

**EVALUATION OF GROUNDWATER TABLE AND
QUALITY IN KRISHNA DELTA, A.P.**



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PREFACE

Groundwater pollution by seawater, geomorphic land forms, tidal forces and man made hazards are major problems faced by many coastal areas of the world. The coastal area is known for wet cultivation mainly by surface water irrigation with groundwater as supplementary source. The increase in population, urbanization and industrialization has created more stress on groundwater resources in coastal areas. Especially to prevent groundwater pollution in deltas and coastal areas, systematic studies are essential to understand flow and geochemical process. In this report, the analysis of historical data pertaining to shallow aquifer (groundwater levels and quality) in Krishna Delta has been presented. Multiple linear regression equations have been developed for Electrical Conductivity of shallow groundwater. The hydrochemistry of samples collected from filter points, tube wells, river, canal and sea is also presented. The report may be useful to understand spatial distribution of water quality parameters and groundwater levels in the study area and also for further studies.

This report entitled “**Evaluation of groundwater table and quality in Krishna Delta, A. P.**” has been prepared by Sh Y.Ramji Satyaji Rao, Scientist ‘C’, Sh S.V.Vijaya Kumar, Scientist ‘C’ with the support of Sh U.V.N.Rao, S.R.A.and D. Mohan Rangan, Tech. Gr.II under the guidance of Dr.K.S.Ramasastri, Scientist ‘F’ and Coordinator. The report is under the work program of Deltaic Regional Centre, Kakinada for the year 1999 – 2000.


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ABSTRACT

The shallow groundwater levels and quality data pertaining to Krishna Delta for about 20 years have been analyzed. The trend analysis of groundwater level data of shallow wells indicated that in the upper part of Krishna Delta the groundwater table raised from the year 1979 to 1999. It may be due to the dense canal network in the delta and increase in irrigated area over a period of time. The groundwater flow direction is observed as the replica of surface gradient except in few places in the Eastern Delta. The comparison between average rainfall and average groundwater table in the study area indicates that the rainfall recharge may not be the major contribution to the ground water storage.

The spatial distribution maps of EC, SAR and Cl/HCO_3 indicated that the salinity in the study area increased from the year 1991 to 1999. It is also observed that there is significant change in water quality from pre monsoon (May) to post monsoon (November) period. The multiple linear regression models have been developed for EC in shallow aquifer. The finger print diagram of water quality parameters of filter points, tube wells, canal water, river water and seawater in the study area are prepared. The spatial distribution maps of Cl/HCO_3 ratio in shallow wells (open wells), filter points and tube wells indicated that there is significant vertical variation of salinity in the study area. The saline water intrusion is not observed in shallow aquifer, but it is observed in deeper aquifer (tube wells) in the study area. Detailed studies are necessary to confirm salt-water intrusion in deeper aquifers of Krishna Delta.

1.0 INTRODUCTION

River Deltas have traditionally been the areas dominant with agricultural land utilization because of their highly favorable geomorphic terrain, productive soil cover and abundant water supply. The deltas of rivers Cauvery, Krishna, Godavari, Mahanadi and the Ganges forming plains of the East Coast of India represent fine examples of intensive agricultural activity. These deltas with rich alluvial soil, which gets enriched annually, and good irrigation network of canals and tube wells support multiple cropping patterns providing relatively high crop yield. Although, over the years, the land use and cropping pattern has remained unchanged in the deltas, yet, a gradual trend of change in landuse pattern is being noticeable in river delta and the reasons could be due to climatic vagaries and changing farming techniques, aquaculture and advances in biotechnology.

Climatically deltas along the East Coast of India experience monsoon rainfall of more than 1000 mm per annum with temperature ranging between 20 to 30⁰ C (Subramaniam and Venkata Rao, 1981). The deltas constitute a part of irrigated agriculture with predominately food crops like paddy, sugarcane, pulses and horticulture like, banana and coconut. Mapping of landforms, land suitability and land use in the Krishna delta using areal photographs have been carried out by Nageswara Rao and Vaidyanadhan (1978 and 1981). Chemical analysis forms the basis of interpretation of the quality of water in relation to source, geology, climate and use. Water being an excellent solvent, so it is important to know the geochemistry of the dissolved solid constituents and methods of reporting analytical data. Exploration carried out by Central Groundwater Board and State Groundwater departments in the coastal alluvium has indicated that near the shore the quality of the water may not be continuously good for irrigation. However tube wells constructed away from the shore did not suffer in quality. The details about the hydrochemistry of Krishna delta are given in the project proposal of studies on 'Fresh-salt water interface in Krishna delta' (SGWD, 1997). However the information available on groundwater levels and quality in deeper aquifers is very limited. In order to identify the salinity sources in the delta, the shallow and deeper aquifers may be studied combinedly to understand flow and hydrochemical process in the delta.

1.1 Scope and Objectives of the study

The groundwater levels, quality and rainfall data pertaining to Krishna Delta during the years 1979 to 1999 have been collected and analyzed to understand the changes in water table and quality conditions over a period of time. The spatial and temporal variations of water levels and quality parameters could provide some useful information on the delta and the possible sources of contamination. This analysis is applicable only to shallow aquifer and it may be useful for the research project on "Study of Fresh-Salt Water interface in Krishna Delta of Andhra Pradesh India" currently ongoing under the hydrology project (Funded by World Bank). The main objectives of the present study are as follows.

- i. Development of database on groundwater levels, quality and rainfall pertaining to Krishna Delta.
- ii. Spatial and temporal analysis of ground water levels and quality in Krishna Delta.
- iii. Demarcation of flow direction and identification of high salinity regions in the study area.
- iv. Development of multiple linear regression models for Electrical Conductivity of groundwater during pre (May) and post (Nov.) monsoon periods.
- v. Comparison between spatial salinity of shallow wells and tube wells in the Krishna Delta.
- vi. Analysis of saline water ingress using $Cl/CO_3 + HCO_3$ ratio.
- vii. Classification of groundwater samples (Stiff, 1951 and ISI, 1983) and its suitability for domestic and irrigation purposes.

2.0 STUDY AREA

2.1 Location

The Sub-arcuate Krishna Delta of 4, 600 sq. km is bounded by latitude $15^{\circ}44' - 16^{\circ}40'N$ and longitude $80^{\circ}20' - 81^{\circ}30'E$ extending from Bapatla in the west to Mandavalli in the east, with its apex centered near Vijayawada. The Delta has 120 km coast along Bay of Bengal. The river Krishna originates in the Western Ghats near Mahabaleshwar and flows towards east debauching into the Bay of Bengal. Along its 1400-km long sinuous course, important tributaries like the Ghataprabha, Malaprabha, Bhima, Tungabhadra, Musi and Munneru join the river. In its journey, the river traverses across various geological formations like the Deccan trap, unclassified crystallines, Cuddapahs and eastern ghat complex before entering the deltaic planes near Vijayawada (+16 MSL). The apex of the delta is flanked by erosional landforms with moderate relief made up essentially of Khondalites. The relief of the delta is low to almost flat. The first distributary of the river branches off north of Avanigadda. The main channel bifurcates into three distributaries further south near Edurmudi. The eastern branch Channel is termed as Golumuttapaya, the central branch is called the Nadimeru and the western most is the Krishna Delta. The location of the Krishna Delta is shown in Fig. 1.

2.2 Geology and Geomorphology

The Krishna Delta is lobate in shape and is unique in having the greatest protuberance of 37 kms from the adjoining coast. It is covered by alluvium comprising a sequence of clay, sand and gravel. Towards the south, beach sands occur along the coast. The thickness of alluvium increases from 25 m at Telaprolu ($16^{\circ}34'N, 80^{\circ}54'E$) in the north to 420 m at Mopidevi ($16^{\circ}04', 80^{\circ}56'$) in the south, near the coast. The depth of the basement increases from 225 m at Telaprolu to more than 600 m at Mopidevi and the alluvium is underlain by Rajahmundry sandstones (Das, 1991). Groundwater occurs under water table conditions and semi confined conditions in the alluvium and under confined conditions in the underlying Rajahmundry sandstones in the northeastern fringe of the delta. The freshwater aquifer in Krishna Eastern Delta occupy comparatively wide and long stretches of the area, occur down to a depth of about 20m. The water table varies from 0.47 to 2.47-m bgl. The yield of the open wells varies from 10 to 16.6 lps for 8 to 10 hours of pumping, and the filter point tube wells (101mm dia.) drilled down to 20m depth yield about 11.11 lps on an average.

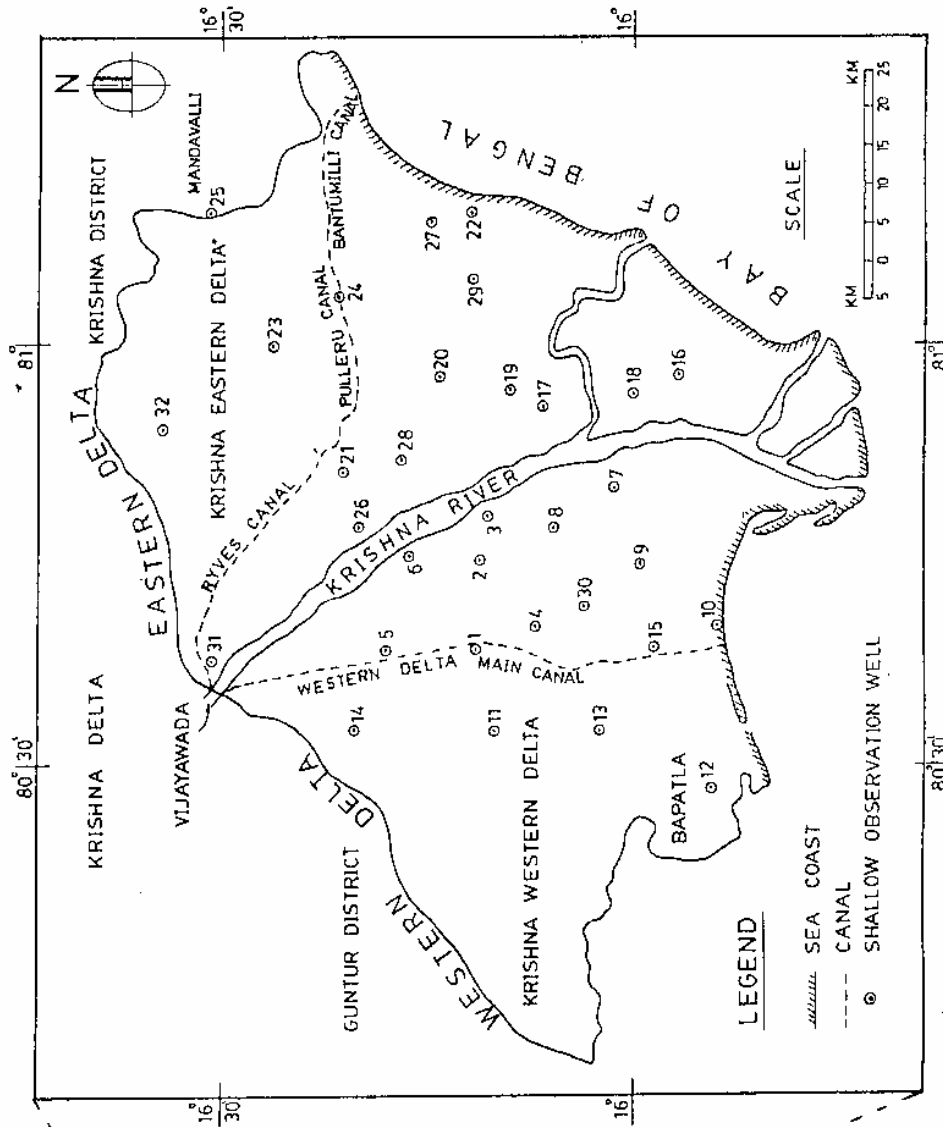
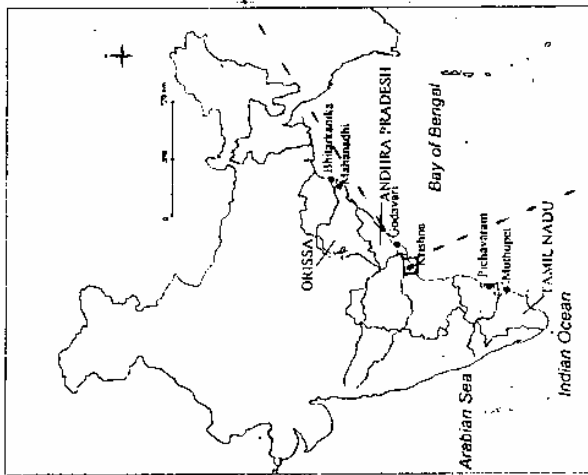


FIG.1 LOCATION OF THE STUDY AREA

The Krishna river is an influent river and the shallow aquifer adjoining it is recharged by the river. According to Das (1991) the most promising area for tapping groundwater appears to be the western part of the Krishna Eastern delta, close to the Krishna river, and the groundwater development is mainly restricted to this tract. The specific conductance of groundwater in alluvial aquifer varies from 407 to 31200 μ moh/cm at 25⁰ C and the Chloride range from 324 to 10,080 mg/l. The quality generally deteriorates with depth, the Chloride content varying from 3989 to 9591 mg/l and specific conductance from 12900 to 23650 μ moh/cm at 25⁰ C. The stages of evaluation of the delta can be well understood from the morphological expression and disposition of several beach ridges and palaeo-delta lobes. Ground surveys and photogeological studies of the Krishna delta reveal five palaeo-delta lobes and equal number of strandlines. The present day configuration of the delta is due to the dominant role-played by various fluvial and marine processes. The fluvial action was responsible in transporting the sediment and these sediments were reworked and deposited by various dynamic process, the imprints of which are preserved in the form of palaeo channel, levee, backswamp and barrier ridges (Mahender Reddy and Sham, 1991). The geological and geomorphological map of the Krishna Delta is shown in Fig. 2.

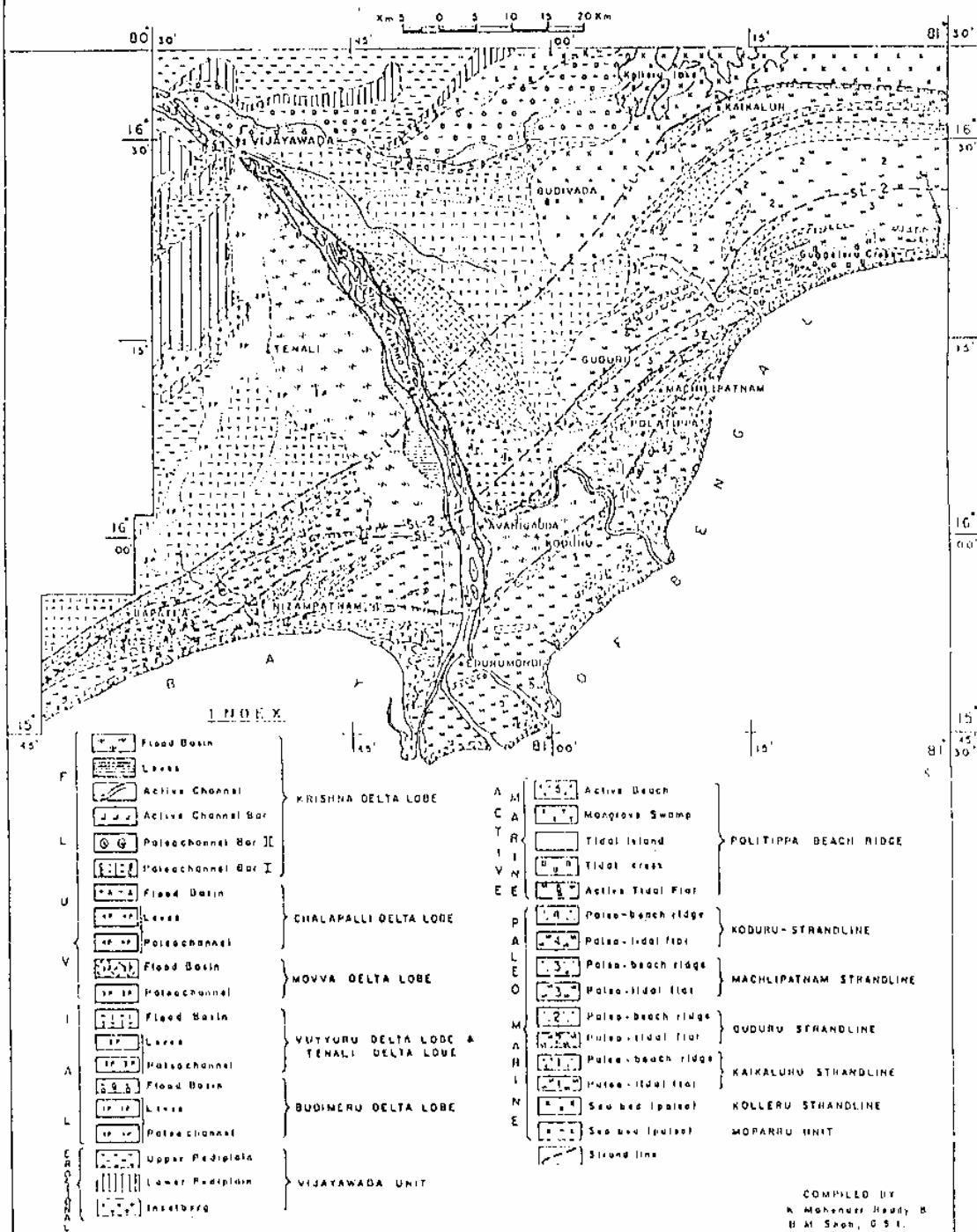
2.3 Soils

The Soils of Krishna Delta are very deep, moderately well drained and very dark grayish brown in colour. Most of the soils have angular blocky structure in the surface and angular blocky peds in the sub soil. The soils are very high in clay content, which ranges between 55 to 70 percent. The organic carbon content of the soil is low ranging from 0.24 to 0.43 percent. The soils have moderate alkaline pH ranging between 8.4 and 8.8 (Pofali et al. 1991). The soils are reported to be dominant in salts of Chloride and Sulphates of Nitrogen followed by those of Mg and Ca. The soils are rich in Potassium (K) and medium to high in Phosphorus (P). The soils are also reported to be deficient in Zn (Bandhopadhyay et. al., 1987).

2.4 Climate

The Krishna Delta is under tropical climate. The rainfall of this area is contributed through southwest and northwest monsoons. The average annual rainfall in Krishna delta is 800 to 1000 mm. The minimum, maximum and average daily temperatures are 16⁰ C, 41.6⁰ C and 27.5⁰ C respectively.

FIG.2. QUATERNARY GEOLOGICAL AND GEOMORPHOLOGICAL MAP OF KRISHNA DELTA, ANDHRA PRADESH



REPRODUCED FROM QUATERNARY DELTAS OF INDIA (1991)

3.0 METHODOLOGY

To evaluate groundwater levels and quality in shallow aquifer of Krishna delta, total 32 observation wells (monitored by Andhra Pradesh State Ground Water Department) have been considered. The continuous groundwater level and groundwater quality data for these wells from the year 1979 to 1999 are not available. Therefore the spatial distribution maps of groundwater levels and water quality parameters (EC, SAR, Cl/HCO_3) during pre (May) and post (Nov.) monsoon periods have been prepared and compared for changes only from the year 1989 to 1999. The trend analysis of groundwater levels in few observation wells has been carried out using 20 years data (1979 to 1999). Multiple linear regression models have been developed for Electrical Conductivity of shallow groundwater during pre (May) and post (Nov.) monsoon periods. Further, the analysis of water quality in filter points, tube wells, river water, canal water and seawater during the month of Nov. 1999 is also carried out in the Krishna delta. The detailed procedures for above analysis are as follows.

3.1 Groundwater Table and Rainfall

The groundwater level fluctuation data in 32 shallow observation wells with respect to M.S.L have been used for present analysis. Due to non-availability of continuous groundwater levels data for uniform period in Krishna Eastern and Western Deltas, only 11 years (1989-1999) data have been considered for spatial evaluation of groundwater levels in the study area. The topographical contour map of the study area has been prepared with one-meter interval. The spatial distribution maps of groundwater levels in the year 1989 (pre and post) and 1999 (pre and post) have been prepared and compared for changes in last 11 years in the study area. The groundwater flow direction is also demarcated in the study area. The long-term groundwater levels data for about 20 years from 1979 to 1999 (pre and post) are available for few wells in the study area. They are Kollipara (6), Repalle (7), Nizampatnam(10), Ponnuru (13), Bhavadevarapali (16), Challapalli (17), Chinamuthevi (20) and Vuyyuru (21). Among these wells, well nos. 6, 7, 10 and 13 are in Krishna western delta and remaining well nos. 16, 17, 20 and 21 are in Krishna eastern delta. The groundwater level trend analysis in each well during pre and post monsoon periods has been carried out in the study area and identified the increasing or decreasing trend in the groundwater level. Further, the average groundwater table (May & Nov.) and average monthly rainfall in the study area for about 11 years have

been calculated. The raingauge stations at Bhavadevara Palli, Challapalli, Machilipatnam, Gudivada, Pamidimukkala, Tenali, Repalle, Nizampatnam and Ponnuru have been considered for estimating monthly average rainfall in the study area. Further seasonal rainfall before the month of May (Nov. + Dec. + Jan. + Feb. + Mar. + Apr.) and before the month of November (May + June + July + Aug. + Sep. + Oct.) has been calculated using arithmetic method. The monthly and seasonal rainfall has been compared with average groundwater table in the study area for about 11 years (1989 to 1999) and the trends in average groundwater table and average rainfall in the study area are also analysed.

3.2 Groundwater quality

The water quality data for about 9 years (1991 to 1999) have been considered for spatial analysis. The water quality data of physical parameters (pH, EC) and chemical parameters (Ca, Mg, Na, K and CO₃, HCO₃, Cl) are only available for monitoring wells. Therefore, due to non-availability of major ion SO₄, the ion balance error is subjected to be high. So limited analysis has been carried out in the study area i.e. only salinity variations. Further in the month of November 1999 a field survey has been conducted to obtain the water quality information of few filter points, tubewells, canal water, seawater, river water etc., in the Krishna Delta. The water quality maps of EC, SAR, Cl/HCO₃ ratio have been prepared for open wells, filter points and tube wells in the study area. Further, an attempt is also made to estimate EC in shallow wells using multiple linear regression models. The detailed procedure for this analysis is as follows:

3.2.1 Hydrochemistry of Shallow wells

With the measured chemical constituents in shallow observation wells the total hardness as CaCO₃ (TH), percentage of Sodium (%Na), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) have been calculated in each well by the following equations respectively.

$$\text{Total Hardness as CaCO}_3 \text{ (TH)} = 2.497 \text{ Ca} + 4.115 \text{ Mg} \quad (1)$$

$$\text{Percentage of Sodium (\%Na)} = ((\text{Na} + \text{K}) / (\text{Ca} + \text{Mg} + \text{Na} + \text{K})) * 100 \quad (2)$$

$$\text{Sodium Absorption Ratio (SAR)} = \text{Na} / \sqrt{(\text{Mg} + \text{Ca})/2} \quad (3)$$

$$\text{Residual Sodium Carbonate (RSC)} = (\text{CO}_3 + \text{HCO}_3) - (\text{Ca} + \text{Mg}) \quad (4)$$

In above equations (2 to 4) all the constituents are in epm. But in equation 1, the units are in ppm. The spatial distribution maps of EC, SAR and Cl/CO₃ + HCO₃ ratio have

been prepared during the month of May 1991, May 1999 and November 1991 and November 1998, and compared for changes over a period of 9 years. It is observed that the water quality data is not available uniformly for all the years. Therefore an attempt has been made to develop statistical model for EC in shallow wells during the pre (May) and Post (Nov.) monsoon periods. The correlation between water quality parameters (EC, Ca, Mg, Na, K, HCO₃, Cl, TH) is calculated using the data of the year 1995 (pre and post monsoon periods). In the year 1995 among 32 observation wells, 31 wells water quality data is available. The quality parameters which are highly correlated with EC (>0.75) are considered for regression models. Using these regression models, EC of shallow groundwater has been estimated for the months of May 1993 and May 1998, and November 1993 and November 1998. The estimated EC and measured EC of groundwater are compared and found the best multiple linear regression models for the shallow aquifer.

