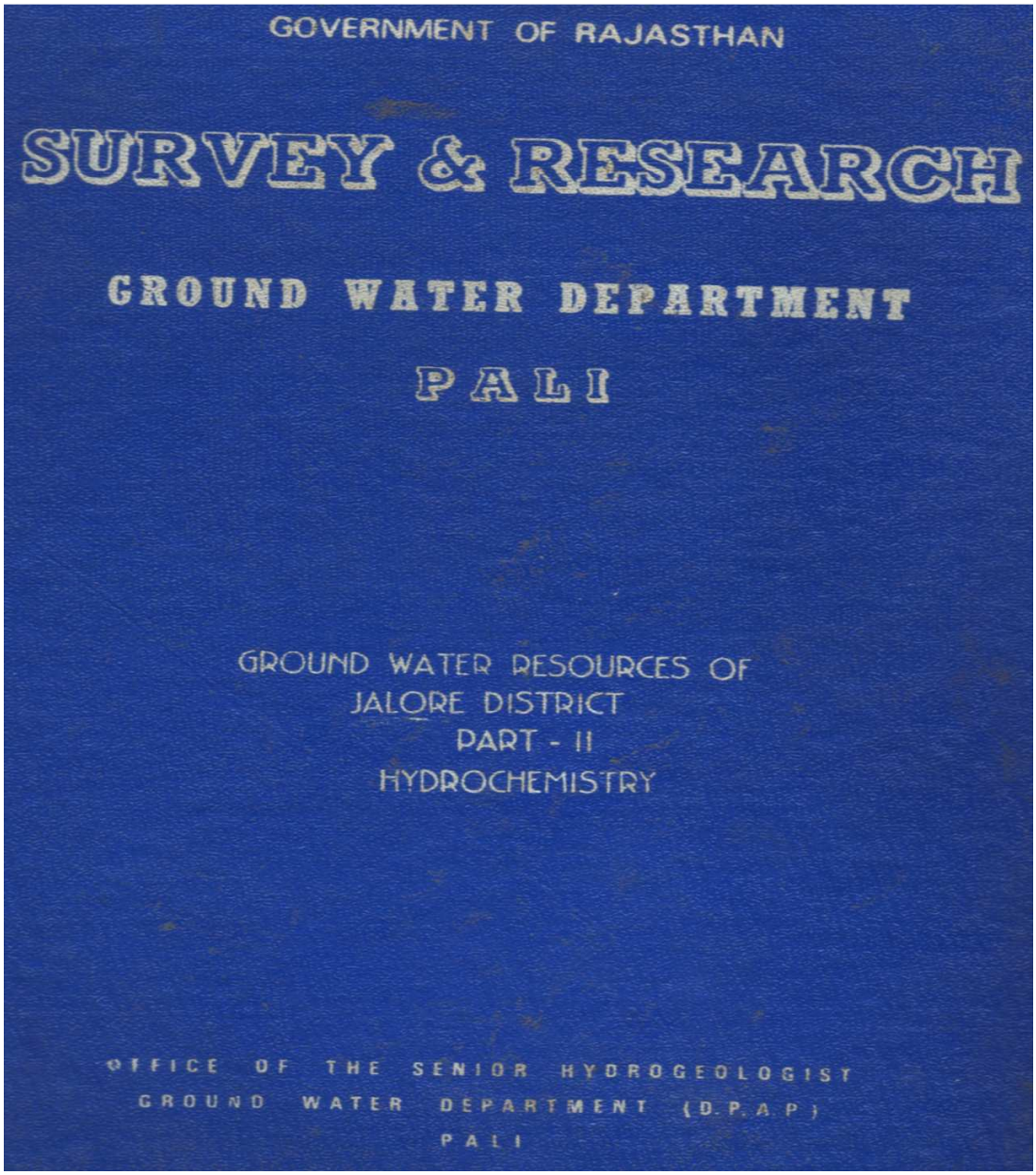

GOVERNMENT OF RAJASTHAN
SURVEY & RESEARCH
GROUND WATER DEPARTMENT
PALI
GROUND WATER RESOURCES OF
JALORE DISTRICT
PART - II
HYDROCHEMISTRY
OFFICE OF THE SENIOR HYDROGEOLOGIST
GROUND WATER DEPARTMENT (D.P.A.P.)
PALI

GOVERNMENT OF RAJASTHAN

SURVEY & RESEARCH

GROUND WATER DEPARTMENT

PALI

GROUND WATER RESOURCES OF
JALORE DISTRICT
PART - II
HYDROCHEMISTRY

OFFICE OF THE SENIOR HYDROGEOLOGIST
GROUND WATER DEPARTMENT (D.P.A.P.)
PALI

GROUND WATER RESOURCES OF JALORE DISTRICT, RAJASTHAN

PART - II HYDROCHEMISTRY

BY

K.K. SANGANERIA
JUNIOR CHEMIST

G.L. MATHUR
TECHNICAL ASSISTANT

&

Dr. C.S. DOSHI
SENIOR CHEMIST

SURVEY & RESEARCH
GROUND WATER DEPARTMENT.

M A Y, 1983

C O N T E N T S

APPENDICES

APPENDIX : I : RESULTS OF CHEMICAL ANALYSES OF WATER SAMPLES FROM PHREATIC AQUIFER COLLECTED DURING PRE MONSOON, 1979.

APPENDIX : II: RESULTS OF CHEMICAL ANALYSES OF WATER SAMPLES FROM DEEPER AQUIFER COLLECTED DURING 1976 - 1982.

ILLUSTRATIONS

PLATE : I MAP SHOWING DISTRIBUTION OF ELECTRICAL CONDUCTIVITY OF GROUND WATER IN PHREATIC AQUIFER : JALORE DISTRICT.

PLATE : II MAP SHOWING DISTRIBUTION OF TOTAL DISSOLVED SOLIDS AND NITRATE IN GROUND WATER OF PHREATIC AQUIFER : JALORE DISTT.

PLATE : III MAP SHOWING DISTRIBUTION OF CHLORIDE AND FLUORIDE IN GROUND WATER OF PHREATIC AQUIFER : JALORE DISTRICT.

PLATE : IV MAP SHOWING DISTRIBUTION OF ELECTRICAL CONDUCTIVITY OF GROUND WATER AND TYPE OF WATER (MODIFIED FROM RESULTS OF DEEPER AQUIFER) : JALORE DISTRICT.

ILLUSTRATIONS

T A B L E S

A B S T R A C T

The report deals with the hydrochemical investigations carried out between 1976 - 1982 in Jalore district, as a part of detailed ground water surveys under Drought Prone Area Programme (DPAP). During these surveys 9,692 water samples were collected periodically and repeatedly, from various water bearing formations and were subjected to chemical analysis. They represent formations ranging from crystalline to the quaternary.

Ground water in the district is fresh to saline and the electrical conductivity in phreatic aquifer and even in deep aquifer varies widely. It is between 430 µS/CM to 27,000 µS/CM and 360 µS/CM to 50,000 µS/CM in phreatic and deeper aquifer respectively. Jaswantpura and Raniwara Panchayat Samities have mostly fresh water, while saline ground water mostly occurs in Sanchore, north of Bhinmal, west of Saila, north of Ahore and Jalore.

Ground water occuring in younger alluvium except in west of Sanchore, is fresh to moderately saline having HCO_3 — Cl type to Cl - HCO_3 type of chemical character, while in older alluvium and tertiary it is mineralised with, predominantly, sodium salts. Waters representing granitic formation are mostly potable and soft with high fluoride content. Nitrate in water is observed in all the formations but it is comparatively less in deeper aquifer.

Bicarbonate type of water occurs along hilly terrain and foot hill zones of Jaswantpura, Raniwara and extreme northern part of Saila close to Siwana hills, which from the recharge zone. The ground water changes to mixed type around Bhinmal, Saila and Jalore to finally chloride type in west of Sanchore, north of Bhinmal, north-west of Saila and north of Ahore.

Ground water from phreatic and deeper aquifers of Jaswantpura and Raniwara is suitable for general domestic use. They are mostly free from harm-ful level of nitrate and fluoride. In parts of Ahore, Jalore, Saila and Bhinmal blocks waters are tolerable but found to contain high fluoride as evident from dental fluorosis amongst the local population. However, drinking water is a problem in Sanchore, north of Bhinmal and west of Saila where it is saline and in some area high nitrate also probilits its use for drinking.

Water quality evaluation for agriculture based on water rating Criteria (1972), has indicated that ground water upto 8,000 µS/CM is suited for use in irrigation. Soils conditions are favourable for growing salt tolerant crops. Few better quality area show high RSC and sodium percentage in ground water, where application of gypsum to the soils before irrigation is suggested.

CHAPTER - 1

I N T R O D U C T I O N

Ground water investigations in part of Jalore district were carried out from time to time by State and Central Ground Water Departments in the last two decades. Based on the findings of these investigations, various minor irrigation schemes and other programmes for exploitation of ground water were subsequently formulated and implemented.

Because of these ground water development programmes certain fresh water areas appeared to be over exploited while vast area of saline track remained untapped, due to nonavailability of detailed informations on hydrogeological and hydrochemical characters of the aquifers.

Therefore, detailed hydrogeological investigation under Drought Prone Area Programme (D.P.A.P.) were initiated from the year 1976 - 77 to evaluate the ground water potential and to delineate precisely the fresh water aquifers in saline area of the district.

The hydrochemical investigations formed a part of these studies with the objective to study the distribution of various dissolved salts in ground water, their relationship to aquifer characteristics and their suitability for drinking, domestic agricultural and livestocks purposes.

LOCATION:

Jalore district is situated in the south western part of Rajasthan and has an areal extent

of 10,640 Sq.Kms. It lies between latitude $24^{\circ}31'$ to $25^{\circ}45'$ and longtitude $71^{\circ}7'$ to $73^{\circ}6'$.

TOPOGRAPHY

In Jalore district elevation of the area ranges from 76.20 mts. above M.S.L. in the west, at the confluence of the Luni and Jawai - Sukari rivers, to 609.60 metres above M.S.L. in the east. Generally, the terrain slopes towards west, the valley floor has an average elevation ranging from 60.96 metres to 213.36 metres above M.S.L. The hill tops are normally shaped by weathering which has given rise to tors and boulders of various shapes and sizes in the eastern part while sand dunes are common topographic features in mid-eastern and western part.

Geomorphologically, the alluvial valley floor belongs to a natural landslope system. Much of the drainage patterns was established during pleistocene and sub-recent times. The arid cycle thus conditioned the initial fluvial land forms through the formation of sand dunes and sandy plains, super imposed on earlier aggregated alluvial plains and slopes.

DRAINAGE - CLIMATE - RAINFALL

The region is drained by the Luni river and its tributaries originating from the Aravalli hill ranges, The main tributaries of Luni river are Jawai, Sukari, Khari, Bandi and Sagi. All rivers are ephemeral with braided meandering courses and

wide flood plains. Besides these, there are innumerable old channels buried under wind blown sand.

The area lies in the arid to semi arid zone of Rajasthan with extremes of climate and high diurnal variations in temperature. May - June is the hottest part of the year when day temperature rises even upto 43°C while December - January experienced extreme winters with temperature falling as low as 2.5°C.

The rainfall in the region is very low and erratic, the normal annual precipitation record--ed is 384.0 mm (1901 - 1981), which shows the probable error of 188.2 mm. South-west monsoon contributes 92.2% of annual rain fall during monsoon period. Most of the rainfall is lost by evaporation and partly by run off. An average annual rainfall recorded at Jalore Station is 379.86 mm.

HYDROGEOLOGY

Geological formations encountered in the area range in age from post Delhi intrusives to the quaternary comprising of loosely consolidated to unconsolidated alluvial deposits and blown sand.

The younger alluvium forms the major promi--sing aquifer in the area having generally fresh water. It is generally loosely consolidated to unconsolidated stream laid deposits of gravels and sands. Older alluvium generally contains saline water or water of mixed character, and is composed of unconsolidated to semi-consolidated sand and gravel with clay, kankar and silts.

Tertiary formations comprising thick consolidated clays, silts and gravel, medium to coarse sand with shale fragment and little clays are found in deeper horizons. It generally yields moderately saline waters.

Malani volcanics consist of rhyplites and felsites, intercalated with acid tuff in pyroclastic material. These are having well developed joints system which are capable of giving moderate discharge, generally yielding fresh water.

Jalore granites also have well developed joints and the weathered mantle which yield mainly fresh and mixed type water depending upon topography of the area.

Erinpura granites are weathered, fractured and well jointed, confined to south of Bhinmal. It contains mainly fresh to tolerable quality of water.

METHODOLOGY.

The following methodology was adopted to study the hydrochemistry of ground water:-

1. On the onset of programme all the earlier water analyses data were compiled and base maps were prepared.

2. In all 9692 water samples were collected between 1976 to 1982. Data of 165 analyses have been selected as representing the different hydrochemical characteristics in the area. These were selected from analysis results of samples collected during the year 1979. The analyses

include the determination of major cations and anions namely sodium, potassium, calcium, magnesium, carbon-ate, bicarbonate, chloride, sulphate, nitrate and fluoride. Specific conductance (expressed in microsiemens per centimeter at 25°C) and pH were also determined instrumentally. The important parameters like total hardness, sodium adsorption ratio, residual sodium carbonate and sodium percentage were calculated for evaluating the suitability for irrigation purpose. These are reported in appendix-I and II. The analyses results are expressed in milli-gram per litre and equivalent per litre.

3. Seasonal samplings of water samples from 165 key wells were carried out during May - June (Pre Monsoon) Oct. - Nov. (Post monsoon) and March (Post irrigation) from 1978 to 81.

4. The data were further projected for their geochemical types.

5. Chemical data so collected were used for preparation of various chemical maps and studies for their seasonal variations, suitability for drinking, domestic and irrigation purposes.

6. Forty nine water samples from deeper aquifers representing different water bearing formations, were also studied, in detail, as enumerated in column 4 and 5.

ACKNOWLEDGEMENTS.

The authors are grateful to Shri S.K. Das, the then Chief Engineer, Ground Water Department, Jodhpur for his keen interest in the investigation.

They express their gratitudes to Shri D.C. Sharma, Superintending Hydrogeologist, Survey & Research for constant guidance and to Shri B.L. Paliwal, Senior Hydrogeologist for all the help extended during preparation of this report.

Their thanks are also due to field Hydrogeologist for collection of water samples and junior collegues of Chemical Laboratory of Pali for analysing and compiling the analysis data.

The authors wish to record their sincere thanks to Shri T.N. Mehra, Chief Engineer, Ground Water Department, Jodhpur for providing all the facilities for publication of this report.

CHAPTER - 2

CUALITY OF PHREATIC WATER

ELECTRICAL CONDUCTIVITY:

In arid and semi arid region ground water is often mineralized, Salinity, a natural phenonmenon, occuring in both soils & waters, is dependent upon climatic conditions of the region. Jalore, being a part of arid region, has ground water with varing degrees of salinity.

The lowest value of electrical conductivity i.e. 430 microsiemens-cm at 25° is observed in two well waters viz. PANSERI AND RAMPURA of P.S. Jaswantpura and Raniwara respectively. Both the wells are situated near the hilly terrain. The highest value of 27,000 microsiemens/cm at 25°C is recorded in well water of village BAORI of P.S. Ahore. The percentage of water samples, in various electrical conductivity ranges of phreatic aquifer, are shown in Fig.1, which indicates the saline character of ground water. Only 26.7% of samples have E.C. value less than 2000 microsiemens.

A map, Plate No.1, showing the electrical conductivity in ground water of district, is prepared on the basis of 165 analysis data. It depicts that fresh ground water (E.C. less than 2000 MS) is found in parts of Jaswantpura, Raniwara and near the river banks around Bhinmal and Saila. Ground water of tolerable quality with 2000 - 4000 E.C. value occurs in western part of Jalore, Ahore and Bhinmal, while Sanchore, north of Ahore, south - west and north east of Jalore and part of Bhinmal have saline waters.

FIG NO:- 1 PERCENTAGE DISTRIBUTION OF E.C. RANGES IN GROUND WATER OF PHREATIC AQUIFER

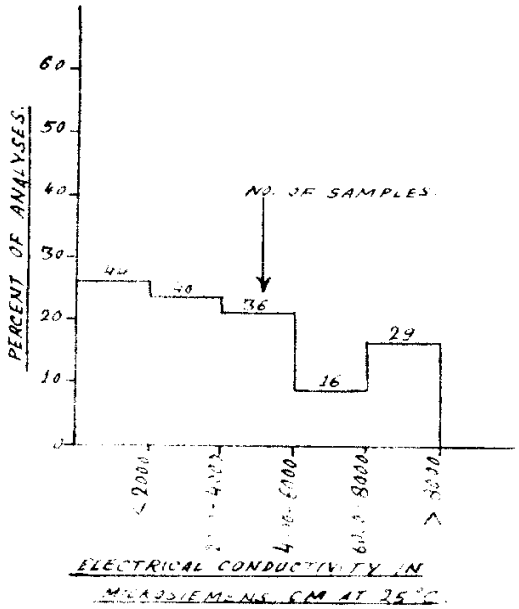
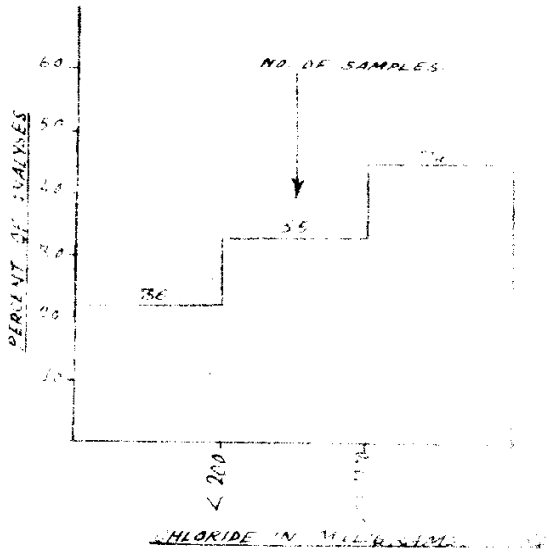


FIG NO:- 2 PERCENTAGE DISTRIBUTION OF CHLORIDE RANGES IN GROUND WATER OF PHREATIC AQUIFER



Since electrical conducitivity of the water is a measure of its total soluble salts, Plate - 2 showing the distribution of T.D.S. is similar to Plate-1. The T.D.S. map Plate - 2 on perusal shows that ground water is gradually getting mineralized from south and south-east to north, north-west and west.

