-79, Compiled by NIH-WHRC/2k)

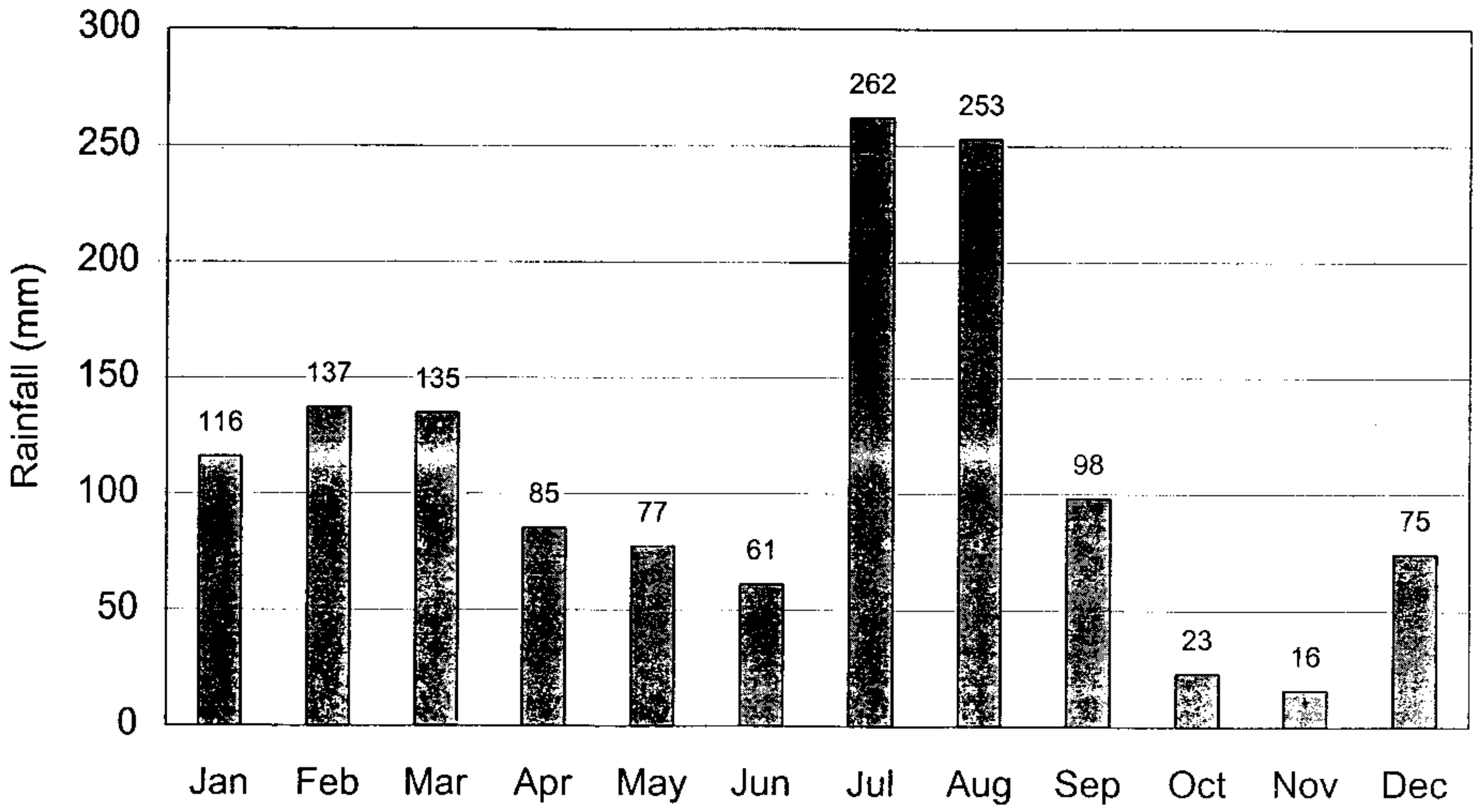


Table-2 General Geological Succession in Udhampur District

Formation	Lithology	Age	Remarks
Alluvium	Boulders, cobbles, pebbles, gravel mixed with varying amount of sand, silt and clay.	Quarternary	The flood plains of the river Tawi and its tributaries on their banks. These deposits possess a good degree of porosity, permeability and groundwater.
Middle Shiwaliks	Coarse, micaceous grey sandstones (poorly cemented) with orange coloured shales.	Upper Miocene	Low permeability of these sandstones, yields low to moderate quantities of water to dugwell, if occurring below saturation zone.
Lower Shiwaliks	Hard compact and bright red sandstones and red purple shales and clays.	Upper Middle Miocene	No ground water structure exists in this formation.
Murrees	Purple/Red coloured sand stones and clay.	Lower Miocene	These formations are widely spread in the district (mainly in central portion) of Udhampur covering about 40% of the area and are totally devoid of ground water.
------------------------------- Unconformity -------------------------------			
Lime stones:			
a) Subathu Limestones	Numulitic lime stones thin bedded nodular bituminous.	Eocene	Exposed as the core of an anticline near Reasi in narrow rim form, good water bearing formations.
------------------------------- Unconformity -------------------------------			
b)Sirban Limestones	White or blue grey dolomitic lime stones.	Permo-Carboniferous	Spread around Trikuta Hills near Reasi, Copper and Zinc are found in Reasi Limestone with veins of nickeliferous pyrites and galena, lime stones are good water bearing formations.
Panjal Volcanics	Bedded tuffs, slates, ash beds and andesitic to basaltic lava flows.	Upper Carboniferous	Spread towards Northern corner of the District covering half of the Gool Gulabgarh Tehsil, totally devoid of ground water resources except springs.

3.5 Soils

In the Udhampur district, the soils are moderately deep to deep on mid hills and plateaus, whereas, deep to very deep at the foothills. The texture in generai is coarse to medium. The Physico-chemical properties at two sites in Udhampur district are given in Tables 3 and 4.

Table-3 shows the soil texture at profile Ramnagar, which was observed as sandy loam to sandy clay loam. The texture of profile at Kandoria is heavy throughout, the depth (loam to sandy clay loam and clay) showing eluviation of clay from upper to lower horizon.

The texture of other profiles located at Rakhromat (about 4 km towards north from Udhampur town) and Karlah (about 6 km towards south from Chenani) was reported as sandy loam and sandy clay loam to clay, respectively (Gupta and Verma, 1975).

Table-3 Physical Properties of Soil Profiles (Gupta and Verma, 1975)

Horizon	Depth	Mechanical Composition, %				Particle Density	Bulk Density	WHC	Pore Space
	Cm	Coarse Sand	Fine Sand	Silt	Clay	G/cc	G/cc	%	%
Location: Ramnagar, 2 Km towards north-east from Ramnagar to Udhampur Road, Elevation: 1000 m amsl.									
A1	0-8	5.9	60.4	12.8	18.4	2.6	1.40	54.4	48.5
B21t	8-21	7.2	51.5	12.9	29.4	2.29	1.17	60.2	49.6
B22t	21-36	14.9	30.1	19.1	34.2	2.4	1.21	52.3	41.8
B3	36-63	8.1	61.1	15.1	17.1	2.6	1.08	48.3	39.4
Location: Kandoria about 8 Km east of Reasi bus stand, Elevation: 810 m amsl.									
Ap	0-15	4.0	38.7	38.8	20.4	2.31	1.05	59.1	48.8
B21t	15-47	20.8	24.6	17.1	36.2	2.28	1.10	60.1	44.6
B22t	47-61	9.6	31.0	16.8	45.1	2.39	1.26	62.9	45.9
B23t	61-99	6.1	41.8	20.2	30.4	2.41	1.08	59.1	44.0

Table-4 Chemical Properties of Soil Profiles (Gupta and Verma, 1975)

Horizon	Depth	pH	$CaCO_3$	O.C	Total N	Fe_2O_3	Al_2O_3	CEC and Exch. Cations, me/100g			
	Cm		%	%	%	%	%	CEC	Ca	Mg	K
Location: Ramnagar, 2 Km towards north-east from Ramnagar to Udhampur Road, Elevation: 1000 m amsl.											
A1	0-8	6.0	-	1.03	0.110	5.1	6.1	11.40	7.55	1.05	0.90
B21t	8-21	6.0	-	1.36	0.130	5.3	5.9	10.18	6.18	1.28	0.27
B22t	21-36	5.8	-	0.96	0.090	8.4	8.7	10.35	6.50	1.50	0.29
B3	36-63	6.1	-	0.60	0.054	4.9	5.1	8.14	6.35	0.55	0.32
Location: Kandoria about 8 Km east of Reasi bus stand, Elevation: 810 m amsl.											
Ap	0-15	7.2	6.11	1.40	0.130	3.1	6.6	18.20	11.94	3.10	0.42
B21t	15-47	7.3	9.10	0.83	0.089	2.9	8.1	14.40	12.70	1.0	0.84
B22t	47-61	7.9	11.90	0.85	0.051	5.1	9.1	13.20	11.70	1.20	0.70
B23t	61-99	7.0	2.80	0.21	0.110	4.4	10.4	11.35	8.90	1.53	0.19

Table-4, shows that pH of the soil profile located at Ramnagar is acidic in nature, which could be attributed due to acidic nature of parent material and leaching of bases due to high rainfall (1850 mm) coupled with leaching of $Al_2O_3 + Fe_2O_3$. Whereas, higher pH in the soil profile at Kandoria may be due to calcareous nature of parent material with less leaching effect as the rainfall is comparatively low (760 mm). The principal saturating cation in these soils is calcium, followed by magnesium, which is in conformity with the earlier reports (Raychaudary et. al., 1963), according to which the soils of Jammu and Kashmir were rich in calcium and magnesium.

Infiltration rate of soils is an important hydrologic parameter, and is responsible for the moisture characteristics in the unsaturated soil zone, which control the cropping pattern in an area. Infiltration rate also controls the flushing of salts from the top soil after rainfall events. A high initial infiltration rate will facilitate quick flushing of salts, whereas high final infiltration rate will control ground water recharge in the saturated zone. Initial and final infiltration rates in the study area are reported in the Table-5 (Omkar and Patwary, 1992-93, Patwary et al., 1997, and Goyal et al., 1999-2000).

3.6 Land Use

The total area of the district, as per village records, is about 4,31,000 hectares. The cultivated land accounts for only 16.34% of this area. The forest occupy 43.28% of the area, cultivable waste land is 17.20%, and the area which is not available for cultivation is 23.18% (Table-6).

3.7 Agricultural Activities

Of the total cultivable land in the district, only 7.54% is being irrigated through State irrigation systems, which implies that about 92% of cultivable land is still depend on rainfall. The main food crops of the district are maize and rice in kharif and wheat in rabi season. The most important crop is maize. In the case of Gool Gulab Garh tehsil, for instance, rice is the staple food. Similarly in the case of Ramnagar tehsil, rice is the co-staple food. The farmers in the district are increasingly using the pesticides and plant protection materials. The use of chemical fertilizers by the cultivators is common. Percent distribution of fertilizers of nitrogenous, phosphatic and potassic compositions is approx. 72, 23 and 5, respectively. The crops grown during Rabi and Kharif season, with fertilizer off-take rates, in Udhampur district are given in Table-7.

Table-5. Infiltration Rate under Different Landuses

S No	Site	Landuse	Infiltration rate (cm/hr)	
			Initial	Final
1	Barola	Fallow	4.8	0.15
2	Maghal	Open Scrub	12.0	0.6
3	Mahar	Agriculture	24.0	2.4
4	Nowain	Open Scrub	18.0	1.6
5	Katra	Urban	2.4	0.4
6	Chamba	Agriculture	30.0	3.2
7	Kunkuny	Nursery	40.8	18.0
8	Chak Bhag	Agriculture	15.6	2.4
9	Kotla	Grass land	20.4	0.4
10	Taror	Agriculture	3.6	0.6
11	Nangal	Agriculture	4.2	1.5
12	Danoa	Fallow	8.4	4.8
13	Mansar	Bare Land	12	2.4
14	Ramnagar	Grass land	12	0.7
15	Surinsar	Grass land	18	0.3
16	Manthal	Forest	18	0.6
17	Kud	Forest	72	1.2

Table-6. Landuse Classification in Udhampur District
(Source: Digest of Statistics, 1997-98, Govt. of J&K)

Land Class	**Area (in 000 Ha)**
Reporting Area	431
Area under Forest	192
Non-agricultural uses	80
Barren & Uncultivable Land	29
Permanent Pastures & other Grazing Lands	11
Misc. Tree Crops	20
Culturable Waste Land	18
Fallow	1
Current Fallow	11
Net Area Sown	70

3.8 Mineral Exploration Activities

Minerals have been exploited in the Udhampur District and used for a variety of purposes since old times. This area has also a history of production of base metals such as Copper, Zinc, Lead and common metal like Iron. The area has shown good presence of Bauxite, Coal, Limestone and Magnesite ores. Bauxite is the main sources of aluminum, fairly extensive deposits of high to low diasporic bauxite occur in the vicinity of Salal, Panhasa, Sangarmarg, Sukhwalgali and Chakar. The Bauxite deposits are suitable for the manufacture of refractory bricks, abrasives and high alumina cement. The Coal has been found in Chinkah, Jangalgali, Chakar, Dhansal and Sewalkot areas of the Udhampur District. Iron is another important metal known to ancients. A low grade iron ore in the form of hematite are reported from Matah Kotla and Sanger section. Cement grade limestone bands occur in the West of Chenab River and in Jangalgali areas of the District. Occurrence of sulphide of copper are reported from Panhasa- Salal area and Dhansal- Sewalkot area within Sirban Limestone of Riasi. Galena is the main source of lead. Galena in association with sphalerite occurs around Sersandu, Darabi Gainta, Rahotkot and Sukhwal. Sphalerite is the main source of zinc. Sphalerite has been observed in the Sirban Limestone of Darabi area of the Udhampur District. Good deposits of magnesite, a main source of magnesium, have been reported by G.S.I. at Katra within the limestone inlier (GSI, 1977).

Table-7: Fertilizer Distribution for Crops in Udhampur District during 1999-2000

(Source: Jt. Director (Central), Dept. of Agri, Jammu).