3.2.2 Hydrochemistry of Filter points and Tube wells

An intensive field survey was conducted in the month of November 1999 and about 48 water samples were collected in the Krishna Delta. These samples have been analyzed for physical and chemical parameters. Among these samples 1 to 24 are from filter points, 25 to 40 are from tube wells, 43 to 46 are of river water, 47 is canal water and 48 is seawater. In each well the ion balance error, SAR, %Na, TH and Cl/CO₃ + HCO₃ ratio have been calculated. The finger print diagrams of average water quality parameters of filter points, tube wells, canal, river and seawater have been prepared. The correlation between water quality parameters in filter points and tube wells are also calculated. The spatial distribution maps of EC, SAR and Cl/CO₃ + HCO₃ ratio have been prepared to study the salinity distribution in shallow aquifer (filter points) and deeper aquifer (Tube wells). In Western Delta only a few tube well samples are considered for present analysis. Therefore, the information in western delta is subjected to an approximation. The comparison of these maps between open wells, filter points and tube wells provide the vertical variations of salinity in the study area.

3.2.3 Classification of groundwater

Due to limited water quality parameters, the samples have been classified according to Stiff (1951) classification only. The water quality parameters are also compared with ISI (1983) maximum permissible drinking water standards. The shallow groundwater is classified according to Total Hardness as CaCO₃.

4.0 RESULTS AND DISCUSSIONS

4.1 Analysis of Groundwater levels

Total 32 shallow observation wells have been considered for groundwater level analysis in the Krishna delta. The details of shallow observation wells and their locations are shown in Table 1 and Fig. 1 respectively. The groundwater levels represent the shallow aquifer (alluvium) of Krishna Delta. The groundwater levels data (w.r.t. MSL) for about 20 years (1979 to 1999) have been used for present analysis. Due to non-availability of continuous water levels for all twenty years, only eleven years (1989 to 1999) pre (May) and post (November) monsoon periods data have been considered for spatial analysis. The ground water levels (w.r.t M.S.L) data for pre and post monsoon periods for all 32 observation wells are given in Table 2. The topographical contour map of the study area has been prepared using the information of reduced level of ground level (Table 1) and the same is shown in Fig. 3. The surface gradient is followed canal gradients. But near seacoast the surface gradient in Krishna Eastern delta is different from Krishna Western delta. The highest altitude (+ 15 m) is observed at Vijayawada (31) and lowest (+ 4 m) is at Nizampatnam (10) in the study area. The groundwater level contours during the month of May 89, May 99, November 89 and November 99 are shown in Figures 4, 5, 6 and 7 respectively. The general groundwater table gradient is replica of topographical gradient. However, the groundwater table contours have followed similar trends during pre and post monsoon periods from the year 1989 to 1999. It is also observed that the groundwater flow direction nearby river branches is not clearly observed. It may be due to the backwater effect in the river course or the local geology (dikes or folds) in the river mouth especially near well nos. 17, 18 and 19 which are located in Krishna Eastern Delta. More studies are necessary to identify groundwater flow contribution to the sea near river mouth. Flow direction is clearly observed along the canal and it could be the reason that the canal water is influencing the nearby groundwater flow direction.

The long term data of groundwater levels in few observation wells (Nos. 6, 7, 10, 13, 16, 17, 20 and 21) for a period of 20 years (1979 to 1999) have been considered for trend analysis. The pre and post monsoon groundwater levels data with respect to M.S.L are given in Table 3 and 4 respectively. The trend analysis for pre and post

Table 1. Details of shallow observation wells in Krishna delta

Sl.No.	Location	Longitude	Latitude	Total Depth from GL (m)	R.L. of Ground Level (m)	R.L. of measuring point (m)	Geology
01.	TENALI	80°38'00"	16°14'00"	6.45	7.380	7.910	Alluvium
02.	VEMURU	80°44'35"	16°10'35"	4.93	6.980	8.030	Alluvium
03.	KOLLURU	80°48'00"	16°10'50"	5.50	7.325	8.225	Alluvium
04.	AMRUTALURU	80°39'45"	16°07'00"	4.50	7.085	7.835	Alluvium
05.	DUGGIRALA	80°37'50"	16°19'35"	7.00	12.650	13.255	Alluvium
06.	KOLLIPARA	80°45'00"	16°17'15"	10.00	12.312	12.927	Alluvium
07.	REPALLE	80°50'00"	16°01'05"	4.30	2.985	3.865	Alluvium
08.	BHATTIPROLU	80°47'03"	16°06'08"	6.00	3.855	4.955	Alluvium
09.	NAGARAM	80°43'35"	16°00'15"	5.00	2.745	3.745	Alluvium
10.	NIZAMPATNAM	80°40'00"	15°54'00"	3.58	3.270	3.900	Alluvium
11.	CHEBROLU	80°31'42"	16°11'48"	9.36	8.775	9.895	Alluvium
12.	BAPATLA	80°28'00"	15°54'00"	4.38	4.680	5.330	Alluvium
13.	PONNURU	80°32'00"	16°03'00"	6.74	6.700	7.250	Alluvium
14.	NAMBURU	80°31'52"	16°21'16"	10.4	16.190	16.890	Alluvium
15.	PVPALEM	80°38'00"	15°59'00"	4.02	3.405	4.055	Alluvium
16.	BHAVDEVARPALI	80°58'18"	15°56'38"	3.50	3.167	3.857	Alluvium
17.	CHALLAPALLI	80°55'50"	16°07'02"	3.40	4.685	4.885	Alluvium
18.	AVANIGADDA	80°54'52"	16°01'12"	6.45	5.039	5.539	Alluvium
19.	GHANTASALA	80°56'40"	16°10'08"	4.25	3.855	4.105	Alluvium
20.	CHINAMUTHEVI	80°57'48"	16°15'24"	5.85	6.110	6.510	Alluvium
21.	VUYYURU	80°50'50"	16°21'40"	6.25	11.615	12.325	Alluvium
22.	MACHILIPATNAM	81°09'30"	16°11'50"	3.93	3.52	4.15	Alluvium
23.	GUDIVADA	80°59'39"	16°26'15"	4.18	6.765	7.435	Alluvium
24.	GUDLAVALLERU	81°03'00"	16°20'37"	5.23	5.260	5.81	Alluvium
25.	MANDAVALLI	81°09'35"	16°30'35"	3.27	3.46	4.18	Alluvium
26.	THOTLAVALLURU	80°46'55"	16°20'40"	9.98	13.320	13.920	Alluvium
27.	PEDANA	81°08'52"	16°14'55"	2.87	3.39	3.89	Alluvium
28.	FAMIDIMUKKALA	80°52'18"	16°16'40"	5.35	8.800	9.100	Alluvium
29.	GUDURU	81°04'52"	16°12'14"	5.23	7.595	8.095	Alluvium
30.	GULLAPALLI	80°40'55"	16°02'50"	4.10	5.445	5.805	Alluvium
31.	VAYAWADA	80°37'00"	16°31'00"	12.7	20.825	21.425	Alluvium
32.	TELAPROLU	80°54'05"	16°34'10"	6.0	10.535	10.815	Alluvium

Table 2. Groundwater levels of shallow observation wells in Krishna Delta (w.r.t. M.S.L. in metres) for the period 1988 to 1999.

Well No.	1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		1999	
	May-89	Nov-89	May-90	Nov-90	May-91	Nov-91	May-92	Nov-92	May-93	Nov-93	May-94	Nov-94	May-95	Nov-95	May-96	Nov-96	May-97	Nov-97	May-98	Nov-98	May-99	Nov-99
1	4.030	5.930	4.480	6.580	4.180	5.580	5.030	6.330	0.930	5.150	3.880	5.380	3.830	5.430	4.590	5.360	3.180	5.480	3.480	5.780	2.050	well abandoned
2	4.030	6.130	4.480	6.260	3.530	5.130	3.380	5.730	3.630	5.670	3.180	5.230	3.330	4.930	4.730	5.180	3.130	5.780	2.050	5.930	2.050	4.770
3	5.455	6.615	4.805	6.675	5.155	6.605	4.325	6.855	5.855	6.255	4.105	5.205	4.055	4.455	3.715	5.505	2.855	4.825	2.755	6.425	1.975	5.325
4	3.865	5.835	3.805	5.725	3.685	5.815	3.535	6.085	3.985	5.435	3.695	5.805	4.585	5.105	3.275	5.735	3.285	6.365	3.485	6.085	3.485	5.535
5	10.350	12.150	10.650	12.250	10.850	11.940	10.260	11.250	10.950	11.312	10.650	11.940	10.650	11.940	10.300	12.120	10.650	11.850	10.250	12.050	9.800	11.750
6	9.732	10.932	10.032	10.442	10.332	11.352	9.832	11.032	10.032	11.312	9.812	10.462	10.662	10.512	9.912	11.512	9.612	11.462	9.462	11.762	10.112	10.572
7	0.445	1.285	0.335	1.765	-0.115	1.735	-0.015	2.435	-0.065	1.165	-0.635	1.385	0.285	1.325	-0.365	1.835	-0.165	1.135	-0.115	1.985	-0.315	1.795
8	1.255	3.205	1.395	3.255	0.655	3.105	0.955	3.455	1.805	2.775	1.885	3.055	2.855	3.175	0.405	2.455	0.255	2.505	0.955	2.855	1.255	1.875
9	0.495	1.195	0.395	1.745	-0.005	1.745	-0.105	1.745	0.095	0.905	-0.155	1.475	0.545	1.295	0.575	1.945	0.700	0.895	-0.455	1.745	0.145	0.695
10	1.520	1.920	1.120	2.080	0.870	1.990	1.120	2.720	1.120	2.410	1.310	1.870	1.470	1.860	1.000	2.620	0.970	2.620	1.170	2.870	1.420	1.870
11	5.265	7.095	5.085	7.295	4.895	7.495	5.595	5.895	4.195	6.425	3.775	7.075	5.175	7.545	4.625	6.875	3.675	6.575	4.325	7.775	4.375	6.155
12	2.800	3.580	2.680	3.800	2.830	3.680	2.530	3.830	2.330	3.130	2.380	3.530	2.380	3.080	2.380	3.830	2.530	3.380	2.630	3.830	2.480	2.690
13	1.990	3.850	2.200	4.000	1.600	5.000	1.450	2.750	1.650	4.250	1.300	5.300	2.460	3.170	1.560	4.200	1.600	4.900	2.200	4.700	1.700	4.050
14																						
15	1.855	2.055	1.805	2.255	0.955	2.155	0.955	3.075	1.355	1.955	0.805	1.105	2.455	2.105	1.295	2.405	1.555	2.205	1.155	2.405	1.405	1.655
16	-0.063	2.287	0.857	2.307	0.807	1.597	0.307	2.647	1.657	2.317	1.147	1.847	1.937	2.167	1.607	2.317	0.557	2.547	0.847	2.237	1.117	2.187
17	2.075	3.755	3.885	3.605	2.715	3.475	2.035	4.555	1.865	3.065	1.955	3.595	3.485	4.250	2.125	3.925	2.385	3.635	2.535	4.515	2.235	3.715
18	0.529	2.859	2.280	3.739	1.639	2.669	1.469	2.609	1.609	3.369	-0.191	3.639	0.689	1.339	-0.141	3.039	-0.081	1.889	0.529	3.919	0.039	1.339
19	0.915	1.515	1.985	2.435	0.255	2.855	0.355	1.445	0.435	1.805	0.005	2.825	2.105	2.405	0.255	3.105	0.175	1.735	0.225	3.065	0.755	1.845
20	1.060	3.410	2.100	3.090	1.910	2.550	1.660	3.690	1.680	3.230	1.640	2.870	1.980	2.360	0.650	2.010	0.560	2.360	0.830	3.320	1.190	2.190
21	7.265	10.465	10.925	10.615	9.515	10.595	8.505	11.175	9.745	10.575	8.585	11.225	10.135	10.135	8.745	10.525	9.065	10.555	8.695	11.115	9.235	10.865
22	0.320	2.040	2.570	2.350	1.480	2.300	1.150	2.970	1.300	1.750	0.830	3.000	1.720	2.180	0.940	2.510	1.000	2.420	0.790	2.450	0.880	1.530
23	3.445	3.345	5.495	3.885	4.765	5.845	3.785	5.835	4.785	5.755	4.735	6.245	5.835	6.065	4.715	6.465	4.315	6.245	4.855	6.365	4.115	6.285
24	2.760	4.600	4.960	4.860	4.890	4.820	2.210	5.220	4.110	4.460	3.700	5.110	4.990	5.010	3.850	5.060	3.670	4.930	3.810	5.180	4.230	4.990
25	1.080	1.180	2.090	2.320	1.460	2.360	0.660	3.060	1.670	2.120	1.170	2.960	2.140	2.100	1.190	2.980	1.320	2.720	1.420	2.890	1.910	2.400
26	5.580	6.970	6.800	6.540	5.200	5.580	5.170	6.570	5.870	7.250	5.400	6.960	5.820	6.370	4.690	9.290	4.470	4.480	4.880	7.320	5.590	6.620
27	1.360	1.960	2.490	2.270	1.630	1.570	1.190	3.130	1.340	1.940	1.080	1.690	2.120	2.370	1.080	2.980	1.260	2.810	1.250	2.740	1.190	2.120
28	6.830	7.560	6.920	7.650	5.310	6.830	5.150	6.220	7.000	7.980	5.250	7.910	7.890	7.270	5.800	8.080	5.600	8.240	5.490	8.070	4.990	8.000
29	5.835	5.165	5.545	5.325	4.385	5.575	4.515	5.185	5.175	5.545	3.745	6.565	5.845	6.145	3.995	6.845	4.565	6.245	4.735	5.505	4.445	5.375
30	3.505	4.595	3.605	4.635	3.425	4.515	3.245	5.045	3.595	4.685	3.705	5.075	3.695	4.465	3.085	4.995	2.645	4.495	3.145	5.085	3.545	4.555
31	9.675	11.445	11.475	11.125	10.845	11.825	11.065	11.765	11.565	11.345	10.735	11.735	10.365	10.775	10.265	11.005	10.475	11.675	10.745	16.455	10.825	10.905
32	7.815	9.915	9.415	10.055	8.415	10.015	7.315	10.295	7.965	9.515	5.175	10.365	9.095	10.335	8.135	10.055	8.535	10.235	8.455	10.475	8.455	8.885