Fresh water mostly contains predominantly bicarbonates of calcium and magnesium but in few well waters sodium- bicarbonate dominates. Analyses showing the tolerable quality of water, have mixed type of solutes while saline water principally contains sodium chloride besides sodium sulphate.

CHLORIDE CONTENT:

Chloride is the principal anion in ground water of arid zones. Chloride, which initially comes from rain, gets gradually enriched due to dissolution of the salts from the earths crust through which the ground water circulates.

Chloride content in ground water varies from 17 mg/l (Panseri, P.S. Jaswantpura) to 9112 mg/l (Baori, P.S. Ahore) Fig.2 shows the percentage of water samples in various ranges of chloride content in ground water. In 21.8 percent of analyses the chloride ranges between 17 to 200 mg/l while 33.3 percent of analyses shows its value between 200 to 1000 mg/l indicating the mineralised nature of ground water. Many analyses (44.9%) show chloride content above 1000 mg/l impairing their potability. Fig. 3

a graph of chloride versus E.C. indicates that the salinity of ground water increases with the increase in concentration of chloride.

Plate III shows the distribution of chloride of phreatic ground water. It depicts that the chloride in water increases with increasing total dissolved solids from south and south-west to west, north-west and north. Central part covering north of Bhinmal also have high chloride content, exceeding above 1,000 mg/l at some places. High contents of chloride in the area indicate that ground water movement is sluggish and slow.

NITRATE:

Nitrate in water is mainly contributed either through sewage pollution or by return flow of irrigation water, leaching nitrogenous fertilizer. However significant amount of nitrate is observed to be contributed by legaume crops to the soils.

Figure-4 shows the different ranges of nitrate in phreatic aquifer and further indicates that 32.7 percent of analyses have nitrate above 100 mg/l. It ranges between zero (many analyses) to 600/l (water of village Murtara silli, P.S. Jaswantpura). Analyses showing high nitrate content are generally observed to have high contents of potassium which shows the direct effects of fertilizer and return flow of irrigation water polluting the ground water and making it unfit for human consumption.

It is observed from the map showing distribution (plate -2) of nitrate that in northern part of the district covering villages Sobrawas,Nandia,

FIG. NO:- 4. PERCENTAGE DISTRIBUTION OF RANGES OF NITRATE IN PHREATIC GROUND WATER.

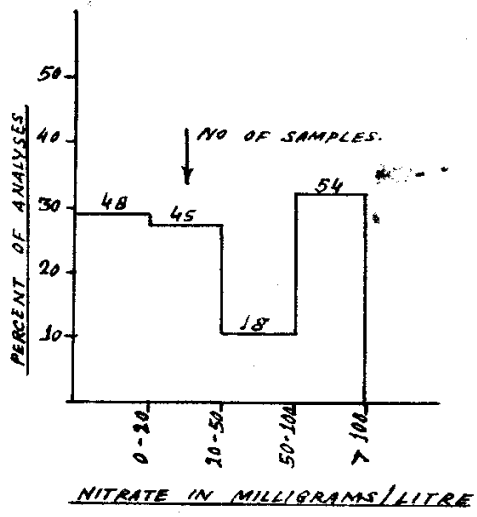
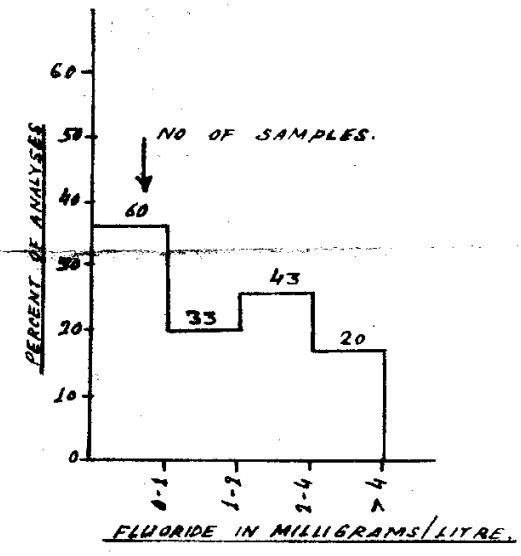


FIG. NO:- 5. PERCENTAGE DISTRIBUTION OF RANGES OF FLUORIDE IN PHREATIC GROUND WATER.



Jesawas around Saila and in eastern part covering Mera - Uparla, Mayla was around Jalore phreatic aquifer has nitrate content more than 250 mg/l. It is further seen that saline waters of west and north also have nitrate content of more than 100 mg/l. It is difficult to find nitrate free water in the above referred area.

However in the southern and central part of the district ground water is free from harmful level of nitrate.

FLUORIDE:

Fluoride is a minor constitutent of igneous and sedimentary rocks. In Jalore district granites and gneissess are the main sources of fluoride for ground water which is evident from the fact that high content of fluoride are found in those wells tapping either granite or gneissess.

Fluoride content in ground water varies from nil to 14.20 mg/l (Morsim, p.s. Bhinmal). The ranges of fluoride and their percentage are shown in figure 5 which depicts that fluoride content exceeded 2 mg/l in 36.36 percent of analyses, while 26.0 percent of analyses falls in the rage of 2 - 4 mg/l of fluoride concentration. The high content of fluoride above 4 mg/l is observed in 17.6 percent of analyses. This shows that fluoride is a proble--matic ingredient in ground water of the district.

It is seen from the plate III that the fluoride contents above 4 mg/l are found in ground water of Ahore, Jalore where wells are tapping granite. Some localised patches around Bhinmal, north-west of Saila, south of Sanchore etc. have fluoride content

more than 4 mg/l in phreatic aquifer.

There is no relationship between fluoride and salinity. However, close relationship could be seen between R.S.C. and fluoride content of the water.

CHEMICAL QUALITY IN RELATION TO AQUIFER:

It is common knowledge that the lithological or minerological character of water bear--ing materials determines to a large extent the chemical quality of ground water. The principal water bearing formation of Jalore district are (a) Younger alluvium (b) Older alluvium (c) Granite (d) Rhyolite. It is observed from the analyses that minimum variation in chemical character is noticed in the granite and rhyolite formations and maximum in alluvial formation. The chemical quality of ground water of the different aquifers is summarised in the table-I.

It is seen from the table - III that the quality of water of these formations is saline except in rhyolite where average range of electrical conductivity of ground water has been found to be 2,450 microsiemens/cm at 25°C.

GROUND WATER IN YOUNGER ALLUVIUM:

Fresh to saline water are found in this formation. Fresh water, mostly containing bicarbonate salts, is found along the banks of Jawai - Sukri river. This formation is mostly consisting of coarse to medium sand, gravels, and pebbles which facilitate the quick movement of water due to high permeability thus reducing the contact time of water with the formation materials.

This aquifer is spread around the confluance of Luni and Jawai - Sukri river, east to west covering southern portion of Raniwara and west of Sanchore i.e. upto Runn. It is represented by 28.48% of total water samples analysed. The range of electrical conductivity in water varies from less than 1,000 to more than 15,000 microsiemens/cm. About 29 % of water samples within this formation range between 5,000 to more than 15,000 microsiemens/cm with an average value of 3,960 microsiemens/cm. The well waters analysed around Sanchore have shown higher value of electrical conductivity i.e. containing more solutes. The reasons being that it is a discharge zone and is situated at lower level where ground water movement is very sluggish. There is enough time for solutes to dissolve more and more salts in water. For this reason the average value of E.C. is higher. The chloride, nitrate and fluoride ranges are varying between 20 - 6717 mg/l, 0-350 mg/l and 0 - 14.20 mg/l with average values of 783 mg/l, 88 mg/l and 2.47 mg/l respectively. Nearly 30% of water samples have chlo--ride content above 1,000 mg/l, nitrate content above 100 mg/l, fluoride content above 2 mg/l and hardness above 600 mgCa-CO_3 /L, thus the potable ground water in this aquifer is of tolerable quality.

In majority of cases, the character of ground water is bicarbonate, bicarbonate- chloride and chloride-bicarbonate type. This type of chemical behaviour has been observed in ground water around Jawai - Sukri river and around Raniwara. But in discharge zone (west of Sanchore), sodium chloride type of water occurs.

TABLE-1: RANGES OF SOME CHEMICAL CONTENTS IN GROUND WATER OF DIFFERENT PHREATIC AQUIFERS.

S. No.	Aquifer.	No. of water sample each aquifer.	% of total water samples.	Electrical conductivity in MS Mini.	Max.	Chloride content in mg/l. Mini.	Max.	Nitrate content in mg/l Mini.	Max.	Fluoride content in mg/l Mini.	Max.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Younger alluvium.	47	28.48	430 Rampura, Ankhol.	19200 Rampura Ankhol 3960 average.	20	6717 Rampura Ankhol 783 average	nil	350 Alri Ankhol 88 average	nil Bhawatra Morsim. Khejdiyali Suntri Sanphara.	14.20 2.47 average
2.	Older alluvium.	95	57.58	430 Panseri Baori 4967 average.	27000	17 Panseri Baori 1328 average.	9112	nil Sankhwali Nimbla 109 average.	600	nil Padarli Rajanwadi Meshpura Golia 1.85 average.	8.00
3.	Granite	20	12.12	750 Jalore Rundmal ki dhani 3593 average.	9300	63 Jalore Rundmal ki dhani 755 average.	2553	nil Bhinmal 124 average	600 Murtara-silli.	0.64 Golwara Bhinmal 2.67 average.	5.00
4.	Rhyolite	3	1.82	830 Lakhawas Chatwara 2450 average.	5300	90 Lakhawas Chatwara. 512 average	1357	nil Lakhawas. Chatwara 73 average.	140	1.00 Vandar Chatwara. 2.09 average.	3.64

GROUND WATER IN OLDER ALLUVIUM:

This formation is mostly consisting of clay and kankar having low transmisivity. Therefore, the water remains in contact with this formation for longer period as compared to younger alluvium. This phenomenon increases the salinity in ground water. Besides this, the base exchange, a characteristic of clayey formation, also adds to salinity of water as well change the chemical composition of ground water.

This aquifer is widely distributed in the Jalore district; mainly in north eastern, southern, western and central parts. It is represented by 57.58% of total water samples analysed. The salinity in water varies from 430 to 27,000 microsiemens/cm with an average value of 4,967 microsiemens/cm. Table-III. The chloride, nitrate and fluoride of ground water in this aquifer average to 1,328 mg/l, 109 mg/l. and 1.85 mg/l respectively. It is also observed from the chemical analyses that 37%, 47%, and 32% of water samples have chloride content above 1,000 mg/l, nitrate content above 100 mg/l and Fluoride content above 2 mg/l respectively. If indicates that the availability of potable ground water is limited in this formation.

Practically sodium chloride type of character is exhibited by the ground water of this aquifer except around south-west and north west of Saila where bicar-bonate- chloride type or chloride - bicarbonate type waters occur.

GROUND WATER IN GRANITE:

Jalore granites are prophyritic in texture, highly fractured and weathered. These rocks have no

primary porosity. The ground water movement takes place through weathered and fractured portions.

Grainite occurs as hydrogeological formation in north-east, central and south-eastern porition of the district near village Rama, Jalore, Jaswantpura and Bhinmal section respectively. It is represented by 12.12 % of total analyses.

It is observed from the analyses that 45 % well waters representing the formation are saline. The reason being the water movement is restricted due to limited extention of fracture with in the aquifer. Analyses of remaining 55 % well waters represent the foot-hill zones and show fresh to mix type of chemical character. It is mainly due to the extention of joints, fractures and weathered mantle in foot hill zones where water movement is quick. The chloride, nitrate and fluoride contents of the water in this aquifer average to 755 mg/1, 124 mg/1 and 2.67 mg/1 respect--ively. This aquifer, thus, yields moderately potable waters, some needing defluoridation.

High value of fluoride in well waters suggested that the possible source of fluoride may be the mineral fluorite and apatite found in granite. Waters occuring in granitic formation are invariably soft due to leaching of alkalis.

RHYOLITE:

Rhyolite occurs as hydrogeological formation around village Vandar, Lakhawas and Chatwara in south, south-west areas.

Ground water is usually fresh i.e. bicarbonate to mix type and occurs under water table condition in weathered and fractured portion of these rocks.

TYPE OF WATER:

On the basis of concentration of three most mobile anions, such as chloride, bicarbonate and sulphate, the ground water of phreatic aquifer is classified into different types by projecting their percentage values on Piper's diagram (Fig.6). The following types of phreatic waters emerge.

			No. of samples
1. Bicarbonate	type HCO_3	50%	26
2. Mix type	type None	50%	28
3. Chloride	type Cl	50%	111
4. Sulphate	type SO_4	50%	0
	Total		165

The plate IV shows the areal distributions of types of phreatic water. It bears resemblance to isocone map plate-II. Their general chemical characteristics are given in table No.II and their associations with cations are shown in table No.III.

BICARBONATE TYPE:

It is fresh water, occupying area 1,2 & 5B of Piper's diagram and generally occuring where rein--fall and infiltration are relatively high. The major characteristics are low dissolved solids and low content of chloride. Only 15.7% water samples have shown bicarbonate type of character with either sodium or Ca + Mg as dominate cation.

It occurs along hilly terrain of Jaswantpura, some area south of Raniwara, a small portion along river Sagi in Bhinmal, northern part of Saila where some recharge is contributed by Siwana hills, and in Jalore where river Jawai is contributing fresh water along the river course to a limited extent around Leta and Keshwana section. Limited extention of bicarbonate type of water is also observed along the course of river Bandi.

Water occuring near the foot hill zones and along river banks has mostly Ca - HCO_3 or Ca + Mg - HCO_3 type of chemical character with an average T.D.S. value around 500 mg/l while that of Na - HCO_3 type occuring adjoining to Ca+Mg-HCO_3 type has an average T.D.S. value around 800 mg/l. It is clear from the above that Ca+Mg-HCO_3 type water is comparatively fresh and close to the recharge area while that of Na-HCO_3 type is relatively more mineralised and away from recharge zone.

MIX TYPE OF WATER:

17.0 % well waters (Table-III) show the mix type of chemical character i.e. none of the anions has shown the concentration more than 50%. They mostly occupy the area 5 A and part of the area 3 close to 5 B of Piper's diagram showing intermediate chemical characters. It is further observed from plate IV that mix type of waters being transitional in character, occupy the area between bicarbonate type and chloride type particularly in Jaswantpura, Raniwara and Saila. In the eastern part, the well waters are in contineous contact with fresh water from catchment area. Whereas

in the west these waters are gradually getting contami--nated by saline waters with the increase in sodium and chloride. In the Charau - Dadhal section the saline waters receive an influence of fresh water from Siwana area resulting in the formation of mix type of water along the northern bank of Jawai - Sukri river. In the central portion around villages Dhansa, Modran and Nun mix type of water is found, due to the recharge from river Bandi, however, in limited area.

It is also observed from the table-II that half of mix type of waters have bicarbonate more than either chloride or sulphate with T.D.S. value below 1,000 mg/1 and they are found mostly adjoining to Na - HCO_3 type of water. In the remaining, it is the chloride which takes the place of bicarbonate and their total dissolved concentration is more than 1,000 mg/1 indicating their saline nature occuring in close vicinity of chloride type of water.

This clearly shows that mix type of water is gradually changing its chemical character from HCO_3- Cl type to Cl - HCO_3 type with the increase in total dissolved solids. Further the total dissolved solids of the mix type of water (Table-II) is ranging between those of HCO_3 - type and Cl- type of waters.

TABLE - II

RANGES OF SOME CHEMICAL CONTENTS IN DIFFERENT TYPES OF WATER OF PHREATIC AQUIFER

Constituents in mg/l	Bicarbonate type 26 analyses			Mix type -28 analyses			Chloride type-111 analyses		
	Min.	Max.	Average.	Min.	Max.	Average.	Min.	Max.	Average.
TDS	270 Panseri	1090 Ahore	635	535 Fatehpur	3840 Kaonla	1435	1152 Modran	17280 Baori	4161
Chloride	17 Panseri	187 Chandur	104	63 Pal	998 Kaonla	320	364 Baretha	9123 Baori	1780
Sulphate	nil Rampura Panseri	90 Ahore	19	25 Fatehpur	836 Kaonla	183	51 Bokra	3547 Baori	418
TH	132 Paharpur	379 Paoli	227	79 Harmu	1906 Kaonla	425	159 Sakria ki dhani	4380 Dhanpura	894
NO_3	Nil Lakhawas Keswana etc.	80 Vandar	21	Nil Dodiyali	600 Murtara silli	146	Nil Dayalpura Dudiya, Bhinmal Ratunja etc.	600 Nimbla	119
F	0.64 Rampura Surawa Panseri Bamanwara.	8.00 Rajanwadi	2.07	Nil Bautra	9.6 Harmu	2.43	Nil Padarli etc.	14.20 Morsim	2.45

TABLE III

COMBINATION OF CATIONS AND ANIONS IN GROUND WATER OF PHREATIC AQUIFER

S.No. Dominant cation.	Dominant anion				Total
	Bicarbonate + Carbonate $HCO_3^- + CO_3^{--}$ 50%	Mix anions 50 %	Chloride Cl^- 50%	Sulphate SO_4^{--} 50%	
1. Sodium + Potassium $Na^+ + K^+$	13 (79)	17 (10.3)	103(62.5)	nil	136 (82.5)
2. Calcium Ca^{++}	2 (1.2)	nil	nil	nil	2(1.2)
3. $Ca^{++} + Mg.^{++}$	11 (6.6)	10 (6.1)	6(3.6)	nil	24(14.5)
4. Mix cations.	-	1(0.6)	2(1.2)	nil	3(1.8)
	26(15.7)	28 (17.0)	111 (67.3)	nil	165 (100.0)

Bracket indicate percentage value

CHLORIDE TYPE OF WATER:

The chloride type of waters, (67.3 % of the total analyses) are those in which chloride is dominant having more than 50 % of the total anionic value. They are characterised by high total dissolved solids, mostly above 2,000 mg/1 with sodium as dominant cation. This is the ultimate stage of cationic and anionic exchange reactions, generally existing in discharge zone.