Kharif Season					Rabi Season				
Major Kharif Crop	Area sown (000 ha)	Fertilizers off-take during Kharif 1999 (Metric Ton)			Major Rabi Crop	Area sown (000 ha)	Fertilizers off-take during Rabi 1999-2000 (Metric Ton)		
		N	P	K			N	P	K
Rice	9.80	944	129.5	5.04	Wheat	38.98	737.4	310	2.6
Bajra	0.3				Barley	1.08			
Maize	55.58				Condiments and spices	0.27			
Millets	0.04				Vegetable and Fruits	0.3			
Pulses	2.47				Oilseeds	4.60			
Sugarcane	0.04								
Fibers	0.05								
Drugs narcotics/Plantation	0.01								
Fodder Crops	0.56								
Total	68.85	944	129.5	5.04		45.23	737.4	310	2.6
Net Area Sown (000 ha) Total area sown – Area sown more than once = 114.08-43.96= 70.12									
Fertilizer application rate, Kg/Ha	-	13.7	1.9	0.07		-	16.3	6.9	0.06

The clay shale bands of Siwaliks, Murees and Nummulitics hold large reserves of industrial clays in Katra-Reasi area and in Tikri area of the district. Stains of malachite along with chalcopyrite and azurite, all copper minerals, are observed in the Main Boundary Fault at Dudura near Katra. Gossan pockets, containing Pb, Zn and Cu, have also been noticed in the district. Hematite chert bands in the Sirban Limestone form the iron ore deposits of Matah (33°09':74°44') and Kotla-Sangar (33°10':74°38') areas. The presence of galena, ore containing Pb and Zn, is reported in Sersandu (33°08': 74°53')-

Kherikot (33°06':74°54') area, in Reasi tehsil. The mineralisation occur in small pockets which appear to be confined to gash veins localised along faults. Also, specks and minor veinlets of sphalerite are observed in the upper quartzite and dolomite bands of the Great Limestone in the area between Kherikot and Pres, a few kilometers southeast of Sersandu.

Magnesite occurrences have been reported in the Great Limestone in Katra area, occurring parallel to the bedding of the dolomite exposed on the hill slopes near Adhkumari. Streaks and veins of magnesite are also seen in the dolomite around Adhkumari and fissure fillings of siderite-magnesite association have been observed on the Reasi-Salal road section. Talc is found as thin veins in the Great Limestones near Reasi in the district.

4.0 METHODOLOGY

Sampling is one of the most important and foremost step in collection of representative water samples for water quality studies. In the present study, 26 surface and ground water samples (from wells, springs and rivers) were collected (Figs. 7 to 10) during June, 1999 (Pre-monsoon) and October, 1999 (Post-monsoon) periods. Appropriate preservatives were added while collecting samples for analysis in the laboratory.

The physico-chemical analysis has been performed following standard methods (APHA, 1985; Jain and Bhatia, 1987-88). The various parameters of water quality have been determined which includes: pH, electrical conductivity, TDS, sodium, potassium, calcium, magnesium, chloride, sulphate, bicarbonate, nitrate, phosphate and fluoride. Among them temperature, hydrogen ion concentration (pH) and electrical conductivity (EC) were determined in field at the time sampling using portable instruments. The EC values observed in the field at various temperatures have been converted using factors for conductivity values at 25 ^{0} C (Saxena, 1990).

The total hardness and calcium hardness were also determined by Ethylene-diamine-tetra-acetic acid (EDTA) titrimetric method, and magnesium hardness was determined by deducting calcium hardness from total hardness. Calcium (as Ca^{2+}) was calculated by multiplying calcium hardness by 0.401, and Magnesium (as Mg^{2+}) by multiplying magnesium hardness by 0.243. Sodium and potassium were determined by flame emission method using a Flame Photometer. Chloride concentration was determined by argentometric method in the form of silver chloride. Acidity/alkalinity was determined by titrimetric method using phenolphthalein and methyl orange indicators. Phosphate, nitrate, sulphate and fluoride concentrations were determined using UV-VIS Spectrophotometer.

The trace elements analysis have been carried out for determination of Pb, Cr, Cd, Ni, Fe, Co, Zn, Mn, and Cu, using Atomic Absorption Spectrophotometer at the Wadia Institute of Himalayan Geology, Dehradun for 15 pre selected water samples belonging to the month of June, 1999.

5.0 RESULTS AND DISCUSSION

5.1 Water Quality Parameters

The analysis of water samples was carried out to determine concentration of sodium, potassium, calcium, magnesium, chloride, sulphate, alkalinity, phosphate, fluoride, pH, electrical conductivity, TDS and temperature. The trace elements analysis of water samples was carried out for Pb, Cr, Cd, Ni, Fe, Co, Zn, Mn and Cu. The water quality parameters have been grouped in accordance with the standards of drinking and irrigation purposes. The water quality data has also been plotted on the Piper, Stiff, U.S.S.L. and Schoeller's diagrams.

5.1.1 Variation of physico-Chemical Parameters: The average and range of concentrations of chemical constituents of the wells, springs and rivers for pre- and post-monsoon periods are given in Tables -8 to10.

Table 8. Physico-Chemical Characteristics of Well Water

Parameters	June, 1999			October, 1999		
	Min	Max	Mean (n=9)	Min	Max	Mean (n=9)
Temp., ^{0}C	19.5	25	22.4	21.4	25	22.9
pH	7.08	8.2	7.71	7.2	8	7.44
EC, μ mhos/cm at 25 ^{0}C	623	1293	947	624	993	819
TDS, mg/l	399	827	606	400	636	524
Alkalinity, mg/l	134	378	256	138	410	208.4
Total Hardness as CaCO3, mg/l	168	398	243	126	360	193.6
Calcium, mg/l	25	86.6	46.3	28.9	56	37
Magnesium, mg/l	13.6	49.6	31	9.2	53.5	24.6
Sodium, mg/l	6.9	76.6	22.8	4.33	40.4	13.4
Potassium, mg/l	1	7.9	3.7	0.57	6.98	2.99
Chloride, mg/l	4	110	25.6	2	60	26
Sulphate, mg/l	1.54	18.41	6	1.6	55.7	15.69
Phosphate, mg/l	0.05	0.62	0.16	0.02	0.3	0.1
Fluoride, mg/l	0	0.6	0.23	0	0.32	0.21

Table 9. Physico-Chemical Characteristics of Spring Water

Parameters	June, 1999			October, 1999		
	Min	Max	Mean (n=11)	Min	Max	Mean (n=11)
Temp., ^{0}C	12	23.5	20.3	16.2	22.7	20.9
pH	7.18	8.1	7.55	7.2	7.6	7.4
EC, m mhos/cm at 25 ^{0}C	567	976	773	551	826	691
TDS, mg/l	363	624	495	353	529	442
Alkalinity, mg/l	158	312	229	110	276	167
Total Hardness as CaCO3, mg/l	142	290	180	102	258	179
Calcium, mg/l	30.5	62.5	40	14.4	42.5	25
Magnesium, mg/l	1.5	41.3	19.3	5.8	45.2	28
Sodium, mg/l	1.46	70.6	15.9	1.6	45.6	14.7
Potassium, mg/l	0.4	6.8	2.6	0.67	5.2	2.2
Chloride, mg/l	2	10	6	0	14	5.27
Sulphate, mg/l	0.18	11	4.4	0.11	11.74	5.5
Phosphate, mg/l	0.04	0.12	0.07	0	0.09	0.05
Fluoride, mg/l	0	0.51	0.2	0	0.72	0.19

Table 10. Physico-Chemical Characteristics of River Water

Parameters	June, 1999			October, 1999		
	Min	Max	Mean (n=6)	Min	Max	Mean (n=6)
Temp., ^{0}C	15.5	30.	24.3	17.8	23.8	21.6
pH	7.1	7.8	7.52	7.2	7.5	7.34
EC, m mhos/cm at 25 ^{0}C	372	725	558	375	574	481
TDS, mg/l	238	464	357	240	367	308
Alkalinity, mg/l	120	216	159	70	216	144
Total Hardness as CaCO3, mg/l	60	224	149	90	212	146
Calcium, mg/l	16.8	39.3	27.70	23.3	31.3	27.8
Magnesium, mg/l	3.9	35.5	19.4	4.8	35.5	18.6
Sodium, mg/l	2.26	9.16	4.92	2.13	9.5	5.4
Potassium, mg/l	1.38	6.48	3.7	0.95	2.57	1.8
Chloride, mg/l	4	14	6.4	2	6	4
Sulphate, mg/l	3.56	101.5	40	2.44	35.1	14.7
Phosphate, mg/l	0.05	1.09	0.5	0	0.1	0.05
Fluoride, mg/l	0	1.25	0.5	0	0.61	0.28

The results are summarized below:

The pH is an important measure of water quality because it represents the chemical nature of water (such as its corrosive tendencies) and the biological life, which usually it supports. Low pH values are indicative of acid waters and high pH values are indicative of alkaline waters (HEC, 1972). In the present study, pH values vary from 7.08 to 8.2 (average 7.71) for wells, 7.18 to 8.1 (average 7.55) for springs, 7.1 to 7.8 (average 7.51) for rivers during June, 1999. During October, 1999, the pH vary from 7.2 to 8.0 (average 7.44) for wells, 7.2 to 7.6 (average 7.39) for springs, 7.2 to 7.5 (average 7.34) for rivers. The average values of pH indicate alkaline nature of surface and ground water. During October, 1999, average values of pH at all sites were observed relatively lesser than pH values of June, 99, which indicate the dilution phenomena of waters due to monsoon rains.

The conductivity value is used for expressing the total concentration of soluble salts in water. In the present study, EC values vary from 623.1 to 1292.7 μ mhos/cm at 25° C (average 946.5) for wells, 567.3 to 976.5 (average 773.6) for springs, 372 to 725 (average 558) for rivers during June, 1999, whereas, 624 to 933 (average 819) for wells, 551 to 826 (average 691) for springs, 375 to 574 (average 481) for rivers during, October, 1999, respectively. The average EC values have been observed in the order of wells> springs>rivers, under both sampling program, which could be due to interaction of waters with the surrounding geology.

Dissolved solids occur mainly because of the presence of inorganic salts and a small amount of organic material. It is a measure of all the non filterable solids in solution. Agricultural, domestic and industrial water users desire water with low concentrations of total dissolved solids (HEC, 1972). In the present study, TDS values vary from 399 to 827 (average 605.8) for wells, 367 to 624 (average 495) for springs, 238 to 464 (average 357) for rivers during June, 1999, and 400 to 336 (average 524) for wells, 353 to 529 (average 442) for springs, 240 to 367 (average 308) for rivers during, October, 1999, respectively. The lower values of TDS during Oct, 99 for wells, springs and rivers as compared to June, 99, indicate the dilution of waters due to monsoon rains. The average TDS values have been observed in the order of wells> springs>rivers, under both sampling program, which indicate relative interaction of waters with the surrounding geology.

Alkalinity in natural water is caused by bicarbonates, carbonates and hydroxides, which can be ranked in order of their association with high pH values. Bicarbonates represent the major form since they are formed in considerable amounts from the action of carbonates upon the basic materials in the soil. Bicarbonate content more than 60 mg/l in the water is necessarily attributed from the biological activities of plant roots, from the oxidation of organic matter included in the soils and in the rock, and from various chemical reactions (Mandel and Shiftan, 1981). Bicarbonate values vary from 134 to 378 mg/l (average 256) for wells, 158 to 312 (average 229) for springs, 120 to 216 (average 159) for rivers during June, 1999, and 138 to 410 mg/l (average 208) for wells, 110 to 276 (average 168) for springs, 70 to 216 (average 145) for rivers during, October, 1999, respectively. The mixing of water with rain is evident during post-monsoon period as compared to pre-monsoon data.

The presence of sodium in the waters is mainly from the minerals such as feldspars and epidote, which are found in the Siwalik sediments in the area. As a contaminant, sodium is important for both domestic and agricultural use of water. Sodium in drinking water is harmful to persons suffering from cardiac, renal or circulatory diseases. Sodium is extremely important in irrigation water, since high concentrations are toxic to plants (HEC, 1972). In the present study, concentration of sodium varies from 6.86 to 76.6 mg/l (average 22.8) for wells, 1.46 to 70.6 (average 15.9) for springs, 2.26 to 9.16 (average 4.92) for rivers, during June, 1999; and 4.33 to 40.41 mg/l (average 23.42) for wells, 1.63 to 45.64 (average 14.77) for springs, 2.13 to 9.53 (average 5.48) for rivers, during October, 1999. It is evident that average concentration of sodium values have not shown the effect of dilution by monsoon rains, and which have rather increased the concentration.

The minerals such as pyroxene, epidote and tourmaline containing calcium are found in Siwalik sediments and might be contributing it to the waters. The presence of magnesium in the waters is attributed to the minerals dolomites and chlorites in the surrounding Siwalik sediments. The main interest in calcium and magnesium is due to their adverse effect on household uses such as laundering and bathing (since they combine with soap and leave precipitates) and on cooking and water heating (since they cause incrustation). For irrigation waters, calcium and magnesium are also important parameters. In some situations they help offset the effects of sodium (HEC, 1972).

The concentration of calcium has been observed to vary from 24.86 to 86.6 mg/l (average 46.3) for wells, 30.46 to 62.5 (average 40) for springs, 16.8 to 39 (average 27.7) for rivers during June, 1999. Similarly, calcium concentration was found varying from 28.9 to 56 mg/l (average 36.98) for wells, 14.4 to 42.5 (average 25) for springs, 23.3 to 31.3 (average 27.8) for rivers during October, 1999. The concentration of magnesium observed varying from 13.6 to 49.6 mg/l (average 31) for wells, 1.5 to 41 (average 19.3) for springs, 3.89 to 35.5 (average 19.4) for rivers, during June, 1999. Similarly, during October, 1999, magnesium concentration varies from 19.2 to 53.5 mg/l (average 24.6) for wells, 5.8 to 45.2 (average 28.3) for springs, 4.8 to 35.5 (average 18.6) for rivers under the present study.

Calcium and magnesium are often indexed by an empirical parameter called hardness. The hardness of water was originally defined in terms of its ability to precipitate soap. It is the property attributable to the presence of alkaline earth (Brown et. al., 1970). Calcium and magnesium, along with their carbonates, sulphates and chlorides, make the water hard, both temporarily and permanent. In this study, total hardness as $CaCO3$ varies from 168 to 398 mg/l (average 243) for wells, 142 to 290 (average 180) for springs, 60 to 224 (average 149) for rivers, during June, 1999, and 126 to 360 mg/l (average 194) for wells, 102 to 258 (average 179) for springs, 90 to 212 (average 146) for rivers, during October, 1999.