DATA NOT AVAILABLE

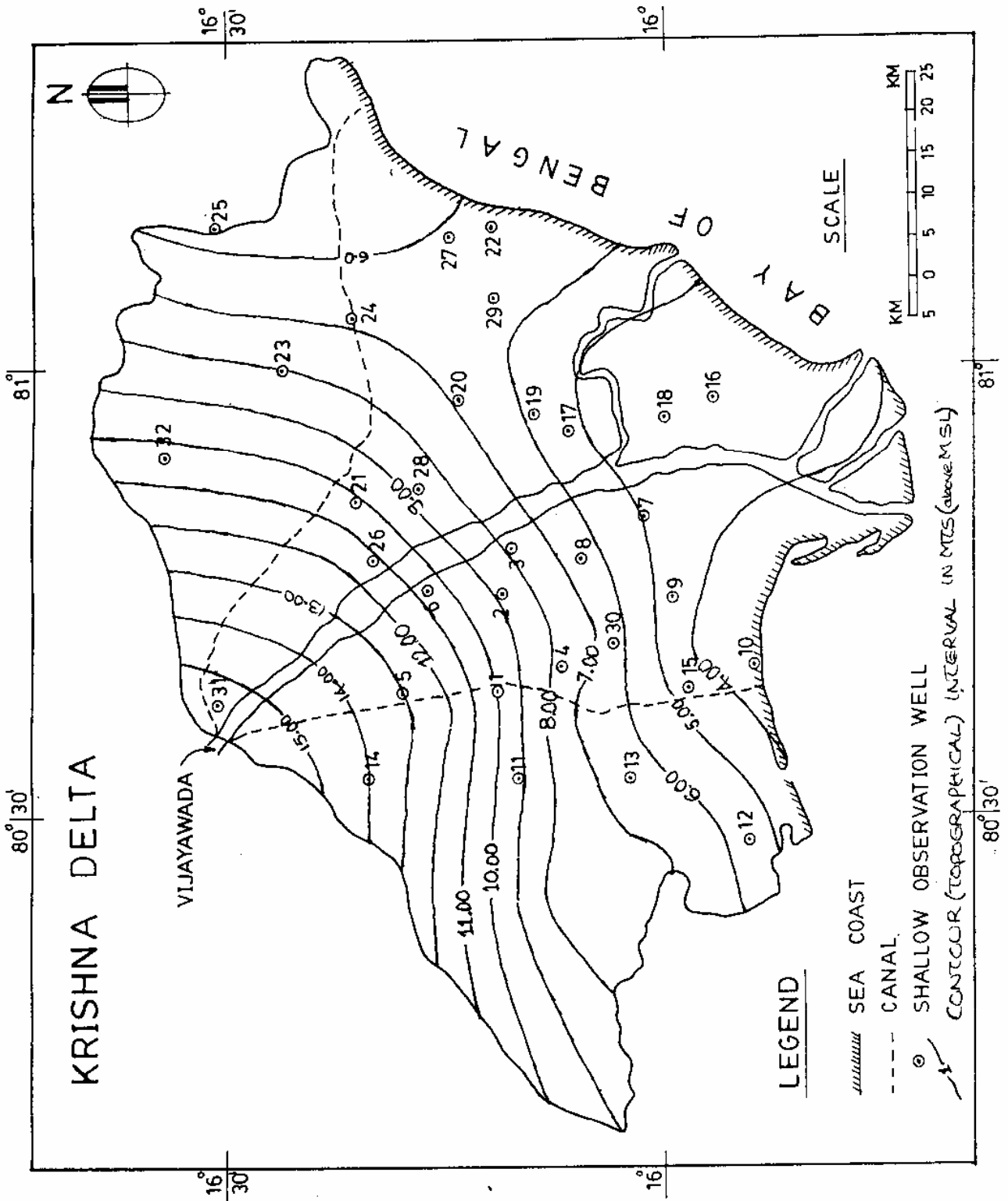


FIG. 3 TOPOGRAPHICAL CONTOUR MAP OF KRISHNA DELTA

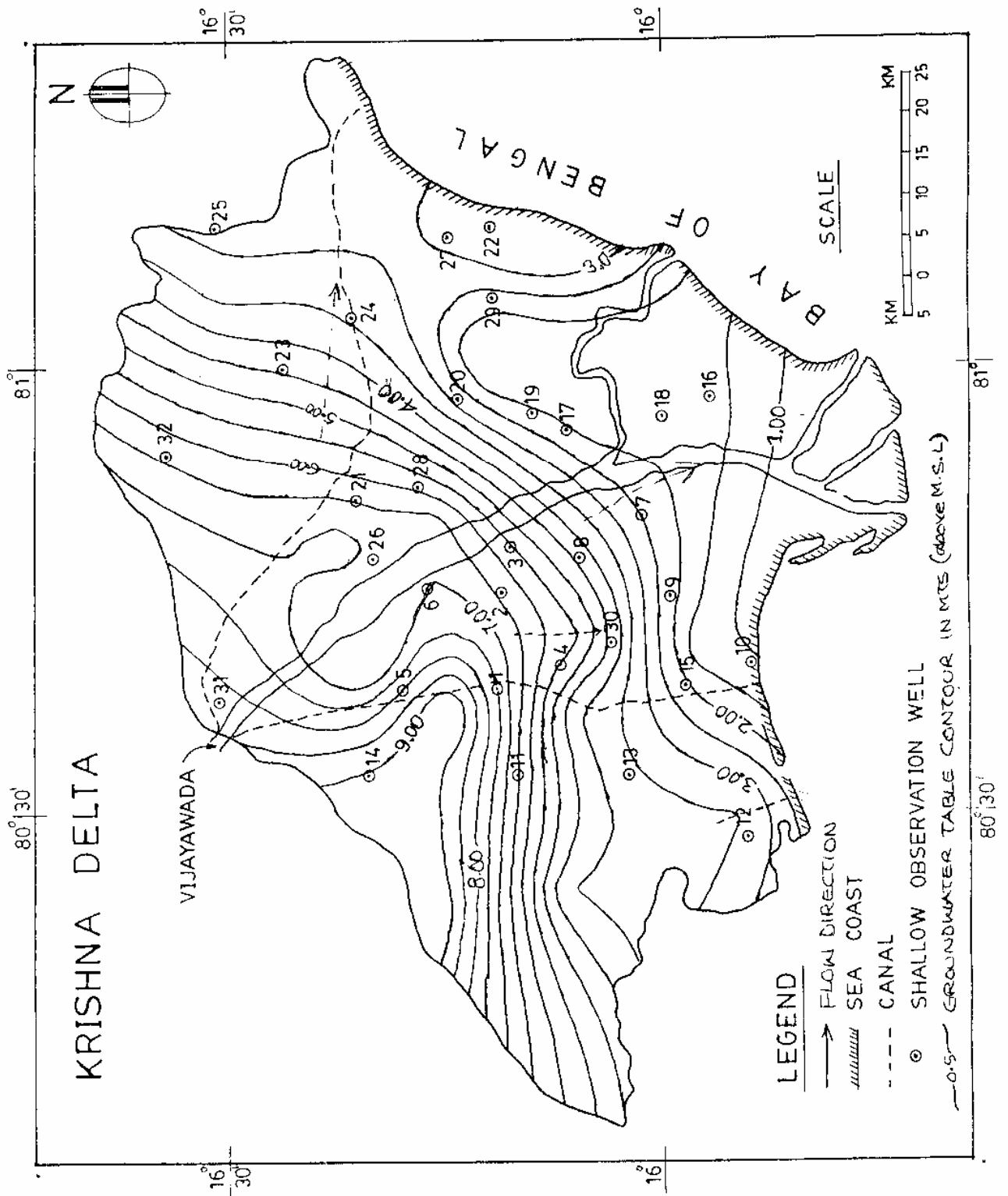


FIG. 4 GROUNDWATER TABLE CONTOUR MAP DURING MAY 1989

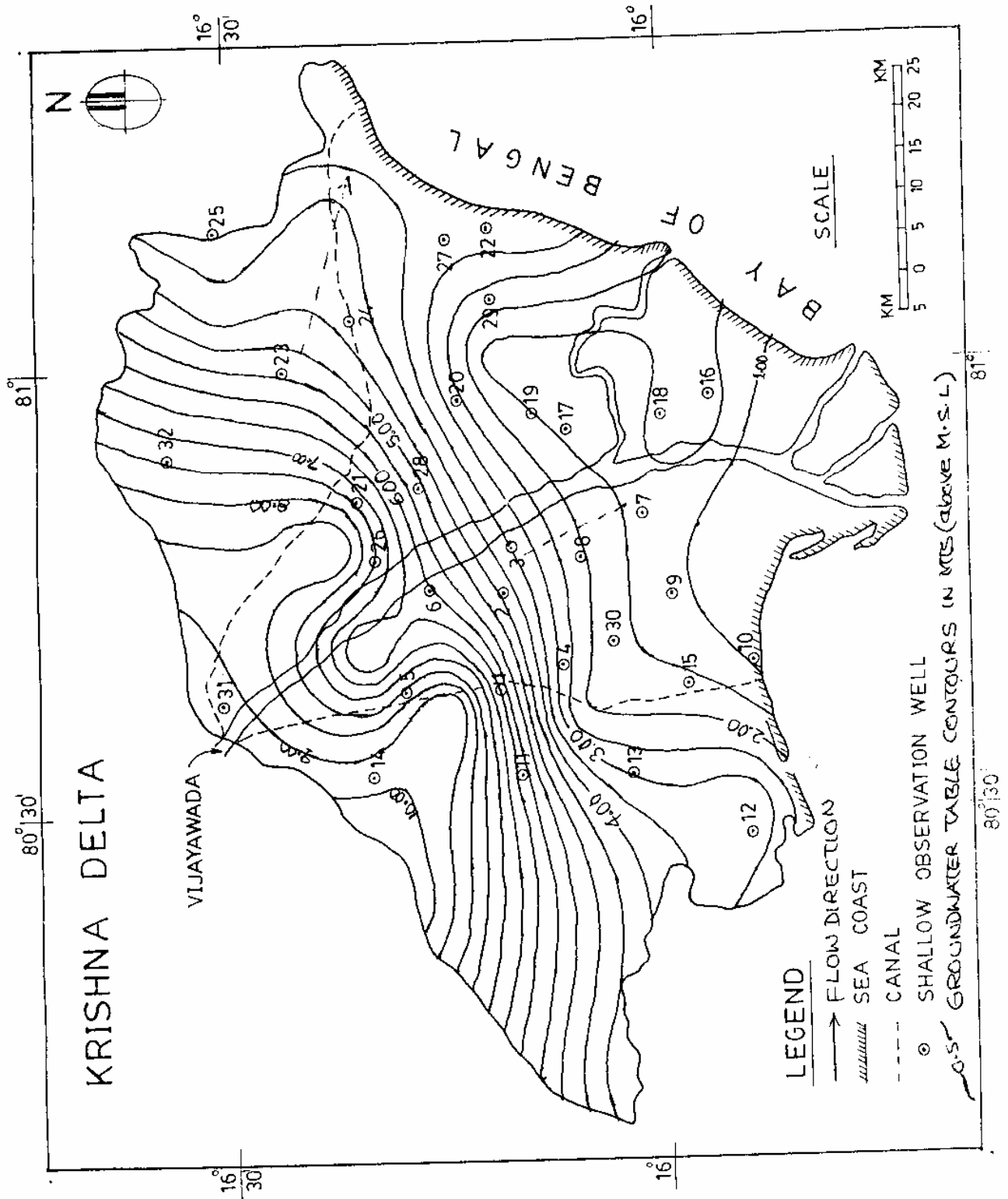


FIG. 5. GROUNDWATER TABLE CONTOUR MAP DURING MAY 1999

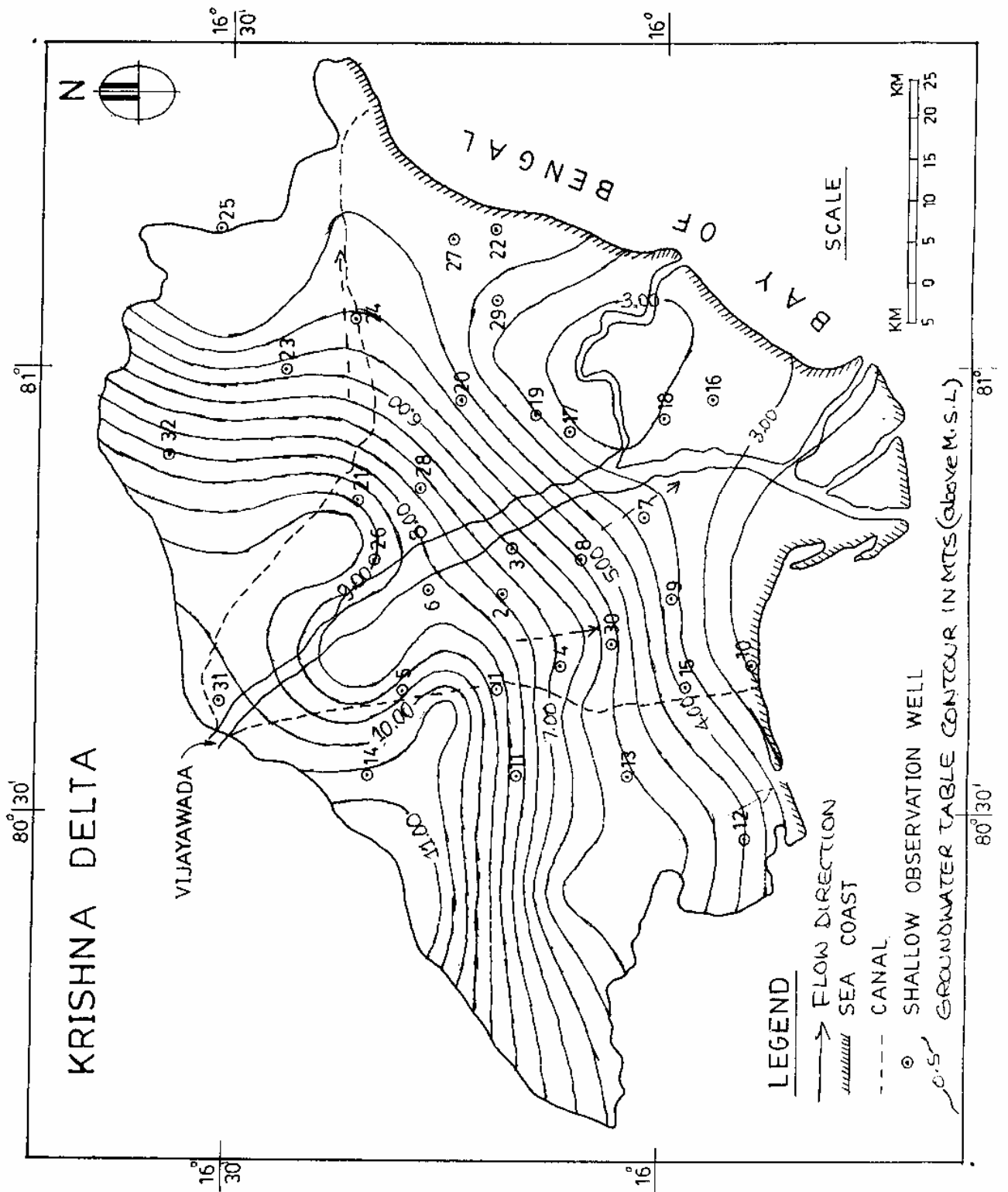


FIG. 6 GROUNDWATER TABLE CONTOUR MAP DURING NOVEMBER 1989

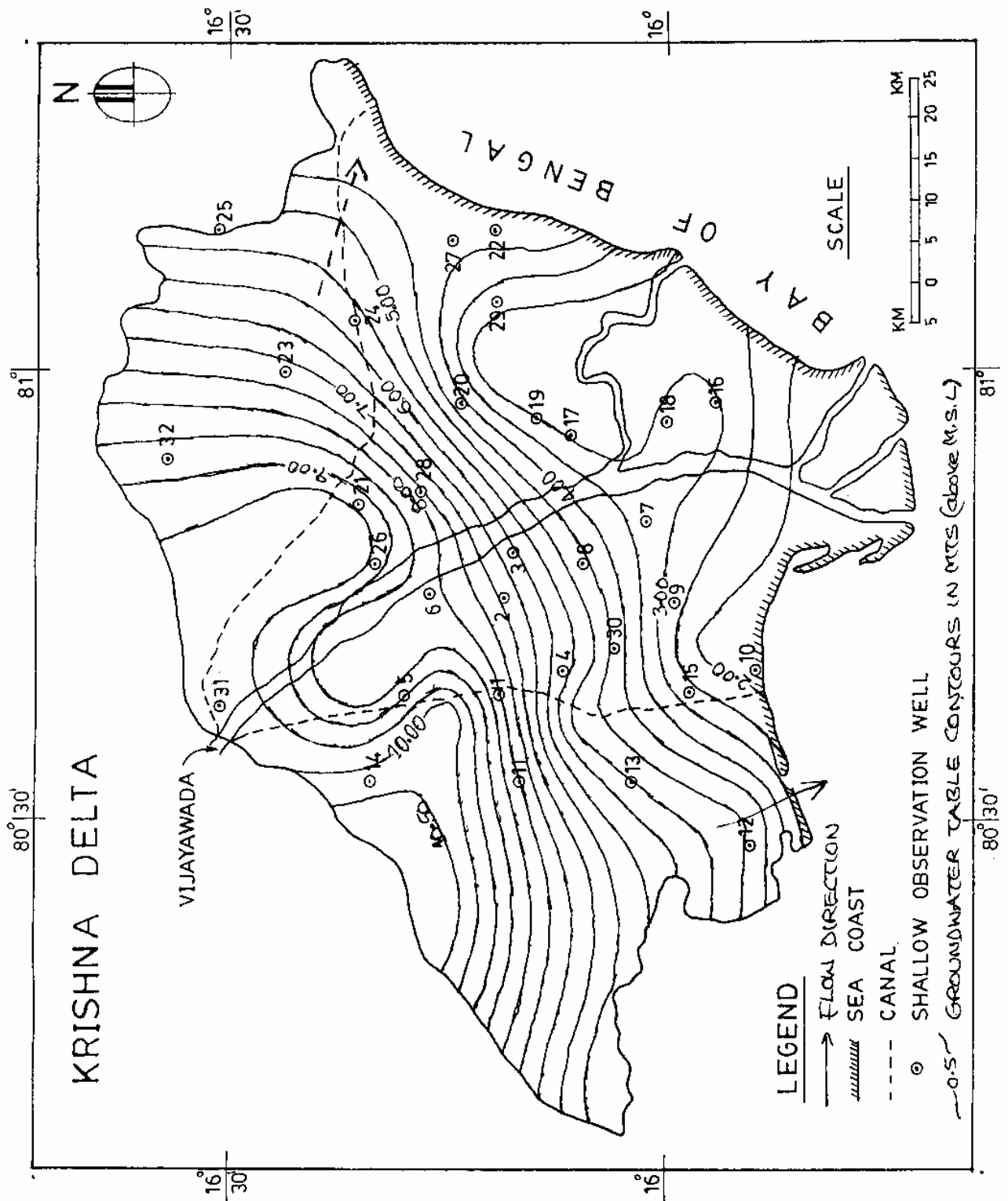


FIG. 7 GROUNDWATER TABLE CONTOUR MAP DURING NOVEMBER 1999

Table 3. Groundwater levels (w.r.t. MSL in metres) during pre monsoon in Krishna Delta

	Kollipara (6)	Repalle (7)	Nizampatnam (10)	Ponnuru (13)	B D Pali (16)	Challapali (17)	Chinamathevi (20)	Vuyyuru (21)
May-79	8.982	-1.405	0.620	2.550	1.337	2.205	2.130	7.975
May-80	9.012	-1.305	1.650	1.280	2.057	1.535	1.990	6.025
May-81	Not Available	Not Available	1.870	1.210	1.107	1.585	2.140	9.515
May-82	9.862	-0.745	0.580	1.740	1.147	1.485	1.850	10.415
May-83	9.062	-1.065	Not Available	Not Available	1.257	2.035	1.850	10.295
May-84	9.682	-0.395	0.970	2.050	1.157	1.835	2.100	10.055
May-85	Not Available	0.325	1.170	2.300	1.137	Not Available	1.780	10.155
May-86	9.272	-0.355	0.800	1.590	1.367	2.545	2.220	10.065
May-87	8.932	Not Available	0.720	1.240	1.207	2.385	2.010	10.125
May-88	8.862	-0.295	1.220	1.860	1.157	2.335	1.910	9.055
May-89	9.732	0.445	1.520	1.990	-0.063	2.075	1.060	7.265
May-90	10.032	0.335	1.120	2.200	0.857	3.885	2.100	10.925
May-91	10.332	-0.115	0.870	1.600	0.807	2.715	1.910	9.515
May-92	9.832	-0.015	1.120	1.450	0.307	2.035	1.660	8.505
May-93	10.032	-0.065	1.120	1.650	1.657	1.865	1.680	9.745
May-94	9.812	-0.635	1.310	1.300	1.147	1.955	1.640	8.585
May-95	10.662	0.285	1.470	2.460	1.937	3.485	1.980	10.135
May-96	9.912	-0.365	1.000	1.560	1.607	2.125	0.650	8.745
May-97	9.612	-0.165	0.970	1.600	0.557	2.385	0.560	9.065
May-98	9.462	-0.115	1.170	2.200	0.647	2.535	0.830	8.695
May-99	10.112	-0.315	1.420	1.700	1.117	2.235	1.190	9.235

Table 4. Groundwater levels (w.r.t. MSL in metres) during post monsoon in Krishna Delta

	Kollipara (6)	Repalle (7)	Nizampatnam (10)	Ponnuru (13)	B D Palli (16)	Challapalli (17)	Chinamuthevi (20)	Vuyyuru (21)
Nov-79	10.092	0.115	1.750	3.890	2.247	3.585	3.310	10.375
Nov-80	10.212	0.005	1.670	4.070	2.207	3.335	3.260	10.575
Nov-81	Not Available	-0.245	1.510	3.810	2.357	3.635	3.820	10.795
Nov-82	10.812	0.775	Not Available	3.950	2.437	3.035	3.460	10.855
Nov-83	10.762	0.425	Not Available	Not Available	2.557	3.385	3.130	10.825
Nov-84	10.902	0.955	2.020	4.500	1.877	2.095	3.540	10.395
Nov-85	Not Available	Not Available	Not Available	Not Available	2.257	3.835	3.270	10.875
Nov-86	10.682	0.655	1.970	4.150	2.547	3.725	3.810	10.635
Nov-87	9.782	0.585	2.080	4.140	2.357	3.535	3.460	11.125
Nov-88	11.332	1.005	2.320	4.650	1.557	3.535	3.160	10.505
Nov-89	10.932	1.285	1.920	3.850	2.267	3.755	3.410	10.465
Nov-90	10.442	1.785	2.060	4.000	2.307	3.605	3.090	10.615
Nov-91	11.352	1.735	1.990	5.000	1.597	3.475	2.550	10.595
Nov-92	11.032	2.435	2.720	2.750	2.647	4.555	3.690	11.175
Nov-93	11.312	1.165	2.410	4.250	2.317	3.065	3.230	10.575
Nov-94	10.462	1.385	1.870	5.300	1.847	3.595	2.870	11.225
Nov-95	10.512	1.325	1.860	3.170	2.167	4.25	2.360	10.135
Nov-96	11.512	1.835	2.620	4.200	2.317	3.925	2.010	10.525
Nov-97	11.462	1.135	2.620	4.900	2.547	3.635	2.360	10.555
Nov-98	11.762	1.985	2.870	4.700	2.237	4.515	3.320	11.115
Nov-99	10.572	1.795	1.870	4.05	2.187	3.715	2.190	10.865

monsoon periods in well nos. 6, 7, 10 and 13 are shown in Fig. 8 and other wells (Nos.16, 17, 20, 21) are shown in Fig. 9. The increasing trend during pre and post monsoon periods for last 20 years has been observed in the study area except in well nos. 16 and 20. The increasing trend may be due to the influence of river water and increase of area under canal irrigation. The same has been revealed from the study on seasonal groundwater balance in Bandar canal command area (Satyaji Rao et al 1994) which concluded that the major recharge contribution to the groundwater in the Krishna Delta is from canal seepage and irrigation return flows. However, the negative trend in well nos. 16 and 20 may be due to the over extraction or the local geological conditions or perched aquifer conditions. The monthly rainfall data of 32 raingauge stations for a period of 10 years (1989 to 1999) are presented in Annexure I. The average groundwater table and average monthly rainfall has been calculated by arithmetic method for a period of 10 years. The comparison of average monthly rainfall and average seasonal rainfall with average groundwater table in the study area is shown in Fig 10(a) and 10(b) respectively. The comparison shows that the recharge of groundwater is not fully dependent on rainfall pattern in the study area. The trend analysis of average seasonal rainfall and average groundwater table in the study area during the period 1989 to 1999 is shown Fig. 11.

The trend analysis (Fig. 11) indicated that there is no much significant change in the average rainfall pattern and post monsoon (Nov.) average groundwater table in the study area. However, the average groundwater table during pre (May) monsoon has been decreased over a period of time. It is to be noted that in few observation wells the increasing trend of water levels has been observed during pre monsoon period. It may be due to the influent effect of Krishna river and nearby canal or local geological conditions. However, the decreasing trend of average groundwater table during pre monsoon period may due to the increase demand of groundwater in the delta. The average groundwater table is calculated by using 32 observation wells data in the study area, which is more realistic to represent the average groundwater table conditions.

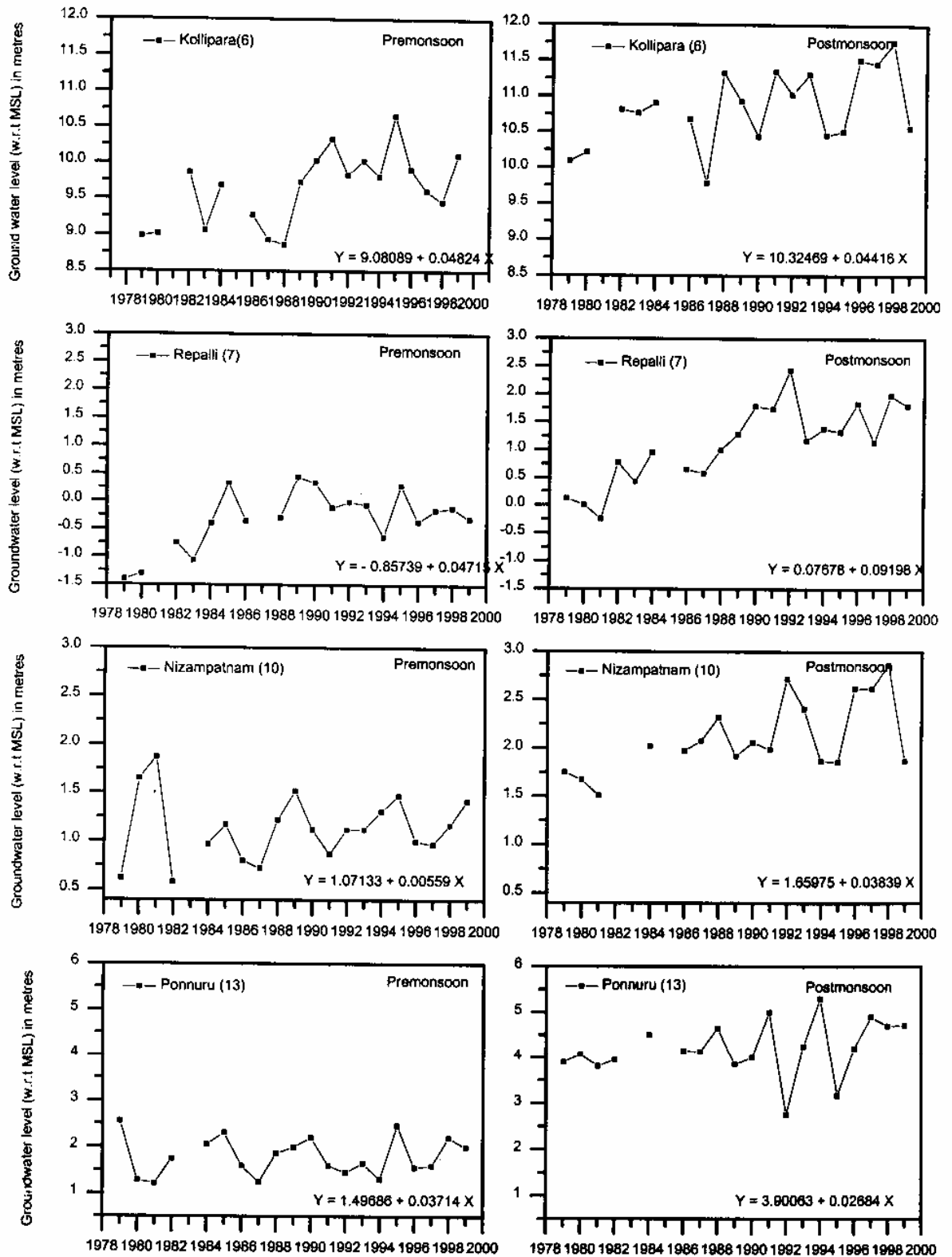


Fig. 8. Trends in Groundwater level (w.r.t MSL in metres) in Krishna Delta for Pre (May) and Post (Nov) monsoon periods during the years 1979 to 1999

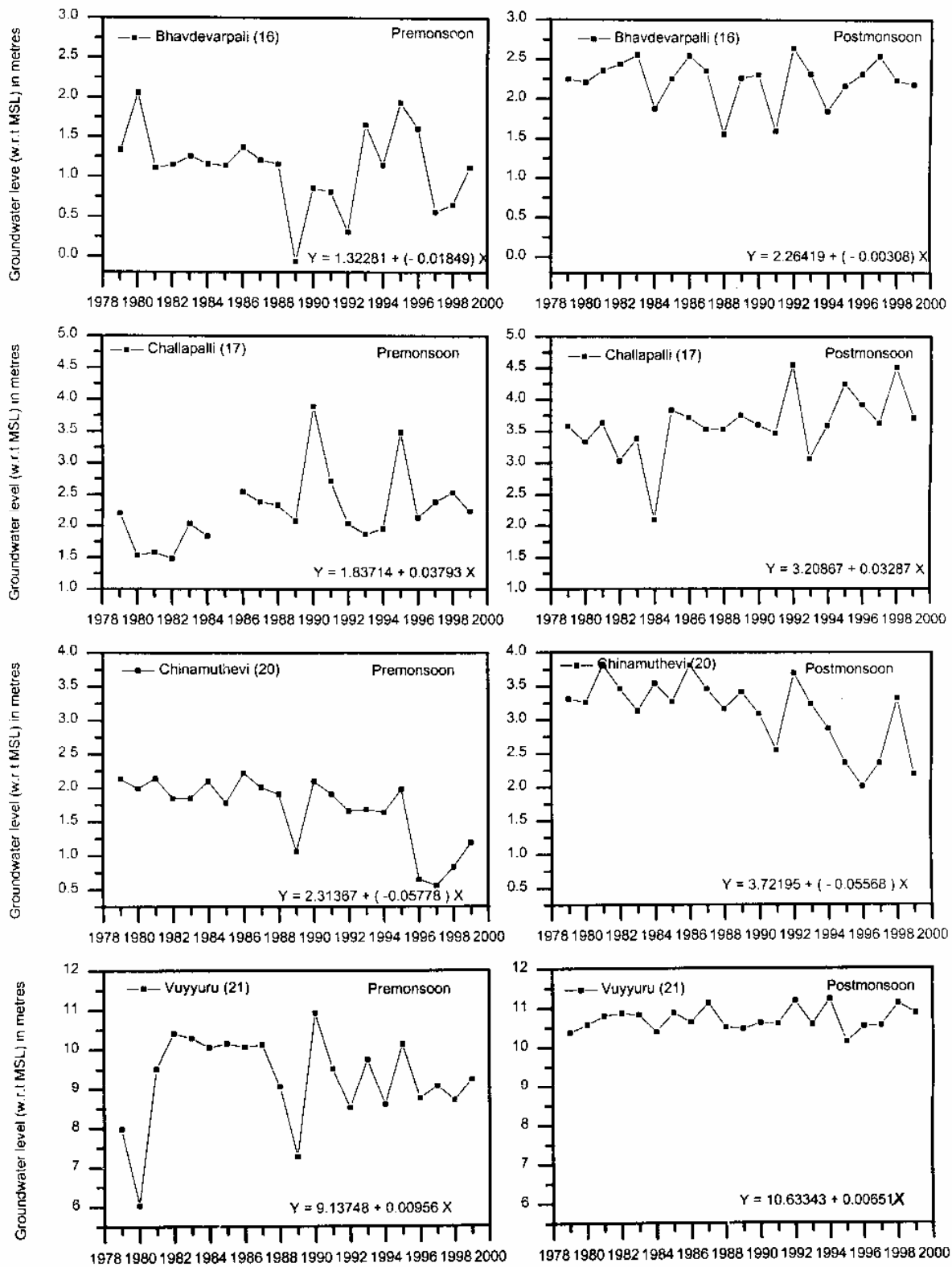


Fig. 9. Trends in Groundwater level (w.r.t MSL in metres) in Krishna Delta during Pre (May) and Post (Nov) monsoon periods during the years 1979 to 1999