They fall in central and extreme end of the area 3 of piper's diagram where mostly analyses of saline waters and sea water plot. Chloride waters are widely distributed, as seen from plate IV, covering central part, western part including Runn, and major area of Ahore block where T.D.S exceeds 5,000 mg/1. Highest salinity (EC 10,000 microsiemens/ cm) in ground water is recorded around Runn area in north and north _ west of Sanchore where ground water exhibits almost sea water type of chemical character i.e. Na _Mg _Ca $-SO_4$ _ $^{H}CO_3$ type. This area forms the discharge zone and practically there exists high water level conditions. This chloride type of water, particularly in south and north _east of sanchore has high contents of potassium and nitrate indicating agricultural activities in these areas. Salinity in ground water occuring around Rama _ Bijli _Ghana _ Raithal section can be attributed to the slow ground water movement restricted by the Siwana hills (on eastern side) . However around village Rama few fresh water pockets, within this saline zone, are located, which appears to be due to some local [illegible] vici[illegible]

recharge condition in the vicinity of hills. Saline condition is also observed in south and south - eastern portion of Jalore town. The area lies under shadow zone of Jalore hills where ground water movement is sluggish.

CATTONIC RATTO

The cationic ratios viz Na/Ca, Na/Ca+Mg and Ca/Mg in respect of types of water have been worked out and shown in tabular form below:-

Type of water.	Na/Ca			Na/Ca+Mg			Ca/Mg		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Bicar-bonate.	0.22	9.05	2.79	0.15	5.02	2.12	0.41	2.63	1.60
Mix	0.47	55.14	5.49	0.30	14.31	2.17	0.20	3.00	1.13
Chlo-ride.	0.97	131.73	10.92	0.58	16.83	3.61	0.02	3.15	0.95

On thorough scrutiny of the above data the following observations are made:

1. The minimum, maximum and average value of Na/Ca and Na/Ca+Mg ratios show the increasing trend from bicarbonate type to chloride type of water. It clearly indicates that the increase in salinity of ground water is mostly contributed by sodium chloride being highly soluble and the product of arid environment.

2. The Ca/Mg ratio shows the decreasing trend in minimum and average value from bicarbonate to chloride type while its maximum value shows the

rise. This further indicate that magnesium shows increasing trend with the increase in salinity while the calcium fluctuates within a limited range because of the low solubilities of its salts (calcium carbonate and calcium sulphate).

In fact the trend in maximum value should have been similar i.e. in decreasing order but two analyses in mix type and one analysis in chloride type have shown the ratio above 2. This exception is due to the association of calcium with either chloride or nitrate. Both these salts are highly soluble.

It has been clearly brought out from the above discussion that the trend (increasing or decreasing) in the cationic ratio has significantly reflected on the chemical type of water.

CHAPTER - 3

QUALITY OF GROUND WATER IN DEEPER AQUIFER

Ground water in phreatic aquifer in Sanchore, Bhinmal, west of Saila, north of Jalore and Ahore is saline. Naturally the deeper source has to be explored.

The chemical characteristics and quality of ground water of deeper aquifers have been studied from 49 analyses representing exploratory and observation wells. Analytical results are given in appendix - II.

The plate IV is the modification of the comparative E.C. values of water samples from both deeper and phreatic aquifer. It depicts the over all salinity of ground water in the district.

As seen from the plates IV and 1, the quality of ground water from the deeper aquifer is less mineralised than that of phreatic aquifer in north-west of Bhinmal around Jodhawas and punasa, west of Saila around Alwara and Dahiwa, south of Sanchore and near pladar, while it is comparatively more saline in west, north-west and north of Sanchore, north of Ahore and Jalore and north-west of Raniwara near Chatwara and Digaon. However, very little difference is noticed in chemical quality of ground water of both the aquifers in central, Southern and eastern parts of Raniwara, Jaswantpura and southern part of Jalore. Based on chemical analyses, the additional potential zone found around Jodhawas and punasa, and near

Dahiwa and Alwara can be suitably exploited for agricultural and domestic utilisation.

The table IV indicates the ranges of salinity in ground water of deep aquifers encountered in various P.S. of Jalore district.

TABLE-IV

TABLE SHOWING THE RANGES OF E.C. (in US/Cm) FOR DEEPER AQUIFERS.

P.S.	No.of analyses.	0-2000	2001-4000	4001-6000	6001-8000	Above.
Ahore	10	1	4	-	2	3
Bhinmal	10	3	1	2	1	3
Jaswantpura	6	5	-	-	1	-
Jalore.	4	2	2	-	-	-
Raniwara	5	3	-	-	-	2
Saila	7	4	2	-	-	1
Sanchore	7	-	-	2	2	3
Total	49	18	9	4	6	12
%	%100	36.7	18.4	8.2	12.2	24.5

On perusal of above table it is seen that 55% of the exploratory and observation wells have yielded fresh to tolerable quality of water while 26% wells have highly saline waters which can not be used for any purposes and mostly found occuring in Ahore, Bhinmal and Sanchore, where phreatic aquifer is also saline.

The salinity is mostly contributed by the sodium salts but in highly saline waters (E.C. 10,000 US/cm) substantial amount of calcium and magnesium salts are observed.

Nitrate content except in few analyses is less than 20 mg/1 and unlike phreatic aquifer it does not show any relationship with either Salinity or hardness or potassium.

Fluoride is compara-tively lower in ground water of deeper aquifer. Twenty two (22) analyses have fluoride content more than 2mg/1. Low Salinity ground water of Jaswantpura, Bhinmal and Jalore has fluoride content more than 2 mg/1 . The deep ground water at Rajanwadi, Jalore has 7 mg/1 of fluoride. Where in phreatic aquifer the fluoride content is 8 mg/1. Deeper saline water of Ahore has also high contents of fluoride (Raithal F-10.0 mg/1, Tarwara F-7.7 mg/1 and Sankarana F-4.28 mg/1) .

Ground water is hard except in Saila and Raniwara where hardness of ground water is below 200 mg /1 as $CaCo_3$.

As seen from the graph, figure 7, of E.C verses chloride, chloride content is found increasing with the increase in salinity upto 8,000 us/cm but with higher salinity value i.e. above 8,000 us/cm the proportional increase in chloride is less. Sulphate is gradually found increasing in high salinity waters. Further it is observed from the graph, Fig.8, of sodium verses chloride, which looks like a scatter for higher values, that the source of salinity is not simply the addition of sodium chloride but further modification by base exchange between formation materials and circulating water. This is evident from the high contents of calcium and magnesium in these high salinity waters.

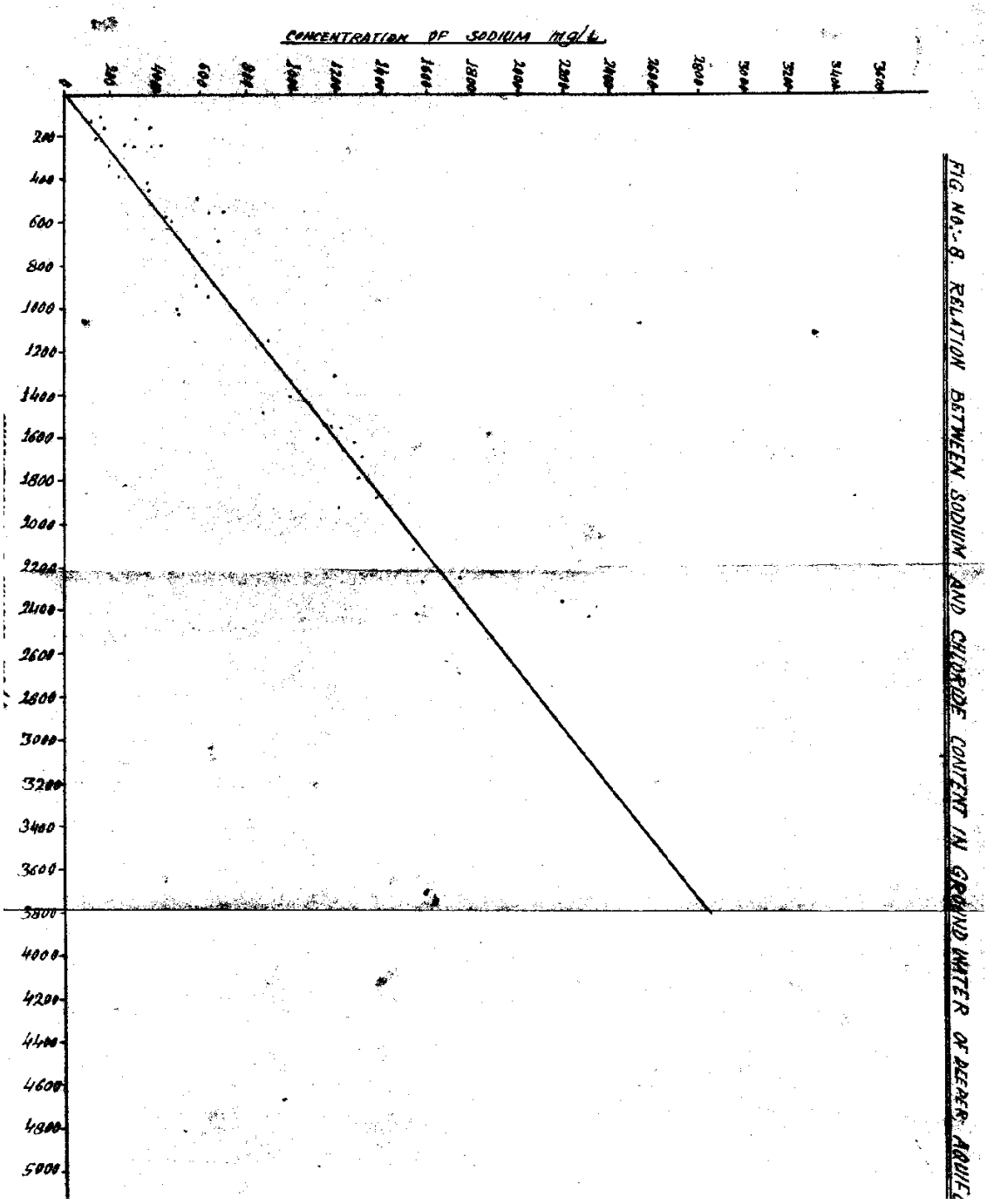


FIG NO.:- 8. RELATION BETWEEN SODIUM AND CHLORIDE CONTENT IN GROUND WATER OF DEEPER AQUIFER

The ratio of total dissolved solids to electrical conductivity varies between 0.55 to 0.93 with an average value of 0.625. However, for saline waters (EC 10,000 us/cm), the average value is 0.69. But in high salinity waters (EC 30,000 µs/cm) of Dugnri, Raithal and Tarwara the ratios are 0.8, 0.83 and 0.93 respectively. However the formula TDs (mg/1) = 0.61 x E.C at 25°C. can be used for rapid calculation of deeper ground water having EC value less than 10,000 us/cm.

CHEMICAL CHARACTERISTICS IN RELATION TO GEOLOGICAL FORMATION:

The influence of geological formation on chemical characteristics of ground water is profound. The chemical changes brought about by different water bearing formations in the ground water of phreatic aquifer have already been discussed in the earlier chaper.

Three water bea-ring formations namely younger alluvium, older alluvium and granite were further explored for deeper aquifer so that some confined and concealed fresh water source may be located. The search brought to light the presence of tertiary (?) as a promising water bearing formation around Jodhawas, north-west of Bhinmal, which has yielded free flowing deep ground water of tolerable quality. However it has yielded saline water further down stream which can be used for livestocks.

TABLE - V

RANGE OF SOME CHEMICAL CONTENTS IN DEEPER GROUND WATER OF DIFFERENT WATER BEARING FORMATIONS

S. No.	Water bearing formation.	No. of analyses of each aquifer.	Percentage.	Minimum - maximum. Average. Electrical conductivity in microsiemens per centimeter at 25°C.	Chloride Cl mg/l	Nitrate NO$_3$ mg/l.	Fluoride F mg/l
1.	Younger alluvium.	9	18.4	1080 Modran - 50,000 Dungri main 8,725	154 Modran - 23180 Dungri 3,325	0 Saila - 85 Sankarna 43	1.0 Bhainswara - 5.32 Modran main 3.15
2.	Older alluvium.	22	44.9	360 Jaitpura. - 43,000 Raithal 7,188	18 Jaitpura - 16,628 Raithal 2,358	0 Umedpura - 105 Kueber 23	0 Raniwara - 10.00 Raithal 2.26
3.	Granite	8	16.3	450 Panseri obs. - 37,000 Chatwera 7,837	12 Panseri. - 12,162 Chatwera 2,311	5 Bhinmal. - 410 Paoli 76	1.08 Khanpur. - 7.60 Korita 2.85
4.	Tertiary + alluvium.	10	20.4	1600 Alwara - 14,700 Chajjala. 7,515	270 Alwara. - 5,140 Chajjla 2,236	15 Batera - 170 Meda 63	0.80 Alwara. - 2.0 Chajjla 1.31

Unlike phreatic aquifer there is a wide variation in chemical characteristics of deeper ground water of all water bearing formations. The minimum, maximum and average values of E.C., chloride, nitrate and fluoride are summerised in the table -V which on persual indicates the overall saline nature of the deeper waters.

The average E.C. and chloride content of ground waters exceed above 7,000 us/cm and 2,200 mg/1 respectively for all the formations. Their nitrate and fluoride contents are comparatively less than those of phreatic water. The maximum fluoride content of ground water from Tertiary is 2 mg/1 while it is above 5mg/1 in waters of the other formations. It is very significant.

The table VI gives the ranges of salinity in deep ground water of different water bearing formations.

TABLE -VI

RANGES OF E.C. (US/CM) IN DEEP GROUND WATER FORMATIONWISE -

Water bearing formation.	No. of analy-ses.	RANGE OF E.C. 0-2000	2001-4000	4001-6000	6000-8000	8000 & above
Younger alluvium.	9	4	1	1	2	1
Older alluvium	22	9	7	-	1	5
Granite.	8	4	-	1	1	2
Tertiary (+01-der elluvium	10	1	1	2	2	4
TOTAL:	49	18	9	4	6	12
%	100	36.7	18.4	8.2	12.2	24.5

The formation wise breekup of salinity in deep ground water indicates that the ground water from older alluvium and tertiary are more saline than those of younger alluvium and granitic formations, where water circulates quicker in coarser formation material and in joints-and fractures respectively, thereby reducing the contact time.

The study of ionic ratios gives useful informations on chemical characteristics. The average Na/Ca ratio (10.5 to 12.0) does not show any signi--ficant variation for younger alluvium, granite and tertiary but it is comparatively less for older alluvium (8.7). Similarly Na/Ca+mg ratio is less for older alluvium, but its average So_4/Cl ratio is higher (0.27) than those of other formations (granite 0.19, younger alluvium 0.16 and tertiary 0.18) . It clearly suggests the calcareous nature of the formation materials in older alluvium.

The average Ca/Mg ratio is more or less same for waters tapping granite (1.14) older alluvium (1.18) and tertiary (1.15) while it is higher for younger alluvium (1.37) .

TYPE OF WATER:

The analyses of deeper ground water like those of phreatic, are classified into different types by projecting their percentage values on piper's diagram (Fig.9) and their formationwise associations with cations are shown in table No. VII. Their chemical characterics are shown in table No. VIII.

	No. of samples
Bicarbonate type.	8
Mix type.	8
Chloride type.	33

On perusal of piper's diagram (Fig.9) it is observed that bicarbonate type of ground water from Jetpura (no.20.23; Raniwara) and Panseri (no. 33,34; Jaswantpura) are of Ca+Mg type with T.D.S less than 300mg/1 and are occupying the area 1 of the diamand shaped diagram. Such low salinity fresh water occurs where rainfall is heaviest, and water circulation within the zone of saturation is quicker. Both these tubewells are within in the catchment zone where geological formation has no control on chemical characteristics of water. The water moves out before any significant chemical change is brought about by the formation materials. The waters of Modran (no.31, Bhinmal) and Raniwara (No. 43) are occupying the area 5 B. They are comparatively saline as the chemical characteristics change from Ca+Mg-HCO_3 type to Na-HCO_3 type with the increase in TDS value around 700 mg/1. They are away from the catchment zone. However the Na-HCO_3 type of water from Rajanwadi (no.38-39-Jalore) is typical of Jalore granite having TDS value of 1,200 mg/1 and fluoride content of 7 mg/1. The higher mineralisation can be attributed to semi arid to arid condition whereeven recharging water itself is saline . The source of fluoride is granite.

The mix type deep waters, from Alwara (No.1), Bautra (No.6), Dahiwa (No.15, 1st zone),Kolar (No.25), Lunasa (No.37), Saila (No.44) etc, mostly occupy the lower part of the area 3 close to 5 B of piper's diagram having transitional chemical characteristics with TDS ranging between 550 mg/1 to about 1,200 mg/1. They gradually change their chemical character from HCO_3- Cl to Cl - HCO_3 type with the increase in mineralisation.