Chlorine is an important water quality parameter in both its elemental and chloride form. Elemental chlorine is very toxic to microorganisms, thus it is used in water purification. A chlorine residual may be toxic to fish and other aquatic life. Chlorides are usually found in, practically, all natural waters. The main minerals containing chloride are sodalite and apatite and both these minerals are very rare in the Siwaliks. The most important source of chlorides in water is the discharge of domestic sewage. Chlorides in drinking water are generally not harmful to human beings until its concentrations is high, although they may be injurious to people suffering from diseases of heart or kidneys. Chlorides are also harmful in irrigation water and are generally more toxic than sulphates to plants (HEC, 1972). In this study, the concentration of chloride varies from 4 to 110 mg/l (average 25.6) for wells, 2 to 10 (average 6) for springs, 4 to 14 (average 6.4) for rivers during June, 1999, and 2 to 60 mg/l (average 26) for wells, 0 to 14 (average 5.3) for springs, 2 to 6 (average 4) for rivers during, October, 1999. It is evident that average concentrations of chloride values have shown the effect of dilution by monsoon rains. The higher values of chlorides for wells and springs in comparison to rivers indicate the greater effect of lithology than the effect domestic sewage under the present study.

Sulphates occur naturally in water as a result of leaching from gypsum and other common minerals. They may also occur as the final oxidized stages of sulphides, sulphites, and thiosulphates which are usually discharged into the system from natural or man-made sources. Sulphate ions may cause the precipitation of calcium ions and lead to sodium poisoning of plants (HEC, 1972). The concentration of sulphate varies from 1.54 to 18.41 mg/l (average 6) for wells, 0.2 to 11 (average 4.4) for springs, 3.6 to 102 (average 40) for rivers during June, 1999, and 1.6 to 56 mg/l (average 15.7) for wells, 0.11 to 11.7 (average 5.6) for springs, 2.4 to 35 (average 14.7) for rivers during, October, 1999. It is evident that the rivers have shown the effect of dilution in the data due to monsoon rains. The higher values of sulphates have been observed in rivers during both periods, which indicate the impact of anthrogenic factors particularly domestic sewage.

Fluorine is considered as an essential element for health. According to the Bureau of Indian Standards (BIS, 1983), a certain amount (0.6 to 1.2 mg/l) of fluorine in drinking is essential. The Indian Council of Medical Research (ICMR) has recommended the highest desirable level as 1.0 mg/l and maximum permissible limit as 1.5 mg/l. This means that the body may tolerate fluoride upto a limit of 1.5 mg/l depending upon the nutritional standards and body physiology. In the present study, the concentration of fluoride varies from 0 to 0.6 mg/l (average 0.23) for wells, 0 to 0.51 (average 0.2) for springs, 0 to 1.25 (average 0.5) for rivers during June, 1999, and 0 to 0.32 mg/l (average 0.21) for wells, 0 to 0.72 (average 0.19) for springs, 0 to 0.61 (average 0.28) for rivers during October, 1999. On perusal of average concentration of fluoride data, mixing of waters with rain water is evident during post-monsoon period as compared to pre-monsoon data.

Phosphorus is an essential nutrient for plant and animal growth, and like nitrogen, it passes through cycles of decomposition and photosynthesis. In nature, phosphorus is found in several minerals in the form of phosphates and is a constituent of fertile soils, plants, and the protoplasm, nervous tissue and bones of animal life. Phosphorus concentrations in excess of about 0.2 mg/l generally indicate that domestic wastes, industrial wastes, or fertilizers from agricultural use have entered the system (HEC, 1972). Phosphate in the study area varies from 0.05 to 0.62 mg/l (average 0.16) for wells, 0.04 to 0.12 (average 0.07) for springs, 0.05 to 1.09 (average 0.5) for rivers during June, 1999, and 0.02 to 0.32 mg/l (average 0.10) for wells, 0 to 0.09 (average 0.05) for springs, 0 to 0.1 (average 0.05) for rivers during, October, 1999. Average phosphate concentration data shows mixing of waters with rain water during post-monsoon period as compared to the pre-monsoon data.

Potassium is usually found as ions in natural waters or in large salt deposits formed by the evaporation of brine. The common source for potassium in the waters is mainly due to contribution from the minerals namely potassium feldspars and potassium mica. It is an essential element required for the plant growth. Concentration of potassium under the present study ranges from 1 to 7.85 mg/l (average 3.74) for wells, 0.4 to 6.8 (average 2.55) for springs, 1.38 to 6.48 (average 3.7) for rivers during June, 1999, and 0.57 to 6.98 mg/l (average 2.99) for wells, 0.67 to 5.2 (average 2.2) for springs, 0.95 to 2.57 (average 1.79) for rivers during, October, 1999.

5.1.2 Variation of Trace Elements: In the present study, trace elements analysis of 15 water samples was carried out for determination of Pb, Cr, Cd, Ni, Fe, Co, Zn, Mn and Cu. The results have been summarized in Table-11. The concentration of Fe, Zn, Mn, Cu and Cr was observed in appreciable quantities under the present investigation. The concentration of Ni, Co, Cd and Pb was also observed relatively in smaller quantities.

5.2 Classification of Surface and Ground Water: In the present study, the surface and ground water has been classified on the basis of widely used graphical methods e.g., Piper, Stiff, U.S. Salinity Laboratory Classification and Schoeller Diagrams. The results of Piper, Stiff and U.S. Salinity Laboratory Classification have been summarized in Table-12. A brief discussion of these classifications for the surface and ground water quality of Udhampur District is given below:

5.2.1 Piper's Classification: The Piper's diagram (1953) is used to identify similarity and dissimilarity in the chemistry of different water samples based on dominant cat-ions and anions. The Piper's diagrams (Figs.11-12) indicate all sites under the Ca^{2+}, Mg^{2+}, HCO_3- hydro-chemical facie during both sampling periods in the part of Udhampur District, two only sites (S-6 and R-3) under Na^+, K^+, HCO_3- and Ca^{2+}, Mg^{2+}, Cl^-, SO_4, respectively.

Table-11. Variation of Trace Elements during June, 1999

Trace Elements	Wells (n= 5)		Springs (n= 5)		Rivers (n= 5)	
PPM	Min.	Max.	Min.	Max.	Min.	Max.
Fe	0.12	2.11	0.21	1.01	0.06	3.14
Zn	0.05	1.61	0.34	2.87	0.02	0.66
Mn	0.01	0.75	0.02	0.06	0.02	0.30
Cu	0.01	0.01	0.01	0.03	0.01	0.01
Ni	<DL	0.02	<DL	0.04	<DL	0.03
Cr	<DL	0.06	<DL	0.06	<DL	0.08
Co	<DL	<DL	<DL	0.0	<DL	<DL
Cd	<DL	<DL	<DL	0.01	<DL	<DL
Pb	<DL	0.01	<DL	0.06	<DL	<DL
Note: <DL = below detection limit or not detected						

Table-12. Summary of Water Classification

A.	**Hydro-chemical Facies using Piper Classification**		
1.	Calcium-Magnesium-Bicarbonate	All sites except S-6 and R-3	All sites
2.	Sodium-Potassium – Bicarbonate	S-6	-
3.	Calcium-Magnesium-Chloride-Sulphate	R-3	-
4.	Sodium-Potassium-Chloride-Sulphate	-	-
B.	**Stiff Classification of Water**		
1.	Magnesium Bicarbonate	R-2, R-5, S-1, S-2, S-4, W-2, W-3, W-6, W-7 (36%)	R-2, R-5, R-6, S-1 to S-9, W-1 to W-4 (61%)
2.	Calcium Bicarbonate	R-1, R-4, S-3, S-5, S-7 to S-11, W-1, W-4, W-5, W-9 (52%)	R-1, R-3, R-4, S-10, S-11, W-6 to W-9 (36%)
3.	Sodium Bicarbonate	S-6, W-8	W-5
4.	Magnesium Sulphate	R-3	-
C.	**U.S. Salinity Laboratory Classification for Irrigation Purposes**		
1.	Medium Salinity Low SAR (C2-S1)	R-1 to R-5, S-2 to S-4, S-8 to S-10, W-9 (48%)	R-1 to R-6, S-2 to S-4, S-7 to S-11, W-2, W-6, W-9 (65%)
2.	High Salinity Low SAR (C3-S1)	S-1, S-5 to S-7, S-11, W-1 to W-8 (52%)	S-1, S-5, S-6, W-1, W-3 to W-5, W-7, W-8 (35%)

5.2.2 Stiff Classification: Stiff (1951) pattern diagram represents chemical analyses in distinctive graphical shapes by plotting ions on parallel axis in meq/l. The scale is divided horizontally for cations on left side and anions on right side by indicating zero concentration in the middle. The analysis for Stiff classification was carried out using the Ground Water Software for Windows. The results are given in Table-12, which indicate that calcium and magnesium bicarbonates dominate in the parts of Udhampur District. Calcium bicarbonate and magnesium bicarbonate together represent about 88% sites during June, 1999 and 97% during October, 1999. The sodium bicarbonate and magnesium sulphate was also present at few locations. Stiff diagrams at 3 locations (R-4, S-9 and W-7) representing rivers, springs and wells are shown in Figs 13-15.

5.2.3 U.S. Salinity Laboratory Classification: The U.S. Salinity Laboratory Classification (U.S.D.A, 1954) is used to interpret the suitability of water for irrigation purposes based on U.S. Salinity diagrams. The U.S. Salinity diagram is a combination of salinity and alkalinity (sodium) hazards plotted on X and Y-axis, respectively. The salinity hazards are expressed in terms of electrical conductivity of water in micro-mhos/cm at 25 ^{o}C and alkali hazards are expressed in terms of sodium adsorption ratio (SAR). The U. S. Salinity diagrams in the present study for pre and post-monsoon data are given in Figs. 16-17.

5.2.4 Schoeller Diagram: The Schoeller Diagram, named after Professor Schoeller, is a group diagram displaying (a) the total concentrations of major cations and anions in both ppm and epm, and (b) the relative water composition for many samples (UN, 1994). In the present study, a Schoeller Diagram has been drawn for Rivers, Springs and Wells, using the GWW software. The relative chemical composition of various samples of Rivers, Springs and Wells for pre and post-monsoon periods in the Udhampur District is shown in Figs. 18 to 23.

Fig 11. Piper Diagram (June, 1999).

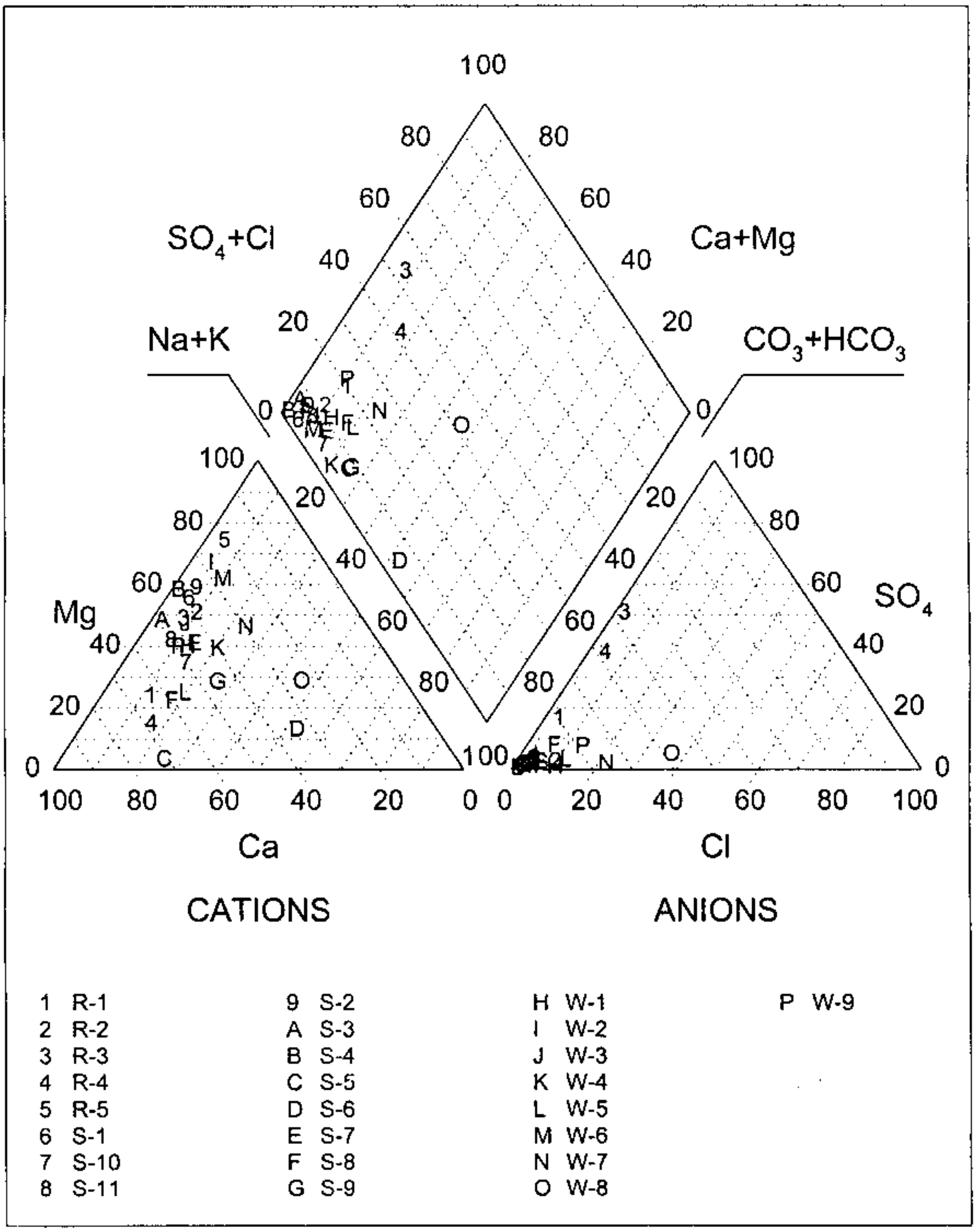


Fig 12 Piper Diagram (October, 1999).