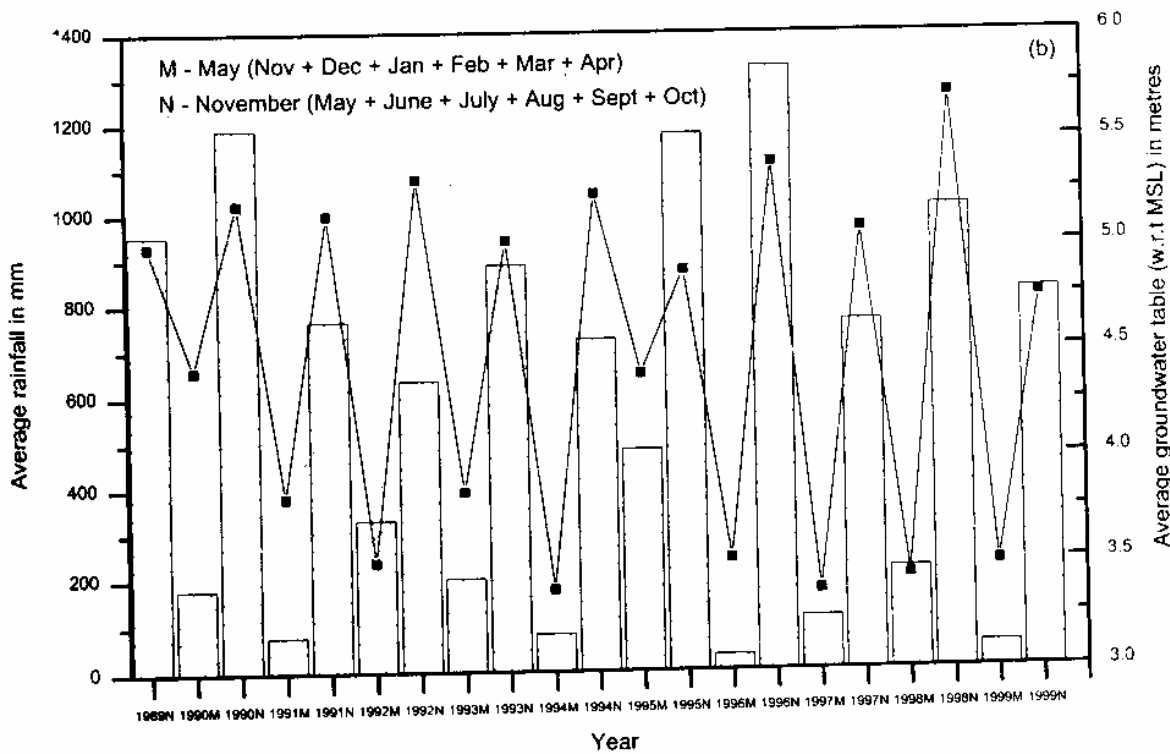
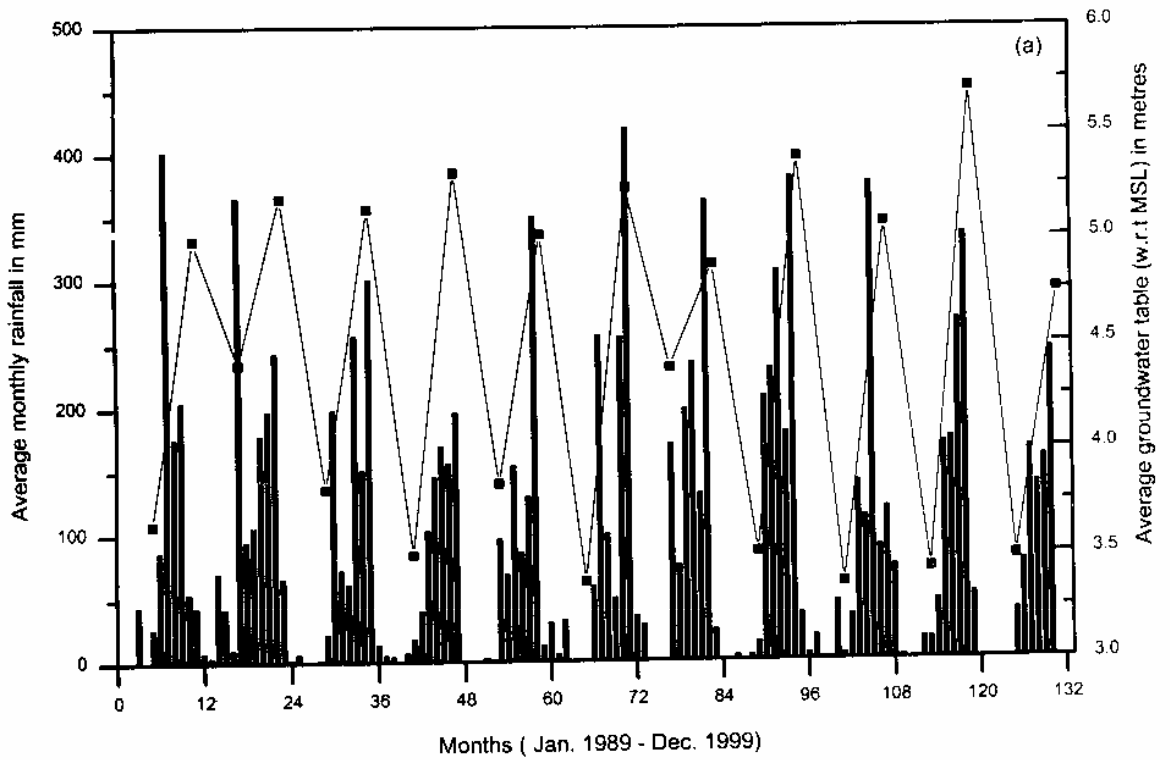


Fig.10. Comparison between average groundwater table and average rainfall in Krishna Delta during 1989 - 1999

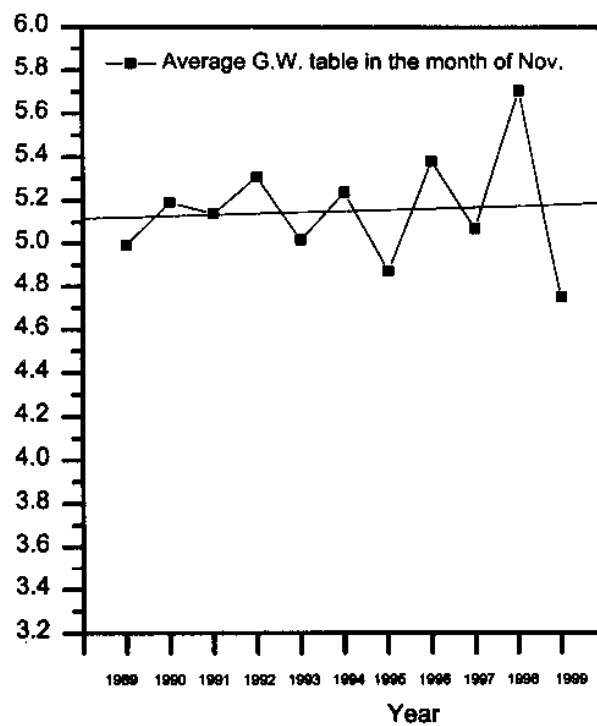
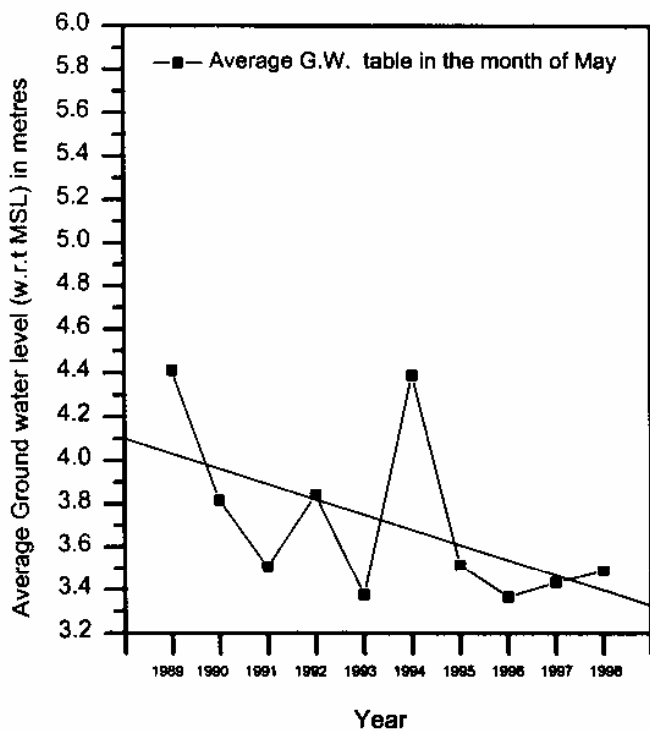
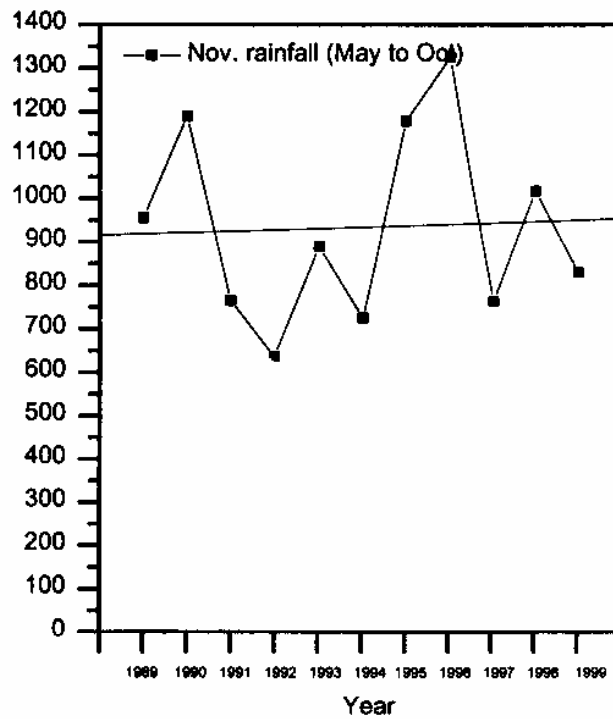
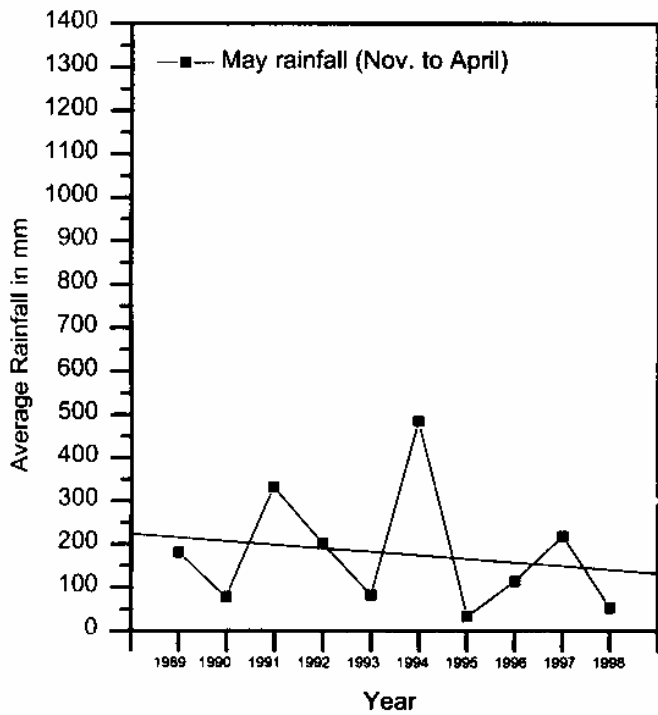


Fig.11. Trends in average rainfall and average groundwater table in Krishna Delta

4.2 Groundwater quality

4.2.1 Hydrochemistry of Shallow (open) Wells

The groundwater quality data of shallow observation wells (32 nos.) for a period of 18 years (1989 to 1999) are given in Annexure II. The data includes physical parameters (pH, EC) and chemical parameters (Ca, Mg, Na, K and Cl, HCO₃, CO₃). The total hardness as CaCO₃ (TH), percentage of Sodium (%Na), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) in each well has been calculated using equations 1, 2, 3 and 4 respectively. The spatial distribution maps of Electrical Conductivity (EC), SAR and Cl/HCO₃ ratio in the study area have been prepared only for pre and post monsoon periods of the years 1991 and 1999 due to non availability of chemical analysis data for all the wells.

The spatial distribution of EC ($\mu\text{moh/cm}$) of groundwater during pre monsoon period (May) of the years 1991 and 1999 is shown Fig.12. Similarly for post monsoon period (Nov. 1991 and Nov. 1998), it is shown in Fig. 13. Due to non-availability of chemical data for the month of November 1999, November 1998 data has been considered for the present analysis. As per the U.S. Salinity Laboratory (1954) classification the EC gives an indication of salinity levels.

EC ($\mu\text{moh/cm}$)	Salinity level
< 250	Low salinity of water
250 to 750	Medium salinity
750 to 2250	High salinity
2250 to 5000	Very high salinity

The shallow aquifer of Krishna delta is between high and very high salinity zone (750 to 5000 $\mu\text{moh/cm}$). No specific trend has been observed in EC during pre and post monsoon periods (Fig.12 and 13). The EC is highly variable and subjected to local conditions of the observation well. In general, the EC values should increase towards seacoast. However, the highest EC values have been observed in well nos. 17, 19, 20 and 28. This may be due to the over exploitation of groundwater or upcoming phenomena in the areas around these wells. The water level trend analysis also confirms that there is decreasing trend in groundwater levels in well no 20 over a period of twenty years. The comparison between pre monsoon and post monsoon EC contours shows that the EC values have increased from pre to post monsoon period at

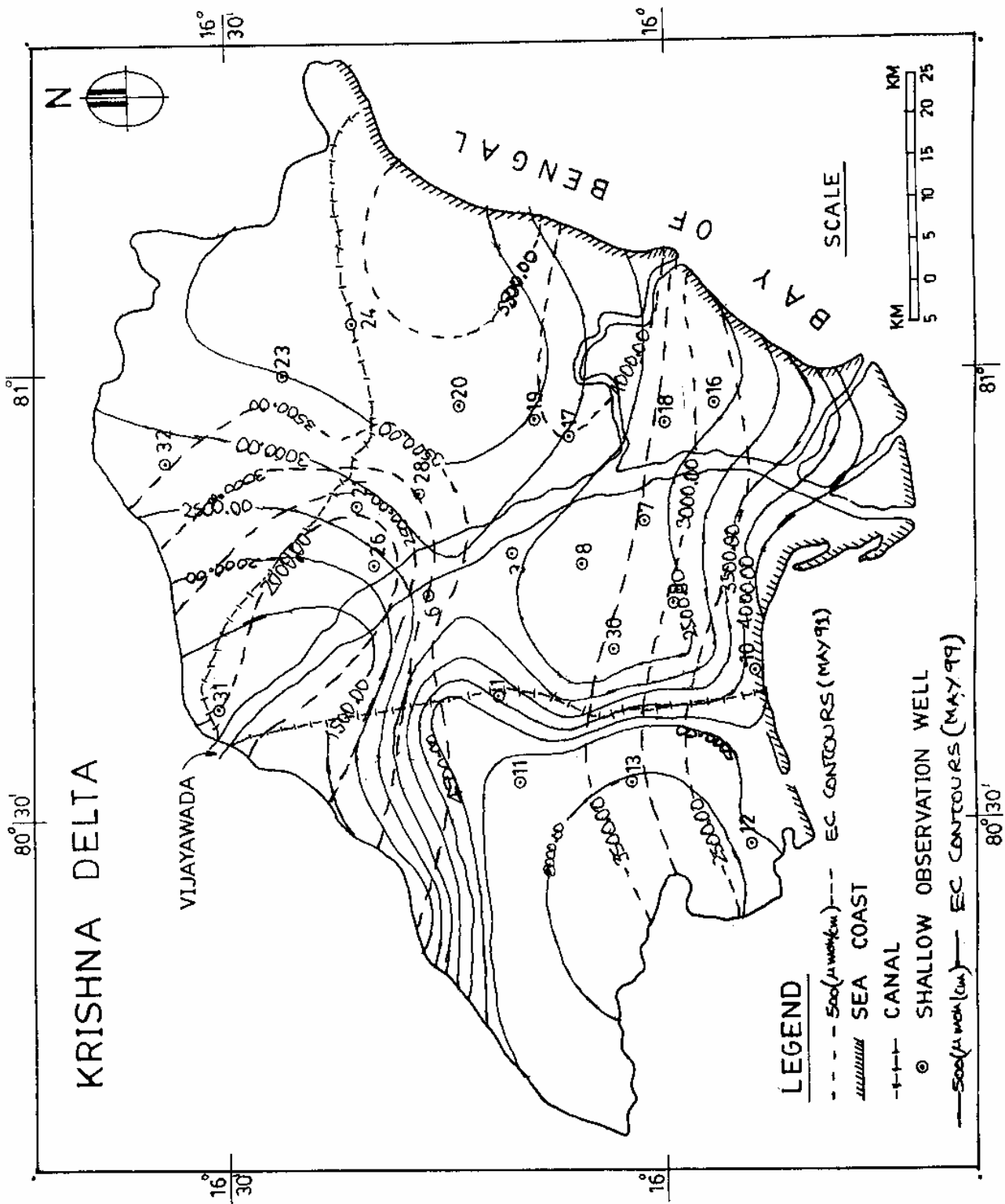


FIG. 12 SPATIAL DISTRIBUTION OF ELECTRICAL CONDUCTIVITY(EC) DURING PRE MONSOON PERIOD (MAY)

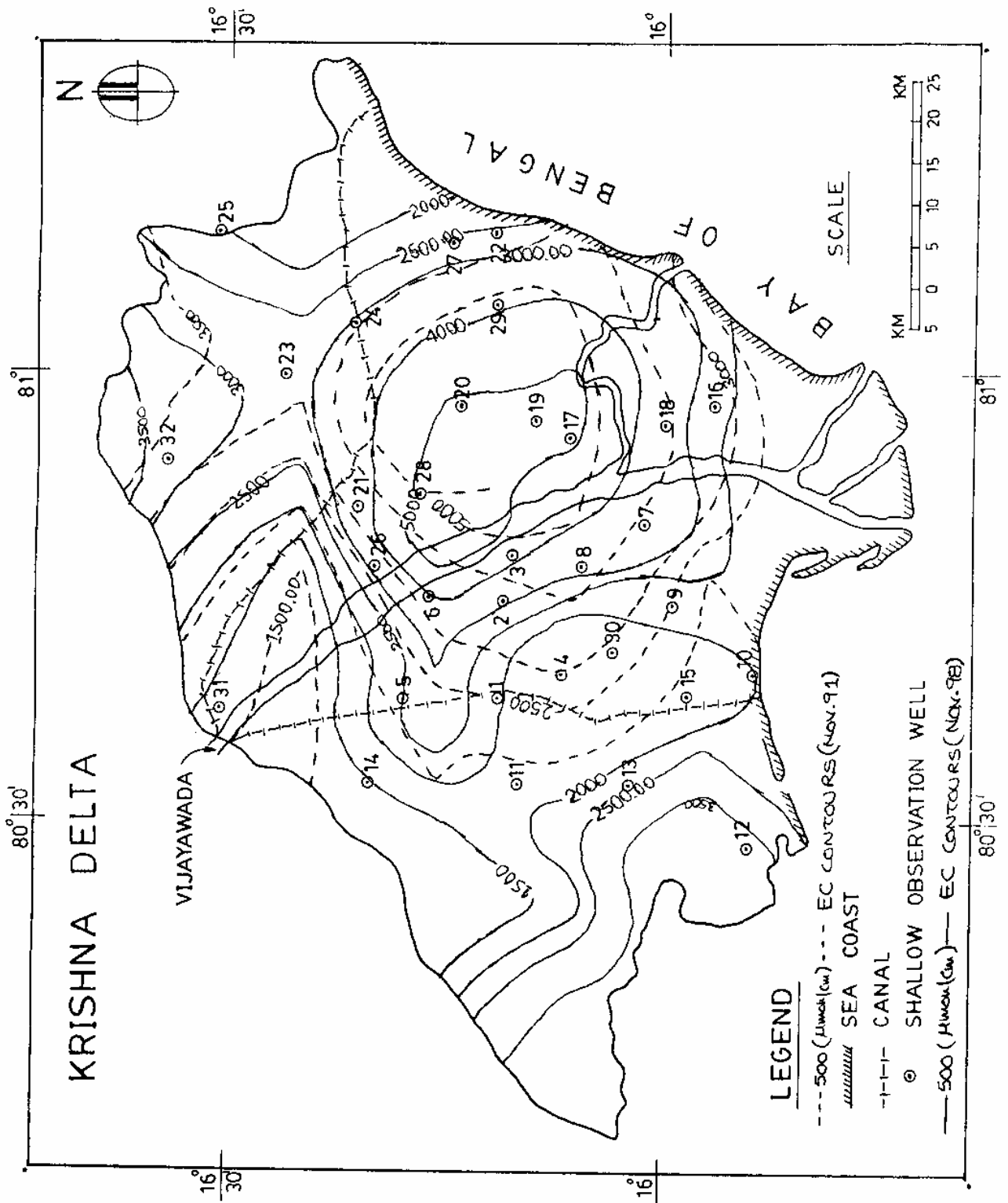


FIG. 13 SPATIAL DISTRIBUTION OF ELECTRICAL CONDUCTIVITY (EC) DURING POST MONSOON PERIOD (NOV.)

some places (19, 20 and 28) and decreased at some places (1, 11, 13 and 15). This may be due to the recharge and discharge conditions in the study area and local geology.