COMBINATION OF CATIONS AND ANIONS IN GROUND WATER OF DEEPER AQUIFERS

S.No. Formation.	Dominant cation.	Dominant anion				Total
		Bicarbonate 50%	Mix none	Mix 50%	Chloride 50%	
1. Younger alluvium.	Na +K	1	2		6	9
	Ca+Mg	-	-		-	-
	Mix	-	-		-	- = 9
2. Older alluvium	Na +K	3	3		13	19
	Ca+Mg	2	-		-	2
	Mix	-	-		1	1 = 22
3. Granite	Na + K	-	1		4	5
	Ca + Mg	2	-		-	2
	Mix.	-	1		-	1 = 8
4. Tertiary.	Na + K	-	2		8	10
	Ca + Mg	-	-		-	-
	Mix.	-	-		-	- = 10
TOTAL		8	9		32	49

RANGES OF SOME CHEMICAL CONTENT IN TYPES OF WATER OF DEEPER AQUIFER

	MIXED TYPE			BICARBONATE TYPE			CHLORIDE TYPE		
	Min.	Max.	Average	Min.	Max.	Average.	Min.	Max.	Average.
T.D.S.	550 Bautra	2020 Bhinmal Golia	1166	220 Jaitpura	1190 Rajanwadi Obs.	575	574 Bautra	40500 Dungri	7510
Cl	107 Paoli	673 Dahiwa	299	12 Panseri Obs.	228 Rajanwadi Obs.	90	143 Bautra	23180 Dungri	3624
SO_4	22 Bautra	223 Dahiwa	96	2 Penseri	84 Raniwara 48 M	32	22 Bautra	6920 Tarwara	885
NO_3	nil Saila	410 Paoli	100	Tr. Rajanwadi Obs.	25 Penseri		nil Bagra, Daspa, Meda Modran, Rai- -thal, Sanka- -rna, Umedpura etc.	170 Obs.	34
F	nil Bautra	7.00 Paoli	2.49	nil Jaitpura Penseri	7.00 Rajanwadi	2.60	nil Bautra Rama etc.	10.00 Raithal	2.22
TH	75 Alwara	446 Kolar	189	70 Rajanwadi	221 Raniwara 48 M	145	190 Pladar	5973 Hariyali	1460

Chloride type of waters representing mostly older alluvium and tertiary occupy the extreme end of the area 3 of piper's diagram. They are saline waters and generally away from the recharge zone. The water of chatwara, Chajjala, Dungari, Raithal, Bharajun and Tarwara almost fall near the plot of sea water, exhibiting $Na-Mg-Ca-ClSo_4 - HCo_3$ type of chemical character.

The sole association of sodium as dominating ion in respect ofmix and chloride type of deeper water indicates the slow circulation resulting in base exchange, and concentration due to very poor permeability of formation (older alluvium, & tertiary).

While superimposing these three types of deep ground water on the map (plate-Iv) showing areal distribution of chemical type of phreatic water it is observed that they are occupying the same zones which have been demarceted for phreatic water. However in saila the extention of mix type of character in deeper aquifer is observed upto Alwara and Dahiwa where /phreaticwater as chloride dominating.

Like phreatic aquifer the cationic ratios viz. Na/Ca, $Na/Ca+Mg$ and Ca/Mg have provided valuable information on different types of water. Their values are shown below in tabular form

Type of water.	RATIO								
	Na/Ca			Na/Ca+Mg			Ca/Mg		
	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.
Bicarbo-nate	0.34	20.17	6.18	0.22	11.96	3.63	0.61	[illegible]	[illegible]
Mix type	1.10	16.61	10.43	0.71	9.98	5.75	0.50	[illegible]	[illegible]
Chloride type	1.50	32.16	11.12	0.76	13.68	3.90	0.18	[illegible]	[illegible]

The following observations are made from the above table:

1. The minimum and the average values of Na/Ca and Na/Ca +Mg ratio show increasing trend from bicarbonate to chloride type of water. However the maximum value for mix type shows a decline instead of proportional rise, which can be attributed to calcare--our nature of the formation material where mix type of water circulates.

2. Like phreatic aquifer, the Ca/Mg ratio shows the similar trend, the minimum and the average value show the declipe but the maximum shows rise.

The decreasing trend in minimum and average value from bicarbonate type of chloride type with rise in salinity indicates that calcium fluctuates within limited range due to low solubilities of its salts while like sodium, magnesium salts are soluble, so its concentration is likely to ncrease in chloride type of saline water.

Only one analyse of chloride type and two of mix type have Ca/Mg ratio above 2 otherwise the trend in maximum value should have been in expected decreasing order.

The trend (increasing or decreasing) in cationic ratio has provided useful informations on chemical type of water.

CHAPTER - 4

SUITABILITY FOR DRINKING

Water used for domestic and drinking purposes should be free from any bacterial contents, turbidity, colour and odour. In Jalore district, ground water is assuming a great importance for domestic utilisation because rainfall is below normal and surface storages are insufficient to meet the perennial requirements. Ground water (protected) generally do not contain suspended matter and bacteria, its use for domestic purpose has been solely considered on the basis of the chemical composition of its solutes or dissolved solids.

The concentration of emany chemical substances in potable water varies widely from place to place so the rigidity of standards of quality can not be enforced. However the potability of ground water of the district has been adjudged mainly on the basis of drinking water standards recommended by the Indian Council of Medical Research (1975). A comparison of standards from World Health Organisation (International) along with I.C.M.R. has been given in table - IX showing maximum concentrations generally acceptable to consumers and also maximum allowable concentration beyond which potability is seriously impaired. The important cons--tituents like - total dissolved solids, chlorides, sulphates, nitrates, fluorides and hardness in ground water are discussed here.

TOTAL DISSOLVED SOLIDS:

The I.C.M.R. recommended an acceptable limit of 500 mg/l and maximum permissible limit of 1500 mg/l of T.D.S It has further relaxed the limit upto 3000 mg/l where better quality of water are not available, provided they do not contain harmful constitutents. It has been observed that people in arid and semi-arid regions drink waters with T.D.S. between 2,500 to 4,000 mg/l and no harmful physiological effects of permanent nature are noticed.

Plate II showing the distribution of total dissolved solids in ground water depicts complete picture of salinity in phreatic and deeper aquifers. It reveals that fresh waters with T.D.S. less than 1,000 mg/l occur in Jaswantpura, Raniwara, and along the banks of river Sukri, while potable waters, having T.D.S. upto 3,000 mg/l are observed in parts of Saila, Jalore, Ahore and Bhinmal. Non-potable saline waters (TDS 3000 mg/l) occur in Sanchore, north-west of Bhinmal west of Saila and north of Ahore, creating serious drinking water problem.

The table X gives the ranges of total dissolved solids in phreatic and deeper ground waters of different blocks of the district. It is observed from the table that 29% of well waters and 43% of tube well waters have TDS value less than 1,500 mg/l, the maximum permissible limit of I.C.M.R. Further 26% and 12% of water from phreatic and deeper aquifers respectively have been found to range between 1,500 to 3,000 mg/l.

43% of the well waters, having more than 3,000 mg/l of T.D.S., are widely distributed throughout the district except Raniwara and Jaswantpura, They should not be used for drinking. Similarly saline deeper waters (45%) from Bhinmal, Jalore and Sanchore should also be rejected. However these saline waters can be used for livestocks.

TABLE - IX

I.S.I.(1975) STANDARDS OF OPHYSICAL AND CHEMICAL QUALITY OF POTABLE WATER COMPARED WITH STANDARDS OF WORLD HEALTH ORGANISATION

No. Water classification and substances.	Units	W.H.O. International(A)		Indian(B)		
		Acceptable.	Allowable.	Acceptable.	Permissible.	Relaxable
1.	2.	3.	4.	5.	6.	7.	8.
1. WATER FOR GENERAL DOMESTIC USE						
1.1. Colour.	mgpt/L	5	50	5	25	-
1.2. Turbidity	mhSio_2/L	5	25	5	25	-
1.3. Taste	-	n.o.	n.o.	n.o.	n.o.	-
1.4. Odour	-	n.o.	n.o.	n.o.	n.o.	-
2. WATER OF SALINITY AND HARDNESS						
2.1 pH	-	7.0-8.5	6.5-9.2	7.0-8.5	6.5-9.2	-
2.2. Total dissolved solids.	mg/L	500	1500	500	1500	3000(b)
2.3. Total hardness.	mgC CO_3/L	n.m.	n.m.	300	600	-
2.4. Calcium, Ca	mg/L[a]	75	200	75	200	-
2.5. Magnesium, Mg	mg/L	50	150	50(a)	100	-
2.6 Magnesium+sodium sulphate	mg/L	500	1000	-	-	-
2.7. Sulphate, SO_4	mg/L	200	400	200	400	-
2.8. Chloride, Cl	mg/L	200	600	200	1000	-
3.1. WATER AFFECTING HUMAN HEALTH						
3.1.1. Fluoride, F.	mg/L	n.m.	1.5	1.0	2.0	-
3.1.2. Nitrate, NO_3	mg/L	n.m.	30	20	[illegible]	100(c)

1.	2.	3.	4.	5.	6.	7.	8.
3.2.	WATER CAUSING TOXIC EFFECTS						
3.2.1.	Lead, Pb	mg/L	n.m.	0.03	-	0.10	-
3.2.2.	Arsenic, As	mg/L	n.m.	0.05	-	0.05	-
3.2.3.	Selenium Se	mg/L	n.m.	0.01	-	0.01	-
3.2.4.	Chromium (b+), Cr	mg/L	n.m.	0.05	-	-	-
3.2.5	Cyanide, CN	mg/L	n.m.	0.20	-	0.05	0.05
3.2.6.	Cadmium, Cd	mg/L	n.m.	0.01	-	0.01	-
3.2.7.	Berium, Ba	mg/L	n.m.	1.00	-	-	-
3.2.8.	Mercury, Hg	mg/L	n.m.	n.m.	-	0.001	-
3.2.9.	Silver, Ag	mg/L	n.m.	n.m.	-	-	-
3.3.	WATER WITH NON-TOXIC METALS						
3.3.1.	Iron, Fe	mg/L	0.3	1.0	0.1	1.0	-
3.3.2.	Mangenose, Mn	mg/L	0.1	0.5	0.1	0.5	-
3.3.3.	Copper, Cu	mg/L	1.0	1.5	0.05	1.5	-
3.3.4.	Zinc, Zn	mg/L	5.0	15.0	-	-	-
3.4.	WATER WITH ORGANIC POLLUTION OF NATURAL ORIGIN						
3.4.1.	BOD 5	mgO_2/L	n.m.	6	-	-	-
3.4.2.	PV (Oxygen obs. $KMnO_4$)	mgO_2/L	n.m.	10	-	-	-
3.4.3.	Ammonia, NH_3	mg/L	n.m.	0.5	-	-	-
3.4.4.	TOTAL NITROGEN, EXCLUSIVE NITRATE.	mg/L	n.m.	0.1	-	-	-

1.	2.	3.	4.	5.	6.	7.	8.
3.5.	WATER WITH ORGANIC POLLUTION INTRODUCED ARTIFICIALLY.						
3.5.1.	Surfactants ABS	mg/L	0.5	1.0	-.	-	-
3.5.2.	Organic matter as carbon in chloroform extract.	mg/L	0.2	0.5	-	-	-
3.5.3.	Phenolic substance as phenol.	mg/l	0.001	0.002	0.001	0.002	-

NOTE: n.m. = Not mentioned.

n.o. = Unobjectionable.
(X) = Odour scale in U.S.A.
(A) = International standards for Drinking water, . W.H.O. Geneva, 1963.
(B) = I.C.M.R. Standards for Drinking Water, India (1975)
(a) = Not more than 50 mg/L, if there are 200 mg SO_4/L; if there is less sulphate, magnesium upto 100 mg/L may be allowed. At the rate of 1 mg/L Mg for every 4 mg/L decrease in sulphate.
(b) = Total Dissolved solids relaxable upto 3000 mg/L in cases where alternete sources are not available within reach.
(c) = More information is required to prescribed e value but in no circumstances should the level exceed 100 mg NO_3/L.

-.-.-.-.-.-

TABLE - X

DISTRIBUTION OF (T.D.S.) TOTAL DISSOLVED SOLIDS IN GROUND WATER

S. No.	Block.	Source	No.of samples.	Renge of T.D.S. in mg/l 0-500	500-1500	1500-3000	Above 3000
1.	Ahore.	Dug wells	25	-	5	8	12
		Tube wells.	10	-	3	2	5
2.	Bhinmal	Dug wells.	22	1	3	6	12
		Tube wells.	10	-	3	1	6
3.	Jalore	Dug wells.	14	1	4	3	6
		Tube wells.	4	-	2	2	-
4.	Jaswantpura	Dug wells.	16	1	7	6	2
		Tube wells	7	2	3	-	2
5.	Raniwara	Dug wells.	27	3	15	4	5
		Tube wells.	5	2	1	-	2
6.	Sanchore.	Dug wells.	37	1	1	10	25
		Tube wells	6	-	-	-	6
7.	Saila.	Dug wells.	24	1	6	7	10
		Tube wells.	7	-	5	1	1
TOTAL:		Dug Wells.	165	8 (4.85)	41 (24.85)	44 (26.67)	72 (43.64)
		Tube wells.	49	4 (8.16)	17 (34.69)	6 (12.24)	22 (44.7)

NITRATE - NO_3 :

Nitrate poisoning has been confined to infants less than three months old but adults drinking the same water are not effected. Gastrointestinal troubles are reported when waters containing high nitrates ($\geq$ 100 mg/l) are used for drinking.

Since the level of nitrate in drinking water is initial factor for determining its fatal effects on infants, the I.C.M.R. after due consideration has recommended 20 mg/l of NO_3 in the water to be used for infants feedings. 100 mg/l is the limit for human consumption.

The distribution map of nitrate plate No.II for phreatic aquifer reveals that major part of the district having T.D.S. more than 3,000 mg/l contains more than 100 mg/l of NO_3 viz. north-east of Jhore, south-east of Jalore and major portion of Sanchore. In fresh water zone (TDS $<$ 1,000 mg/l) nitrate above 100 mg/l is observed towards north-east of Raniwara. In general major part of the district except Sanchore T.S. have nitrate value in phreatic aquifer less than 100 mg/l. The range of nitrate as seen from the table XI indicates that nitrate in deeper aquifer is comparatively very less than that of phreatic aquifer.

TABLE - XI

DISTRIBUTION OF NITRATE IN GROUND WATER

S. No.	Block.	Source	No.of samples.	Range of NO_3 in mg/l			
				0-20	21 - 50	51 - 100	> 100
1.	Ahore	Dug wells.	25	13	6	1	5
		Tube wells.	10	7	1	2	-
2.	Bhinmal	Dug wells.	22	5	5	-	12
		Tube wells.	10	6	1	3	-
3.	Jalore	Dug wells.	14	4	6	1	3
		Tube wells.	4	4	-	-	-
4.	Jaswant-pura.	Dug wells.	16	4	6	4	2
		Tube wells.	7	3	2	-	2
5.	Raniwara	Dug wells.	27	8	9	3	7
		Tube wells.	5	4	1	-	-
6.	Sanchore	Dug wells.	37	9	3	5	20
			6	2	1	1	2
7.	Saila	Dug wells.	24	5	8	4	7
		Tube wells.	7	2	2	2	1
TOTAL		Dug wells.	165	48 (29.09)	43 (26.05)	18 (10.91)	56 (33.94)
		Tube wells.	49	28 (57.14)	8 (16.33)	8 (16.33)	5 (10.20)

FLUORIDE:

Fluorides are regarded as essential constituents of drinking waters for preventing dental carries in children. It has been observed that relative freedom from decay could be conferred by the presence of about 1.0 mg/l in drinking water but concentration over 1.5 mg/l cause mottled enamel. While reguler intake of high concentration of fluoride may cause endemic cumulative fluorosis resulting damage to children and adults.

Therefore, in the assessment of safety of a water supply with respect to the fluoride the total daily fluoride intake by the individual must be considered which inturn depends upon the climatic conditions. In view of the above observations the I.C.M.R. (1975) has suggested 1.0 mg/l as acceptable limit and maximum permissible limit of 2.0 mg/l in drinking water.

The distribution map of fluoride plate-III for phreatic aquifer reveals that concentration of fluoride above 2 mg/l in ground water having total dissolved solids less than 3,000 mg/l is observed around Bhinmal, south-west of Saila along river Sukari and major portion of Jalore. The table-XII gives different ranges of fluoride in well waters of various blocks of the district.

The area, having TDS value more than 3,000 mg/l in phreatic ground water with fluoride content more than 2 mg/l, are the upper portion of Jhore upto Shankhwali - Manpura, north-west and western

portion of Saila. In general it can be inferred from the distribution map that ground water in Jalore district has fluoride content more than 2mg/l. Jalore, Bhinmal and Ahore blocks are problematic area where several cases of Skeletal fluorosis have been noticed.

Fluoride in phreatic aquifer having TDS less than 3,000 mg/l, varies from 0 to 8 mg/l (Rajanwadi - Jalore) and in deeper aquifer it ranges from 0 to 10.00 mg/l (Raithal). It is observed from the table No.XII that fluoride in deeper aquifer is not as high as in phreatic aquifer.

The potable tubewell waters of Bhinmal - Golia (3.6 mg/l), Punasa (3 mg/l), Modran (5.32 mg/l), Korita (7), Rajanwadi (7.00 mg/l), Sankarna (4.28 mg/l), Paoli (7.0 mg/L) a Flader (2.00 mg/l) should be used only after defluoridation or by mixing water containing no fluoride so that fluoride content will remain below 2 mg/l.

TABLE - XII

DISTRIBUTION OF FLUORIDE IN GROUND WATER

S.No.	Block	Source	No.of samples.	Range of F in mg/l 0 - 1	1 - 2	2 - 4	> 4
1.	Ahore	Dug wells.	25	8	3	8	6
		Tube wells.	10	3	1	3	3
2.	Bhinmal	Dug wells.	22	4	6	4	8
		Tube wells.	10	2	4	3	1
3.	Jalore	Dug wells.	14	4	1	5	4
		Tube wells.	4	-	-	2	2
4.	Jaswantpura	Dug wells.	16	6	3	5	2
		Tube wells.	7	3	-	2	2
5.	Raniwara	Dug wells.	27	12	7	6	2
		Tube wells.	5	3	1	1	-
6.	Sanchore	Dug wells.	37	14	9	10	4
		Tube wells.	6	2	3	1	-
7.	Saila	Dug wells.	24	12	5	4	3
		Tube wells.	7	5	2	-	-
		Total Dug wells	165	60 (36.36)	34 (20.61)	42 (25.45)	29 (17.57)
		Tube wells	49	18 (36.73)	11 (22.45)	12 (24.49)	8 (16.33)

CHLORIDE:

All natural waters contain chlorides. The chlorides are usually taken in the form of common salt as a part of normal diet and are not considered harmful to the consumer unless suffering from dise--ases of heart or kidney. A salty taste is imported to water at chloride concentrations of about 300 mg/l and the tolerance to chloride of human being varies with climate.

Since there are no adverse physiological affect of chloride on consumers, the I.C.M.R. (1975) has suggested acceptable limit as 200 mg/l and maximum permissible limit as 1000 mg/l. The permissible limit appears to be safe for hot climate where it helps in alleviating salt depletion of body. Moreover in hot climatic area mostly saline waters are available for drinking and people are used to their salty taste.