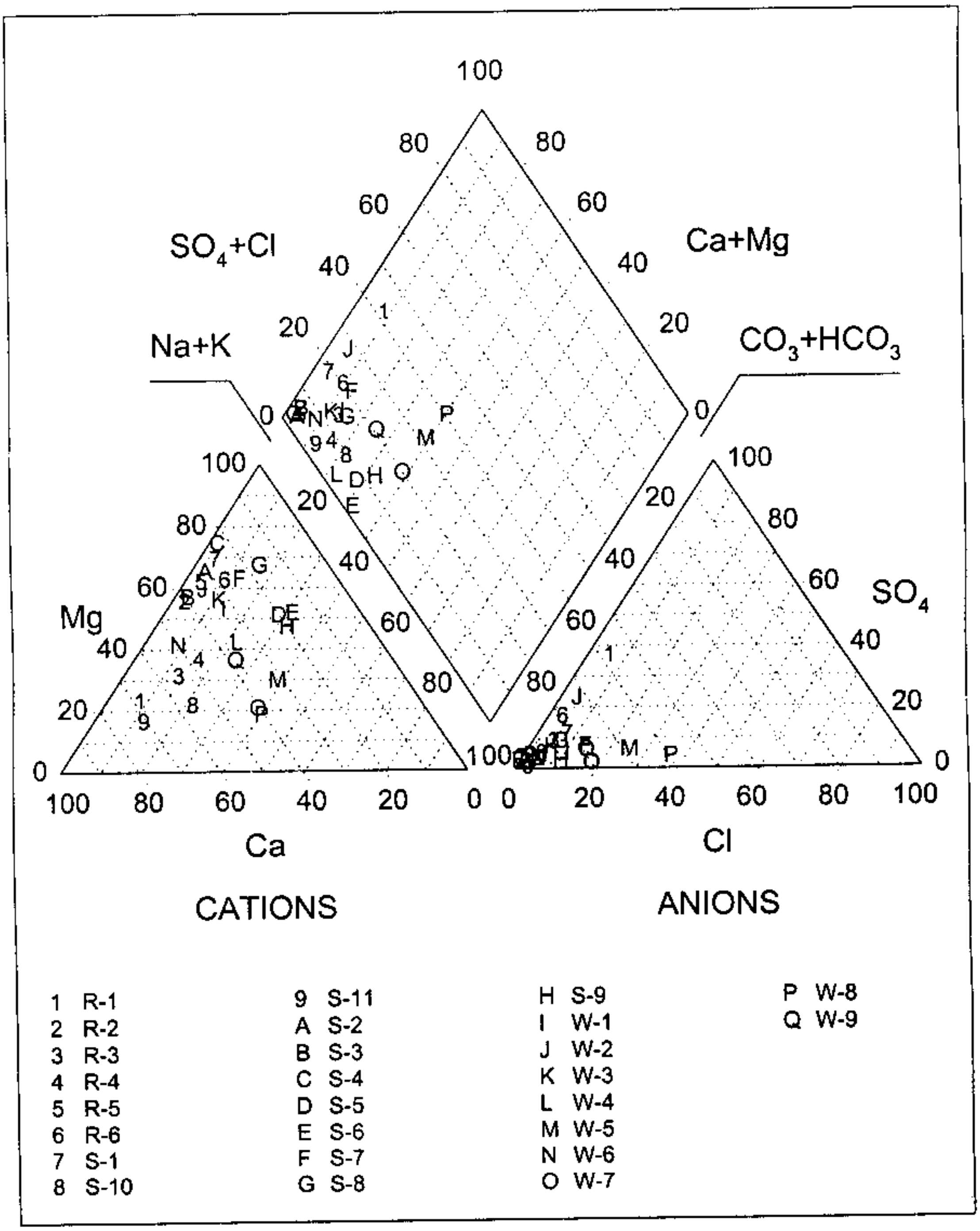
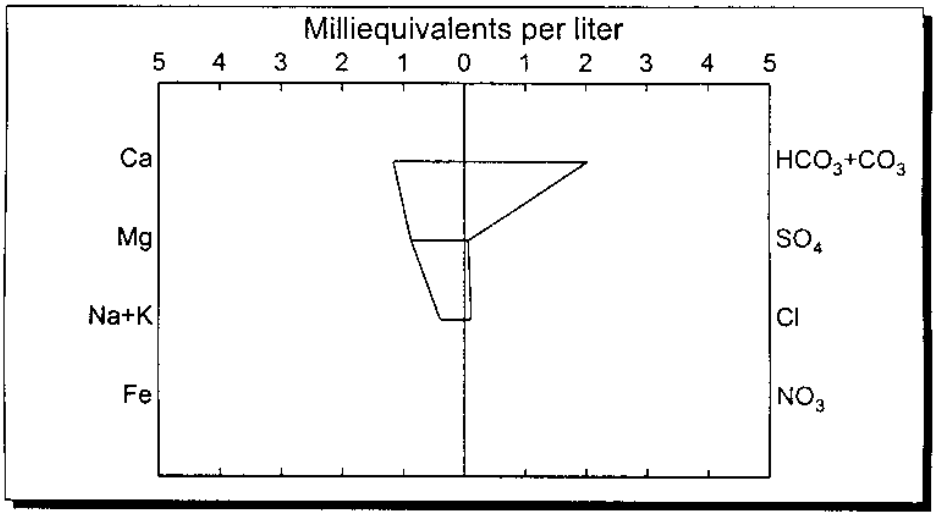


Fig 13 Stiff Diagram of Water Sample from River Tawi (R-4) (October, 1999).



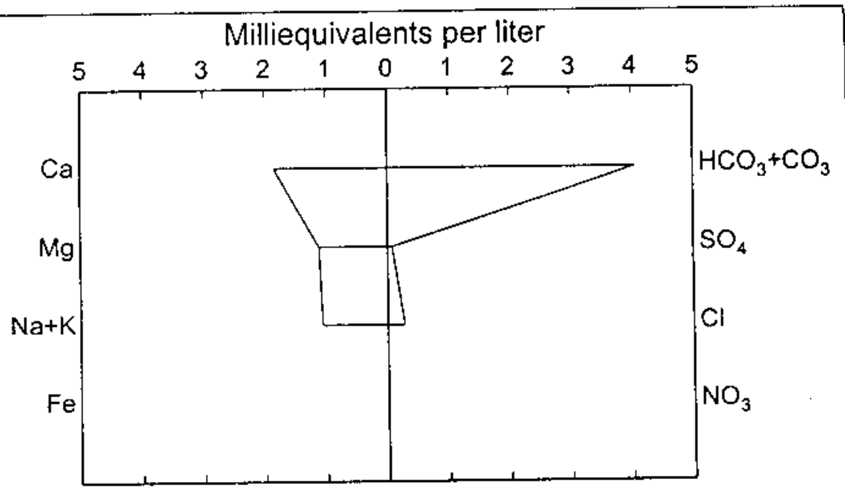
Cations					
	Ca	***Mg***	***Na***	***K***	***Fe***
Milliequivalents per liter	1.1627	0.8802	0.3558	0.04500	
Milligrams per liter	23.30	10.70	8.18	1.76	

Anions					
	HCO3	***CO3***	***SO4***	***Cl***	***NO3***
Milliequivalents per liter	2.03236		0.06496	0.11284	
Milligrams per liter	124.00		3.12	4.00	

Mn	NO2	PO4 0.00063	F 0.0221	B	SIO2
TDS 273.00	Hardness 102.0	Alkalinity 124.0	Conductivity 426.40	pH 7.77	SAR 0.3521

Water Type	***Calcium Bicarbonate***	Cations (epm) 2.4	Anions (epm) 2.2
		Error Balance 4.51	

Fig 14. Stiff Diagram of Water Sample from Chenani (S-9) (June, 1999).



Cations					
	Ca	*Mg*	*Na*	*K*	*Fe*
Milliequivalents per liter	1.8363	1.1187	0.9701	0.08796	
Milligrams per liter	36.80	13.60	22.30	3.44	

Anions					
	HCO3	*CO3*	*SO4*	*Cl*	*NO3*
Milliequivalents per liter	4.06472		0.07828	0.28210	
Milligrams per liter	248.00		3.76	10.00	

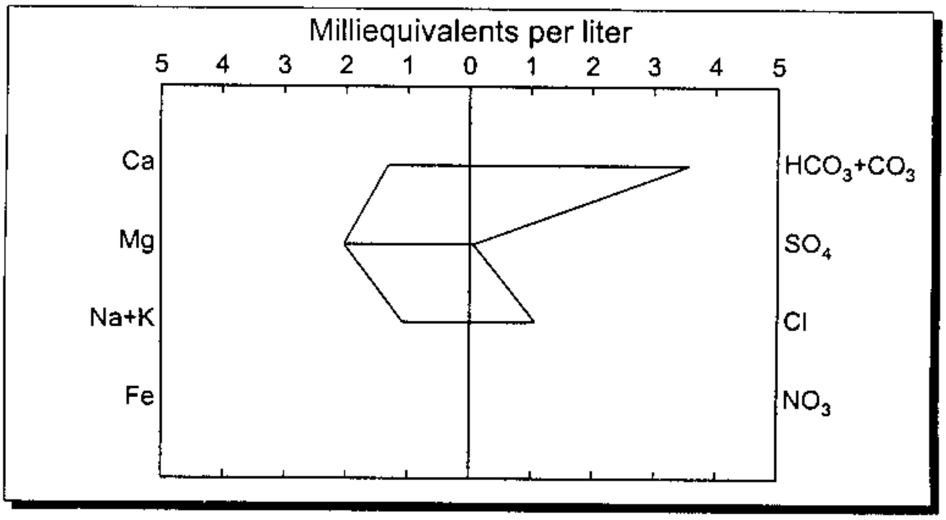
Mn	NO2	PO4 0.00379	F 0.0111	B	SIO2
TDS 511.80	Hardness 148.0	Alkalinity 248.0	Conductivity 799.80	pH 7.60	SAR 0.7980

Water Type	**Calcium Bicarbonate**	Cations (epm) 4.0	Anions (epm) 4.4

Error Balance 5.05

STIFF Diagram

Fig 15. Stiff Diagram of Water Sample from Manwal (W-7) (June, 1999).



Cations					
	Ca	*Mg*	*Na*	*K*	*Fe*
Milliequivalents per liter	1.3174	2.0318	1.0196	0.05549	
Milligrams per liter	26.40	24.70	23.44	2.17	

Anions					
	HCO3	*CO3*	*SO4*	*Cl*	*NO3*
Milliequivalents per liter	3.57302		0.06392	1.07198	
Milligrams per liter	218.00		3.07	38.00	

Mn	NO2	PO4	F	B	SIO2
		0.00221	0.0311		
TDS	Hardness	Alkalinity	Conductivity	pH	SAR
607.10	168.0	218.0	948.60	8.15	0.7879

Water Type	Magnesium Bicarbonate

Cations (epm)	Anions (epm)	Error Balance
4.4	4.7	3.47

Fig 16. U.S. Salinity Diagram (June, 1999).

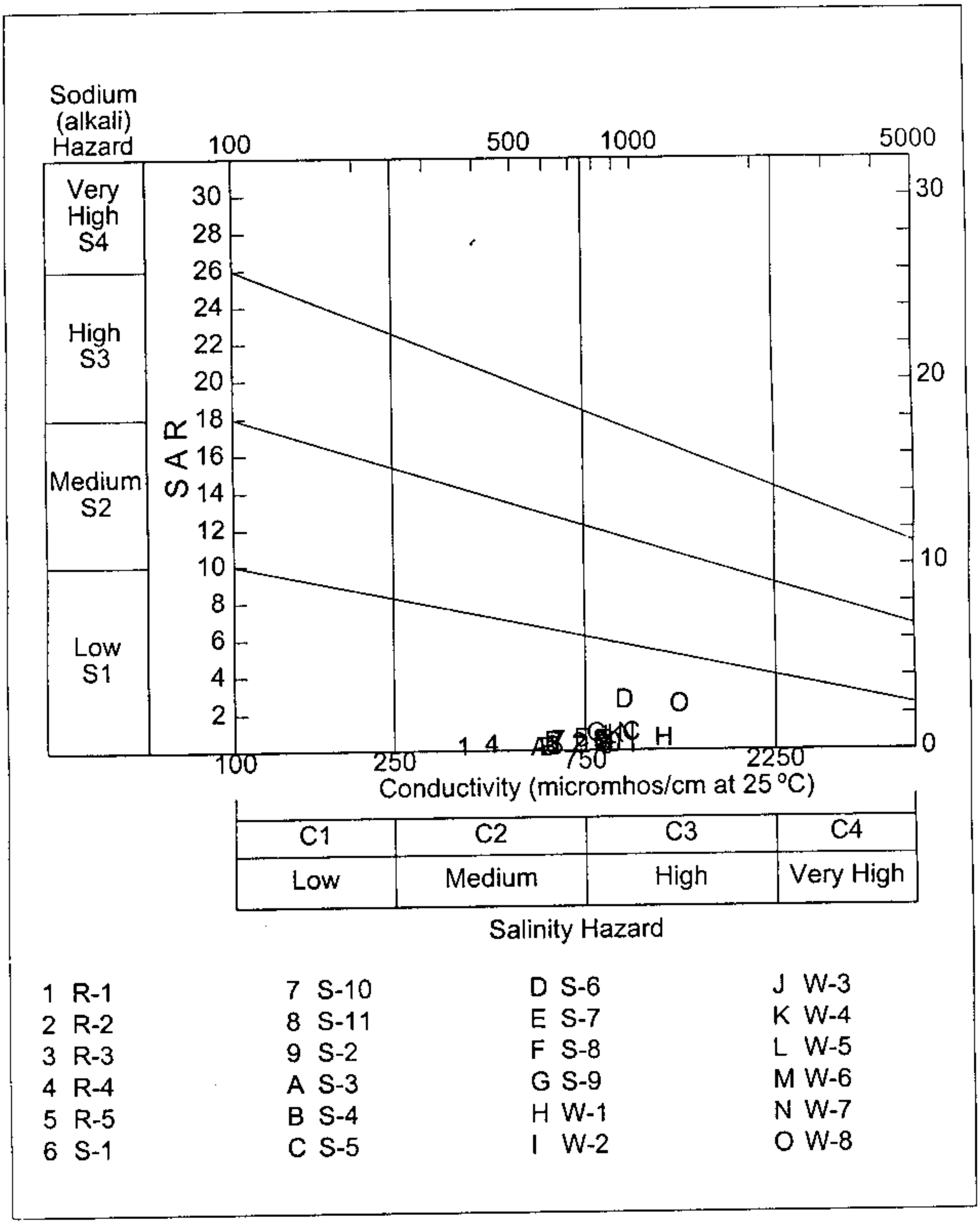


Fig 17. U.S. Salinity Diagram (October, 1999).