The spatial distributions of SAR during pre monsoon (May 1991 and May 1999) and post monsoon (Nov. 1991 and Nov. 1998) in the study area are shown in Figures 14 and 15 respectively. The spatial distribution maps indicate that the sodium hazard in the study area is between low and medium (2 to 18).

SAR	Sodium Hazard
2 to 10	Low
10 to 18	Medium
18 to 22	High
> 22	Very high

It is observed that the SAR values are significantly decreasing from pre monsoon to post monsoon period. This may be due to recharge of groundwater. The spatial distributions of Cl/HCO_3 ratio during pre monsoon (May 1991 and May 1999) and post monsoon (Nov. 91 and Nov. 98) periods are shown in Fig.16 and 17 respectively. It is quite interesting to observe that the Cl/HCO_3 ratio is low in pre monsoon and quite high in post monsoon period. There is no systematic trend of Cl/HCO_3 ratio observed during pre monsoon period (Fig.16). However, there is a trend in Cl/HCO_3 ratio during post monsoon period for the years 1991 and 1998. Further the ratio has been increased from the year 1991 to 1998 (pre and post monsoon periods only). This shows that the increase in salinity may not be due to the salt-water intrusion in the study area. High Cl/HCO_3 ratio indicates brackish water near the coast and further indicates seawater contamination due to low-level groundwater table conditions. High Cl/HCO_3 ratio indicates high salinity zones but its exact source can not be identified. If any other source does not exist other than sea coast, it can be assumed as sea water intrusion. The Cl/HCO_3 ratio of seawater is 133.8 (Ion ratio by weight, Goldberg, 1963). However Mendhekar and Pandey (1976) had discounted the idea of intrusion by seawater but claimed that salinity increase was due to use and reuse of groundwater in arid areas (Junagadh and Amreli districts, Gujarat) so that the recharge water is quite saline. Prasad and Sinha (1969) in their studies in Gandhechi area of Jamnagar district had reported on the occurrence of $Cl-HCO_3$ type waters in water table aquifers dominated by clays but not specified any source for high salinity

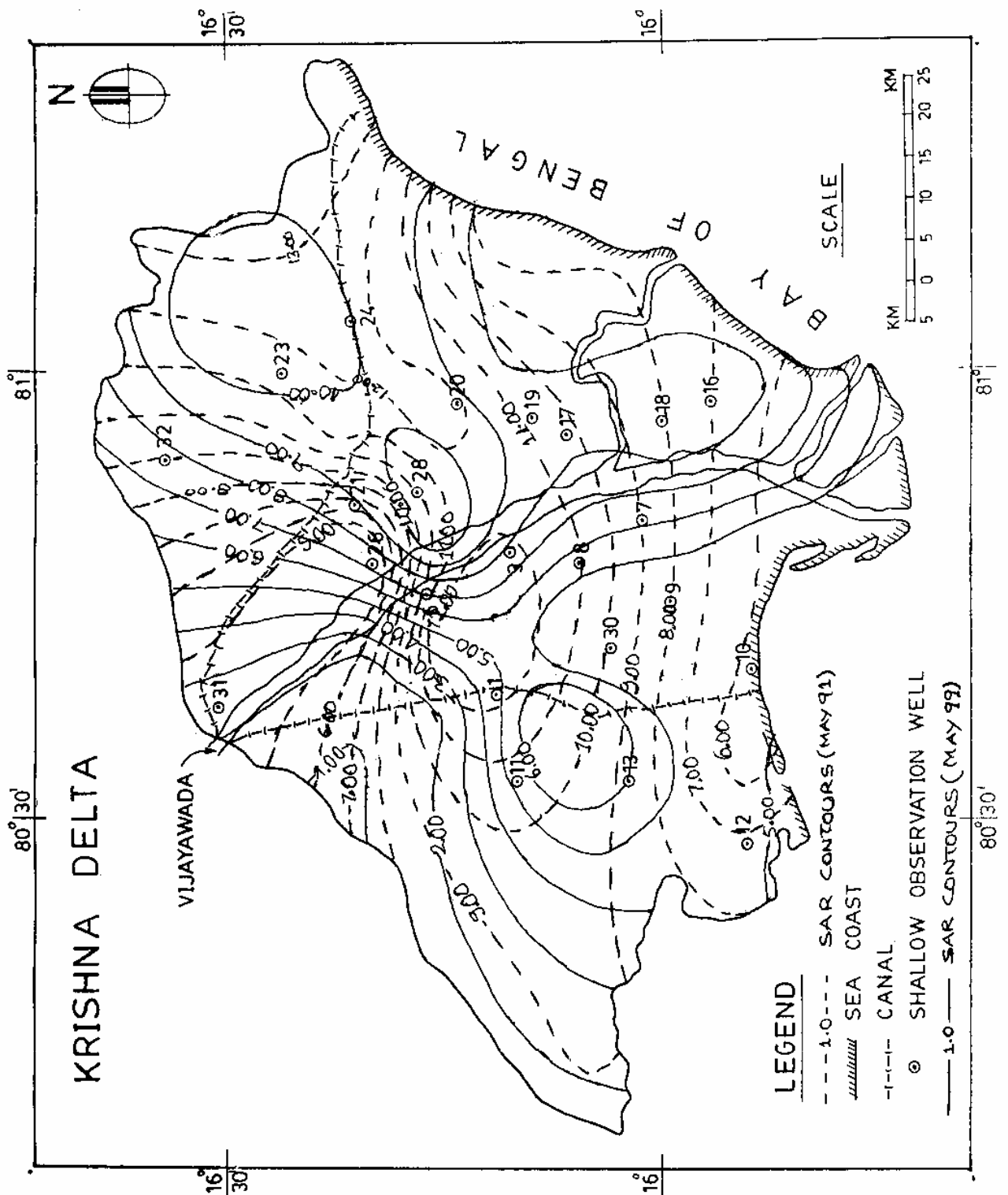


FIG. 14 SPATIAL DISTRIBUTION OF SODIUM ABSORPTION RATIO (SAR) DURING PRE MONSOON PERIOD (MAY)

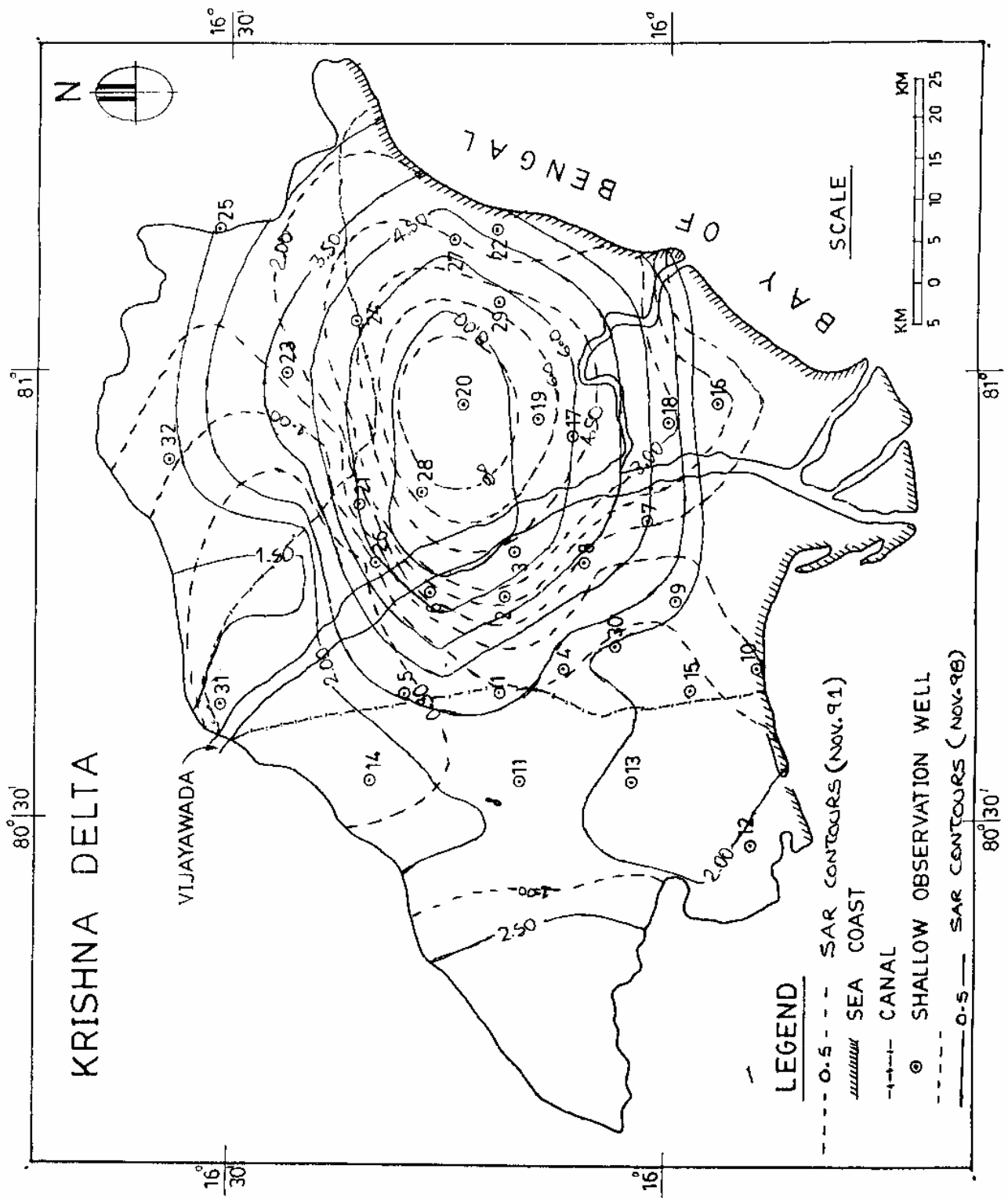


FIG. 15 SPATIAL DISTRIBUTION OF SODIUM ABSORPTION RATIO (SAR) DURING POST MONSOON PERIOD (NOV.)

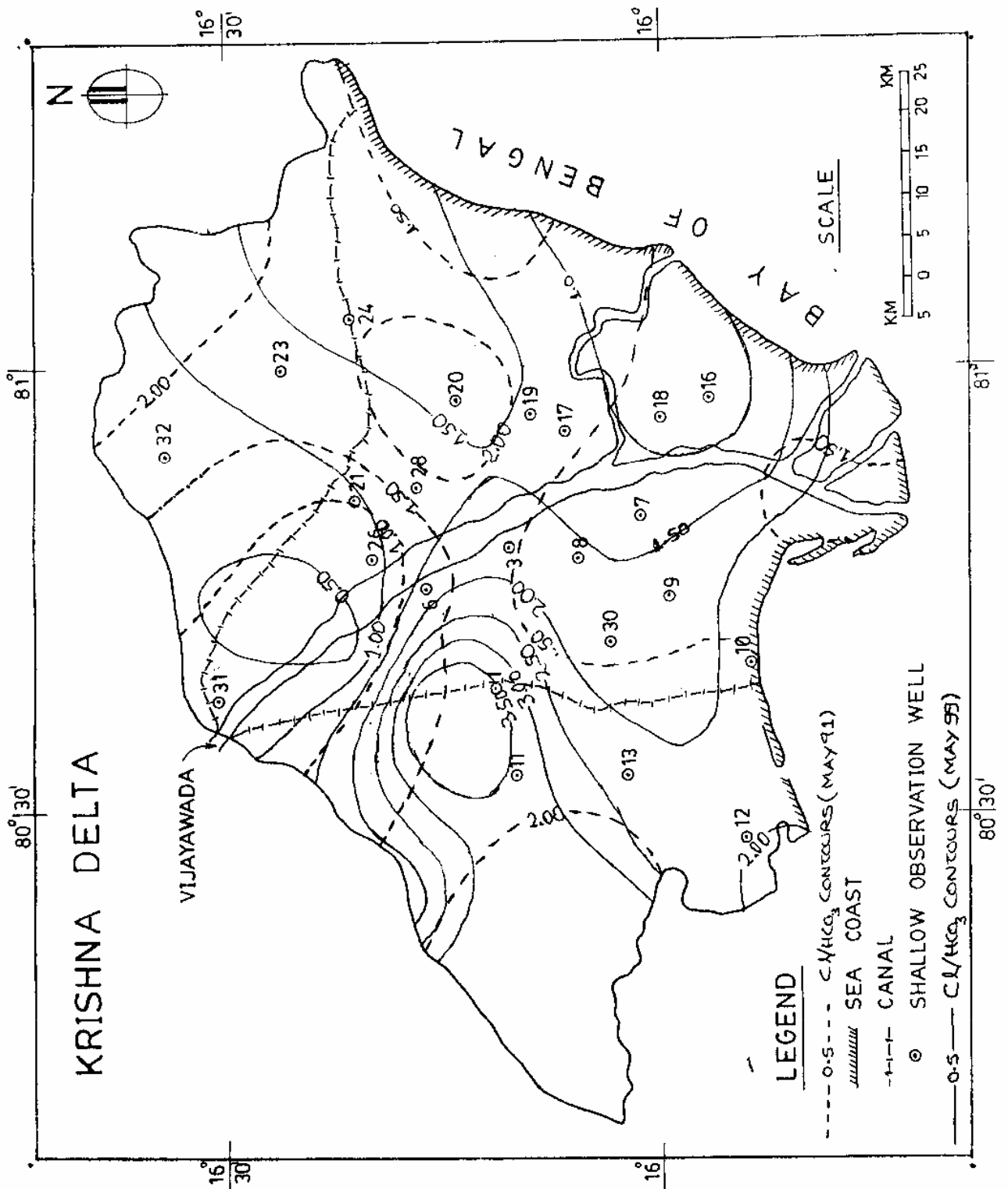


FIG. 16 SPATIAL DISTRIBUTION OF CH_4/CO_2 RATIO DURING PRE MONSOON PERIOD (MAY)

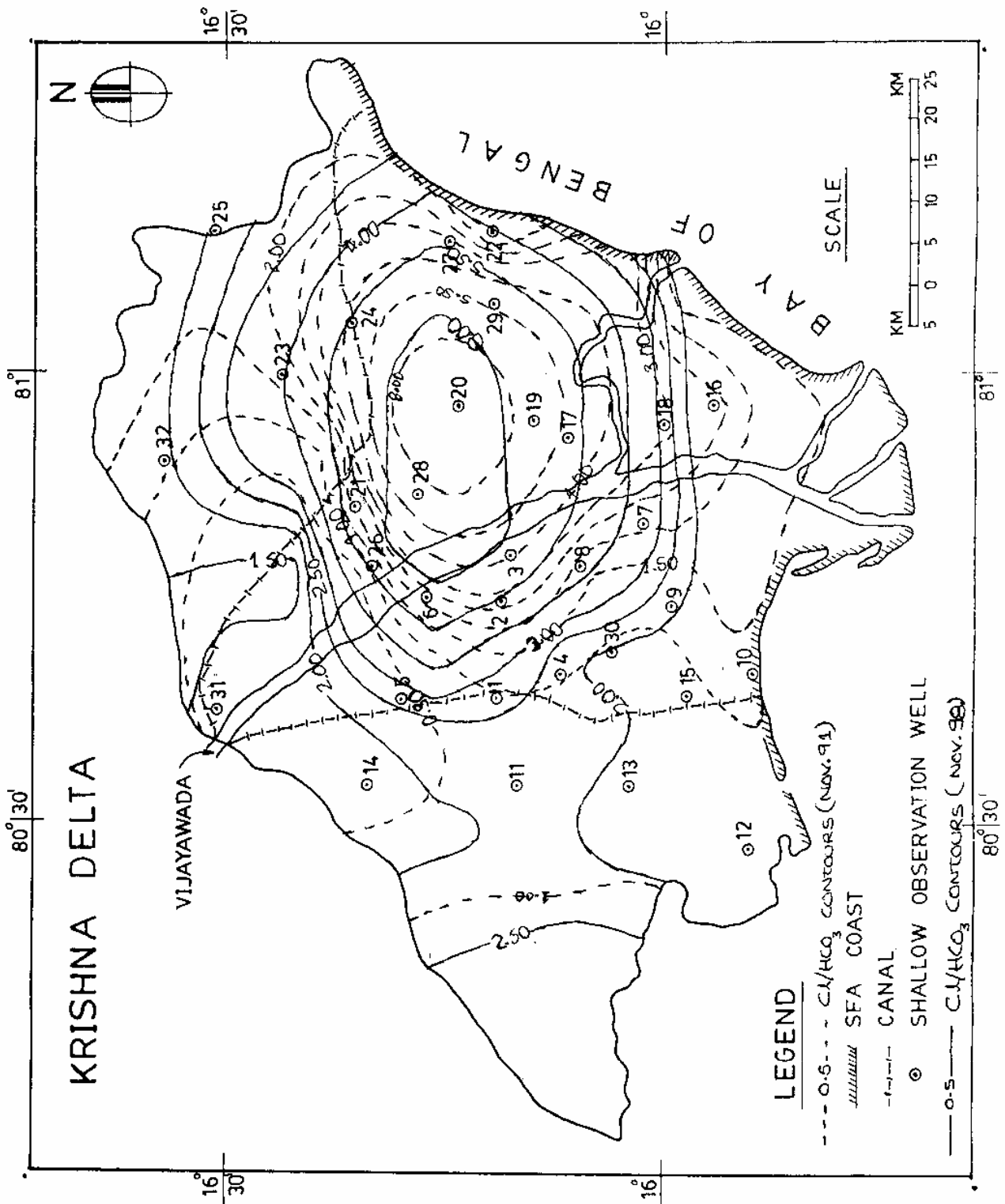


FIG. 17 SPATIAL DISTRIBUTION OF Cl/HCO_3 RATIO DURING POST MONSOON PERIOD (NOV.)

of groundwater in a part of the area. Therefore the shallow aquifer of Krishna delta needs extensive investigations to find out the sources of salinity.

4.2.2 Multiple linear regression models for Electrical Conductivity

The year 1995 has been chosen to represent water quality of shallow aquifer. Because, among 32 observation wells, 31 observation wells water quality data is available. The correlation between major ions in shallow aquifer during pre and post monsoon periods is calculated and the same is given in Table 5 and 6 respectively. The water quality parameters which are highly correlated with EC have been selected (>0.75) for multiple linear regression models. Models 1 to 6 are developed based on pre (May 1995) monsoon and models 6 to 12 are developed for post (Nov. 1995) monsoon water quality data. The measured EC values of May 1993 and May 1999, and Nov.1993 and Nov. 1998 are compared with computed values (models 1 to 12). The performance of these regression models for pre monsoon and post monsoon periods is given in Table 7 and 8 respectively. Among all regression models, model nos. 1 to 3 and 7 to 9 are considered best for pre and post monsoon periods respectively. The comparison between measured EC and computed EC values of shallow groundwater during pre and post monsoon periods are shown in Fig. 18(a) and 18 (b) respectively. The best regression models for estimating reliable EC values in Krishna Delta for pre (May) and post (Nov.) monsoon periods are as follows.

$$EC = 495.311 + 1.927Cl + 2.473 Na + 6.557 Mg \text{ (pre monsoon)} \quad (5)$$

(Efficiency = 80.2% and RMS = 482.8)

$$EC = -133.033 + 0.939 Cl + 3.878 Na + 3.240 Mg \\ + 1.017 TH + 0.721 HCO_3 \text{ (post monsoon)} \quad (6)$$

(Efficiency = 82.60 % and RMS = 318)

Therefore, any missing values of EC during pre and post monsoon periods of shallow aquifer could be estimated by using above equations.

4.2.3 Hydrochemistry of filter points, tube wells, canal water, river water and seawater.

An Intensive field survey was conducted in the month of November 1999 and about 48 water samples were collected in the Krishna Delta. The samples include filter Points (8 to 15 mt depth from ground level), tube wells (75 to 100 mt depth from ground level), canal water, river water and seawater. These samples have been

Table 5. Correlation between major ions in Krishna Delta (31 samples) in the month of May 1995

	EC	HCO ₃	Cl	Na	K	Ca	Mg	Total Hardness
EC	1.000							
HCO ₃	0.772	1.000						
Cl	0.936	0.652	1.000					
Na	0.795	0.535	0.717	1.000				
K	0.272	0.170	0.173	0.241	1.000			
Ca	0.644	0.518	0.656	0.190	0.089	1.000		
Mg	0.788	0.704	0.784	0.387	-0.079	0.755	1.000	
Total Hardness	0.783	0.678	0.784	0.337	-0.021	0.892	0.970	1.000

MODELS:

1. $EC = 78.336 + 1.623 Cl + 2.463 Na - 3.310 Mg + 1.455 T.H. + 1.022 HCO_3$
2. $EC = 292.179 + 1.464 Cl + 2.955 Na - 1.674 Mg + 1.621 T.H$
3. $EC = 495.311 + 1.927 Cl + 2.473 Na + 6.557 Mg$
4. $EC = 596.477 + 3.341 Cl + 1.730 Na$
5. $EC = 884.577 + 4.153 Cl$
6. $EC = 795.585 + 5.385 Na$

Table 6. Correlation between major ions in Krishna Delta (31 samples) in the month of November. 1995

	EC	HCO ₃	Cl	Na	K	Ca	Mg	Total Hardness
EC	1.000							
HCO ₃	0.659	1.000						
Cl	0.895	0.438	1.000					
Na	0.821	0.583	0.634	1.000				
K	0.632	0.393	0.443	0.536	1.000			
Ca	0.697	0.374	0.761	0.279	0.199	1.000		
Mg	0.800	0.530	0.825	0.398	0.341	0.819	1.000	
Total Hardness	0.783	0.471	0.830	0.352	0.280	0.958	0.950	1.000

MODELS:

7. $EC = -133.033 + 0.939 Cl + 3.878 Na + 3.240 Mg + 1.017 T.H. + 0.721 HCO_3$
8. $EC = 8.854 + 0.686 Cl + 4.382 Na + 5.013 Mg + 1.076 T.H.$
9. $EC = 61.485 + 1.006 Cl + 4.081 Na + 11.873 Mg$
10. $EC = 509.796 + 2.542 Cl + 3.416 Na$
11. $EC = 1213.273 + 3.636 Cl$
12. $EC = 641.187 + 6.604 Na$

Table 7

Comparison between measured EC (May 1993 and May 1999) and computed EC (May 1993 and May 1999) using regression models 1 to 6 (calibrated using May 1995 measured EC values)

Statistical Parameters	Measured EC (58 samples)	Computed EC using linear regression models					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Mean	3364	3330	3391	3334	3396	3504	2763
Std. Deviation	2465	2557	2566	2312	2414	2749	1287
Correlation coefficient (EC vs. Models)	-	0.980	0.982	0.981	0.967	0.940	0.617
Efficiency (%) (Models)	-	79.1	80.2	80.2	74.4	61.1	17.0
RMS (EC vs. Models)	-	509.6	483.0	482.8	626.1	950.1	2026.6
Coefficient of determination (EC vs. Models)	-	0.960	0.964	0.963	0.934	0.883	0.381

Table 8

Comparison between measured EC (Nov. 1993 and Nov.1998) and computed EC (Nov.1993 and Nov.1998) using regression models 7 to 12 (calibrated using May 1995 measured EC values)

Statistical Parameters	Measured EC (58 samples)	Computed EC using linear regression models					
		Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Mean	2629	2643	2770	2871	2709	3004	2473
Std. Deviation	1845	1963	2000	2097	1772	1697	1740
Correlation coefficient (EC vs. Models)	-	0.988	0.989	0.980	0.927	0.890	0.651
Efficiency (%) (Models)	-	82.60	80.69	71.59	61.96	41.95	18.26
RMS (EC vs. Models)	-	318	353	519	695	915	1495
Coefficient of determination (EC vs. Models)	-	0.975	0.978	0.961	0.858	0.792	0.424