It is observed from the distribution map (Plate No.III) of chloride in phreatic ground water that northern, southern part of Jalore, north-west and north-east of Ahore, western part of Saila, west and south of Bhinmal and around Sanchore block have ground water with chloride content more than 1,000 mg/l The chloride concentration increases as the salinity increases from south to north-west, north and west. The north-west and west appears to be a discharge zone. Most of the wells in Sanchore, Saila, Ahore, Jalore contain high chlorides which restrict their use for domestic utilization. The table gives the ranges of chlorides in the well waters of different blocks.

TABLE XIII

DISTRIBUTION OF CHLORIDE IN GROUND WATER

S.No.	Block	Source	No.of samples.	Range of Cl in mg/l		
				0-200	200 - 1000	Above 1000
1.	Ahore	Dug wells.	25	3	9	13
		Tube wells.	10	-	3	7
2.	Bhinmal	Dug wells.	22	3	7	12
		Tube wells.	10	1	2	7
3.	Jalore	Dug wells.	14	3	3	8
		Tube wells.	4	1	3	-
4.	Jaswantpura	Dug wells.	16	5	7	4
		Tube wells	7	4	1	2
5.	Raniwara	Dug wells.	27	17	6	4
		Tube wells.	5	3	-	2
6.	Sanchore	Dug wells.	37	1	11	25
		Tube wells.	6	-	-	6
7.	Saila	Dug wells	24	3	12	9
		Tube wells	7	3	3	1
	Total	Dug wells	165	35 (21.21)	55 (33.33)	75 (45.45)
		Tube wells.	49	12 (24.49)	12 (24.49)	25 (51.02)

Further the analysis of table No. XIII depicts that the chloride content is high in deeper aquifer and about 51% well waters have chlorides above 1,000 mg/l and therefore are not suitable for drinking.

HARDNESS:

Hardness in water is usually judged, by the consumer by the amount of soap required to produce lather. Hardness is caused by the dissolved calcium and magnesium salts. Iron and aluminium also contribute towards hardness if present in large amounts. The temporary hardness includes that portion of calcium and magnesium that would combine with the bicarbonate and the small amount of carbonate present and can be virtually removed by boiling the water. Similarly the parmanent hardness is caused by those amounts of calcium and magnesium that would normally combine with sulphate, chloride, and nitrate ions present in water. This portion of hardness can not be removed by boiling.

The hard water has no major harmful affects on the health of consumers, but the main deterimental effect of hardness is economical, hence the I.C.M.R. (1975) has promulagated the following limits.

Highest acceptable limit - 300 mg $CaCO_3$/L

Maximum permissible limit - 600 mg $CaCO_3$/L.

On reviewing the value of total hardness (appendix-I) of the phreatic aquifer, it is revealed

that 45% well waters have very high values (above 600 mg $CaCO_3$/L) which are distributed through out the district.

Table No.XIV shows the distribution of hardness in phreatic as well as deeper aquifers of the district. It is observed from the table that hardness in water in deeper aquifer is comparatively less than phreatic well waters. The Dug well yielding water with hardness above, 1,000 mg $CaCO_3$/L should not be used for drinking purpose. Thus well waters of Bala (TH-2, 255 mg $CaCO_3$/L), Meda (1,615 mg Ca CO_3/L), Dhanpura (4,500 mg $CaCO_3$/L), Korka (1,386 mg $CaCO_3$/L), Ankhol (2,677 mg $CaCO_3$/L), Dungri (1,420 mg $CaCO_3$/L), Amli (1,126 mg $CaCO_3$/L), Bhawatra (2,032 mg $CaCO_3$/L), Bishangarh (1,981 mg $CaCO_3$/L) etc. are very hard. They are also saline (TDS $>$ 5,000 mg/L), thus not potable. Water sample of well at Agdawa having hardness more than 1,000 mg/l but TDS less than 2,500 mg/l is to be rejected on the basis of high value of hardness and fluoride (F. 4. mg/L).

TABLE - XIV

DISTRIBUTION OF HARDNESS VALUES IN GROUND WATER

S.No.	Block	Sources.	No.of samples.	Range of TH in mg/l 0 - 300	300 - 600	> 600
1.	Ahore	Dug wells	25	5	6	14
		Tube wells.	10	2	3	5
2.	Bhinmal	Dug wells.	22	8	1	9
		Tube wells.	10	4	1	5
3.	Jalore	Dug wells.	14	4	3	7
		Tube wells.	4	2	2	-
4.	Jaswantpura	Dug wells.	16	5	8	3
		Tube wells	7	3	3	1
5.	Raniwara.	Dug wells	27	14	6	7
		Tube wells	5	3	1	1
6.	Sanchore	Dug wells	37	4	9	24
		Tube wells	6	1	1	4
7.	Saila	Dug wells	24	7	6	11
		Tube wells	7	6	-	1
Total:		Dug wells.	165	47 (28.48)	43 (26.06)	75 (45.45)
		Tube wells.	49	21 (42.86)	11 (22.45)	17 (34.69)

SULPHATE:

Higher concentrations of sulphate (above 400 mg/l) in drinking water may have a laxative effect on new users but normally do not effect the taste. The I.C.M.R. (1975) has recommended an acceptable concentration of 200 mg/l and 400 mg/l as maximum permissible concentration.

The table No. XV shows the concentration of sulphate in water samples collected from different blocks of the district.

On going through the table it is seen that 24.24% of samples from phreatic aquifer and 32.65% of samples from deeper aquifer have sulphate content above 400 mg/l and as such they are not safe for drinking. The high sulphate content was observed mostly in high saline waters of Bhinmal and Sanchore blocks. Only in one analysis of Murtara Silli of Jaswantpura both sulphate and magnesium have exceeded the limits of potability. Nitrate is also high 600 mg/l, therefore it should not be used for drinking.

It is inferred from the above discussions that drinking water is a problem in major part of Sanchore block, north-west of Saila, north of Ahore, central part of Bhinmal, and southern part of Jalore as some of the chemical constituents like NO_3, F, Cl, TDS etc. in ground water are beyond relaxable and harmful levels and unfit for human consumption. Water treatment processes to remove them are costly. So

far no concentrated attempt has been made to study the physiological effects of these excessive salts on local inhibitants. However, dental and skeletal fluorosis have been reported in Jalore and Ahore blocks.

A source, free from harmful chemical constituents, within the area has to be found out and protected, else better quality of water has to be transported at a great economic loss.

TABLE - XV

DISTRIBUTION OF SULPHATE IN GROUND WATER

S.No.	Block	Source	No.of samples.	Range of SO_4 in mg/l. 0-200	200 - 400	> 400
1.	Ahore	Dug wells	25	10	4	11
		Tube wells	10	5	2	3
2.	Bhinmal	Dug wells	22	7	6	9
		Tube wells	10	3	3	4
3.	Jalore	Dug wells	14	9	4	1
		Tube wells	4	4	-	-
4.	Jaswantpura	Dug wells	16	11	3	2
		Tube wells	7	5	-	2
5.	Raniwara	Dug wells	27	23	4	-
		Tube wells	5	3	1	1
6.	Sanchor	Dug wells	37	10	15	12
		Tube wells	6	-	1	5
7.	Saila	Dug wells	24	10	9	5
		Tube wells	7	4	2	1
	Total	Dug wells	165	80 (48.48)	45 (27.27)	40 (24.24)
		Tube wells	49	24 (48.98)	9 (18.37)	16 (32.65)

CHAPTER-6

SUITABILITY FOR IRRIGATION

It is well known fact that the prosperity of an area is directly related to its irrigated lands. In semi-arid region like Jalore, the main source of irrigation is ground water because rainfall is limited and no other source of irrigation is available. Development of soil salinity and alkalinity are intimately related to the chemical composition of irrigation waters which in turn effects the crop productivity. Therefore, the quality of ground water is very important in determining its suitability for irrigation. Besides the chemical quality of ground water, the following factors should also be given due considerations for determining the quality standards of irrigation waters. Factors effecting the quality of water for irrigation are:-

A. CLIMATE: It has a bearing on salinity in soils due to precipitation and evaporation. Salt tolerance of crops also depends upon climatic conditions.

B. TOPOGRAPHY: It is responsible for drainability of soluble salts in soils.

C. SOIL CHARACTERISTICS: Texture, nature of clay minerals, organic matter, nature and concentration of salts present in soils are few important characteristics which determine the effect of irrigation water on the soil.

D. SALT TOLERANCE OF CROPS: Type of crops to be grown also determines the suitability of irrigation water. Crops like Bajara, Cotton, Jawar etc. can be grown with relatively saline waters on saline soils while the some water may not be suitable for irrigation of the salt sensitive crops (Citreus, lemon etc.) even on good soils.

E. EFFECT OF FERTILIZERS AND MANURES:
Though the use of fertilizers and manures increases the crop productivity, their effects on soil properties with respect to the type of fertilizers being applied to the soils can not be ignored.

F. WATER AND SOIL MANAGEMENT PRACTICES:
These control the accumulation of soluble salts in soils depending upon the texture of soils, water applied and drainability of the area.

CLASSIFICATION OF IRRIGATION WATER:

The water quality criteria for irrigation is a complex subject and as such it has never been possible to have a fool proof criteria because the growth of a specific crop depends on various factors and not merely on the chemical composition of irrigation water. But it was soon realized that the factors enumerated above are responsible for this complexity. Thus the criteria which have been proposed by various workers for assessment of quality of irrigation water may not be applicable under particular condition. However, for classification of the ground water for irrigation purposes, chemical composition of the water alone has been taken into consideration and following parameters for evaluating the suitability of water for irrigation have been studied.

1. Total soluble salts evaluated as Electrical conductivity.
2. The proportion of cations viz. SAR and sodium persent.
3. The relation of bicarbonate to alkaline earths.

The final recommendations for irrigation use have been considered on the basis of water Rating criteria proposed by Anonymous (1972), as it takes into account all the related factors viz. soils, waters and crops.

TABLE - XVI

ANONYMOUS WATER QUALITY RATINGS (BHUMBLA ET. AL-1972) ALONG WITH DISTRIBUTION OF SALINITY IN GROUND WATER.

Nature of soil	Crops to be grown.	Upper permissible limit of E.C.of water for safe use for irrigation.	No.of water samples		Percentage of water samples	
			Phreatic aquifer.	Deeper aquifer.	Phreatic aquifer.	Deeper aquifer.
1.	2.	3.	4.	5.	6.	7.
1. Deep black soils and alluvial soils having a clay content more than 30% soils that are fairly to moderately well drained.	Semi tolerant Tolerant.	1500 2000	44	18	26.7	36.7
2. Heavy textured soil having a clay content of 10-20%, soils that are well drained interna--lly & have a good surface drainage system.	Semi tolerant. Tolerant.	2000 4000	40	9	24.2	18.4
3. Medium textured soil having a clay content of 10-20% soils that are very well drained internally & have good surface drainage system.	Semi tolerant. Tolerant.	4000 6000	36	4	21.8	8.2
4.Light textured soils having clay content of less than 10% soils that have exoellent internal & surface drainage.	Semi tolerant. Tolerant. Above.	6000 8000 8000	16 29	5 13	9.7 17.6	10.2 26.5

NOTE:

1. In the above proposed limits of water quality it is presumed that the ground water table at no time of the year is with in 1.5 metres from the surface. If the water table does come up within the root zone the above limits need to be reduced to half the above values.

2. If the soils have impeded internal drainage either on account of presence of harf pans, unsually high amounts of clay or other morphologic reasons, for advisory purposes, the limit of water quality should again be reduced to half.

3. If the waters contain soluble sodium percentage more than 70, gypsum should be added to soil occassionally.

4. If supplemental canal irrigation is available waters of Higher electrical conductivity could be used profitably in lean periods.

5. The above scheme act only as guidelines and the actual user should keep in view the specific local conditions.

However, passing reference has been made to classify the analyses based on modified U.S. salinity Laboratory diagram. According to it, nearly 40% waters fall in C_5 -S_4 (EC 4000 - 6000 µS/cm) and C_6-S_4 (EC 6000 - 10000 µS/cm) group and 10% in C_7-S_4 (EC 10000 µS/cm) group, hence can not be utilised on most of the soils for irrigation purpose. But rest of the 50% analyses are falling under C_2 to C_4 class of EC and S_1 to S_3 and even S_4 class of sodium adsorption ratio. They can be utilised with due precautions on most soils, however on clayey soils management practices are to be followed.

Since the soils of Jalore district are mainly sandy, loamy sand and sandy loam, the classification proposed by Anonymous (1972) holds good as a guideline under the conditions prevailing in the district.

ANONYMOUS WATER RATING CRITERIA (1972):

It is based on field experience of various agricultural experts working on utilisation of saline water under various soil conditions and different crop patterns. It takes into account the salinity hazard in terms of electrical conductivity of water and alkalinity hazard as sodium percentage and residual sodium carbonate.

SALINITY HAZARD - ELECTRICAL CONDUCTIVITY:

165 and 49 representative analyses of ground water from phreatic and deeper aquifer respectively are grouped in different E.C. ranges and are presented, percentage wise, in table XVI.

Distribution of water samples of different EC ranges shows that 72.7 percent of analyses are equally distributed in EC range upto 6000 µS/cm while 17.6 percent analyses show salinity more than 8000 µS/cm and the remaining 9.7 percent have salinity between 6000 to 8000 µS/cm.

Plate IV based on periodic water analyses from phreatic as well as from deeper aquifers, depicts that the ground water in the district is of moderate to high salinity. Distribution of EC ranges in water samples of different panchayat samities show that ground water in Jaswantpura, Raniwara, part of Saila and part of Jalore is comparatively of low salinity where as ground water in Bhinmal, Sanchore, Ahore is of high salinity. The entire western part of the district has saline ground water having EC value more than 8000 µS/cm. However, localised fresh water pockets, usually perched water, observed here and there in this salinity infested western part but they are of no significance for any meaningful utilisation.

Soils are mostly sandy, loamy sand and sandy loam in textures with depth generally exceeding 60 cm. Water table is fairly deep. Hence, use of waters upto 8000 µS salinity for irrigation is not likely to result in increase of salinity of the irrigated soils except in certain isolated patches of high clay content. Waters with EC more than 8000 µS/cm should not be generally used. However, in certain area high salinity waters are being used for growing salt tolerant crops mainly Kharchia wheat, by adopting proper irrigation practices.

Salt tolerant crops viz. wheat, rayda, barley, sunflower etc. can be successfully cultivated with these waters with appropriate level of fertiliser application and providing 30&50 percent additional irrigation water for leaching. Normal to above normal rainfall occuring in the district can be considered sufficient for leaching soluble salts accumulated in the soils as a result of irrigation with saline waters.

SODIUM HAZARD:

The sodium hazard in irrigation waters was evaluated on the basis of soidum to other cationic ratios such as SAR, sodium percentage and Na/Ca or Na/Ca+Mg. Sodium in relation to other cations of the water, effects the soil characterics. Soils irrigated with high sodium water become impermeable and hard creating serious drainage problem. It also deprives the plants from available micronutrients for maintaining healthy condition. On the other hand a low ratio tends to maintain the soils in good condition favourable for good crop.

SODIUM/CALCIUM AND SODIUM/CALCIUM & MAGNESIUM VALUES:

If the ratios exceed 1 in irrigation waters, sodium accumulation tends to become a problem in the soils. It is particularly true for the soils having high clay content but on sandy soil water with high ratios can be used. It is less than 1 in about 10 percent of analyses thus remaining waters, when used for irrigation can cause sodium problem.

SOIDUM PERCENTAGE - Na%

Anonymous water rating criteria (1972) has indicated that waters with sodium percentage more than 70 create sodium accumulation in soils. As seen from table XVIII more than 40 percent and 65 percent analyses for phreatic and deeper respectively have sodium percentage above 70 and their use for irrigation needs suitable amendment. In such cases application of gypsum directly to the soils is effective.

RESIDUAL SODIUM CARBONATE- RSC:

Residual sodium carbonate is often found in appreciable quantities in waters of low salinity. When waters containing high RSC are used for irrigation, they effect the soil characteristics adversely because of their strong alkaline nature.

The water rating criteria has indicated that waters with RSC upto 2 meq/1 can be used for irrigation without needing any amendment, but when exceeds this value, grinded gypsum at the rate of 8.5 quintal per hcatare meter of water is to be applied to counter-act theeffect of 1 meq/1 RSC of irrigation water.

It is seen from the table XVII that 63% and 61% analyses from phreatic and deeper aquifer respectively do not show any RSC value while 25% and 27% analyses respectively have RSC value above 2 meq/1 needing corrective measures like application of gypsum. The table further indicates that the RSC toxicity is high in low EC waters (< 4000 $\mu S/cm$) as compared to high salinity waters.

Sodium hazard, contributed by any of the above discussed properties can be reduced to a minimum level by correct application of gypsum to the soils as suggested.

The discussions, on salinity and sodium hazards of the ground water of Jalore district, have lead to the conclusion that with proper soil-water plant management the ground water with E.C. less than 8,000 µS/cm can be profitably used for irrigation purpose mainly for semi-tolerant and tolerant crops as the soil conditions are favourable.

TABLE - XVII

DISTRIBUTION OF SOIDUM PERCENT AND RESIDUAL SODIUM CARBONATE IN GROUND WATER

S. No.	E.C. µS/cm	SODIUM % (No. of analyses)						RSC (No.of analyses)							
		Phreatic			Deeper			Phreatic				Deeper			
		70%	70%	Total	70%	70%	Total	0	2	2	Total	0	2	2	Total
1.	0 - 2000	38	6	44	11	7	18	12	16	16	44	5	5	8	18
2.	2000 - 4000	25	15	40	2	7	9	26	3	11	40	4	1	4	9
3.	4000 - 6000	19	17	36	-	4	4	29	0	7	36	3	0	1	4
4.	6000 - 8000	7	9	16	-	5	5	11	1	4	16	5	0	0	5
5.	8000	9	20	29	4	9	13	26	0	3	29	13	0	0	13
TOTAL:		98	67	165	17	32	49	104	20	41	165	30	6	13	49
%		59.4	40.6		34.7	65.3	-	63.0	12.1	24.9		61.2	12.2	26.6	

CONCLUSIONS

Waters of Jalore district, from phreatic and deeper aquifer have been analysed chemically and studied for chemical properties of water bearing formations and chemical types. These have been further interpreted for domestic and irrigation utilisation.