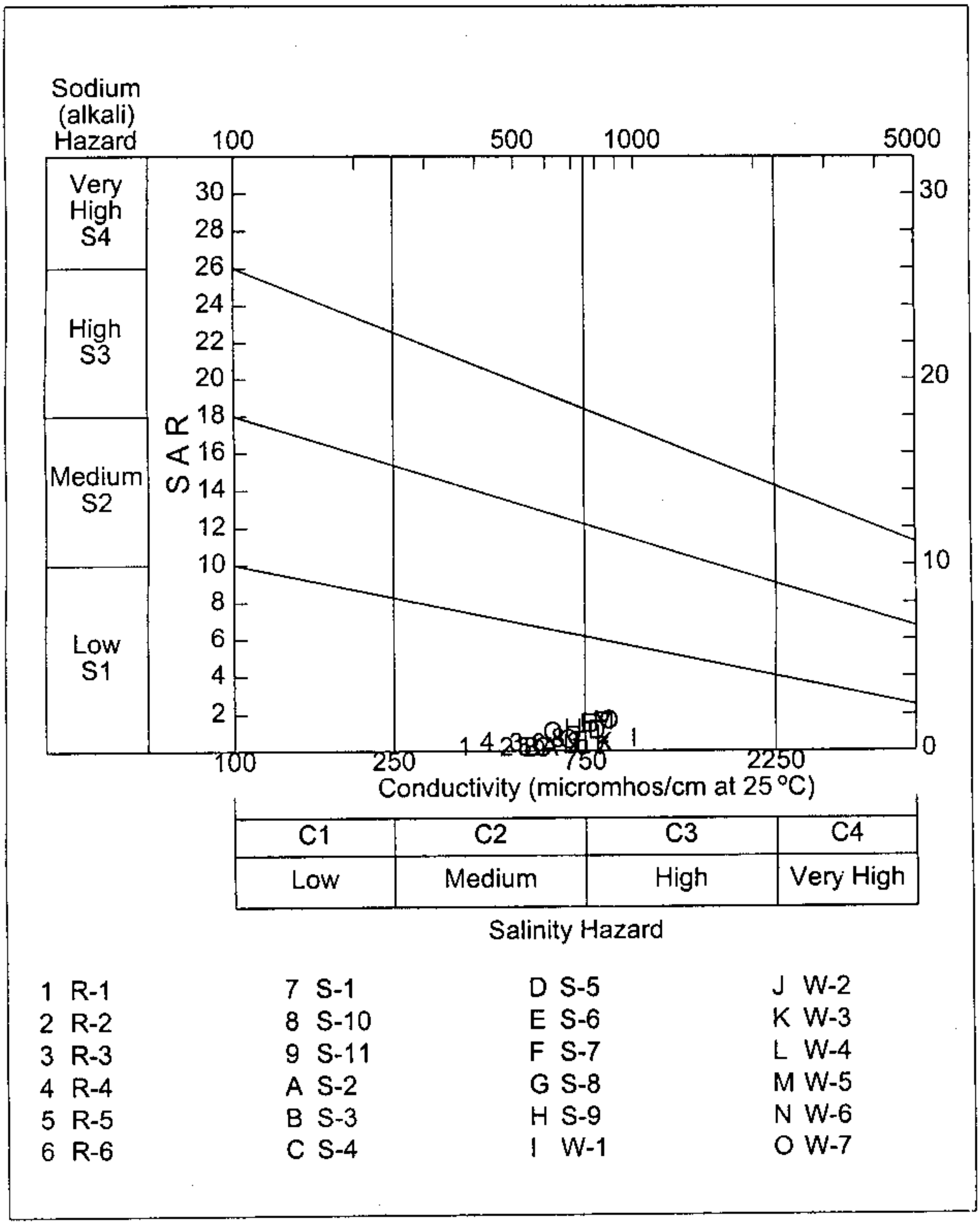


Fig 18 Schoeller Diagram for Wells (June, 1999).

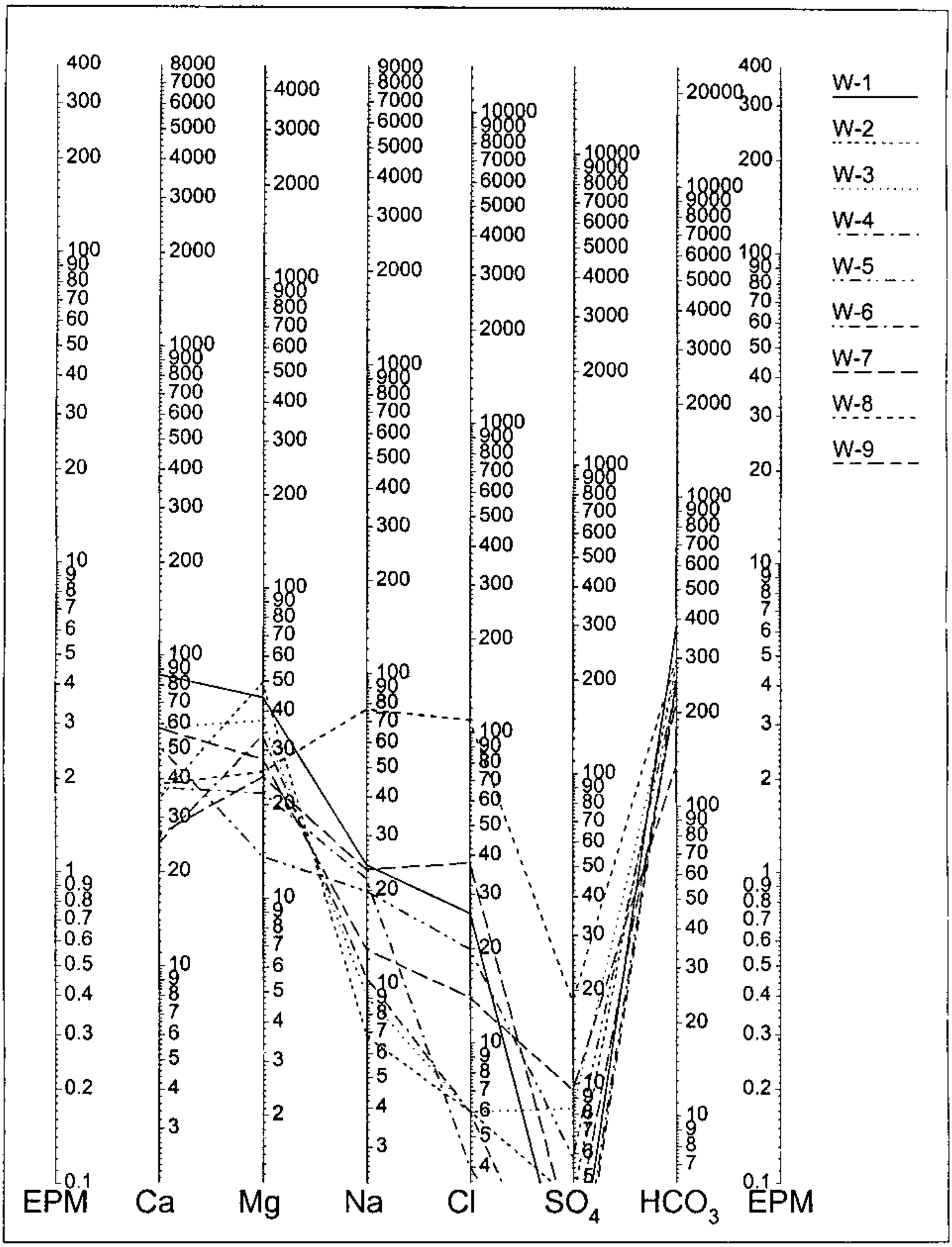


Fig 19 Schoeller Diagram for Springs (June, 1999).

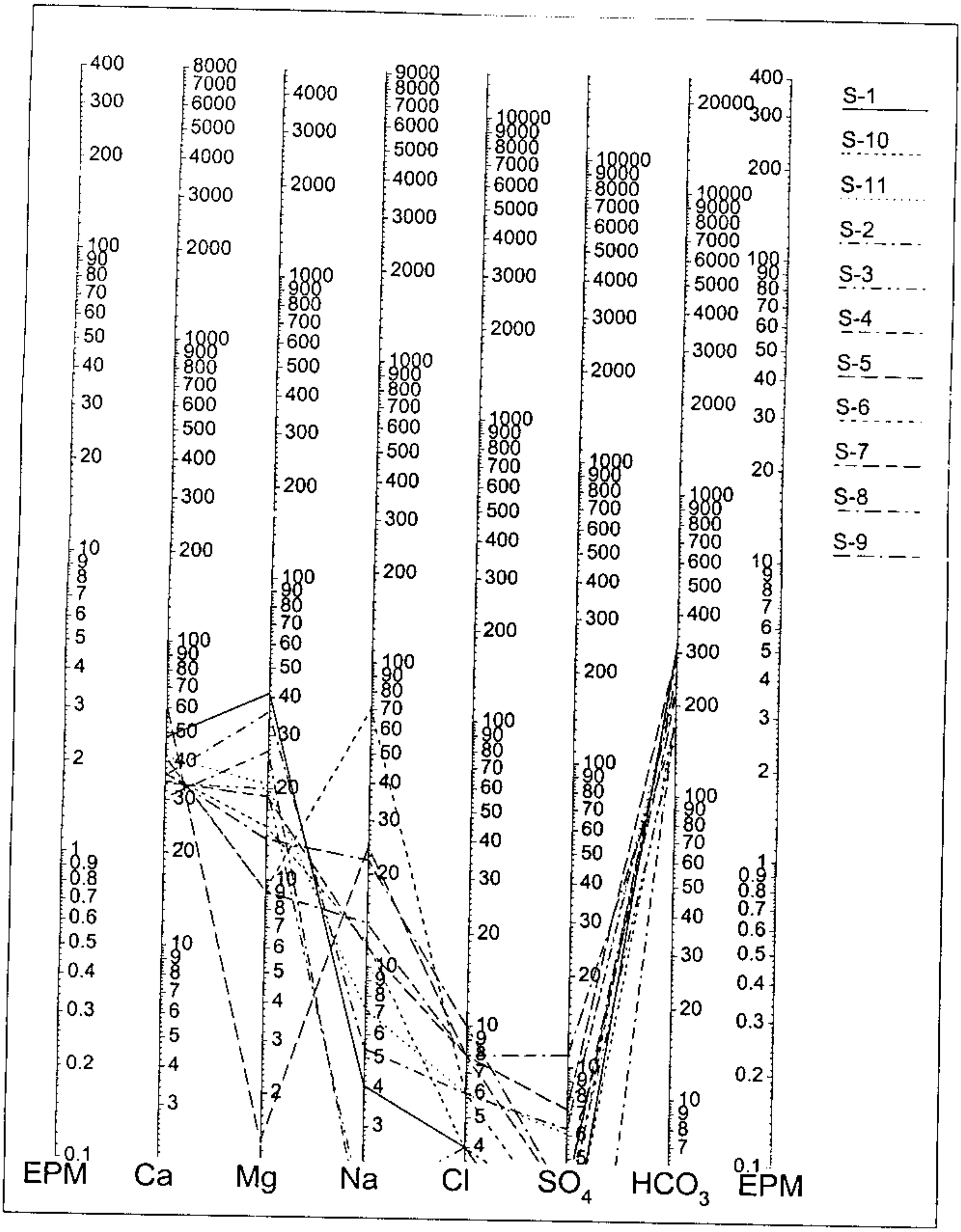


Fig 20. Schoeller Diagram for Rivers (June, 1999).

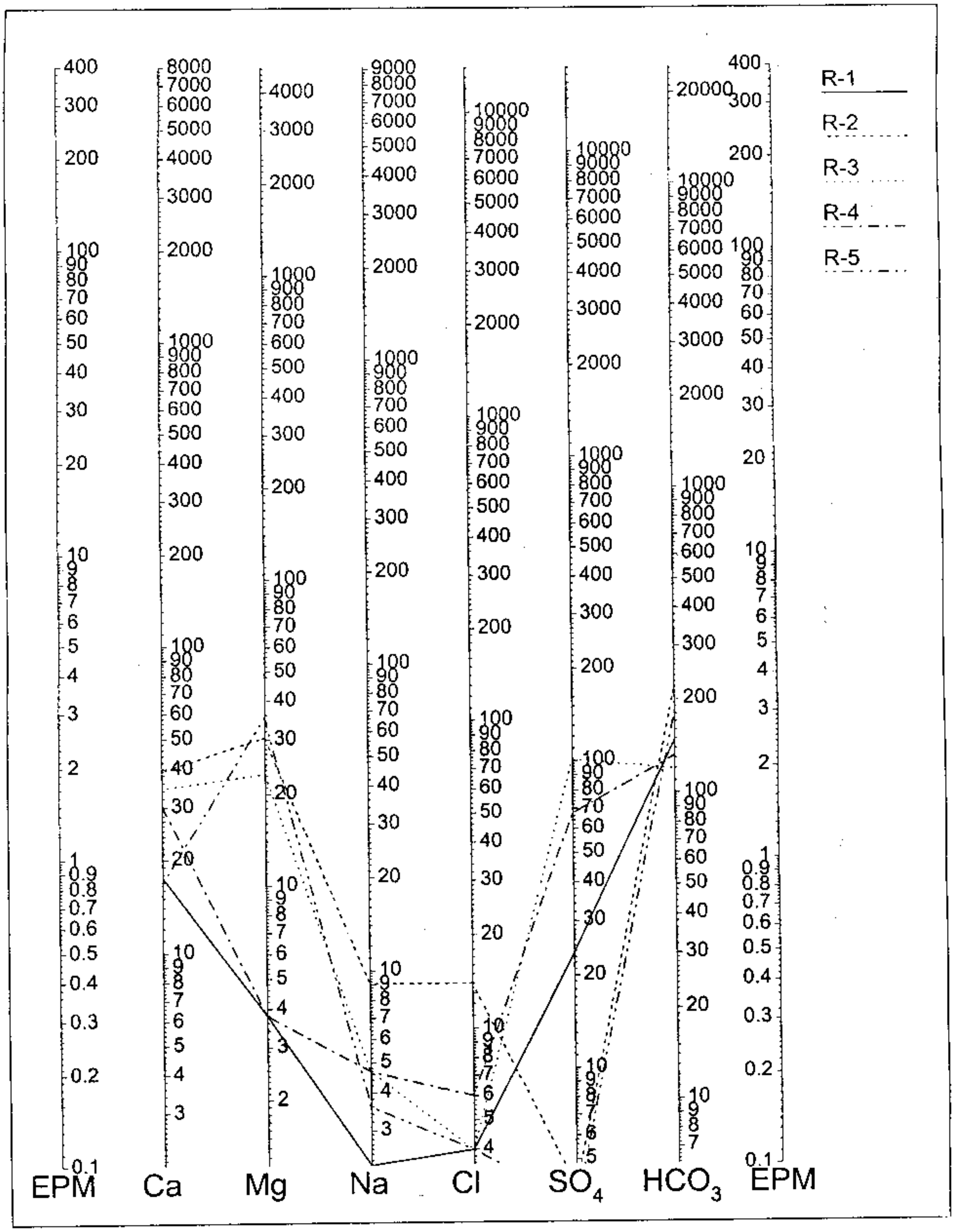


Fig 21. Schoeller Diagram for Wells (October, 1999).