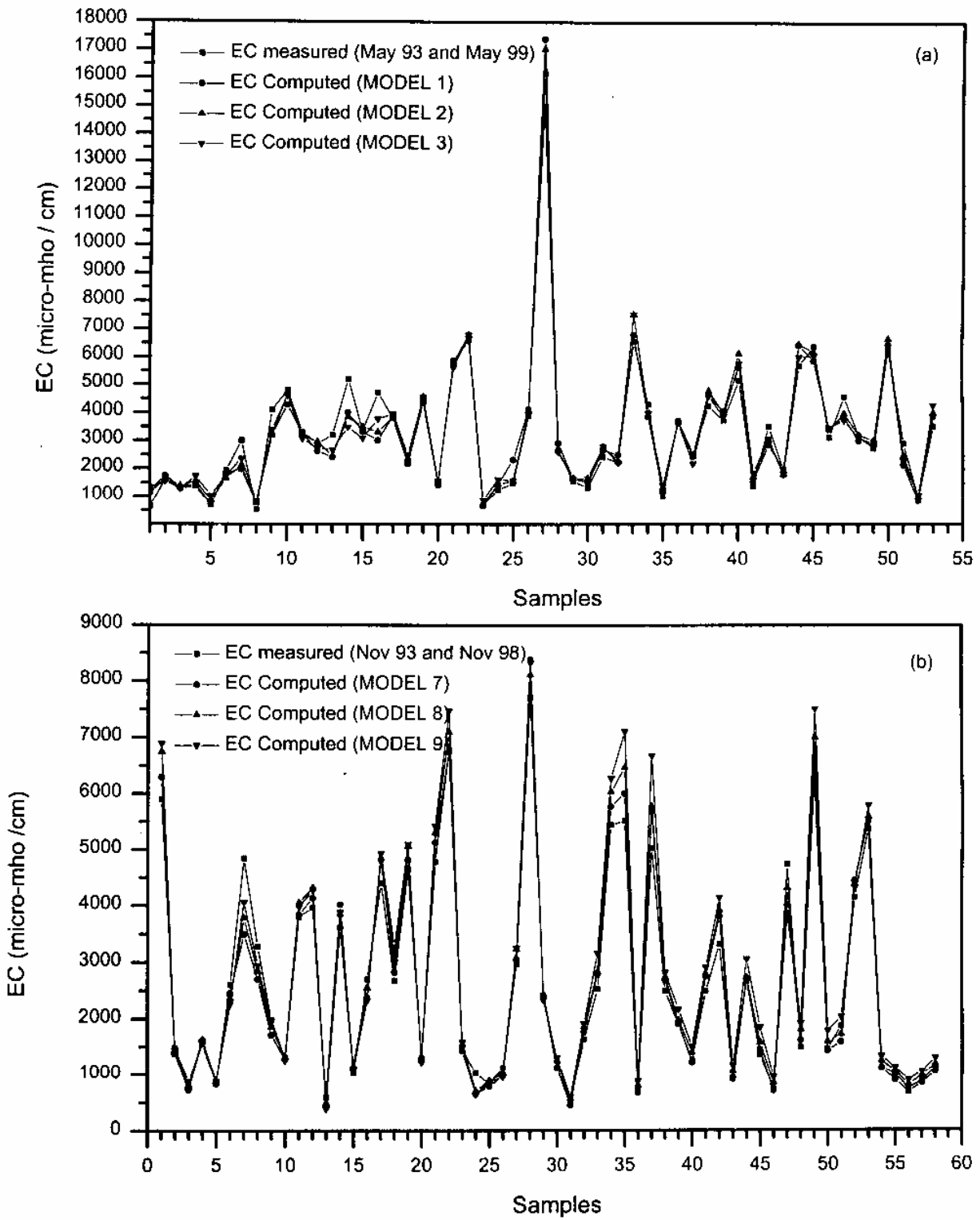


Fig.18. Comparison between measured EC and computed EC in Krishna Delta.

analysed for physical (pH, EC) and chemical parameters (Ca, Mg, Na, K and Cl, HCO₃, CO₃, F). The Ion Balance Error (IBE), Sodium Absorption Ratio (SAR), percentage of Sodium (% Na), Total Hardness as CaCO₃ (TH) and Cl/CO₃+HCO₃ ratio have been calculated in each observation well. The water sample details and water quality parameters are given in Table 9. The locations of these samples in Krishna Delta are shown in Fig. 19. The finger print diagram of average water quality parameters of different samples is shown in Fig. 20. The highest concentrations of major ions are observed in seawater and lowest in canal water. Due to backwater effect in Krishna River, the river sample is showing the high concentrations next to the seawater. The parallel trend (Fig. 20) indicates the dilution phenomena of groundwater samples in the study area. The correlation between major ions in filter points and tube wells is given in Table 10 and 11 respectively. The spatial distribution of EC, SAR and Cl/HCO₃ ratio (filter points) in the month of November 1999 is shown in Figs. 21, 22 and 23 respectively. Similarly these distributions in tube wells in the study area are shown in Figs. 24, 25, 26 respectively. The EC, SAR and Cl/HCO₃ ratio in both the samples (filter points and tube wells) are increasing towards seacoast and significant vertical variations can be observed from these spatial distribution maps. However, in open wells these trends are not observed clearly. It may be due to the local environment of the well and these wells prone to easy contamination by various activities. Due to limited tube wells in Krishna western delta the extrapolation contours are subjected to an approximation. This preliminary analysis of tube wells data indicated that there might be saline water intrusion in deeper aquifers.

4.3 Classification of groundwater

The Stiff (1951) classification indicated that 80% of groundwater samples are under NaCl type. The EC, HCO₃ and Cl values in few observation wells (3, 4, 7,10,19, 21 and 32) are exceeded the ISI (1983) maximum permissible limits of drinking water standards. According to Total Hardness classification as CaCO₃, the shallow groundwater quality is hard to very hard (150 to 1000 ppm) in the study area.

Table 9. Groundwater quality data of filter points, tubewells, Canahwater, Riverwater and sea water in Krishna Delta during the month of November 1999

Well No.	Location	Type of Sample	pH	EC (μ mho/cm)	TDS (mg/l)	CO ₂ (mg/l)	HCO ₃ (mg/l)	Cl (mg/l)	F (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	IBE	SAR	%Na	T.H. (mg/l)	Cl / (CO ₂ +HCO ₃)
1	Venuru	Filter Point	7.60	816	522	0	280	90	0.1	107	8	48	15	2.1	3.5	57.2	160	0.453
2	Praturu	Filter Point	7.95	545	349	0	180	69	0.1	45	2	40	24	3.7	1.4	33.6	200	0.541
3	Gullapalli	Filter Point	7.51	2230	1427	0	490	350	0.1	288	11	144	44	9.1	5.4	54.2	540	1.007
4	Chintalapudi	Filter Point	7.84	1695	1085	0	430	280	0.1	163	11	96	73	4.8	3.1	40.6	540	0.918
5	Pedapudi	Filter Point	8.20	480	307	0	160	50	0.1	47	2	32	19	6.4	1.6	39.9	160	0.441
6	*Duggirala	Filter Point	8.15	1495	957	0	370	200	0.1	204	24	40	58	10.9	4.8	58.4	340	0.762
7	EduJanaka	Filter Point	8.65	1675	1072	20	300	370	0.1	202	30	48	68	2.0	4.4	54.5	380	1.631
8	Sangameswaram	Filter Point	8.04	1735	1110	0	540	230	0.1	250	29	48	49	2.1	6.1	64.4	320	0.601
9	Pedagadimotu	Filter Point	8.11	1389	889	0	340	200	0.1	216	6	32	39	7.1	6.1	66.6	240	0.830
10	*Avanigadda	Filter Point	8.53	2330	1491	40	370	470	0.5	345	20	48	88	7.8	6.8	61.7	480	1.617
11	Elamaru	Filter Point	8.87	997	638	60	250	130	0.5	208	5	16	5	2.4	11.6	88.3	60	0.591
12	Ainampudi	Filter Point	8.62	1500	960	40	360	250	0.1	237	4	32	15	2.5	10.9	82.1	140	0.882
13	Nagapattanam	Filter Point	8.05	2050	1312	0	600	280	0.1	393	12	40	19	2.6	12.8	83.0	180	0.658
14	Kuchipudi	Filter Point	7.95	1282	820	0	320	170	0.1	170	3	64	39	10.6	4.1	53.9	320	0.749
15	Tadepalli	Filter Point	8.40	1277	817	100	330	180	0.1	270	5	24	15	2.2	10.7	83.0	120	0.590
16	Srikakulam	Filter Point	8.83	859	550	80	170	80	0.5	185	5	16	5	12.6	10.3	87.1	60	0.451
17	Ventragada	Filter Point	8.30	974	623	100	200	100	0.1	162	7	36	19	9.0	5.4	68.3	170	0.470
18	Gandigunta	Filter Point	7.98	711	455	0	223	80	0.1	37	7	32	19	-15.2	1.3	36.2	160	0.506
19	Pamaru	Filter Point	8.56	1489	953	39	301	290	0.1	280	7	32	24	3.0	9.1	77.6	160	1.203
20	Vaikkaragedda	Filter Point	8.27	1391	890	0	369	170	0.1	195	36	32	49	10.4	5.1	62.6	280	0.650
21	Peddakammavaripalem	Filter Point	8.27	650	416	0	155	100	0.1	60	4	32	34	6.6	3.3	49.2	300	0.910
22	Vijayawada Collectors Office	Filter Point	7.44	1168	748	0	262	180	0.1	131	4	64	34	6.6	3.3	49.2	300	0.969
23	Kanuru / Penamaluru	Filter Point	7.87	596	381	39	165	70	0.1	83	4	32	10	0.6	3.3	60.5	120	0.484
24	Edujugallu / Kankipadu	Filter Point	7.85	880	563	0	233	120	0.1	154	3	32	10	6.6	6.1	73.7	120	0.726
25	Hamsaladevi	Tube Well	7.93	15260	9766	0	370	4500	0.1	2090	110	544	549	10.5	15.1	56.5	3620	17.154
26	Manikonda	Tube Well	8.50	850	544	40	240	100	1.5	159	2	16	10	0.5	7.7	81.1	80	0.504

27	Katunu	Tube Well	8.23	1322	846	0	255	100	0.5	192	7	64	29	27.9	5.0	60.5	280	0.553
28	Bollapadu	Tube Well	7.38	866	618	0	136	110	0.5	105	16	64	19	24.9	3.0	51.1	240	1.141
29	Mudunuru	Tube Well	8.65	970	621	60	190	130	0.1	178	5	16	15	6.6	7.7	79.5	100	0.733
30	Iluru	Tube Well	8.00	1285	822	0	390	170	0.1	168	47	64	15	1.3	4.9	65.8	220	0.615
31	Nagavapadu	Tube Well	7.60	1440	922	0	369	150	0.1	122	64	40	68	11.1	2.7	47.8	380	0.573
32	Manjulu	Tube Well	8.23	5300	3392	0	359	1400	0.1	651	23	112	141	-0.7	9.7	62.7	860	5.500
33	Kona	Tube Well	7.60	8900	5696	0	155	3160	0.1	931	23	464	399	2.5	7.7	42.3	2800	28.755
34	Gandigunta	Tube Well	7.67	1890	1210	0	456	180	0.1	164	12	144	58	15.4	2.9	38.4	600	0.557
35	Uruturu	Tube Well	8.74	2280	1459	39	427	420	0.1	463	14	24	44	8.9	13.0	81.0	240	1.271
36	Vanukuru / Pennaluru	Tube Well	8.75	679	435	0	184	80	0.1	49	4	84	24	10.9	1.3	30.2	290	0.613
37	Ramapuram / Nandiwada	Tube Well	8.37	4870	3117	78	291	1440	0.1	744	9	152	126	2.5	10.8	64.5	900	5.504
38	Lankadoddi / Gudlavaleru	Tube Well	8.09	4880	2771	0	446	1160	0.1	767	8	72	63	0.8	15.9	79.3	520	3.668
39	Molligunta / Repalle	Tube Well	8.51	2680	1715	39	213	720	0.1	512	10	32	39	3.7	14.4	82.4	240	4.030
40	Talatiippa / Repalle	Tube Well	8.23	2820	1805	0	200	776	0.1	519	10	144	10	8.7	11.3	74.0	400	5.472
41	Garuvapalem / Nizampatnam	Dug Well	8.59	766	503	40	170	108	0.1	130	3	24	15	5.9	5.1	70.2	120	0.725
42	Kothapalem / Repalle	Dug Well	8.29	5460	3494	0	350	1601	0.1	912	152	136	97	5.5	14.6	74.7	740	6.452
43	Pallipalem	River	7.58	1040	666	0	270	160	0.1	90	8	80	39	6.6	2.1	36.4	360	0.836
44	Near Hamsalekshmi River	River	8.40	14380	9203	0	370	4800	0.1	2381	100	136	404	1.1	23.2	72.7	2000	18.298
45	Near Venkatar	River	8.50	660	422	20	170	70	0.1	86	8	32	15	7.9	3.1	58.2	140	0.520
46	Eshmoga	River	8.45	18960	11750	40	420	5300	0.1	2500	100	200	802	8.2	17.7	59.5	3800	16.251
47	Tenali	Canal	7.76	456	292	0	160	40	0.1	40	3	32	19	6.9	1.4	36.5	160	0.353
48	Nizampatnam	Sea water	8.17	33000	21120	0	160	11100	0.5	6400	200	280	607	4.6	49.3	81.6	3200	97.849

T.H - Total Hardness as CaCO₃

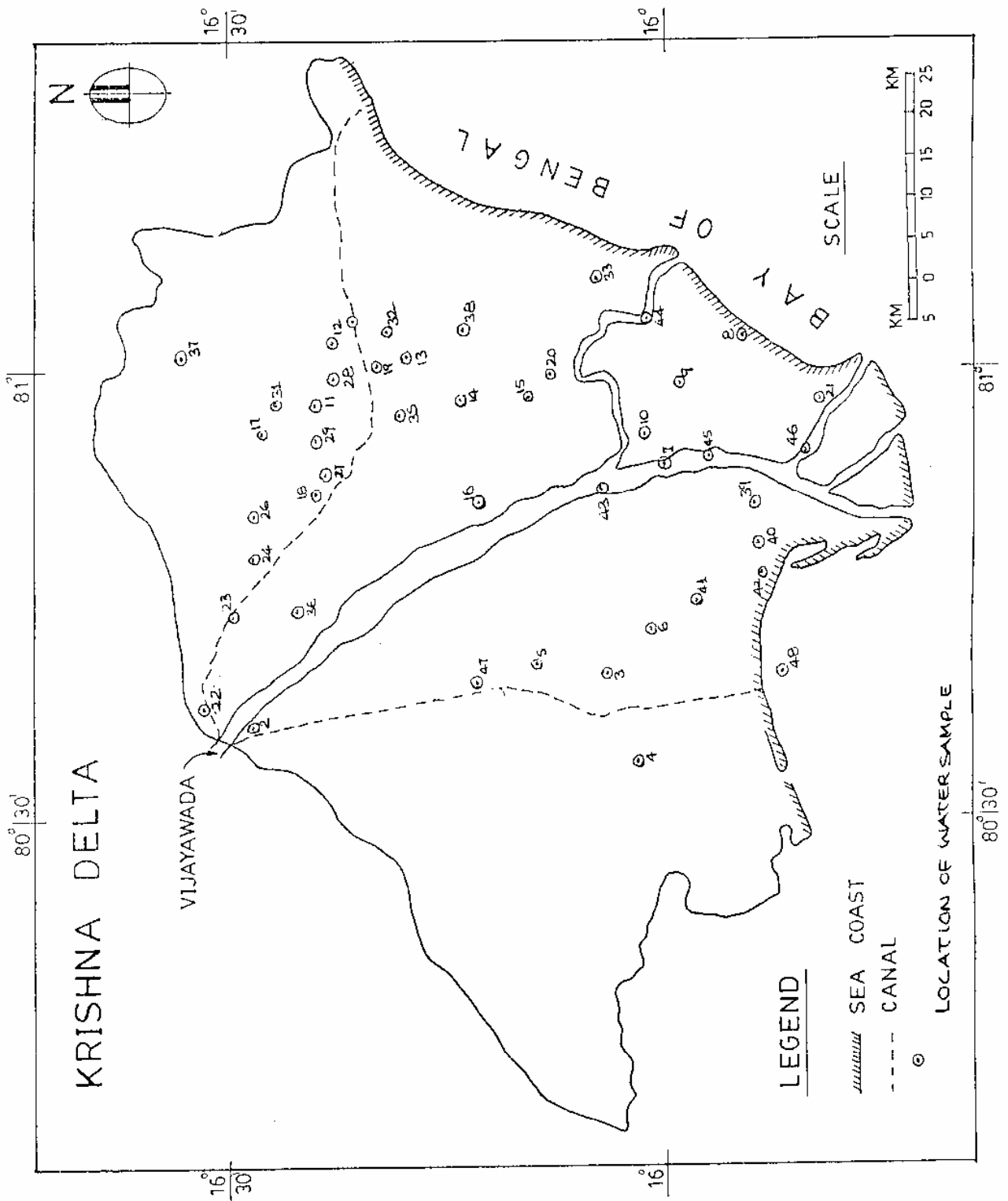


FIG. 19 LOCATION OF WATERSAMPLES COLLECTED IN THE MONTH OF NOVEMBER 1999 IN KRISHNA DELTA

Fig 20. Fingerprint diagram of the filter point, tube well, sea water, canal water, river water in Krishna delta

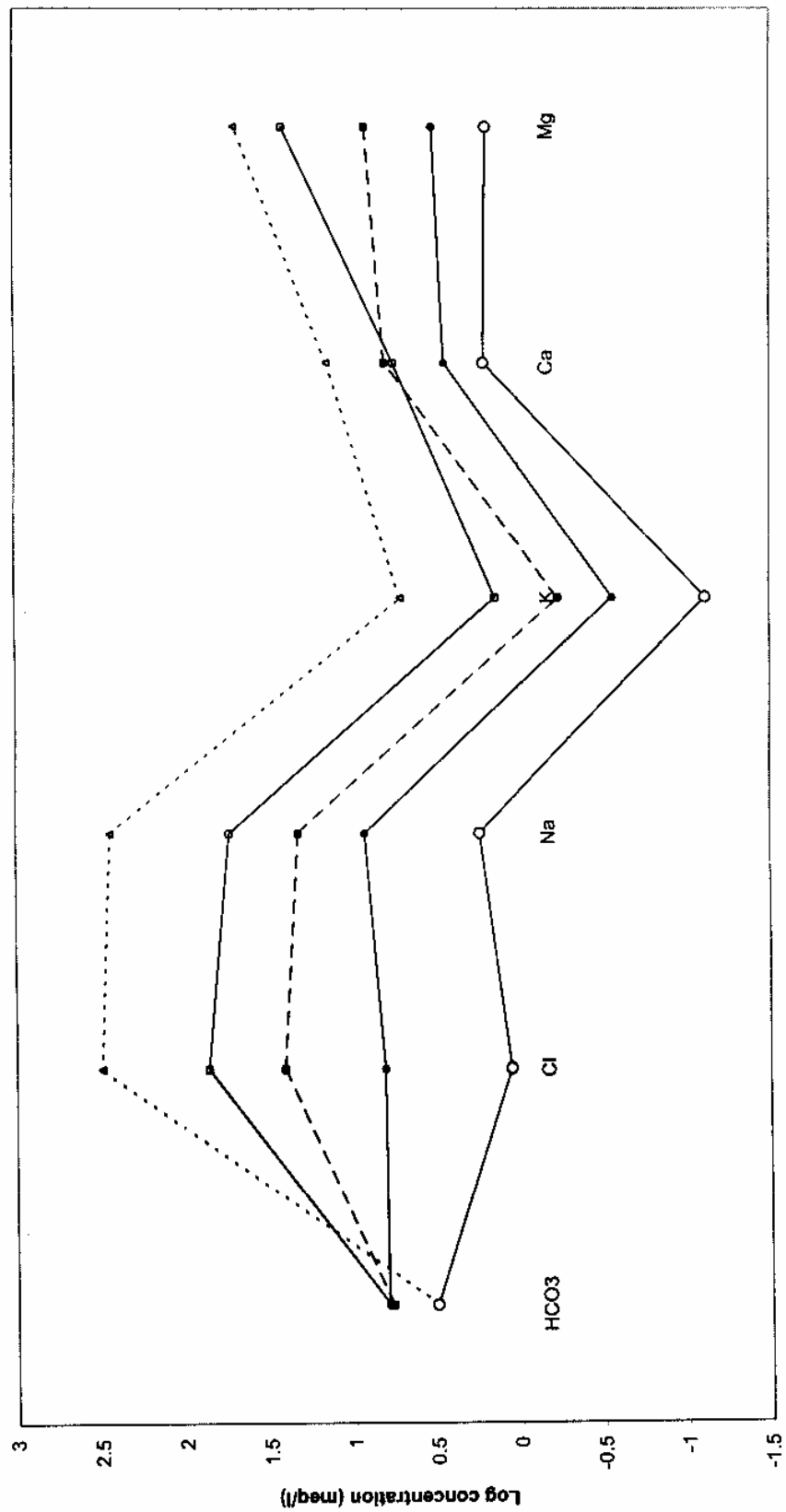


Table 10. Correlation between major ions in Filter Points in Krishna Delta (No. of samples :30) during the month of Nov.1999.

	Ca	Cl	EC	HCO ₃	K	Mg	Na	Total Hardness
Ca	1.000							
Cl	0.750	1.000						
Ec	0.797	0.960	1.000					
HCO ₃	0.392	0.378	0.593	1.000				
K	0.230	0.444	0.495	0.472	1.000			
Mg	0.864	0.857	0.859	0.363	0.514	1.000		
Na	0.311	0.750	0.794	0.595	0.393	0.413	1.000	
T.H.	0.961	0.834	0.859	0.391	0.390	0.969	0.378	1.000

Table 11. Correlation between major ions in Tube wells in Krishna Delta (No. of samples :16) during the month of Nov.1999.