Phreatic water occuring in three major water bearing formations viz. younger alluvium, older alluvium and granite is fresh to saline. Saline water, with E.C. above 8,000 µS/cm occurs in Sanchore, north of Ahore, south-west and north-east of Jalore and part of Bhinmal (Plate-I.).

Ground water occuring in younger alluvium covering an area around the confluence of Luni and Jawai - Sukri rivers is less mineralised having bicarbonate, bicarbonate- chloride to chloride type. Saline ground water occurs in discharge zone, west of Sanchore.

Older alluvium, distributed mainly in north-eastern, south western, western and central parts of Jalore mostly yields sodium chloride type saline to highly saline water. More than 30% of analyses from this formation have high contents of nitrate, fluoride and chloride, prohibiting their use for domestic utilisation.

Both fresh and saline waters occur in granites. Fresh to moderately saline waters occuring near the foot hill zone of Jalore, Jaswantpura and

Raniwara are soft with high content of fluoride. Saline waters occuring around Bhinmal and Ahore are of chloride type. Defluoridation or dilution by low fluoride water is suggested for bringing down the harmful level of fluoride before the water is supplied for drinking.

The gradual change of chemical type with the increase in total concentration from Siwana hills to south-west (Bagora) and from foot hills zones of Jaswantpura and Raniwara to north-west and west is confirming to flow direction.

Deep ground waters are hard and more mineralised in Sanchore, Ahore and Jalore but around Jodhawas, Punasa in Bhinmal and near Alwara- Dahiwa in Saila they are comparatively less mineralised. The chemical contents, like TDS, Chloride, Sulphate etc. of deeper ground water representing older alluvium, younger alluvium and granites are comparatively higher than those of phreatic ground water. However the concentrations of nitrate and fluoride are compara-tively less.

The ground water from the tertiary, hither to concealed, but now a promising potential aquifer has a tolerable quality of water (Jodhawas, Bhinmal) and can be exploited for both agricultural and domestic utilisation.

The change in chemical type of deeper ground water i.e. from bicarbonate to chloride type is well in confirmation with that of phreatic water. However, the ground water of phreatic aquifer from Dahiwa and Alwara are chloride type but in deeper water they are either bicarbonate type or mixed type.

The suitability of ground water for drinking purposes was judged on the basis of standards recommended by I.C.M.R. (1975). Only 29% and 42% analyses from phreatic and deeper ground water respectively fall under permissible level of TDS i.e. 1500 mg/l though some of them are not potable because of their high contents of nitrate and fluoride. However, 43% and 44% analyses from phreatic and deeper ground water respectively are unsuitable. Their total dissolved contents have exceeded the value of 3000 mg/l. Majore part of Sanchore, north-west of Saila, north of Ahore, central part of Bhinmal and southern part of Jalore have such unsui--table waters unfit for human consumption. Drinking water is a major problem of these area.

The recommendations on suitability of ground water for irrigation, are based on anonymous water rating criteria (1972) considering both salinity and sodium hazards. According to the classification ground water from phreatic and deeper aquifer having EC value upto 8000 µs/cm can be used for growing tolerant and semi tolerant crops by adopting proper soil water plant managements. 17.6% and 26.5% analyses from phreatic and deeper ground water reapectively are not recommended as their E.C. value have exceeded above 8,000 µS/cm.

..*.*.*.*.*.*.*.*.*.*.*
..*.*.*.*.*.*.*.*.*.*
..*.*.*.*.*.*.*
..*.*.*.*.*
..*.*.*
***

APPENDIX-I

CHEMICAL ANALYSES OF WATER SAMPLES COLLECTED FROM PHREATIC AQUIFER OF JALORE DISTRICT

RESULTS ARE EXPRESSED IN MILLI-EQUIVALENT PERLITER (UPPER VALUE) AND MILLIGRAMS PER LITER/(LOWER VALUE)

Sl. No.	Code No.	Location	ECX10^6 (Micro-Siemens/Cm.	TDS by calculation.	pH	Na^+	K^+	Ca^{+2}	Mg^{+2}	Cl^{-1}	$SO4^{-2}$	CO_3^{-2}	HCO_3^{-1}	NO_3^{-1}	F mg/L	TH mg/L	Na%	RSC
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
AHORE BLOCK:																		
1.	1.	AHORE	1710	1090	7.85	14.13 325	0.07 3	1.56 31	1.25 51	4.31 153	1.87 90	-	11.77 681	0.16 10	4.0	140	83.1	8.86
2.	2.	BALA	18300	11710	7.75	167.46 3850	0.64 25	9.80 196	35.30 429	176.60 6262	19.50 937		9.33 569	0.50 31	3.2	2255	78.55	-
3.	3.	BANKLI	4000	2560	7.7	32.67 750	0.15 6	3.38 68	3.22 39	24.29 861	7.65 367	-	7.84 478	-	5.3	2330	82.9	1.24
4.	4.	BAORI	27000	17280	7.5	241.40 5550	0.13 5	32.50 651	60.90 741	257.0 9123	73.90 3547	-	8.68 530	-	4.4	4670	72.07	-
5.	5.	BHADRAJUN KI DHANI	3100	1980	7.8	21.74 500	0.48 19	4.32 86	2.75 33	14.18 503	3.48 167	-	9.37 572	2.25 140	0.32	353	74.2	2.30
6.	6.	BHAINSWARA	2250	1440	7.7	13.48 310	0.10 4	4.89 100	2.34 28	13.23 469	1.46 70	-	6.37 388	0.24 15	1.0	361	64.8	-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7.	7.	BHAWRANI	8000	5120	7.7	55.45 1275	0.15 6	10.97 220	16.54 201	55.66 1973	17.61 846	-	9.21 562	1.45 90	4.00	1375	66.7	-
8.	8.	BHUTI	4800	2655	7.55	23.05 530	0.30 12	10.97 220	9.73 118	29.11 1032	6.67 320	-	4.61 281	4.03 250	1.00	1035	52.32	-
9.	9.	BEDANA	3200	2050	7.6	18.96 390	0.07 3	6.08 124	6.24 76	21.68 767	1.56 75	-	6.27 383	0.65 40	1.00	616	57.8	-
10.	10.	BIDLI	4500	2880	7.8	21.31 490	0.43 17	11.70 234	9.88 120	31.37 1112	6.67 320		4.90 299	0.72 45	2.96	1079	49.2	-
11.	11.	BITHURA	5000	3200	7.85	43.49 1000	0.05 2	2.76 56	3.93 48	29.01 1029	7.86 378	-	12.84 783	0.32 20	2.64	334	86.6	6.15
12.	12.	DAYALPURA	10500	6720	7.65	86.99 2000	0.92 36	19.04 381	16.32 198	64.44 2290	58.60 2819	-	3.53 215	-	2.32	1768	70.5	-
13.	14.	DODIYALII	1020	650	7.6	5.65 130	0.07 3	2.76 56	1.04 13	4.73 168	0.73 35	-	4.31 263	-	0.32	190	59.3	0.51
14.	15.	DUDIYA	11100	7100	7.9	92.42 2125	0.15 6	12.50 250	11.42 139	74.60 2648	28.10 1350	-	12.94 790	-	4.0	1196	79.32	-
15.	16	GHANA-I	8700	5570	7.5	58.75 1351	0.32 12	13.26 266	17.58 214	64.26 2280	15.14 727	-	10.68 652	0.32 20	1.64	1542	65.3	-
16.	18.	JAITPURA	4800	3072	8.1	40.23 925	0.15 6	3.74 76	6.82 83	23.25 824	9.68 465	-	19.21 1172	0.24 15	4.32	528	78.97	8.65

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
17.	19	KAONLA	6000	3840	7.9	15.65 360	9.97 390	23.40 469	14.72 179	28.16 998	17.00 336	-	11.56 705	7.25 450	0.64	1906	24.55	-
18.	20	MANPURA	7900	5060	7.8	67.41 1550	0.43 17	4.68 95	8.10 98	56.88 2017	9.32 448	-	13.52 825	0.56 35	7.32	639	83.6	0.74
19.	21	NIMBLA	7100	4540	8.5	67.41 1560	0.07 3	1.61 33	3.69 45	37.33 1324	12.85 617	2.16 65	10.49 640	9.67 600	5.32	265	92.62	5.19
20.	22	PADARLI	4300	2750	7.50	22.18 510	0.02 0.8	10.04 201	7.43 90	31.47 1116	3.38 162	-	5.49 335	0.66 10	-	873	56.04	-
21.	23	PARASIA	3900	2500	7.7	22.18 510	0.40 16	5.09 102	8.69 106	27.59 978	1.88 90	-	7.64 466	0.16 10	1.64	689	61.0	-
22.	24	RAMA	2850	1820	7.9	10.87 250	3.58 140	4.78 97	5.72 70	12.66 449	4.01 193	-	3.63 221	4.27 265	0.32	525	43.6	-
23.	25	RUNDMAL-KI-DHANI	9300	5950	8.3	77.20 1775	0.15 6	4.12 82	11.20 136	72.00 2556	17.18 825	0.78 23	4.51 275	0.24 15	4.32	766	83.39	-
24.	26	SANKHWALI	1140	730	7.85	9.13 210	0.07 3	1.14 23	1.56 19	1.23 44	0.80 38	-	10.29 628	-	3.64	135	63.72	7.59
25.	27	UMEDPURA	2130	1360	7.85	14.13 325	0.07 3	3.02 61	2.54 31	10.87 385	1.77 85	-	7.06 431	0.40 25	1.64	278	71.51	1.50

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
BHINMAL BLOCK:																		
26.	28	BAGAWAS	6200	3970	7.75	50.01 1150	0.31 12	4.84 97	10.97 133	44.41 1575	8.88 407	-	10.68 652	1.77 110	1.96	790	75.62	-
27.	29	BHAGAL BHIM	3500	2240	7.6	26.53 610	0.18 7	5.30 108	4.63 56	19.28 684	5.82 280	-	8.82 538	2.18 135	4.32	496	72.40	-
28.	30	BHINMAL	8100	5180	7.5	68.50 1575	0.13 5	5.88 120	7.48 91	62.08 2200	12.13 583	-	7.94 484	-	5.00	668	83.55	-
29.	33	DAMAN	5900	3790	7.8	39.62 750	7.68 300	9.10 180	14.14 172	33.07 1173	15.40 740	-	7.35 448	7.26 450	0.64	1162	51.34	-
30.	36	DUMARIA	2610	1670	8.05	15.22 350	0.08 3	4.68 95	8.42 102	10.39 368	5.10 245	-	7.74 472	4.19 260	3.32	655	53.59	-
31.	37	GOLIA	1860	1190	7.55	14.35 330	0.05 2	2.55 52	2.29 28	8.60 305	1.72 83	-	7.64 466	0.48 30	5.00	242	74.58	2.80
32.	38	JERAN	3400	2180	8.1	22.18 510	0.10 4	5.50 110	6.10 74	20.07 712	6.26 301	-	7.78 475	0.08 5	0.80	580	65.47	-
33.	39	JESAWAS	7500	4800	7.95	69.59 1600	0.23 9	1.60 32	3.10 38	43.45 1541	7.72 371	-	14.90 909	8.87 550	7.64	235	93.38	10.20

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
34.	40	JETU	11700	7490	7.55	95.70 2200	0.10 4	7.90 160	24.66 300	101.50 3602	12.68 609	-	10.58 646	1.69 105	2.32	1128	74.55	-
35	41	JUNJANI	2700	1730	7.85	16.09 370	1.79 70	4.37 88	5.82 71	15.12 536	3.95 190	-	7.45 454	0.80 50	196	509	57.32	-
36.	42	KHUSALPURA	1230	780	7.95	7.61 175	0.82 32	2.34 48	1.98 24	4.25 151	1.06 51	-	6.27 383	0.56 35	2.32	216	59.68	1.95
37.	43	LEDARMER	3150	2010	7.95	19.57 450	0.08 3.1	4.32 86	6.05 74	20.54 727	3.46 166	-	6.47 395	0.65 40	1.60	519	65.19	-
38.	44	MEDA	14100	9025	7.75	132.66 3050	2.56 100	10.50 210	21.80 265	135.60 4810	19.80 951	-	10.40 640	2.90 180	0.32	1615	79.19	-
39.	45	MORSIM	9000	5760	8.6	88.67 2139	1.92 75	1.36 28	4.00 49	60.86 2158	15.48 744	3.14 94	14.99 915	0.80 50	14.20	268	92.41	12.77
40.	46	NANDIA	8600	5500	7.95	71.76 1650	7.03 275	3.74 76	9.56 116	57.08 2024	12.98 624	-	11.74 700	8.87 550	1.96	665	77.92	
41.	47	NAVARAUTA	10500	6720	7.9	86.99 2000	0.74 29	7.70 154	18.30 223	85.98 3052	14.62 702	-	11.27 688	3.06 190	5.32	1300	76.49	-
42.	48	NIMBAWAS	750	480	7.6	4.13 95	0.08 3	2.39 49	1.72 21	2.36 84	0.43 21	-	5.19 317	0.08 5	1.64	205	49.64	1.08

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19
43.	49.	PHAGOTRA	3500	2240	8.0	32.62 750	0.08	1.46 30	2.02 24	21.73 770	2.96 142	-	8.72	2.10 130	1.32	174	90.01	5.18
44.	50.	PUNASA	1230	790	8.00	9.57 220	0.64 25	1.40 29	1.82 22	4.63 164	1.53 73	-	6.17 376	0.24 15	2.32	161	71.26	2.95
45.	51.	RANGALA	10500	6720	8.2	100.03 2300	0.38 15	4.00 80	3.00 36	86.81 3078	13.80 663	-	16.09 982	3.39 210	7.20	350	93.13	9.09
46.	52.	SEWRI	6400	4090	7.85	35.88 825	0.15 6	18.20 365	12.60 153	55.48 1967	6.52 313	-	5.18 316	Nil	Nil	1540	53.69	-
47.	53.	SOBRAWAS	6100	3900	7.85	56.04 1300	0.08 3	0.94 19	2.39 29	36.29 1287	6.34 305	-	13.72 837	4.19 260	8.00	166	94.31	10.39
48.		JALORE BLOCK :																
48.	56.	BAGRA	4500	2880	7.75	34.80 800	0.66 26	7.24 145	4.94 60	32.73 1161	3.39 163	-	10.94 668	0.40 25	1.56	609	73.05	-
49.	57.	BAKRAROAD	3900	2490	7.7	34.14 785	0.04 1.4	1.73 34	3.26 40	19.39 688	7.25 348	-	11.45 699	0.32 20	4.50	250	87.16	6.46
50.	59.	BIDBAR	5400	3950	7.45	39.15 900	0.09 3.5	4.60 92	9.60 117	40.61 1440	3.99 192	-	8.90 540	1.05 65	3.60	710	73.26	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
51.	60.	BOKRA	5200	3330	7.8	25.00 575	0.10 4	12.68 254	12.90 157	42.52 1508	1.06 51	-	7.05 430	0.56 35	0.32	1279	49.30
52.	61.	DHANPURA	16350	10460	7.35	102.21 2950	0.33 13	66.50 1212	21.10 257	165.70 5851	9.80 471	-	8.48 517	0.32 20	-	4050	55.45
53.	62.	GODHAN	4600	2940	7.5	33.66 774	0.07 3	5.04 101	5.82 71	29.38 1042	4.63 222	-	10.38 633	0.24 15	2.64	543	75.46
54.	63.	JALORE	750	480	7.5	2.52 58	0.12 5	2.49 50	2.50 30	1.79 63	0.49 24	-	5.09 311	0.40 25	2.64	249	33.03
55.	65.	MAYLAWAS	1380	883	7.4	2.39 55	3.32 130	4.71 94	2.64 32	2.88 102	0.63 30	-	5.94 362	3.31 205	2.40	368	18.30
56.	66.	MERA-UPARIA	2010	1280	7.6	6.08 140	0.17 7	6.34 127	5.72 70	5.67 201	2.32 111	-	5.68 347	4.59 285	4.32	603	33.20
57.	67.	MESHPURA	5700	3650	7.9	47.84 1100	0.12 5	2.39 48	4.89 59	37.98 1347	7.29 350	-	11.17 682	-	8.00	365	86.60
58.	68.	MITHRI	9500	6080	7.4	59.81 1275	0.10 4	16.84 337	19.04 232	85.98 3052	3.88 186	-	6.07 370	0.65 40	-	1794	60.65
59.	69.	RAJANWADI	1470	940	7.95	11.96 275	1.02 40	1.14 23	2.13 26	2.64 94	1.11 53	-	11.56 705	10.56 635	8.00	163	73.60