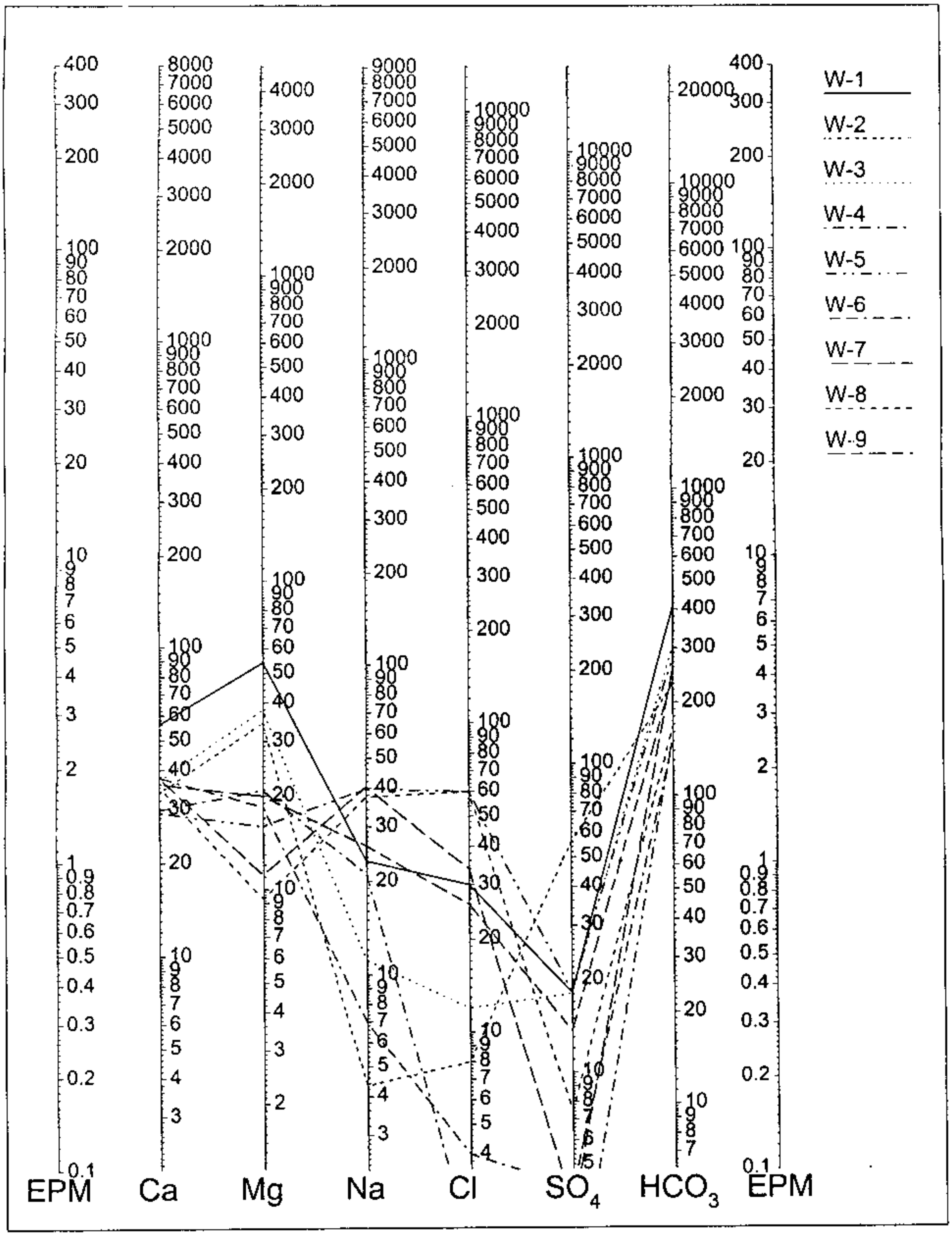


Fig 22. Schoeller Diagram for Springs (October, 1999).

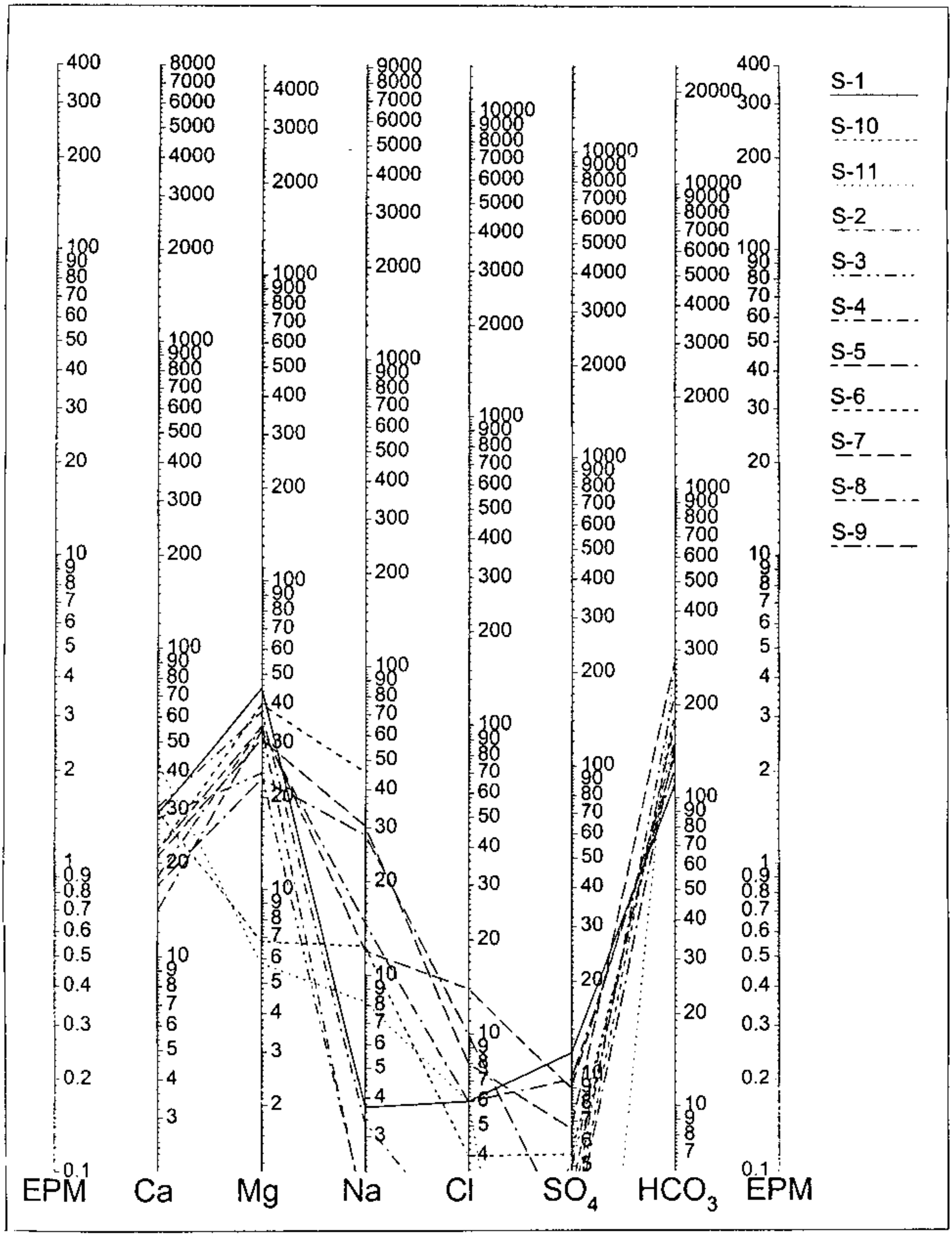
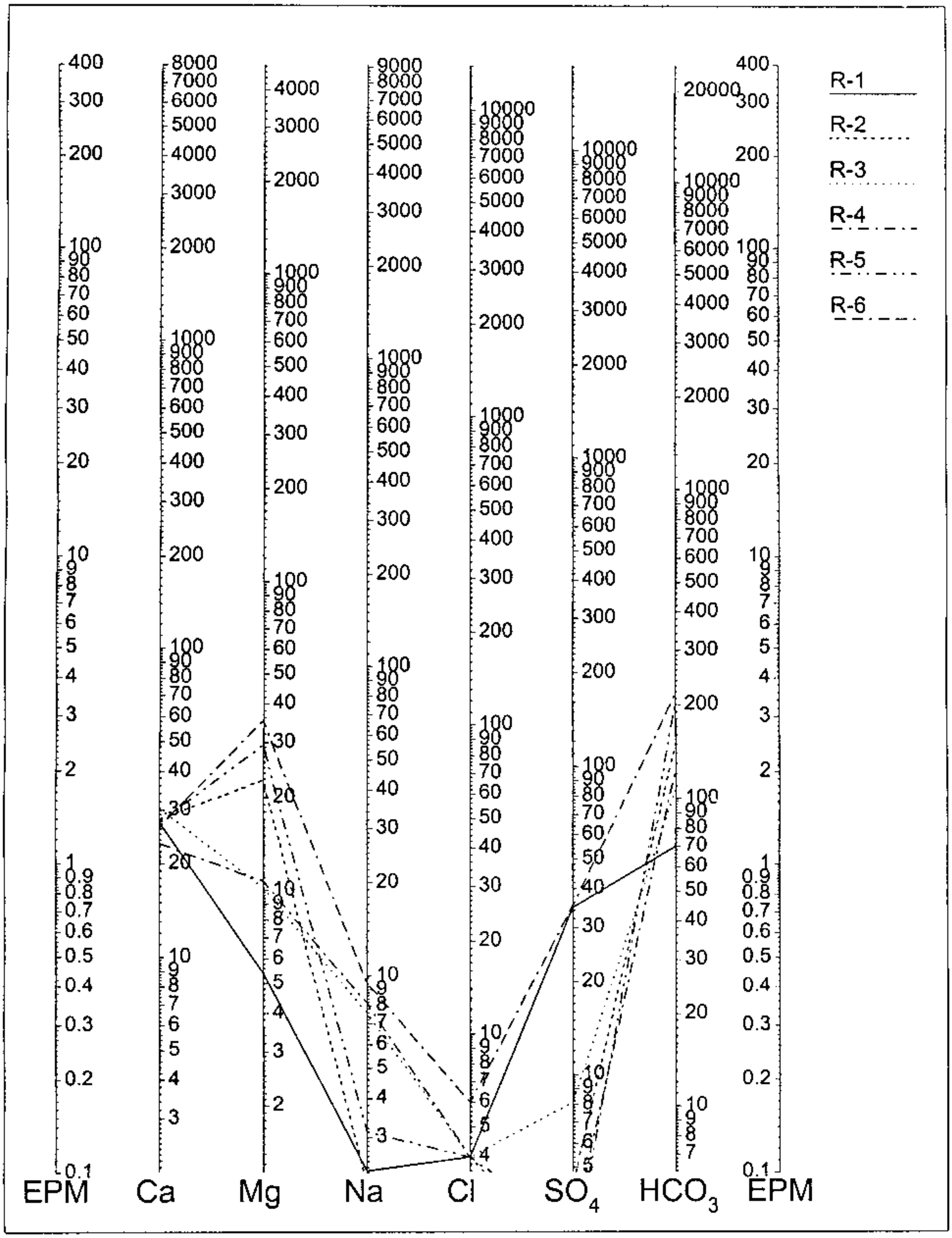


Fig 23. Schoeller Diagram for Rivers (October, 1999).



5.3 Water Quality Evaluation for Drinking Purposes

The various physico-chemical parameters of water quality have been compared with the Standards norms (BIS, 1983; WHO 1984) for drinking water quality (Table-13).

Table-13. Summary of Drinking Water Quality

Water Quality Parameters	Limits for Drinking Purposes (BIS, 1983)	Sites Exceeding the Limits	
		June, 1999	October, 1999
PH	6.5 – 8.5	-	-
Sodium	50 mg/l	W-8, S-6 (8%)	-
Calcium	75 mg/l	W-1 (4%)	-
Magnesium	30 mg/l	W-1, W-2, W-3, W-6, S-1, S-2, R-2, R-5 (32%)	W-1, W-2, W-3, S-1, S-2, S-4 to S-8, R-6 (44%)
Total Hardness	300 mg/l	W-1, W-3 (8%)	W-1 (4%)
Chloride	250 mg/l	-	-
Sulphate	150 mg/l	-	-
Fluoride	0.6-1.2 mg/l (desirable)	-	S-1, S-9, R-1 (12%)
	< 0.6 (not desirable)	W-1 to W-9, S-1 to S-11, R-1, R-3, R-4 (92%)	W-1 to W-9, S-2 to S-8, S-10, S-11, R-2 to R-6 (88%)
	>1.2 <1.5 (not desirable, >1.5 is harmful)	R-2, R-5 (8%)	-

Trace Elements (Sites: W-1, W-2, W-4, W-6, W-9, S-2, S-6, S-8,S-10, S-11, R-1, R-2, R-4, R-5, R-6)

Trace Elements	Tolerance Limits for Drinking Purposes (BIS, 1983)	June, 1999
Fe	0.3 mg/l	W-1, W-4, W-6, W-9, S-2, S-10, S-11, R-1, R-2, R-5 (67%)
Cu	1.5	-
Mn	0.5	W-4 (7%)
Cd	0.01	-
Pb	0.1	-
Zn	15	-
Cr	0.05	W-2, W-4, S-6, R-1, R-2 (33%)

Table-13 show that, pH range of 6.5 to 8.5 is normally acceptable and the pH of all sites has been observed within the prescribed limit during both sampling programs. The concentration of sodium more than 50 mg/l makes the water unsuitable for domestic uses. Sodium concentration has been obtained within the prescribed limit at all sites except at sites W-8 and S-6 during pre-monsoon. The upper limits for calcium and magnesium for drinking water are 75 and 30 mg/l respectively (BIS, 1983). The results indicate that the concentration of calcium was also within permissible limit at all sites during both sampling periods except at site W-1 during pre-monsoon. However, the magnesium was dominant in the area that exceeds at about 32% sites during pre-monsoon and 44% during post-monsoon periods. Magnesium (Mg) deposits possibly occur in the recharge areas of springs/wells, whereas, in case of rivers the main occurrence of these elements may be due to passing through these formations. According to GSI (1977), the presence of Mg is due to magnesite, which have been reported in the great limestones in Katra area of Jammu Province.

Further, taking total hardness limit of 300 mg/l (BIS, 1983) into account for drinking purposes, it exceeds at 8% sites during pre-monsoon and 4% during post-monsoon periods only. However, majority of sites (60%) belonged to very hard (Total hardness > 180 mg/l) during pre-monsoon period as per classification of Durfor and Becker (1964). During post-monsoon period, very hard and hard category of water samples were equal (42%) as a result of shifting the water samples from very hard category to hard due to dilution effect of monsoon rains (Table- 14).