	Ca	Cl	EC	HCO ₃	K	Mg	Na	Total Hardness
Ca	1.000							
Cl	0.952	1.000						
Ec	0.926	0.991	1.000					
HCO ₃	-0.008	0.136	0.232	1.000				
K	0.622	0.615	0.667	0.429	1.000			
Mg	0.964	0.970	0.960	0.119	0.693	1.000		
Na	0.850	0.954	0.976	0.284	0.632	0.889	1.000	
T.H.	0.986	0.973	0.958	0.078	0.669	0.995	0.884	1.000

T.H. - Total Hardness as CaCO₃

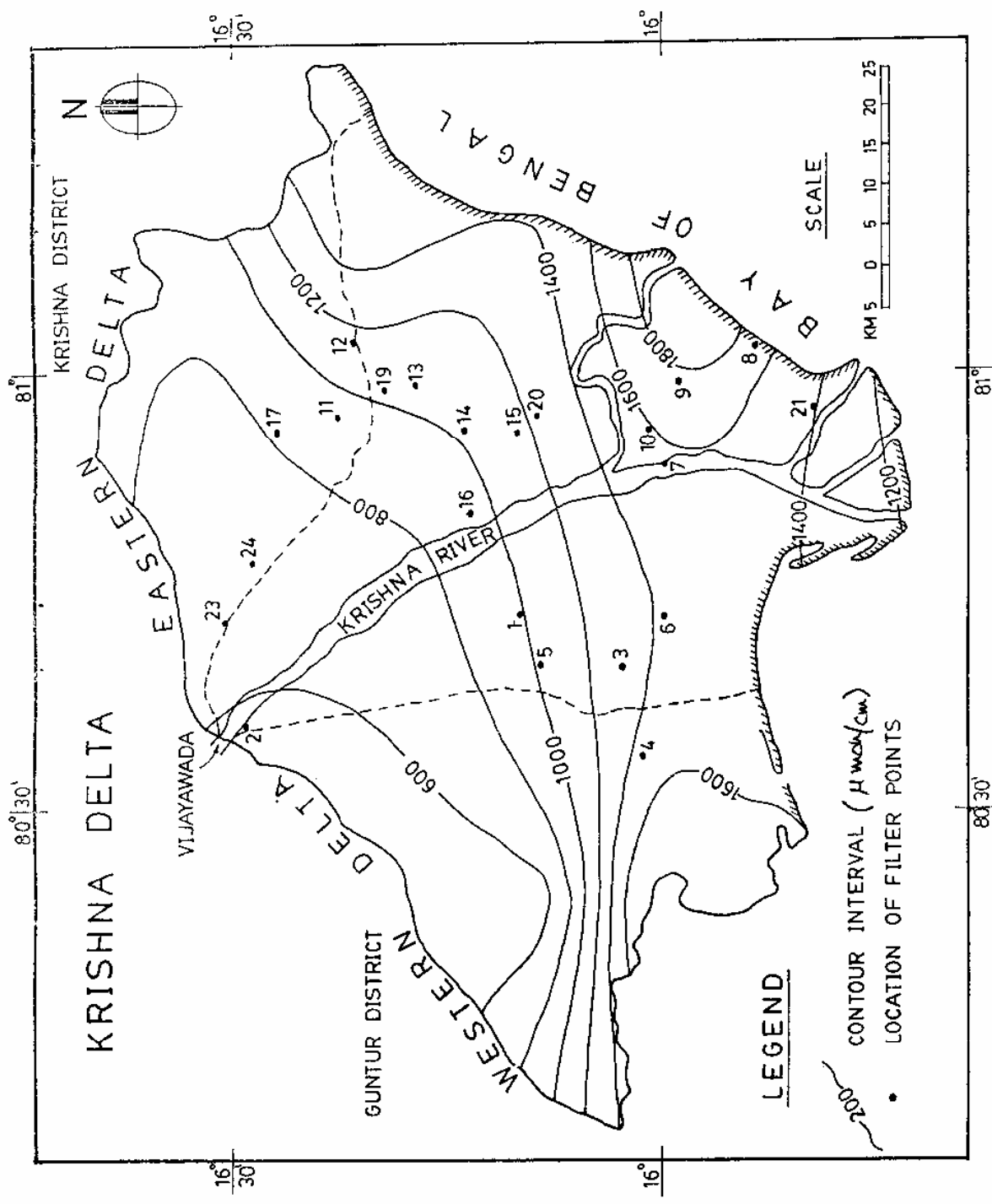


Fig.21 EC ($\mu\text{ mho/cm}$) CONTOURS OF FILTER POINTS IN KRISHNA DELTA DURING NOVEMBER 1999

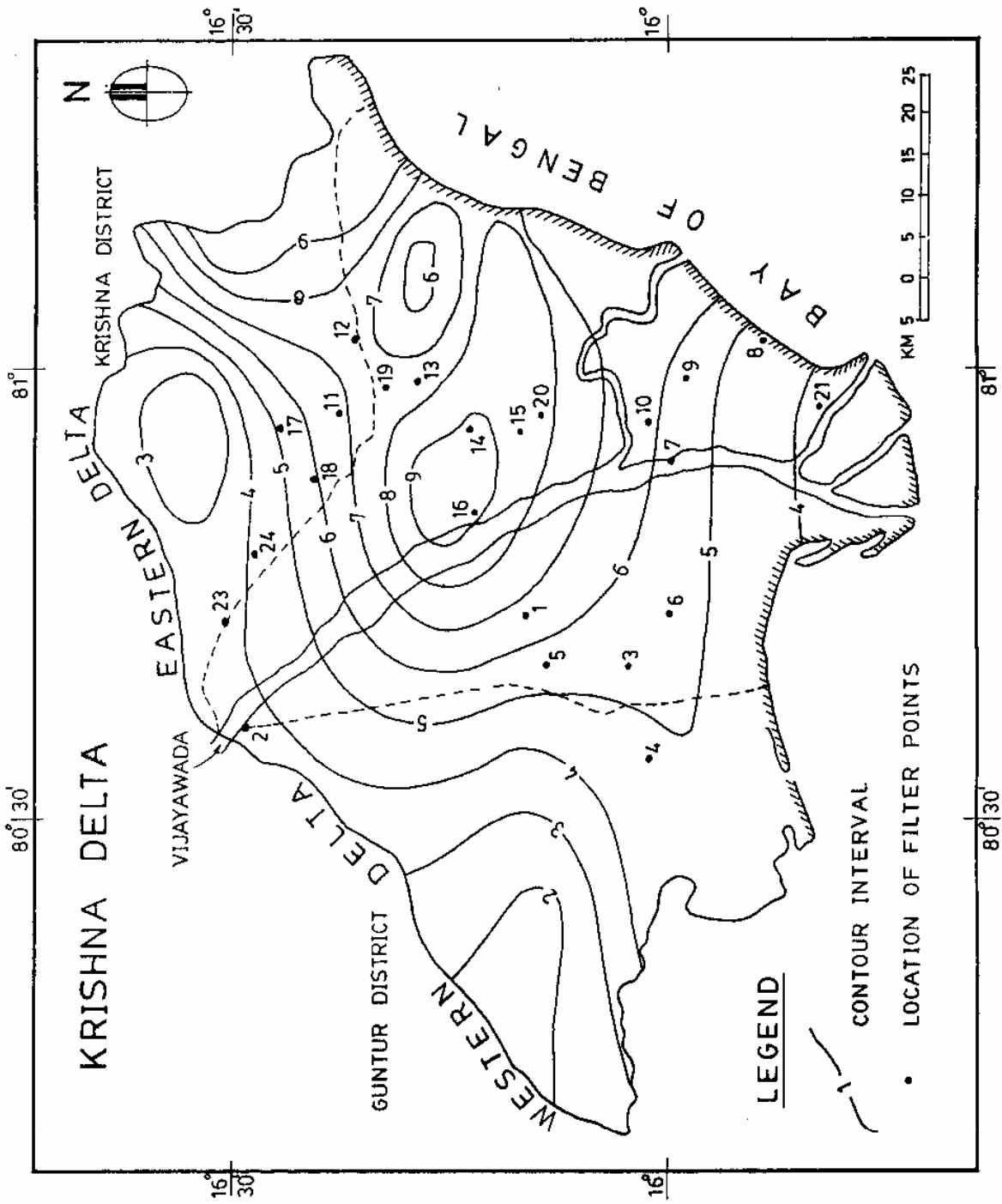


Fig. 22 SAR CONTOURS OF FILTER POINTS IN KRISHNA DELTA DURING NOV. 1999

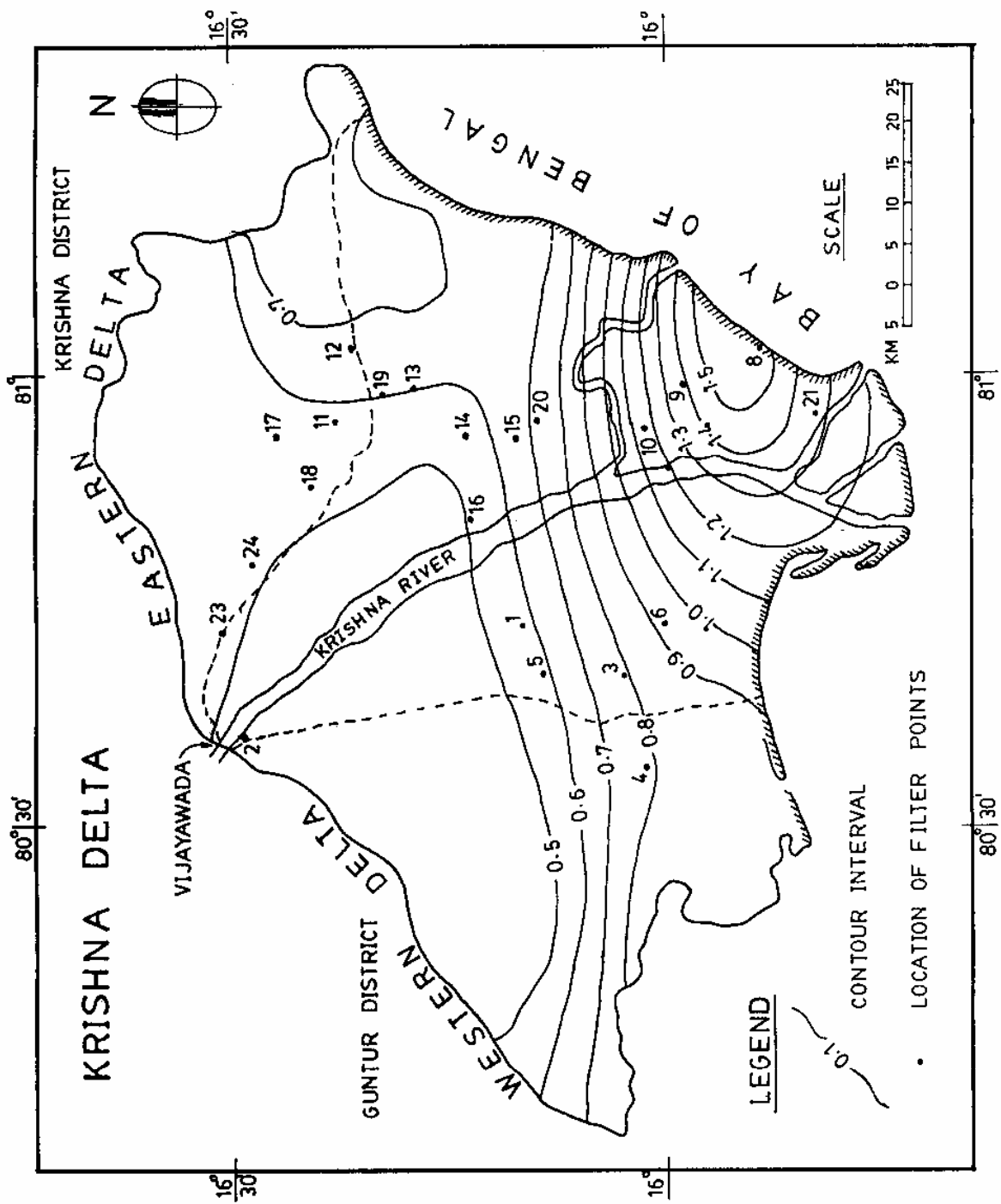


FIG. 23 CI/HCO₃ RATIO CONTOURS OF FILTER POINTS IN KRISHNA DELTA DURING NOVEMBER 1999

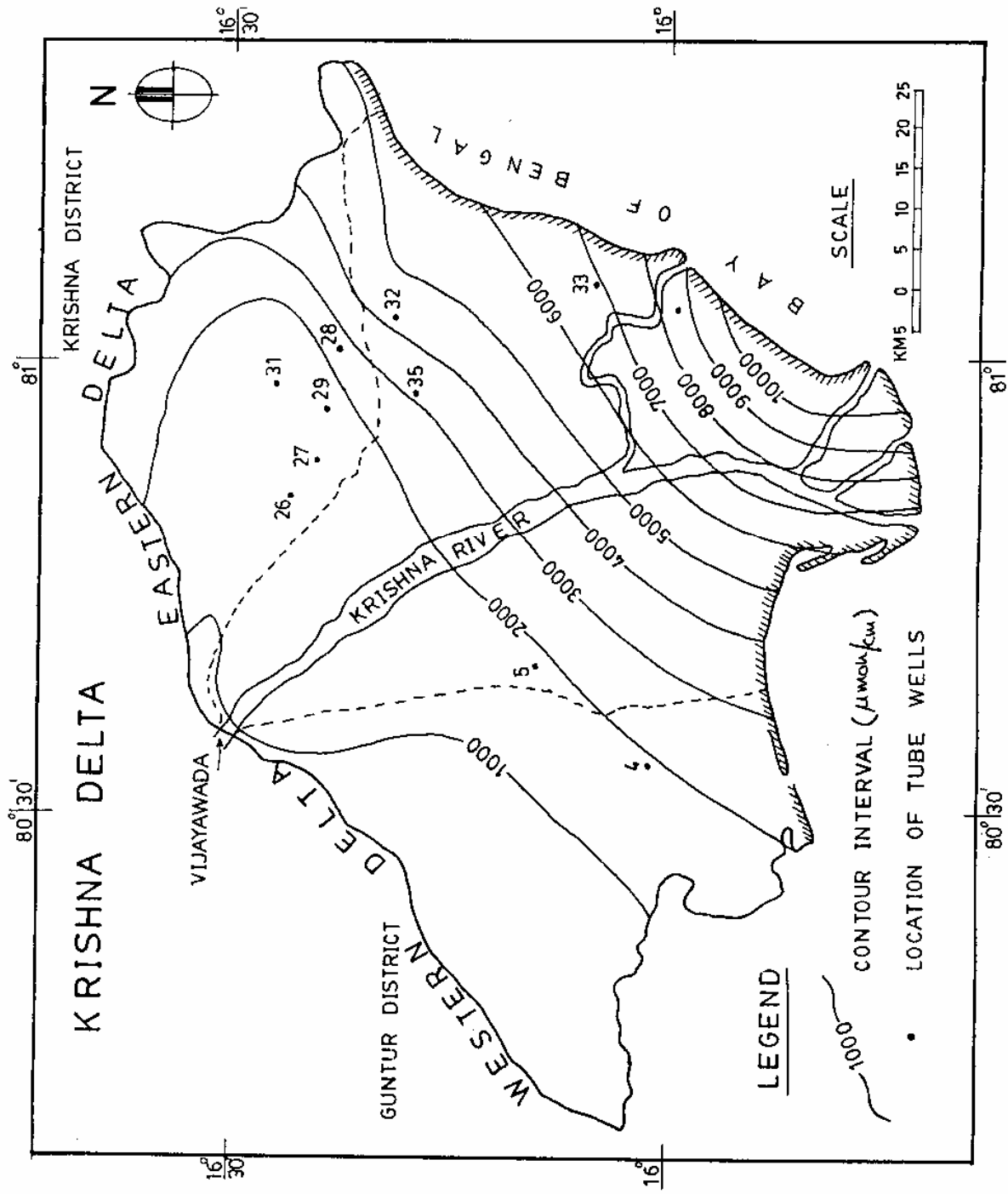


Fig.24 EC ($\mu\text{mho/cm}$) CONTOURS OF TUBE WELLS IN KRISHNA DELTA DURING NOVEMBER 1999

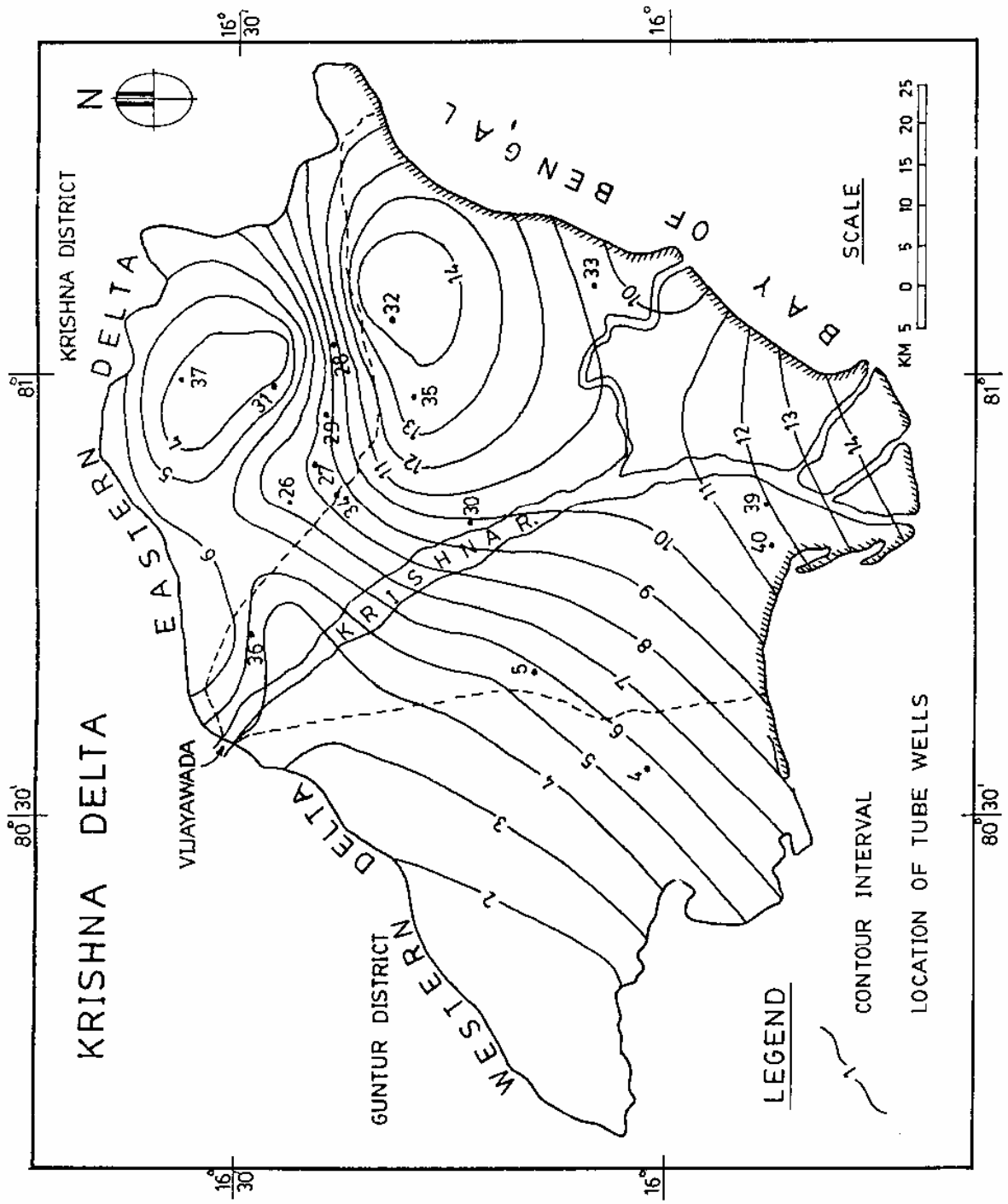


Fig. 25 SAR CONTOURS OF TUBE WELLS IN KRISHNA DELTA DURING NOV. 1999

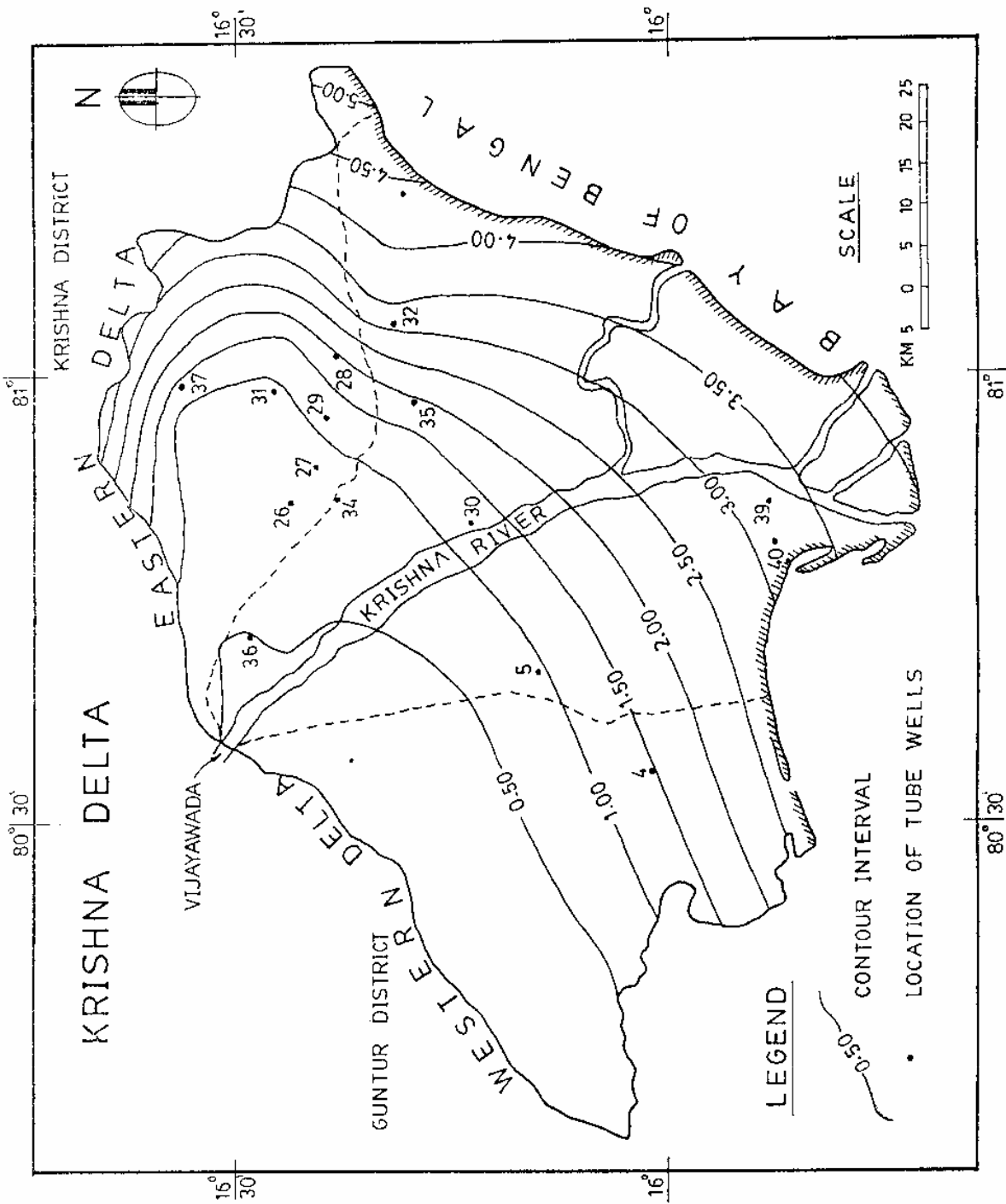


Fig. 26 CI/HCO₃ RATIO OF TUBE WELLS IN KRISHNA DELTA DURING NOV. 1999

5.0 CONCLUSIONS

The groundwater levels and quality evaluation has been carried out for shallow aquifer of Krishna Delta. The groundwater levels and quality data of 32 observation wells have been used in the present analysis. The topographical and groundwater table (w. r. t. MSL) contour maps have been prepared for the study area. It is observed that the groundwater flow gradient is replica of surface gradient in the study area. However the groundwater flow direction is not clearly observed at river mouths. It may be due to the backwater effect in the Krishna River. The maximum and minimum groundwater table contours in the study area are observed as + 10 mt and + 2 mt respectively. The decreasing trend in average groundwater table has been observed during pre monsoon (May) period from the years 1989 to 1999. It may be due to increase of groundwater utility over a period of time especially in pre monsoon period. The comparison between average groundwater table and average rainfall indicated that the major recharge to the groundwater is not from the rainfall in the study area.