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
60.	70.	REWAT	5700	3650	8.0	27.83 640	4.34 170	8.74 175	12.63 [illegible]	41.49 1473	4.48 215	-	4.80 293	2.50 155		[illegible]	51.93	-
61.	71.	SIYANA	1320	845	7.25	8.70 200	0.46 18	2.25 45	1.28 16	6.14 218	1.22 59	-	5.30 323	0.73 45	2.80	177	68.56	1.77
		JASWANTPURA:																
62.	72.	BHARUDI	1290	731	7.6	8.70 200	0.24 1.6	1.92 39	2.16 26	4.12 146	0.06 3	-	7.95 485	0.40 25	2.00	204	67.86	3.87
63.	73.	BUSAON	5850	3520	7.6	48.71 1120	0.11 4.4	3.36 67	4.42 54	42.14 1496	11.21 538	-	5.72 349	0.73 45	4.40	389	86.06	-
64.	74.	CHANDUR	1275	738	7.65	6.31 145	0.08 3.1	3.65 73	2.49 30	5.26 187	0.69 33	-	7.31 446	-	0.80	307	50.36	1.17
65.	75.	DHANJI-KA-BARA.	3950	2170	7.4	26.10 600	0.06 2.3	3.36 67	8.32 107	28.03 994	2.24 106	-	7.31 446	0.57 35	3.60	609	68.08	-
66.	76.	DHANSA	945	583	7.6	6.00 138	0.04 1.6	1.68 33	1.87 23	3.19 112	0.26 12	-	6.78 414	0.24 15	1.60	178	62.56	3.23
67.	77.	GOLANA	2115	1150	7.7	11.41 263	0.15 6	3.66 73	4.71 57	10.67 378	2.08 100	-	7.62 465	-	2.80	419	57.25	-
68.	78.	JHAK	5750	3520	7.4	44.36 1020	1.07 42	5.18 104	6.82 83	36.48 1293	7.36 354	-	10.39 634	4.04 250	2.80	600	77.24	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
69.	79.	JASWANTPURA	1125	625	7.45	5.44 125	0.06 2.3	2.88 58	2.78 34	4.51 160	0.33	-	6.15 375	0.08 5	2.40	283	48.74	0.49
70.	80.	KEBIA	3700	2240	7.95	27.84 640	Tr.	3.43 79	5.51 67	18.96 670	4.06 195	-	12.25 747	1.21 75	4.00	447	75.69	3.31
71.	81.	KORITA	4000	2430	7.6	32.62 750	0.13 5.1	4.51 90	4.12 50	23.81 844	5.24 252	-	11.02 672	0.48 30	0.40	432	78.83	2.39
72.	82.	MANDOLI	2640	1510	7.4	19.14 440	0.16 6.1	3.07 62	2.88 35	15.55 551	1.61 77	-	7.84 478	0.97 60	2.00	298	75.80	1.89
73.	83.	MODRAN	1950	1150	7.9	8.70 200	0.03 1.1	5.33 106	6.38 78	12.00 425	6.05 149	-	4.66 284	0.40 25	0.40	586	42.56	-
74.	84.	MORTARA SILLI	4550	2910	7.45	24.36 560	3.99 156	9.46 190	9.55 116	17.44 618	12.68 609	-	8.37 511	9.68 600	4.80	951	51.44	-
75.	85.	PANSERI	430	270	7.85	0.60 14	Tr.	2.65 54	1.35 16	0.47 17	-	-	3.82 239	0.40 25	0.64	200	13.04	-
76.	86.	PAOLI	1335	760	7.15	5.44 125	0.14 5	4.03 80	3.55 43	4.41 156	0.92 44	-	7.21 440	0.65 40	0.80	379	44.33	-
77.	88.	TATOL	5050	3000	7.3	30.88 710	0.56 22	9.98 200	8.64 105	37.64 1335	6.68 321	-	5.94 362	1.62 100	0.80	931	61.68	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
		* RANIWARA BLOCK :																
78.	89.	AJODAR	640	410	7.6	2.74 63	0.17 7	2.91 59	1.46 18	1.98 70	0.33 16	-	4.80 293	-	1.00	218	38.16	0.4
79.	90.	ALRI	1950	1240	8.4	14.44 332	0.13 5	2.60 53	3.85 47	9.73 345	3.38 158	0.73 23	5.78 353	0.40 25	1.96	322	60.80	0.4
80.	91.	BAMANWARA	960	614	7.4	4.87 112	3.64 33	3.17 65	2.29 28	1.70 60	0.07 3	-	9.41 574	-	0.64	273	43.60	3.9
81.	92.	BANETHA	2760	1760	8.05	11.30 260	0.07 3	4.95 99	7.19 87	10.28 364	3.09 148	-	7.55 461	2.10 130	4.40	606	48.10	-
82.	93.	CHATWARA	5350	3420	7.8	44.58 1025	0.36 14	2.39 49	6.66 81	38.27 1357	5.82 280	-	8.04 491	2.26 140	3.64	452	82.57	-
83.	94.	DADOKI	5100	3260	7.75	36.05 875	0.74 29	8.37 168	4.95 61	27.12 962	7.61 364	-	10.19 622	6.61 410	2.96	668	72.96	-
84.	95.	DHANOL	1470	940	7.85	6.08 140	2.43 95	3.02 62	3.27 40	4.63 164	1.11 53	-	6.37 389	2.10 130	0.64	314	41.08	0.0
85.	96.	DHANWARA	1380	880	7.8	10.00 230	0.66 26	2.03 41	2.02 24	4.82 171	1.73 83	-	7.64 466	0.64 40	3.64	202	67.98	3.59
86.	97.	DIGAON	5500	3520	8.5	52.19 1200	0.08 3	1.09 22	2.96 36	39.59 1404	2.13 102	1.96 59	11.56 705	0.72 45	4.64	202	92.67	7.5

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
87.	98.	PATEHPURA MALWARA	810	535	7.75	3.21 75	0.05 2	2.55 51	3.88 47	2.40 65	0.52 25	-	5.87 358	0.56 35	0.80	321	33.13	-
88.	99.	GANG	1665	1060	8.00	13.48 310	0.95 37	1.72 35	2.07 25	5.38 191	2.77 133	-	8.43 514	0.96 60	3.32	189	73.98	4.64
89.	100.	GOLWARA	2580	1650	7.35	9.78 225	0.05 2	9.98 200	5.88 71	17.86 633	1.82 87	-	5.19 317	0.24 15	0.64	793	38.07	-
90.	101.	HARSHWARA	1050	670	8.4	5.45 130	2.05 80	1.51 31	2.44 30	2.36 84	2.31 111	0.78 23	5.68 347	0.72 45	0.80	197	48.50	2.51
91.	102.	JETPURA	1680	1070	7.7	3.26 75	2.43 95	6.86 137	4.53 55	4.82 171	1.45 70	-	4.80 293	4.92 305	0.64	568	19.09	-
92.	103.	KAGMAL	700	450	7.75	3.47 80	0.07 3	2.44 50	1.93 23	1.32 47	0.28 13	-	5.88 359	0.24 15	1.96	218	43.87	1.51
93.	104.	KARDA	3000	1920	7.8	15.87 388	0.28 11	5.56 111	9.21 112	20.22 717	3.02 145	-	6.47 395	0.72 45	2.32	738	52.85	-
94.	105.	KORKA	6100	3900	8.4	38.04 875	0.25 10	10.19 204	17.53 213	48.38 1715	3.94 189	1.37 41	12.25 747	-	0.32	1386	57.63	-
95.	106.	LAKHAWAS	830	530	7.65	3.96 91	0.08 3	3.17 65	2.24 27	2.55 90	0.23 11	-	6.17 395	-	1.64	270	41.90	1.06

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
96.	107.	MARUWARA	915	585	7.9	4.43 102	0.18 7	2.24 46	3.53 43	2.93 104	0.69 33	-	5.68 347	0.72 45	1.64	288	42.68	-
97.	108.	PAL	1125	720	7.7	2.83 65	4.35 170	2.34 48	2.29 28	1.79 63	1.30 62	-	5.49 335	2.58 160	1.00	231	23.96	0.86
98.	109.	RAMPURA	430	275	7.6	0.78 18	0.12 5	2.44 50	1.30 16	0.57 20	-	-	3.82 233	0.40 25	0.64	187	16.81	0.08
99.	110.	RANIWARA	1140	730	7.7	3.04 185	0.54 21	2.08 42	2.13 26	3.31 117	0.23 11	-	9.31 568	0.24 15	1.64	210	62.86	5.10
100.	111.	RATANPURA	1020	650	7.45	5.74 132	0.18 7	2.29 47	3.69 45	4.06 144	0.90 43	-	5.88 359	0.24 15	1.32	299	48.23	-
101.	112.	ROPST	5750	3680	7.6	43.50 1000	0.33 13	8.01 160	7.75 94	45.93 1628	7.08 340	-	5.68 347	0.64 40	3.32	788	73.00	-
102.	113.	RORA	1140	730	7.55	3.26 75	3.32 130	2.24 46	2.68 32	2.17 77	0.80 38	-	7.05 430	1.21 75	1.96	244	28.42	2.16
103.	114.	SEWARA	4400	2810	7.45	27.40 630	0.15 6	9.93 200	8.06 98	25.99 922	5.20 250	-	5.09 311	8.06 500	0.32	889	60.17	-
104.	115.	VANDAR	1170	750	7.85	6.96 160	0.07 3	3.43 70	2.76 34	2.55 90	1.16 56	-	7.55 461	1.29 80	1.00	309	52.65	1.36
		SANCHORE BLOCK:																
105.	116.	AGHALPURA	5200	3330	8.15	36.97 850	0.35 14	4.93 99	12.66 1364	38.46 1364	7.63 166	-	6.96 425	1.37 85	1.12	879	67.33	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19
106.	117.	AGDAWA	3650	2330	7.7	13.04 300	0.07 3	8.29 166	14.01 998	28.16 998	1.44 69	-	4.99 299	1.01 100	4.00	1115	36.82	-
107.	118.	AMLI	13650	8730	7.75	137.01 3150	5.11 200	8.74 175	13.78 163	116.94 4146	1.76 84	-	42.60 2599	0.46 30	4.00	1126	84.33	20.08
108	119.	ANKHOL	19200	12290	7.65	173.98 4000	0.87 34	14.95 299	38.60 469	189.45 6717	21.90 1052	-	7.25 442	5.64 350	3.32	2677	76.17	-
109.	123.	BHADRUNA	3400	2170	7.9	20.01 460	6.14 240	2.62 53	4.83 59	16.73 593	2.70 130	-	9.51 580	3.63 225	0.32	372	59.55	2.06
110.	124.	BHAWATRA	9900	6330	7.5	63.28 1455	0.69 27	21.52 431	19.12 232	91.00 3230	6.14 295	-	4.21 257	-	-	2032	60.49	-
111.	125.	BINJROL	2840	1820	7.7	15.65 360	10.23 400	1.05 21	1.42 17	12.09 429	2.91 140	-	11.76 718	1.12 70	7.32	123	55.20	9.29
112.	127.	BIRAWA	4100	2620	7.3	21.31 490	1.02 40	9.80 196	9.44 115	29.48 1045	3.19 153	-	3.88 237	4.92 305	0.40	962	51.25	-
113.	128.	CHITALWANA	3900	2490	7.3	29.57 680	0.25 10	5.35 117	4.89 59	24.29 861	6.27 301	-	7.45 455	1.61 100	-	512	73.83	-
114.	130.	DEDUA	6000	3840	7.8	40.23 925	3.19 125	5.35 109	14.18 172	46.97 1665	5.01 241	-	7.55 461	2.82 175	1.32	976	63.91	-

1,	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
115.	131.	DHANI-GUDA HEMA	11400	7290	7.25	75.02 1725	6.39 250	6.20 124	12.48 152	71.44 2533	11.48 551	-	9.41 574	1.77 110	3.32	934	75.48	-
116.	132.	DHANTA	3400	2170	7.75	17.83 410	4.35 170	7.12 143	4.99 61	15.95 566	3.29 158	-	5.51 330	8.33 520	-	606	[illegible]	-
117.	133.	DUGAWA	4900	3130	7.65	23.92 550	10.23 400	7.66 153	9.93 121	22.96 814	12.41 596	-	11.86 724	5.24 325	-	899	46.23	-
118.	134.	DUNGRI	4900	3130	7.7	23.80 547	0.25 10	9.76 196	18.64 227	28.16 998	11.62 558	-	6.08 371	5.70 350	1.32	1420	45.38	-
119.	135.	GARDALI	6100	3900	7.85	26.09 600	15.35 600	5.76 115	8.28 101	39.50 1400	7.23 347	-	7.55 461	1.21 75	2.60	702	47.03	-
120.	137.	HOTIGAON	4600	2940	7.85	38.05 875	0.35 14	3.67 73	5.88 72	32.51 1153	6.47 311	-	7.35 448	-	0.64	477	79.35	-
121.	139.	JHAB	9200	5890	7.75	70.67 1625	6.39 250	6.20 124	12.48 152	71.44 1533	11.48 551	-	9.41 574	1.77 110	3.32	934	73.81	-
122.	140.	JODHAWAS	3650	2330	7.55	26.09 600	1.02 40	6.19 124	4.20 51	23.81 844	4.75 228	-	6.76 412	0.72 45	-	519	69.57	-
123.	143.	KHEJDI-YALI	9600	5760	7.65	64.93 1495	1.91 75	15.96 320	12.92 157	78.06 2768	9.38 451	-	5.59 341	-	-	1444	67.83	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
124.	144.	LALPUR	5900	3770	7.4	21.74 500	7.16 280	12.60 253	18.16 221	45.08 1598	2.73 131	-	11.07 675	0.16 10	1.64	1538	36.44	-
125.	145.	MELAWAS	11700	7490	8.15	100.03 2300	0.36 14	7.98 160	22.26 271	104.76 3712	17.36 834	-	4.70 287	-	0.64	1512	76.57	-
126.	146.	NALDHRA	9300	5950	7.65	61.98 1425	0.17 7	16.16 323	18.70 227	78.12 2795	11.06 531	-	4.80 293	1.85 115	2.64	1743	63.60	-
127.	147.	NIMBAU	2040	1300	7.75	10.87 250	3.20 125	2.62 53	3.52 43	9.35 332	3.01 145	-	5.68 347	1.69 105	1.32	307	53.78	-
128.	148.	PATHMEDA	3500	2240	8.10	26.53 610	0.20 8	4.25 85	8.19 100	19.56 694	8.05 387	-	10.19 622	0.24 15	1.64	622	67.73	-
129.	149.	PALADAR	8300	5310	7.75	58.71 1350	7.67 300	5.78 118	15.32 186	58.78 2084	6.76 325	-	12.94 790	7.26 450	1.32	1055	67.11	-
130.	150.	RAMPURA	4900	3130	7.75	29.57 680	2.30 90	8.71 174	10.35 126	34.30 1216	6.43 309	-	8.33 508	1.45 90	0.32	953	58.06	-
131.	151.	RANODAR-KA-GULIA	8600	5500	7.60	70.67 1625	0.33 13	8.50 170	8.93 108	68.80 2439	10.57 508	-	5.68 347	2.66 165	2.32	871	79.91	-
132.	152.	SAKRIA-KI-DHANI	2730	1750	8.05	22.18 510	0.30 12	0.93 19	2.26 27	12.44 441	2.67 128	-	9.59 585	0.48 30	8.00	159	86.40	6.40
133.	154.	SANGDAVA	11100	7100	7.50	91.34 2100	0.48 19	11.76 236	17.00 207	97.14 3444	12.84 617	-	6.08 371	2.42 150	1.64	1438	75.75	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
134.	156.	SARNAU	5600	3580	7.8	40.23 925	0.36 14	9.03 181	9.87 120	41.86 1484	6.48 311	-	9.55 461	2.42 150	0.64	945	67.61	-
135.	158.	SIWARA	5700	3650	8.00	47.34 110	4.47 175	2.73 55	4.72 57	32.98 1161	9.62 462	-	13.72 837	3.22 200	4.64	372	80.05	6.27
136.	159.	SUNIRI	9200	5890	8.7	56.54 1300	2.55 100	17.22 345	18.38 224	82.22 2915	10.20 490	0.39 12	5.90 360	-	-	1780	9.71	-
137.	160.	SURAWA	650	416	7.45	2.74 63	0.08 3	2.78 57	2.52 31	1.42 50	0.85 41	-	5.29 317	0.24 15	0.64	265	33.74	-
138.	161.	TAMPI	6050	3370	7.75	45.67 1050	2.55 100	4.88 98	6.35 77	42.81 151	7.32 352	-	5.88 359	3.63 225	1.64	561	76.82	-
139.	162.	TENTROL	5600	3580	8.25	48.93 1125	0.20 8	1.84 37	5.51 67	39.50 1400	6.48 311	0.39 12	5.09 311	4.51 280	3.64	367	86.63	-
140.	163.	VANK	6700	4290	8.30	59.30 1375	0.17 7	3.99 80	5.14 63	54.15 1928	5.64 271	2.35 71	5.49 335	0.16 10	3.32	456	86.54	-
141.	164.	WIROL	6000	3340	8.05	34.79 800	7.67 300	1.67 33	2.83 34	36.82 1305	6.02 289	-	13.23 809	3.63 225	7.64	225	74.08	8.76
		SAILA BLOCK:																
142.	165.	BAKRA	5200	3330	7.3	25.00 575	0.10 4	12.68 254	12.90 157	42.52 1508	1.06 51	-	7.05 430	0.56 35	0.32	1279	49.30	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
143.	166.	BISALA	5600	3530	7.7	34.79 800	0.35 14	10.92 219	6.50 79	38.08 1350	10.21 490	-	6.37 389	0.96 60	-	871	66.19	-
144.	167.	BAUTRA	2530	1650	7.4	7.82 180	0.15 6	7.28 149	7.12 87	9.07 322	3.55 170	-	4.61 231	6.04 375	-	720	35.00	-
145.	168.	BISAN-GARH	10200	6530	7.6	69.59 1600	0.20 8	19.34 388	20.23 247	87.50 3102	10.78 518	-	9.30 598	0.40 25	0.40	1981	63.60	-
146.	169.	CHARAU	1290	825	7.65	6.52 150	0.15 6	1.92 39	5.00 61	5.20 134	2.98 143	-	6.08 371	0.56 35	1.64	346	48.00	-
147.	170.	DADHAL	5050	3230	8.00	48.93 1125	0.69 27	4.26 85	3.70 45	27.50 975	6.45 310	-	22.05 1345	0.16 10	6.32	398	85.04	14.09
148.	171.	DAHIWA	2760	1765	7.35	20.88 480	0.25 10	4.21 84	2.81 84	15.78 559	3.74 180	-	6.96 425	0.89 55	1.00	351	74.17	-
149.	172.	DETA	1950	1250	7.9	9.13 210	0.51 20	2.83 57	3.66 45	6.85 243	4.47 215	-	4.69 286	1.53 95	2.60	324	56.60	-
150.	173.	GOL	1890	1210	7.9	9.13 210	2.81 110	3.33 68	2.65 32	6.52 231	2.81 135	-	8.23 502	0.48 30	1.00	299	50.94	2.25
151	174.	GOLIA	2940	1880	7.75	25.22 580	0.07 3	1.14 23	2.89 35	10.77 381	6.15 245	-	12.54 765	0.40 25	8.00	201	86.00	8.51