Table-14. Categorisation of Water on the Basis of Hardness (Durfor and Becker, 1964)

Hardness	Category of water	Site Code in June, 1999	Site Code in October, 1999
0-60 mg/l	Soft	R-1	-
61-120 mg/l	Moderately Hard	R-4	R-1, R-3, R-4, S-10 (16%)
121-180 mg/l	Hard	S-3, S-5 to S-10, W-7 (32%)	R-2, S-3, S-8, S-9, S-11, W-4 to W-9 (42%)
> 180 mg/l	Very Hard	R-2, R-3, R-5, S-1, S-2, S-4, S-11, W-1 to W-6, W-8, W-9 (60%)	R-5, R-6, S-1, S-2, S-4 to S-7, W-1 to W-3 (42%)

Chloride and sulphate concentrations have been observed within their prescribed limits at all sites in the study area, during both sampling periods. The desirable range of fluoride for drinking water is 0.6 to 1.2 mg/l (BIS, 1983). The results of the present study have shown fluoride concentration within desirable range (0.6–1.2 mg/l) at about 12 % sites only during post-monsoon period. However, the fluoride concentration at majority of sites (92% sites during pre-monsoon and 88% during post-monsoon) has been observed below desirable limit (0.6-1.2 mg/l). Whereas, the fluoride concentration observed above desirable limit (>1.2 mg/l) at about 8% sites only and it could be tolerated by human body, since it was still within the maximum allowable limit (1.5 mg/l) for drinking purposes.

Trace elements analysis of 15 water samples (n=15, W-1, W-2, W-4, W-6, W-9, S-2, S-6, S-8, S-10, S-11, R-1, R-2, R-4, R-5, R-6) collected during pre-monsoon has been carried out for determination of Fe, Zn, Mn, Cu, Ni, Pb, Cr, Cd and Co. The results were compared with the standard norms (BIS, 1983) for drinking purposes, which showed higher concentration of Fe, and Cr at about 67% and 33% sites, respectively. Fe deposits possibly occur in the recharge areas of springs/wells, whereas, in case of rivers the main occurrence of these elements may be due to flow of water through these formations. According to GSI (1977), the main source of iron ores is due to deposits of Hematite chert bands in Matah and Kotla Sangar area of Udhampur District. The presence of Manganese (Mn) in the Sivaliks has been found in association with iron (illenite and magnetite) and it is available in the surrounding rocks in abundance. Since most of the manganese is co-precipitated with other metal oxides resulting in its low concentration in the water samples.

Chromium (Cr) is mostly found in basic rocks. According to Gupta & Verma (1975) soils reaction of the study area have been observed as acidic (Ramnagar) and basic (Kandoria, near Riasi). Chromium (Cr) present in potable waters above a 3 μ g/l level indicates the presence of industrial waste (Jain & Bhatia, 1987-88). According to GSI (1977), Chromite in the brown hills of Dras in Ladakh District in the J & K has been observed, further investigation in other parts of the State is yet to be undertaken. Durani (1993) reported the concentration of Cr varying in the order of 0.04 to 0.06 ppm in the Mansar lake (Udhampur district), even though the lake is situated in acidic environment. In the present study, the maximum concentration of Cr was observed 0.06 mg/l in wells/springs and 0.08 mg/l in Chenab River (R-1), indicating possible origin of traces from rocks, because the industrialization is very limited in the Udhampur district.

Cadmium is also found in basic rocks. It is highly toxic when taken by mouth or inhaled and has been implicated in some cases of food poisoning. A concentration of 200μ g/l has been found lethal to certain fish. The Cd in the waters of Mansar and

Surinsar lakes have been reported very low (less than 0.01 ppm, Durani, 1993). In the present study, Cd was observed below detection limit at all sites except at Tickery (S-11), where its concentration was 0.01 mg/l. The maps showing exceeding limits of water quality parameters in the study area have been shown in Figs. 24-25.

5.4 Water Quality Evaluation for Irrigation Purposes

The irrigation water quality refers to its suitability for agricultural uses. The suitability of irrigation water depends upon many factors including the quality of water, soil type, salt tolerance characteristics of the plants, climate and drainage characteristics of the soil etc. However, the main soluble constituents of water, which determine suitability of irrigation water are calcium, magnesium, sodium, chloride, sulphate and bicarbonate. In some cases, Boron content may also effect the suitability of water for irrigation for certain crops. The values of EC, SAR, SSP, Doneen's Permeability Index and Residual Sodium Bicarbonate are given in Tables-15 and 16. In the present study, the interpretation of the water quality data for irrigation has been carried out based on guidelines given by Ayers (1977), Christiansen et al., (1977), Doneen (1964) and USDA (1954). The results have been described as follows:

5.4.1 Salinity: The Total concentration of soluble salts (salinity) in irrigation water can be expressed for assessment of water for irrigation in terms of electrical conductivity and affects availability of water to crops. In the present study, 44% water samples lie under medium salinity (i.e. EC range, 250-750 micro mho/cm) and 56% under high salinity zone (i.e. EC range, 750-2250 micro mho/cm) during pre-monsoon period. Whereas, 64% lie under medium salinity (i.e. EC range, 250-750 micro mho/cm) and 36% under high salinity zone (i.e. EC range, 750-2250 micro mho/cm) during post-monsoon period.

It is evident the dilution effect of water due to monsoon rains, which have caused 10% shifting of sites from high salinity to medium salinity zone during post-monsoon period (Table-17). According to the classification suggested by Ayers (1977), the water samples lying under "No Problem" and "Increasing Problem" zones of the salinity are also given in the Table-17. The sites showing high salinity (Increasing Problem) in the study area are given in Figs. 26-27.

Fig. 24 : Map showing locations where parameters exceeded permissible limits for drinking water (June 1999)

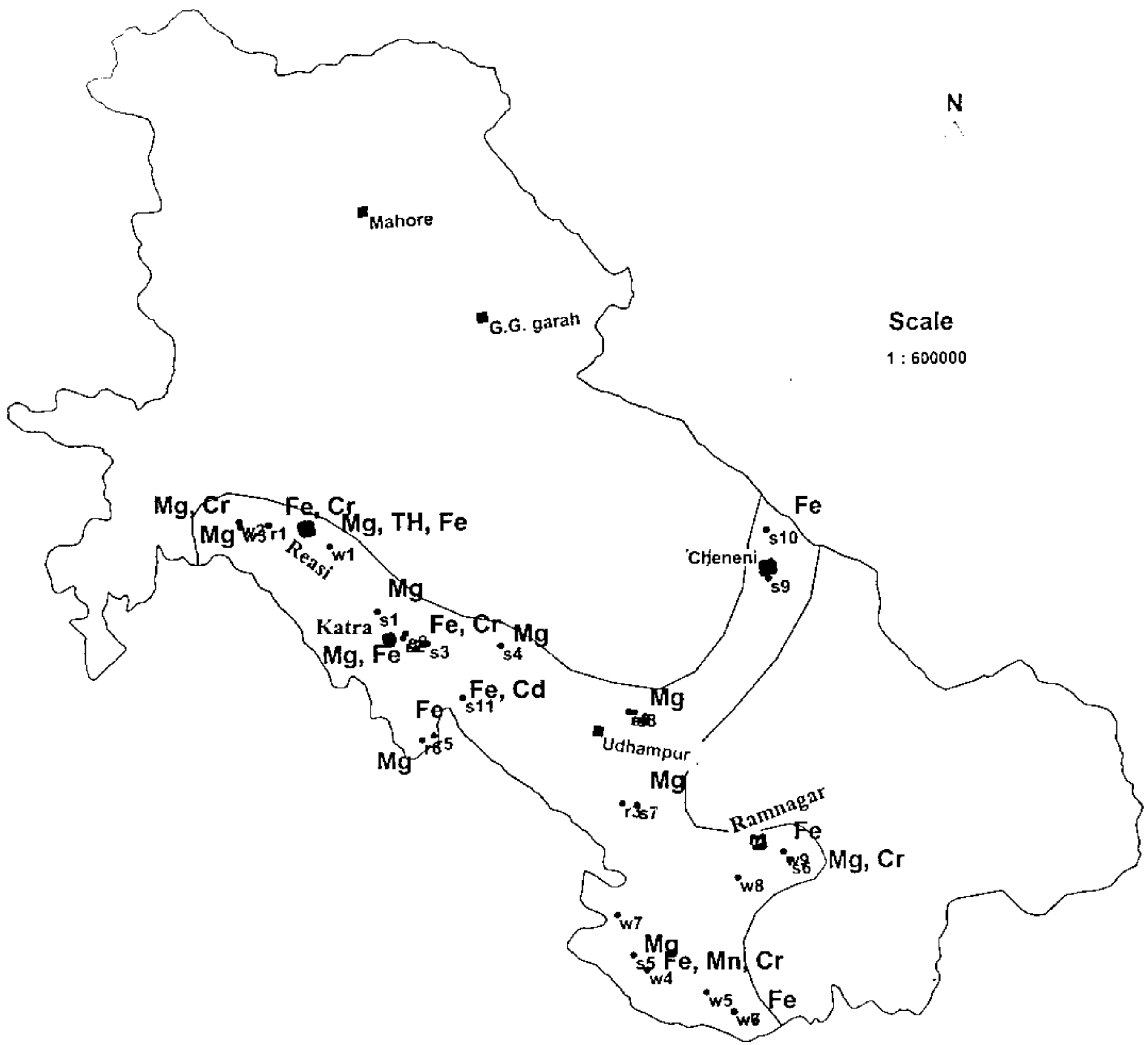


Fig. 25 : Map showing locations where parameters exceeded permissible limits for drinking water (October, 1999)

Fig. 26 : Map showing high salinity (750 to 2250 micromho/cm) sites for irrigation purposes (June 1999)

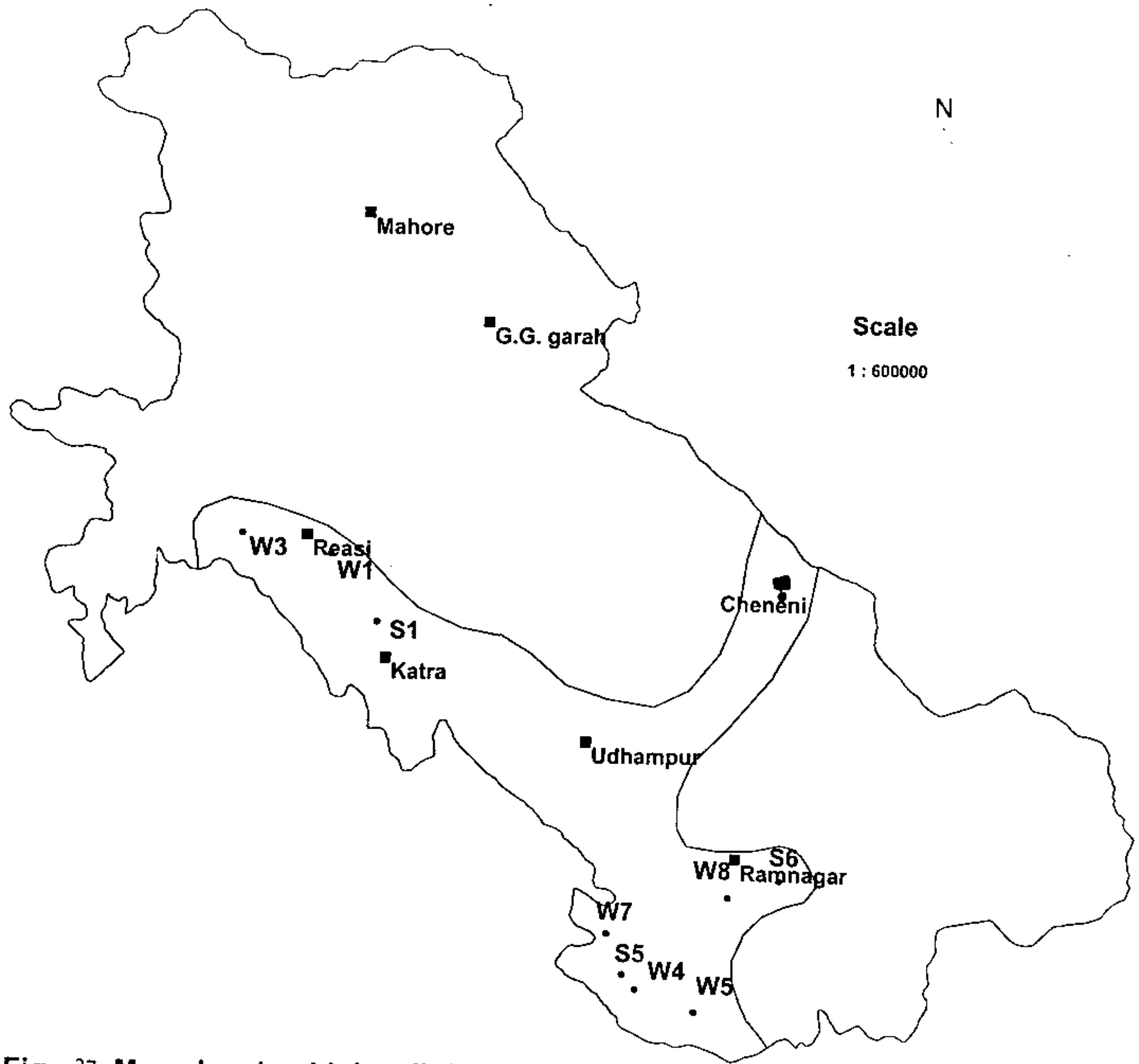


Fig. 27 Map showing high salinity (750 to 2250 micromho/cm) sites for irrigation purposes (October, 1999)

Table-15. Irrigation Water Quality Parameters during June, 1999

Sites	Codes	EC µ mh/cm	SAR	SSP	PI (Doneen)		RSC me/l
					PI Value	Class	
Chenab	R-1	372	0.13	12.17	127.5	III	1.23
Banganga	R-2	725.4	0.27	10.06	46.7	I	-0.94
Tawi (d/s at Udh.)	R-3	623.1	0.15	7.91	41.8	I	-1.67
Tawi (u/s at Udh.)	R-4	437.1	0.22	16.84	81.9	II	0.32
Jhajjar River	R-5	632.4	0.12	4.92	47.9	I	-0.81
Agharjitto	S-1	846.3	0.1	5.70	40.8	I	-0.69
Katra	S-2	734.7	0.15	5.89	43.1	I	-1.09
Chamba	S-3	567.3	0.06	2.89	49.0	I	-0.77
Chiryai	S-4	604.5	0.05	1.94	47.6	I	-0.70
Kakrai	S-5	976.5	0.84	25.7	76.08	I	1.64
Nauzi (Ramnagar)	S-6	939.3	2.58	53.22	88.3	II	1.78
Khu Nalla	S-7	827.7	0.40	14.58	62.9	I	0.23
Udhampur	S-8	734.7	0.51	18.22	65.7	II	-0.09
Chenani	S-9	799.8	0.80	26.32	76.0	II	1.10
Kud	S-10	641.7	0.42	15.67	62.2	II	-0.13
Tikeri	S-11	837	0.23	8.27	56.7	I	0.26
Reasi	W-1	1181.1	0.53	13.26	39.3	I	-1.76
Talwara	W-2	985.8	0.18	5.36	40.4	I	-1.11
Talwara	W-3	892.8	0.23	9.01	38.6	I	-1.71
Chani	W-4	892.8	0.70	20.92	64.4	I	0.45
Paldai	W-5	864.9	0.64	20.11	62.7	I	0.25
Chinal	W-6	837	0.32	10.92	54.8	I	-0.07
Manwal	W-7	948.6	0.79	24.24	66.5	I	0.21
Dehari	W-8	1292.7	2.34	46.64	75.0	I	0.81
Ramnagar	W-9	623.1	0.85	11.14	35.3	I	-3.04

5.4.2 Toxicity: Presence of few specific constituents beyond a limit in irrigation water may adversely affect the satisfactory growth of some field crops. These include boron, chloride and sodium. Boron is an essential nutrient for plant growth and it only becomes toxic beyond 2 ppm in irrigation water for most of the field crops. In the present study, the toxicity due to chloride and sodium concentration has been discussed.