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
152.	175.	HARMU	2550	1680	7.8	22.61 520	0.61 24	0.41 8	1.17 14	8.16 289	5.72 275	-	11.14 680	0.65 40	9.60	79	91.14	9.56
153.	176.	KHATLAUA	5400	3455	8.00	48.93 1125	0.51 20	1.40 28	0.07 37	34.96 1240	4.66 224	-	9.80 598	4.52 230	1.20	223	90.76	5.33
154.	177.	KESHWANA	1260	806	7.6	9.13 210	0.05 2	1.25 26	1.52 18	4.54 161	1.11 53	-	6.57 401	-	3.64	138	76.40	3.80
155.	178.	KUABER	3900	2496	7.6	21.31 490	0.48 19	6.50 130	7.96 97	16.25 576	4.64 223	-	7.15 436	9.35 580	0.80	723	58.78	-
156.	179.	MEGALWA	6700	4290	7.8	46.75 1075	9.59 375	3.03 62	7.74 94	35.74 1267	12.44 598	-	14.08 859	4.19 260	-	541	69.61	3.26
157.	180.	MOKNI-KHERA	1560	990	7.7	6.30 145	0.05 2	6.40 128	2.13 26	5.67 201	1.35 65	-	4.51 275	3.14 195	-	426	42.30	-
158.	181.	OTHWARA	7600	4865	7.9	59.80 1375	0.84 33	6.45 129	10.09 123	48.67 1726	16.70 802	-	12.94 790	0.65 40	1.32	827	77.50	-
159.	182.	PAHAR-PURA	750	480	7.5	4.48 103	0.12 5	1.92 39	0.73 9	1.51 54	0.49 24	-	5.19 317	0.16 10	196	132	61.80	2.54
160.	183.	PANTHERI	13800	8830	7.55	119.61 2750	7.67 300	13.50 270	9.90 120	116.20 4120	16.80 807	-	18.42 1124	0.24 15	1.32	1170	79.40	-
161.	184.	RATUNJA	7000	4480	7.6	46.75 1075	2.55 100	9.88 198	7.90 56	50.37 1786	8.17 392	-	9.70 592	-	-	889	69.69	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
162.	185.	SANPHARA	3200	2050	7.75	12.17 280	1.27 50	10.19 204	6.45 78	20.32 720	3.80 183	-	5.00 305	1.04 5	-	832	40.46	-
163.	186.	SAILA	3500	2240	7.65	16.96 390	0.10 4	6.66 133	10.76 131	21.19 358	4.68 225	-	5.39 329	0.48 30	0.32	871	49.2	-
164.	188.	SIRANA	7300	4670	7.5	63.06 1450	0.56 22	5.09 102	8.64 105	54.71 1940	7.81 375	-	10.98 670	3.87 240	2.64	606	81.52	-
165.	189.	TILORA	1320	845	7.9	9.13 210	0.05 2	2.39 48	2.29 28	5.76 204	1.56 75	-	6.08 371	0.40 25	2.96	234	65.87	1.40

CHEMICAL ANALYSIS OF WATER SAMPLES COLLECTED FROM DEEPER AQUIFERS, JALORE DISTRICT.

APPENDIX - 2

RESULTS ARE EXPRESSED IN MILLI-EQUIVALENT PER LITER (UPPER VALUE)
AND MILLIGRAMS PER LITER (LOWER VALUE).

S. No.	LOCATION	ECX10^6 (Micro-Siemens/cm	TDS (mg/L)	PH	Na^{+}	K^{+}	Ca^{+2}	Mg^{+2}	Cl^{-1}	So_4^{-2}	Co_3^{-2}	HCO_3^{-1}	NO_3^{-1}	F (mg/L)	TH (mg/L)	Na%	RSC (meq/L)
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
1.	ALWARA	1600	958	8.75	14.13	0.05	1.14	0.35	7.62	1.49	1.21	5.45	0.48			90.35	5.17
					325	2	23	4	270	72	36	333	30	0.80	75		
2.	BAGRA (Test well)	3400	2060	7.6	25.92	0.05	4.24	5.09	25.01	3.89	0	7.07	0			72.90	-
					580	2	85	62	887	189		432		2.80	465		
3.	BAGRA	5555	3300	7.80	39.25	1.27	10.60	2.17	32.26	14.01	0	6.07	1.26			73.60	-
					900	50	212	26	1144	673		371	78	2.48	638		
4.	BAGRA (Obs.)	3600	2180	7.8	27.83	0.05	4.64	4.93	26.51	3.97	-	6.83	0			81.43	-
					640	2	93	60	940	191		417		2.40	478	74 31	
5.	BAUTRA	8900	5580	7.95	75.60	N.D.	8.18	9.50	68.04	19.79	-	5.18	0.24			81.04	-
					1738		164	115	2412	950		316	15	092	884		
6.	BAUTRA (Test well)	880	550	7.5	5.22	0.13	2.67	1.29	3.33	0.45	-	4.41	0.89			56.07	0.45
					120	5	54	16	118	22		260	55	Tr.	198		
7.	BAUTRA	930	574	8.05	4.91	0.15	3.01	1.63	4.02	0.45	-	3.94	1.05			50.62	-
					113	6	60	20	143	22		240	65	Tr.	232		
8.	BALWARA 42 M.	14,100	8930	7.95	102.17	0.99	24.15	33.02	127.68	16.97	-	8.77	N.D.			63.52	-
					2350	39	483	396	4527	814		534		N.D.	2858		
	112 M.	15,300	9720	7.7	106.52	1.12	16.58	42.82	136.00	26.73	-	7.44	-			63.76	-
					2450	47	337	513	4822	1281		543	-		2970		
	BHADRAJUN	35,210	-	7.15	-	-	-	-	11655	-	-	-	-	Well was abondoned saline formation.			

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
9.	BHAINSWADA	1800	1000	7.65	10.43 240	0.15 6	4.03 82	2.19 27	10.60 378	0.42 20	-	6.26 382	0.24 15	1.32	313	61.90	-
		1770	1040	7.5	10.87 250	0.02 1	4.44 89	2.29 28	10.75 381	0.93 45	-	6.36 388	0.24 15	1.44	336	61.30	-
10.	BHINMAL	10350	6630	7.7	97.86 2250	0.13 5	4.12 82	6.90 83	84.96 3016	19.20 922	-	7.42 453	0.08 5	1.96	551	39.77	-
11.	BHINMAL GOLIA	3400	2020	7.85	30.23 695	N.D.	1.82 36	1.21 15	15.62 554	4.49 215	-	12.19 743	0.96 60	3.60	151	26.38	9.16
	BHUTI	-	-	-	-	A	B	O	N	D	O	N	E	D	-	-	- High Salinity & shallow basement.	
12.	BINJROL KA GOLA																	
	273 M.	12000	7800	7.6	80.47 1850	0.20 8	29.90 592	26.50 322	122.60 4347	10.52 505	-	3.83 234	0.65 40	0.80	2820	58.70	-
	235 M.	12300	7760	7.65	80.47 1850	0.20 8	30.90 618	25.10 305	122.22 4334	9.42 452	-	4.24 259	0.56 35	0.80	2800	58.85	-
13.	CHATWARA	37000	21280	7.05	245.06 5635	0.30 12	56.58 1131	69.00 828	343.00 12162	28.56 1368	-	3.84 231	0.16 10	1.20	6279	66.07	-
	CHANDUR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
14.	CHAJJALA 95 Metres.	14700	10050	8.10	152.03 3500	0.13 5	6.43 129	11.58 141	144.90 5140	18.57 892	-	5.15 814	0.89 55	2.00	901	88.30	-
	278 -284 M	7800	4980	8.00	76.11 1750	0.08 3	2.97 60	5.15 63	63.16 2239	10.45 502	-	8.88 542	0.56 35	2.40	406	90.25	0.76
15.	A.DAHIWA 220-235 1st Zone	1760	1080	8.35	16.96 390	0.05 2	1.05 20	1.20 15	7.29 244	2.30 110	2.02 61	5.25 320	0.72 45	1.20	113	88.05	5.02
	IIIrd 60-90 Zone	3450	2000	8.30	29.36 675	0.08 3	2.30 46	2.06 25	19.00 673	4.65 223	1.41 42	7.07 431	1.53 95	1.60	218	86.86	4.12

1. 2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
IVth 60-90 zone.	2760	1690	8.35	25.56 [illegible]	0.03 3	1.63 33	1.34 [illegible]	13.63 483	3.70 [illegible]	2.01 61	6.26 381	2.02 125	1.60	151	39.22	5.26
16.DASPA 187 M.	9000	5450	7.15	57.00 1311	0.17 [illegible]	20.39 407	20.39 243	83.51 2961	6.33 313	-	5.53 337	0	0.4	[illegible]	58.19	-
87 M.	6500	3920	7.90	53.25 1225	0.13 5.2	9.11 182	6.53 78	54.40 1921	4.85 202	-	7.64 466	0	0.44	732	77.15	-
17. DIGAON	6400	3930	7.8	57.68 1325	0.15 6	2.52 51	5.09 62	47.44 1682	7.79 314	-	10.98 760	0.40 25	2.80	330	38.13	3.37
151 M.	10350	6650	7.6	89.16 2050	0.23 9	8.46 170	18.68 227	101.36 3594	7.64 367		5.55 338	0.48 30	1.00	1357	76.51	-
180 M.	7500	4640	7.7	67.41 1551	0.17 7	2.76 55	7.44 90	59.52 2110	10.10 458	-	8.99 549	0.16 10	1.32	510	86.67	-
18. DUNGARI	N.D.	40500	7.3	623.90 14348	3.06 130	22.08 442	62.10 745	653.70 23180	40.43 1924	-	3.64 527	0.24 15	3.20	4209	87.70	-
19. COLAN	1620	[illegible]	7.6	9.82 226	[illegible]	5.25 105	[illegible]	0.31 30	[illegible]	-	6.10 372	0.24 15	2.80	407	62.13	-
20. HARIYALI	16200	11260	7.6	91.34 2100	0.2 8	61.15 1223	58.40 712	133.55 5317	26.40 1097	-	2.25 137	0.40 25	0.40	5973	45.22	-
21. JAITIPURA 26.37(Gogani) 42.75	10700	6756	7.7	101.09 2325	0.05 2	3.70 74	14.62 178	68.20 2423	20.40 1363	-	12.51 763	0.24 15	2.40	916	84.62	-
JAITPURA.	9900	6570	7.75	95.65 2200	0.08 3	3.38 68	13.70 167	66.20 2351	29.02 1393	-	12.41 757	0.16 10	2.80	854	84.79	-
22. JETPURA 21.36 [illegible]	4[illegible]	251	7.9	1.61 37	0.05 2	2.34 47	0.82 10	0.51 18	0.16 8	-	4.082 249	0.08 5	0	161	32.92	0.85
23. JETPURA 23.52	360	220	8.2	1.74 40	0.05 2	1.20 24	0.82 10	0.68 24	0.23 11	-	2.65 162	0.16 10	0	103	45.08	0.58

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
24.	JODHAWAS	5650	3358	7.5	43.43 1000	0.13 5	6.73 135	6.29 76	39.69 1407	11.61 558	-	5.92 301	0.24 15	1.60	651	[illegible]	
25.	KOLAR	1470	950	7.35	6.30 145	0.53 21	5.71 114	3.21 40	5.57 197	1.90 91	-	5.65 345	2.01 125	4.00	443	[illegible]	-
26.	KUABER 50 M.	3000	2010	8.1	27.63 635	0.15 6	1.72 34	2.93 35	15.44 548	7.33 376	-	7.47 456	1.60 105	-	[illegible]	26.2	2.02
	KUABER 170 M.	5800	3760	7.8	50.99 1173	0.12 5	4.55 91	7.47 91	43.52 1545	11.92 572	-	7.37 449	0.32 20	0.72	601	80.77	-
27.	KORATA	6200	3760	8.2	53.06 1220	0.13 5	1.65 33	9.11 111	43.80 1554	11.06 530	-	8.16 497	0.24 15	7.60	538	82.97	-
28.	KHAN PUR	5000	3100	8.2	38.06 875	0.13 5	5.79 115	9.39 114	41.66 1478	6.65 319	-	4.99 304	0.16 10	1.88	759	71.00	-
29.	MEDA	6200	3830	8.05	43.83 1125	0.10 4	7.66 154	3.04 98	45.78 1605	9.14 433	-	8.01 489	1.77 110	0.80	735	75.59	-
30.	MEDA (Obs)	6600	4110	7.65	56.11 1290	0.08 3	5.56 111	5.57 68	45.78 1623	9.84 477	-	10.01 611	2.73 170	1.60	5 56	83.36	-
31.	MODRAN	1080	640	7.9	7.61 175	.02 1	1.47 30	1.73 21	4.34 154	0.70 34	-	5.84 356	0.16 10	5.32	160	70.27	2.64
32.	MODRAN (Obs)	1305	730	8.1	7.83 180	Tr.	2.30 46	2.96 36	6.84 3243	0.79 38	-	4.95 302	-	3.32	260	59.82	-
33.	PANSERI (Obs)	480	280	8.1	1.43 33	0.13 5	2.44 49	0.90 11	0.82 29	0.04 2	-	3.88 237	0.08 5	-	169	28.46	0.58
34.	PANSERI (Obs)	450	270	8.2	0.87 20	0.02 1	2.54 51	1.31 16	0.34 12	0.04 2	-	3.88 237	0.40 25	-	192	18.35	0.04

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
44.	SOLA 120 M.	1320	830	7.95	11.74 270	.02 1	1.20 24	1.20 15	6.47 229	0.96 46	-	6.49 396	-	1.60	(45)	32.62	4.-
	SALLA	1320	800	7.95	11.74 270	.02 1	1.04 21	1.20 15	6.57 233	0.75 36	-	6.63 368	- -	2.00	112	33.86	3.7
45.	SANKARANA 40 M	7680	4800	8.0	68.51 1575	0.08 3	3.74 75	7.89 96	63.77 2264	5.97 237	-	9.92 605	0.80 57	4.28	582	85.39	-
	SANKARANA 46 M.	7590	4820	7.95	68.51 1575	0.08 3	3.49 70	8.06 98	63.46 2253	6.04 290	-	9.69 591	1.13 70	4.28	577	85.33	-
	SANKARANA 48 M.	7700	4720	7.95	68.51 1575	0.08 3	3.24 65	8.09 98	63.73 2260	5.86 231	-	9.58 585	1.37 85	4.28	567	85.72	-
46.	SANKARANA (Obs)(24-29)	6400	4090	7.4	56.48 1299	0.08 3	4.04 81	6.41 78	50.22 1783	4.56 219	-	13.08 798	-	3.6	525	84.21	-
	SANKARANA (17-22) (24-33) (38-49)	6750	4320	7.0	59.74 1374	0.10 4	3.49 70	17.93 218	52.73 1372	15.49 744	-	12.34 753	-	2.4	1076	73.44	-
47.	UMADPURA -IInd	2036	1190	8.05	16.09 370	0.03 1	1.95 39	2.90 35	11.66 413	1.33 68	-	7.78 475	-	2.20	243	76.73	2.9
	UMADPURA StageIIIrd	2596	1500	7.65	19.60 450	0.10 4	3.30 66	3.35 41	15.93 567	2.33 112	-	8.63 527	-	2.00	333	74.38	1.9
	UMEDPURA Stage IVth	2711	1600	7.7	19.60 450	0.10 4	3.40 68	3.45 42	16.63 590	2.83 130	-	8.34 539	-	2.00	343	73.82	1.9
48.	UMEDPURA (Obs)	2037	1220	8.15	16.09 370	0.03 1	1.80 36	3.05 37	12.03 427	1.43 69	-	7.78 475	-	2.00	243	76.73	2.9
49.	TARWARA	35000	32490	8.2	435.00 10000	0.20 8	23.60 472	94.00 1143	389.30 13300	144.10 6920	-	3.72 227	-	7.68	5880	78.69	-

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
35.	PALADER	5400	3318	7.65	51.97 1195	0.30 12	1.90 38	1.90 23	36.67 1300	4.84 232	- -	11.85 723	1.21 75	2.00	190	92.68	8.05
36.	POALI	1750	1160	8.0	13.92 320	0.05 2	0.96 19	1.93 22	3.04 107	1.17 56	-	5.66 345	6.61 410	7.0	145	33.00	2.56
37.	PUNASA	1410	860	8.2	10.87 250	0.28 11	1.48 30	1.73 21	6.86 243	0.93 45	-	6.47 395	0.40 25	1.32	160	75.70	3.26
38.	PUNASA 243 M.	1590	1010	7.9	13.91 320	0.94 37	0.97 19	0.76 9	6.86 243	2.61 125	-	6.37 389	0.40 25	3.00	36	83.9	4.64
	PUNASA 117 M.	1530	930	8.0	13.04 300	0.28 11	0.92 18	1.02 12	6.66 236	2.56 123	-	6.14 375	0.08 5	3.36	97	35.45	4.20
38	RAJANWADI (Obs).	1650	1050	8.25	16.74 384	0.02 1	0.83 16	0.57 6	4.22 150	1.09 52	1.06 31	11.39 695	0.16 10	7.0	70	92.05	11.05
39.	RAJANWADI	1890	1190	7.8	13.65 429	0.02 1	1.10 22	0.57 7	6.42 228	1.29 62	-	12.34 753	Tr.	6.8	86	91.69	10.67
40.	RAITHAL	43000	37240	7.55	478.45 11000	.33 13	21.10 423	79.30 964	468.40 16628	135.90 6524	-	8.93 543	-	10.00	5020	82.61	-
41.	RAMA	3796	2190	7.5	22.18 510	0.08 3	9.58 192	6.02 73	28.95 1025	2.16 104	-	6.07 370	1.13 75	-	780	58.58	-
42.	RAMA (Obs)	3673	2130	7.6	21.74 500	0.08 3	8.98 180	6.82 83	28.25 1003	1.68 81	-	5.11 312	1.29 80	-	791	57.79	†
43.	RANAWARA 28 M.	1080	700	8.05	6.96 160	0.15 6	2.00 40	2.42 29	2.96 105	1.75 84	-	7.57 462	0.24 15	1.6	221	60.36	3.15
	RANIWARA 49 M.	1080	690	8.0	7.13 164	0.15 6	1.75 35	2.88 35	3.05 108	1.92 92	-	7.43 453	0.24 15	Tr.	232	59.86	2.90