5.4.2.1Toxicity due to Chloride: According to the Ayers (1977), the concentration of chlorides has also been classified as "No Problem" (chloride< 4me/l), "Increasing Problems" (chloride 4-10 me/l) and "Severe Problem" (≳10 me/l) zones. In the present study, all samples could be represented under "No Problem zone" (chloride<4me/l) during both sampling programs.

Table-16. Irrigation Water Quality Parameters during October, 1999

Sites	Codes	EC, µ mh/cm	SAR	SSP %	PI (Doneen)		RSC Me/l
					PI	Class	
Chenab	R-1	375.4	0.10	8.49	61.7	II	-0.65
Banganga	R-2	477.4	0.07	3.44	49.2	II	-0.82
Tawi (d/s at Udh.)	R-3	509.9	0.30	13.98	61.3	II	-0.62
Tawi (u/s at Udh.)	R-4	426.4	0.35	16.42	74.4	II	-0.01
Jhajjar River	R-5	527.9	0.10	4.33	49.7	I	-0.45
Juni River	R-6	573.8	0.28	9.87	49.3	I	-0.70
Agharjitto	S-1	826.2	0.10	4.40	28.3	I	-3.35
Katra	S-2	612	0.10	3.79	42.5	I	-1.07
Chamba	S-3	550.8	0.06	3.56	49.0	I	-0.80
Chiryai	S-4	586.5	0.05	2.50	46.2	I	-0.90
Kakrai	S-5	800.7	0.98	28.56	69.6	I	0.90
Nauzi (Ramnagar)	S-6	765	1.34	31.96	58.7	I	-1.34
Khu Nalla	S-7	729.3	0.38	13.41	46.0	I	-1.64
Udhampur	S-8	683.4	0.49	16.22	50.9	I	-1.40
Chenani	S-9	698.7	1.07	33.11	71.1	II	-0.30
Kud	S-10	642.6	0.53	22.26	79.6	II	0.25
Tikeri	S-11	703.8	0.31	12.95	71.1	II	0.45
Reasi	W-1	993	0.53	14.22	43.9	I	-0.48
Talwara	W-2	740.5	0.13	5.73	45.1	I	-0.78
Talwara	W-3	835.9	0.31	11.60	49.8	I	-0.01
Chani	W-4	830.3	0.73	22.84	60.9	I	-0.68
Paldai	W-5	964.9	1.49	39.42	77.0	I	0.16
Chinal	W-6	695.6	0.23	8.94	50.3	I	-0.97
Manwal	W-7	863.9	1.48	38.75	73.4	I	-0.27
Dehari	W-8	824.8	1.45	40.68	79.0	I	0.20
Ramnagar	W-9	624.2	0.85	25.15	56.7	I	-1.26

Table-17. Irrigation Water Quality on the basis of Salinity Hazards

USDA Classification		Ayers Classification		Site Code	
Salinity Zone	EC(µmhos/cm at 25^0C)		Effects	June, 1999	October, 1999
Low Salinity	< 250	0-750	No Problem	-	-
Medium Salinity	250-750			W-9, S-2 to S-4, S-8, S-10, R-1 to R-5 (44%)	W-2, W-6, W-9, S-2 to S-4, S-7 to S-11, R-1 to R-6 (64%)
High Salinity	750-2250	750-2750	Increasing Problem	W-1 to W-8, S-1, S-5 to S-7, S-9, S-11 (56%)	W-1, W-3 to W-5, W-7, W-8, S-1, S-5, S-6 (36%)
Very High Salinity	2250-5000	>2750	Severe Problem	-	-

5.4.2.2 Toxicity due to Sodium: If the proportion of sodium is high, the alkali hazard is high; and conversely, if calcium and magnesium predominate, the hazard is less. If water used for irrigation is high in sodium and low in calcium, the cation exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of the clay particles. A simple method of evaluating the danger of high-sodium is the sodium- adsorption ratio (SAR), and the equation is given as:

$$SAR = \frac{Na^+}{[(Ca^{++} + Mg^{++})/2]^{0.5}}$$

The sodium percentage (soluble sodium percentage, SSP) is also an important parameter, which indicates quantitatively the harmful effect of sodium content and may be required to replace with other less harmful cations through base exchange reaction in the soil. It may be expressed as below:

$$Na\% = \frac{Na^+ + K^+}{Ca^{++} + Mg^{++} + Na^+ + K^+} * 100$$

In calculation of SAR and SSP, all ionic concentrations are expressed in milli equivalent per liter (meq/l). The values of SAR and SSP for pre and post-monsoon periods are given in Tables 16 and 17. According to United State Department of Agriculture (USDA, 1954), SAR is appropriate basis for classification of water for agriculture. In the present study, SAR values of all sites lie below 10 during both sampling programs. Accordingly, the ground water in the study area could be classified under excellent category of water for irrigation (Table-18). Percent sodium up to 50% is acceptable for the purpose of irrigation. Above 50% sodium, alkalization steadily increases and soil will support little or no plant growth. In the present study, percent sodium lies at all sites below the limit of 50% during both periods except at S-6 (53.22%) during June1999 (Tables 15 and 16).

Table-18. Classification of Irrigation Water on the Basis of SAR Values

SAR	Water Class	Site Code in	
		June, 1999	October, 1999
< 10	Excellent	All sites	All sites
10-18	Good	-	-
18-26	Fair	-	-
>26	Poor	-	-

5.4.3 Permeability (Doneen's Permeability Index): The soil permeability is affected by long term use of irrigation water. It is influenced by sodium, calcium, magnesium and bicarbonate contents of soil. Doneen (1964) has evolved a criterion for assessing the suitability of water for irrigation based on Permeability Index (PI):

$$PI = \frac{Na + (HCO3)^{0.5}}{(Ca+Mg+Na)} * 100$$

The values of Permeability Index are given in Tables 15 and 16. According to Doneen (1964) classification (Raghunath, 1987), ground water in the study area could be classified as "good category" for irrigation, because it belongs to mostly either under class I or class-II during both sampling periods, except at one location (R-1) during June, 1999.

5.4.4 Miscellaneous Problems: In this category, problems related with crop production due to water quality, such as excessive vegetative growth, white deposits on fruits or leaves due to sprinkling with high bicarbonate water, and problems related to pH have been discussed (Prasad, et al., 1994). The satisfactory range of pH for irrigation is same as for drinking (pH: 6.5-8.5). In the present study, the result shows that pH values at all sites fall within range under both sampling periods.

5.4.4.1 Bicarbonates: Classification of irrigation water, as suggested by Ayers (1977), is given in Table-19. It is evident that all samples are lying under "Increasing Problem" zone (bicarbonate, 1.5 - 8.5 me/l) during both periods of sampling, except at site R-1 during October 1999.

Table-19. Classification of Irrigation Water on the basis of Bicarbonate

Bicarbonate (me/l)	Effects	Site Code in	
		June, 1999	October, 1999
0-1.5	No Problem	-	R-1
1.5-8.5	Increasing Problem	All sites	All sites except R-1
> 8.5	Severe Problem	-	-

5.4.4.2 Residual Sodium Carbonate: The quality of water for irrigation can also be assessed by the quantity, Residual Sodium Carbonate (RSC) and it is considered an additional criterion for determining the suitability of irrigation water. The quantity of bicarbonate concentration of water plays a significant role in RSC. If water contains high concentration of bicarbonate ion, there is a tendency for calcium ions to precipitate as carbonates. As a consequence, the relative proportion of sodium ion increases and gets fixed in the soil by the process of Base Exchange, thereby, decreasing the soil permeability. The RSC is calculated using the following equation:

$$RSC\ (meq/l) = (HCO_3 + CO_3) - (Ca + Mg)$$

United States Salinity Laboratory Staff (USDA, 1954) observed that the water containing more than 2.5 meq/l of RSC is generally not suitable for irrigation. Water containing 1.25 to 2.5 meq/l RSC is marginal and if contains less than 1.25 meq/l is absolutely safe. On perusal of data, it is evident that RSC of almost all samples lie under safe category (< 1.25 me/l) during both sampling periods, except at sites S-5 and S-6 during June, 1999. At these two sites, water belongs to marginal category (1.25to 2.5 me/l). The values of RSC are given in Tables 15 and 16, and results have been summarized in Table- 20.

5.4.4.3 Sulphate: According to Scofield's classification (Christiansen et. at. 1977), all water samples fall under excellent category (sulphate <4 meq/l) during both the sampling periods under the present study (Table-21).

5.4.5 U.S. Salinity Laboratory Classification: The interpretation based on U.S. Salinity Diagrams as plotted in the present study (Fig. 16 and 17) show, 52% of water samples under C3-S1 (high salinity- low SAR) class and 48% under C2-S1 (medium salinity- low SAR) category during June 1999. Similarly, data of another sampling as plotted for October 1999 show, 35% water samples under C3-S1 category, and remaining 65% under C2-S1 category indicating possible shift of water classes from high salinity to medium salinity due to dilution caused by monsoon rains. Since, the water type e.g., C3-S1, C2-S1 forms majority in the parts of Udhampur in the present study, and this type of water should be used for soils of medium to high permeability.

Table-20. Classification of Irrigation Water on the basis of RSC

RSC (meq/l)	Category	Site Code in	
		June, 1999	October, 1999
< 1.25	Safe	All sites except S-5 and S-6	All sites
1.25-2.5	Marginal	S-5, S-6	-
>2.5	Unsuitable	-	-

Table-21. Classification of Irrigation Water on the basis of Sulphate

Sulphate (me/l)	Effects	Site Code in	
		June,1999	Ocober,1999
0-4	Excellent	All sites	All sites
4-7	Good	-	-
7-12	Permissible	-	-
12-20	Doubtful	-	-
>20	Unsuitable	-	-

6.0 CONCLUSIONS

In the present study, average values of pH indicate alkaline nature of surface and ground water. The study has shown the majority of sites (60%) under very hard category (Total hardness > 180 mg/l) during pre-monsoon period. During post-monsoon period, however, very hard and hard categories of water samples were equal (42%), due to dilution effect of the monsoon rains. Average EC values have been observed in the order of wells> springs>rivers, under both sampling programs, which could be due to interaction of waters with the surrounding geology. Among the sampling sites, higher values of sulphate have been observed in rivers during both periods, which possibly were due to the impact of anthropogenic activities in the area.

The results of trace elements were compared with the standard norms for drinking purposes, which shows a higher concentration of Iron (Fe) and Chromium (Cr) at about 67% and 33% sites, respectively. The main source of iron ores is due to deposits of Hematite chert bands in Matah and Kotla Sangar area of Udhampur District. Fe deposits possibly occur in the recharge areas of springs/wells, whereas, in case of rivers the occurrence of these elements may be due to flow of water through these formations. The presence of Manganese (Mn) in the Sivaliks has been found in association with iron (illenite and magnetite) and it is available in the surrounding rocks in abundance, however its low concentration could be due to co-precipitation with other metal oxides. Cr and Cadmium (Cd) are generally found in basic rocks. In the present study, the maximum concentration of Cr was observed 0.06 mg/l in wells/springs and 0.08 mg/l in Chenab River (R-1), which could be attributed from rocks rather than industrial sources, which are very limited in the Udhampur district. The concentration of Cd was below detection limits in all samples except at S-11, where its concentration was equal to tolerance limit 0.01 mg/l for drinking purposes. Therefore, regular monitoring is necessary to further investigate the presence of Cadmium, which is a very toxic element.

—Magnesium (Mg) was dominant in the area and exceeds the limit at about 32% sites during pre-monsoon and 44% during post-monsoon periods as compared with the standards for drinking purposes. The source of Mg in waters is due to magnesites, which are present in the great limestones in Katra area of Jammu Province. Mg deposits also occur in the recharge areas of springs/wells, whereas, in case of rivers the occurrence of these elements may be due to flowing water through these formations.

The results of the present study have shown fluoride concentration within desirable range (0.6–1.2 mg/l) at about 12 % sites only during post-monsoon period. However, the fluoride concentration was observed below desirable range (0.6-1.2 mg/l) at majority of sites (92% sites during pre-monsoon and 88% during post-monsoon).

Almost all sites fall under the Ca^{2+}, Mg^{2+}, HCO_3- hydro-chemical facie during both sampling periods as per the Piper's classification. The analysis of data for Stiff classification indicates dominance of calcium and magnesium bicarbonates. Accordingly, calcium bicarbonate and magnesium bicarbonate together represents about 88% sites during June, 1999 and 97% during October, 1999.

In the study, 52% of water samples belonged to C3-S1 (high salinity- low SAR) class and 48% under C2-S1 (medium salinity- low SAR) category during June 1999 as per the U.S. Salinity Diagrams. An another sampling carried out during October 1999 has shown, 35% water samples belonged to C3-S1 category and remaining 65% under C2-S1 category, indicating a shift from high salinity to medium salinity due to dilution of salts as a result of rains.

Ground water in the study area could be classified as "good category" for irrigation as per the Doneen's classification, because it belongs to mostly either under class-I or class-II during both sampling periods, except at one location (R-1) during June, 1999. The concentration of bicarbonate of all samples was found to be lying under "Increasing Problem" zone (bicarbonate, 1.5 - 8.5 me/l) during both periods of study from irrigation point of view, except at site R-1 during October 1999. However, it is evident that RSC of almost all samples lie under safe category (< 1.25 me/l) during both sampling periods.

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