The spatial distribution maps of EC, SAR and Cl/HCO₃ pertaining to shallow aquifer have been prepared in the study area during the years 1991 (May and November) and 1999 (May) and 1998 (November). From these maps it is inferred that the salinity in the study area has increased from the year 1991 to 1999. It is also observed that there are significant changes in hydrochemistry of shallow aquifer from pre to post monsoon period. As per the EC, SAR and TH ranges, the study area is classified as medium to high salinity, low to medium sodium hazard and hard to very hard respectively. According to Stiff classification, most of the wells (80%) are under NaCl type. The EC, HCO₃ and Cl values in few wells were exceeded the permissible limits of ISI drinking water standards. The multiple linear regression models developed for the study area during pre (May) and post (November) monsoon periods are $EC = 495.311 + 1.927Cl + 2.473 Na + 6.557Mg$ and $EC = -133.033 + 0.939Cl + 3.878Na + 3.240Mg + 1.017TH + 0.721 HCO_3$ respectively.

The groundwater chemistry of filter points, tube wells, canal water, river water and seawater is presented. The fingerprint diagram of water quality parameters for these samples indicated that high concentration of chemical parameters is observed in the

seawater and low in the canal water and other samples quality is between of them. The spatial distribution maps of EC, SAR, Cl/HCO_3 for filter points and tube wells indicated that there is a significant vertical variation of water quality in the study area and also the increasing trend of these parameter are observed towards sea. The correlation between major ions pertaining to filter points and tube wells is calculated. The Cl/HCO_3 ratio variations indicate possible seawater intrusion in the study area. More studies on deeper aquifer (water levels and quality) are necessary to confirm this phenomena in the study area.

ACKNOWLEDGEMENTS

The authors are highly thankful to Director, A.P State Groundwater Dept., Hyderabad for giving permission to analyze their monitoring wells data in Krishna Delta. The co-operation of Dr.Srinivasa Rao, Deputy Director, SGWD, Vijayawada and Deputy Director, SGWD, Guntur is duly acknowledged. Authors are also thankful to the staff of SGWD, Vijayawada and Guntur for their help in collecting the data.

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ANNEXURE I
(1 to 10)

Monthly Rainfall Data(mm) in Krishna Delta

1.Tenali

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	68.3	0	0	6	6.2	128	170	305.5	15.5	200.5	30	101.5
1986	42	5.2	0	0	19.6	75.4	117.6	256.9	31.5	27.9	62.5	0.2
1987	8.4	0	3.6	24	32.3	48.2	113.9	144.9	46.1	185.6	367	42
1988	0	0	0	41	29.6	62.2	299.7	379	170.9	6.8	2.7	43.6
1989	0	0	39	0	19.2	76.6	385.8	122.3	253.9	19.4	21.1	4
1990	18.6	35	24.7	0	380.8	111.6	82.7	109.3	282.6	281.2	48.5	0
1991	0	0	0	16	5.6	125.8	57	143.8	230.4	62.1	270.2	0
1992	0	12.2	0	3.4	19.8	18.8	93	160.2	165.6	82.4	124.4	0
1993	0	0	9.2	5.6	232.4	79.6	197.8	66	77.6	431	3.2	18.8
1994	2.4	52.8	0	0	0	100.6	206.4	126.4	75	171	385.8	0
1995	31.8	0	0	0	110.2	93.8	248.8	206.4	44.2	344.9	10	0
1996	0	0.4	0	1.8	2.4	164.6	222.8	493.6	183	155.8	22.8	7.1
1997	26	2.2	0.3	36.9	6.3	25	142.8	107.6	457	82.9	149.2	24.6
1998	5.6	0	13.6	72.4	20	79	200	181.4	387.6	258.2	63.4	0
1999	0	3.2	0	0	0	74.6	219.2	195.2	131	274.4	0	0

2.Vemuru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	0	0	0	0	0	154.1	173.5	474.9	177	194.7	18.6	9.2
1997	11.8	0	11.5	25.5	0	18.1	91.8	140.6	474.1	129.8	22.8	26.6
1998	0	0	0	52	8.2	56.8	217.8	199.4	298.6	253.9	110.2	0
1999	0	0	0	0	0	46	144.4	190.1	307.2	193.7	0	0

3.Kolluru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	0	0	0	18	0	32.7	147.2	139.7	478.7	100.2	71.8	40.4
1998	10	0	0	32.2	3.5	133.5	173.2	165.7	323.5	308.2	124.4	0
1999	0	0	0	0	0	81.5	258.8	175.2	287.2	371.2	0	0

4. Amrataluru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	0	0	0	0	0	0	184.2	354.6	217	2.7	3.6	90.2
1989	0	0	56.2	0	37	58.2	440	134.6	201	0	45.4	1.8
1990	23.2	50.7	20	0	434.8	115.8	57.4	145.4	87.2	158.4	54.2	0
1991	0	0	0	0	31.4	227	63.6	110.4	304.8	87	250.4	8.4
1992	0	6.8	0	2.2	15.2	30.8	109.8	119	253.8	87.2	220.6	0
1993	0	0	52.8	2.4	199	33.8	183	120.4	81.2	271	5.8	28.2
1994	2.2	38.4	0	0	0	116.2	190.4	70.6	66.6	221.5	394.8	0
1995	81.6	0	0	0	147.5	26.5	231.4	257.1	78.2	342	0	0
1996	0	0	0	0	0	160.4	173.7	190.4	132.3	256.2	33.2	4.2
1997	1.2	0	0	40.8	12.2	22.9	70.4	78.6	324.9	41.1	47.2	19.9
1998	4	0	0	44.7	10.2	140	217.2	132	315.4	373.4	82.6	0
1999	0	0	0	0	0	81.2	138.2	171.2	251.2	160.2	0	0

5. Duggirala

Not Available

6. Kollipara

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	0	0	0	0	2.4	24.6	70.1	156.9	215.1	64.1	126.6	0
1993	0	0	13.2	29.9	151.2	77	190.4	76.6	52.2	233.7	35.4	12.8
1994	0	47.4	0	0	0	57.8	288.2	199.2	39.2	184.4	275.2	0
1995	25.8	0	0	0	93.6	85	222.4	133.8	121.6	377	55.2	0
1996	0	3.6	0	0	8.6	177	245.2	226.6	71	229.9	15.8	8.8
1997	5.4	0	0	69.2	0	39.8	125	133	386.4	61.4	117.1	18.6
1998	0	0	31.4	53.4	1.8	66	216.8	125	228.4	186.5	60.9	0
1999	0	0	0	0	0	90.9	225.3	171	199.1	208.7	0	0

7.Repalle

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	61.2	0	0	0	6	58.2	153.7	256.1	54.9	268.9	20.1	124.4
1986	58.6	70.2	0	32.6	6.3	114.4	135.9	236.4	21	136.6	113.9	0
1987	0	0	0	5.7	0	31.9	86.1	229.8	94.6	156.2	325.4	25
1988	0	0	0	23.6	37.1	85.2	234.3	220.3	255	40	23.2	121
1989	0	0	37.2	0	27.7	72	419.7	94.8	314.2	64.6	56.1	0
1990	21	66	27.8	38	402	126	162.7	239	121	287.2	56.9	0
1991	6.2	2	0	3	3.4	249.3	58.8	131	254.4	255.6	410.8	31.7
1992	7.2	0	0	12.4	6.6	73.6	85.2	91.6	155.7	80.4	217.7	0
1993	0	0	1.4	0	130	51	140	55	144	456.9	22.5	60.8
1994	0	11	0	5.2	5	68.2	206.2	103.5	12.3	284.6	508.8	0
1995	20	0	0	0	122.4	57	179.8	235.8	164.2	264.8	46.8	0
1996	0	0	0	18.8	54	295.4	171.6	310.3	208.2	554.1	44.7	13.6
1997	13.4	0	0	33.2	0	15.9	83.9	101.3	398.9	82.9	99.4	71.6
1998	0	0	0	28.3	14.8	28.7	139.3	121.4	246.9	409.6	90.8	0
1999	0	0	0	0	0	105	145.1	141.7	211.5	348.4	0	0

8. Bhattiprolu

Not Available

9.Nagaram

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	24.8	0	0	0	6.4	102.7	202.2	71.2	77.3	112.1	0	0.2
1986	0	0	0	0	0	0	203.9	234.4	67.1	75.7	106.3	0
1987	0	0	8.8	10.6	3.2	51.3	39.6	231.9	63.5	166.8	297.4	18.7
1988	0	0	11.1	16.8	54.1	55	220.1	327.6	168.5	31.7	24	115.5
1989	0	0	63	0	13.3	137.3	348.6	73.4	226.8	28.4	35	10.8
1990	6.6	83.2	22.4	0	481	99.6	91.6	145.4	208.5	235.8	83.2	0.6
1991	10.4	3.2	0	0	9.2	276.4	84.2	124.7	229.6	141.8	264.4	8.4
1992	6.6	0	0	0	18.4	44.8	120.2	94.3	151.2	116	180	0
1993	0	0	0	6.8	77.4	42.2	111.4	141.8	289.8	342.2	29	33.2
1994	4.8	18	0	0	5.8	71.6	184.8	96.8	31.4	277.4	447	0
1995	108.2	0	0	0	259.4	30.4	122.2	292.8	161	230.2	4.6	5
1996	0	6.8	0	6	41.2	113.8	106.2	282.4	191.8	419.8	44.7	13.6
1997	18	0	3	50.8	3.8	0	95.2	66	474	46	119.6	62.4
1998	104.8	0	0	48.4	8	25.2	155.4	148.4	255	382	117.7	0
1999	0	0	0	0	0	61	160.6	161.2	211	270.8	0	0

10. Nizampatnam

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0	0	0	0	0	47.8	312.7	55.5	212.2	42	65.8	0
1990	0	103.6	19.4	0	548.6	25.8	50.4	154.8	161.8	208	163	2.9
1991	0	0	0	0	51	356.8	33	107.8	344.6	196.4	329.4	24.8
1992	40	0	0	0	51.2	17.4	66.3	104	211.4	73.2	248.4	0
1993	0	0	2.2	0	106.1	92.2	90.8	118	282.7	353.2	31	69.4
1994	11	51.2	0	0	0	28.6	220.2	89.2	7.4	292.2	427.4	0
1995	94.8	0	0	0	177.7	90.4	108.4	221.4	121	176.2	0	0
1996	0	0	0	0	25.5	91.6	109.2	360.6	132.6	446	53	18.8
1997	32.8	0	0	97.8	5.8	10.2	68.8	179	411.4	126.8	163	161.4
1998	5	0	0	27.6	12.8	51.6	225.8	190	399.4	347	36	0
1999	0	0	0	0	0	57	105.2	212.5	313.5	252.8	0	0

11. Chebrolu

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	10.4	25.2	76.4	3.4	345.7	187.4	116.2	143.8	181.8	117.1	52.2	0
1991	20.6	0	0	0	60	198	138.3	147.7	267.2	157	164.2	0
1992	0	8.2	0	11.4	44.4	26.6	85	129.8	238	191.8	115.8	0
1993	0	0	21.6	37.6	202.8	44.1	171.7	74.8	131.6	194.1	46.4	32.6
1994	0	25.6	0	0	28.6	63.6	177.4	126.6	47.6	224	325.6	0
1995	26.4	0	0	0	110.2	69.6	208.8	256	33.2	341.8	34.6	0
1996	0	0	0	0	35.6	101.4	199	250	99.6	163.6	46.2	8.2
1997	9.9	0	0	35.8	15.2	39.6	86	94.8	376.8	64.8	31.2	33.6
1998	0	0	0	38.6	28.7	112.6	207.8	104.8	276.2	227.6	51.4	0
1999	0	0	0	0	0	128.6	219.2	125.8	208	115.6	0	0

12. Bapatla

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0	0	75.6	0	29	49.2	389.8	66.2	171.8	60	106	0
1990	27	108.8	13	0	737	75	28.8	171.4	186.2	169.2	155	0
1991	6	0	0	0	5	232.2	65	101.6	254.4	79.2	276.3	0
1992	30.2	0	0	14.8	18.6	73.3	103.9	141.2	217.8	63.4	234.2	0
1993	0	0	0	0	75	81.4	83.7	63.4	320.5	228.4	41.2	104.6
1994	0	25	0	0	0	65.8	106.8	66.2	68.8	309.4	431.1	0
1995	159.8	0	0	0	199.6	21.4	121.8	256.6	92.8	210.7	8.4	0
1996	0	0	0	3.2	2	61.8	78.8	378.1	164.6	399.2	75.6	19.8
1997	21.8	0	0	72.8	10.8	28	54.4	200.9	352.8	140.8	77.2	105.8
1998	2.6	0	0	20.4	26.4	65.4	113	127	300	431.4	65.4	0
1999	0	0	0	0	0	65	40.6	167	200.1	275.2	0	0

13. Ponnuru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0	0	22.8	0	28	124.5	542	99.6	143.4	24	38.4	0
1990	0	73.2	25.6	0	519.2	117	57.8	209.2	197	151	63.6	0
1991	0	0	0	0	26.2	179.2	75.2	134	248.8	77.4	259	0
1992	0	21	0	0	9.2	47	128	81.2	133	84	141.6	0
1993	0	0	123	0	81	54.2	121.2	78.8	122.6	225.8	8.2	39.2
1994	0	37.6	0	0	0	98.2	136.9	43.4	51.4	188.8	316	0
1995	0	0	0	0	179.4	28.9	181.6	300.6	55.6	365.2	0	0
1996	0	0	0	0	19.2	115.1	179.4	264.5	171.4	263.9	29.8	7.6
1997	14.6	0	0	25	0	57.2	17.1	77.2	428.6	49.4	42.6	47.4
1998	0	0	0	10.2	29.4	60	133.6	101	218.3	261.5	41.5	0
1999	0	0	0	0	0	73.6		149.2	115.8	177	0	0

14. Namburu

Not available

15. P.V. Palem

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	20	0	0	33.6	15.4	3.2	60.1	150.6	130	61.2	84	85.2
1998	0	0	0	9.6	22	105.7	179	165.4	190.5	353.8	64.2	0
1999	Not available											

Monthly Rainfall(mm) Data of Krishna Eastern Delta

16. Bhavadevarapalli (Nagayalanka)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0.0	0.0	83.6	00.0	22.3	134.2	378.0	98.4	204.3	10.3	44.3	15.6
1990	0.0	0.0	32.1	10.0	405.8	88.2	113.0	191.4	266.8	303.7	115.9	5.4
1991	4.3	0.0	00.0	00.0	0.0	188.5	122.2	168.1	267.9	259.4	428.8	38.6
1992	0.0	0.0	00.0	9.8	24.6	15.2	93.4	177.2	214.2	100.0	319.8	00.0
1993	0.0	0.0	00.0	00.0	108.4	46.6	167.2	37.8	151.5	464.2	30.8	35.8
1994	11.2	86.0	00.0	00.0	0.0	37.0	218.2	87.0	7.6	380.6	528.2	00.0
1995	1.8	0.0	00.0	00.0	192.4	75.6	179.4	185.2	153.3	205.1	66.2	00.0
1996	0.0	0.0	00.0	14.4	0.0	195.2	146.2	338.4	141.4	423.2	61.0	30.6
1997	13.0	0.0	00.0	70.4	0.0	19.8	127.0	72.6	395.8	127.4	189.2	99.4
1998	0.0	0.0	0.0	0.0	0.0	4.6	128.6	169.4	337.8	442.4	54.4	0.0
1999	0.0	0.0	0.0	0.0	118.2	44.2	128.1	102.1	196.6	313.0	0.0	0.0

17. Challapalli

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	N.A	N.A	N.A	N.A	N.A	N.A	67.0	472.4	171.8	167.3	74.7	49.1
1990	4.3	160.1	81.0	39.0	341.4	68.7	167.3	210.2	143.5	396.1	40.0	9.3
1991	8.3	0.0	00.0	00.0	5.0	191.3	62.0	191.5	261.8	186.2	364.8	32.0
1992	0.0	0.0	00.0	39.8	26.0	71.6	127.8	133.2	143.8	104.6	233.0	00.0
1993	0.0	0.0	00.0	1.4	129.8	64.2	158.8	95.6	113.1	297.8	00.0	19.0
1994	0.0	22.4	00.0	00.0	0.0	39.2	325.4	119.4	39.2	262.8	430.7	00.0
1995	56.6	0.0	00.0	00.0	210.9	48.6	199.4	351.5	156.2	340.8	16.8	00.0
1996	0.0	20.0	00.0	1.8	4.0	232.8	478.0	323.1	247.0	554.0	22.4	21.0
1997	10.2	11.8	00.0	53.3	0.0	35.2	185.3	96.1	376.6	56.2	109.4	50.8
1998	0.0	0.0	0.0	0.0	2.4	15.6	172.6	202.1	242.1	371.5	42.2	0.0
1999	0.0	0.0	0.0	0.0	74.8	109.0	161.3	95.9	173.8	328.2	0.0	0.0

18. Avanigadda

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	N.A	N.A	N.A	N.A	N.A	51.0	92.8	220.8	24.4	134.6	121.1	7.6
1987	1.0	0.0	15.0	14.0	0.0	54.8	121.6	221.2	39.0	130.4	248.1	39.2
1988	0.0	0.0	0.0	0.0	13.6	68.0	276.8	327.4	265.4	21.8	15.0	139.0
1989	0.0	0.0	53.2	0.0	20.0	90.8	420.0	135.6	329.6	21.6	71.4	0.0
1990	0.0	27.2	35.2	31.2	275.8	84.6	161.2	176.4	180.1	392.5	64.5	9.3
1991	2.2	0.0	0.0	0.0	3.2	312.9	110.0	173.8	280.2	211.6	439.6	19.0
1992	0.0	0.0	0.0	0.0	23.4	57.4	68.8	113.4	125.8	111.6	254.2	0.0
1993	0.0	0.0	0.0	0.0	43.2	53.8	180.0	54.6	175.8	921.8	14.6	71.8
1994	19.0	16.2	0.0	0.0	0.0	68.4	252.8	102.6	5.8	402.2	472.3	0.0
1995	4.6	0.0	0.0	0.0	262.8	71.8	177.4	145.4	118.0	340.6	125.2	0.0
1996	0.0	0.0	0.0	17.6	4.8	257.8	310.0	595.4	200.6	529.2	66.6	30.6
1997	8.0	0.0	0.0	51.0	0.0	19.8	127.0	72.6	163.5	206.4	152.2	102.4
1998	0.0	0.0	0.0	0.0	11.4	19.6	215.6	252.6	248.2	507.7	98.4	0.0
1999	0.0	0.0	0.0	0.0	166.4	66.9	235.2	185.8	266.0	303.4	2.1	0.0

19.Ghantasala

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	N.A	N.A	N.A	N.A	N.A	53.7	52.6	443.7	120.3	110.1	10.5	00.0
1990	0.0	84.5	63.4	15.7	366.0	150.0	100.3	170.6	94.7	223.3	35.0	3.6
1991	8.2	0.0	00.0	00.0	18.6	185.6	56.4	125.0	120.2	62.4	298.4	6.6
1992	0.0	0.0	00.0	00.0	3.4	9.8	61.2	91.2	75.4	33.0	130.4	00.0
1993	0.0	0.0	00.0	13.2	83.0	47.8	163.2	63.0	41.1	173.6	00.0	27.2
1994	0.0	8.2	00.0	00.0	0.0	33.4	337.6	91.8	38.8	130.2	479.2	00.0
1995	23.2	0.0	00.0	00.0	160.6	68.4	186.0	191.2	142.0	344.3	32.0	00.0
1996	0.0	2.4	00.0	00.0	3.5	210.6	320.8	251.8	245.5	428.0	22.0	17.8
1997	4.6	0.0	00.0	35.8	0.0	26.8	221.4	77.0	351.0	52.2	56.2	44.5
1998	0.0	0.0	0.0	0.0	6.2	25.8	116.4	225.6	209.0	312.4	30.8	0.0
1999	0.0	0.0	0.0	0.0	102.0	128.2	115.0	77.8	135.6	213.6	0.0	0.0

20.Chinamuthevi (Movva)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	N.A	N.A	N.A	N.A	N.A	72.4	167.8	241.9	22.4	41.9	79.2	00.0
1987	41.8	0.0	10.0	21.4	5.4	61.8	113.6	202.5	93.3	144.2	215.3	6.6
1988	0.0	0.0	00.0	5.4	22.8	66.4	434.8	392.3	269.2	34.2	22.4	54.8
1989	0.0	0.0	77.4	00.0	32.0	65.0	295.8	182.7	144.6	24.6	29.8	00.0
1990	0.0	45.8	64.4	13.8	498.6	275.3	103.0	327.8	109.5	208.2	34.0	00.0
1991	0.0	0.0	00.0	00.0	29.4	138.5	90.8	216.2	312.6	106.6	305.6	00.0
1992	0.0	0.0	00.0	22.2	7.2	17.4	156.8	189.2	225.0	56.8	136.9	00.0
1993	0.0	0.0	21.2	46.4	123.4	83.8	214.0	118.4	40.6	193.9	4.2	65.6
1994	0.0	0.0	00.0	00.0	0.0	44.6	398.9	121.2	42.2	233.8	433.7	00.0
1995	18.0	0.0	00.0	00.0	136.4	76.6	124.0	178.6	67.8	320.9	6.4	00.0
1996	0.0	0.0	00.0	51.6	0.0	159.8	198.0	177.6	78.4	160.5	8.6	18.6
1997	7.6	0.0	00.0	38.8	0.0	20.2	73.8	49.0	236.0	68.8	34.0	44.4
1998	0.0	0.0	0.0	0.0	1.4	37.2	120.6	126.6	151.8	249.6	48.8	0.0
1999	0.0	0.0	0.0	6.2	64.6	77.6	107.0	124.6	127.4	248.0	0.0	0.0

21.Vuyyuru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	N.A	N.A	N.A	N.A	N.A	N.A	141.5	108.5	299.8	17.1	20.8	62.4
1987	0.0	0.0	25.2	40.0	0.0	78.2	90.3	314.4	50.8	172.8	30.4	4.4
1988	0.0	0.0	00.0	52.5	14.2	33.3	402.5	400.4	222.8	16.2	00.0	43.6
1989	0.0	0.0	48.7	9.2	6.4	90.4	358.7	244.2	110.4	37.6	17.0	00.0
1990	0.8	39.2	34.2	3.2	352.0	193.7	108.5	122.6	164.6	152.8	25.2	4.2
1991	0.0	0.0	00.0	00.0	52.2	121.9	64.4	212.6	260.4	88.2	15.3	00.0
1992	0.0	1.2	00.0	00.0	0.0	20.0	105.8	149.8	144.8	104.0	96.0	00.0
1993	0.0	0.0	00.0	22.8	80.4	28.8	141.6	40.8	49.8	236.3	7.0	15.1
1994	0.0	29.7	00.0	3.0	0.0	48.5	349.9	200.8	44.8	352.2	43.6	00.0
1995	21.4	0.0	00.0	00.0	120.7	110.5	205.6	203.5	80.6	445.0	00.0	00.0
1996	0.0	0.0	00.0	00.0	6.0	234.8	244.0	332.0	113.4	134.3	28.6	4.4
1997	61.1	0.0	40.1	6.0	0.0	76.0	191.9	261.8	336.0	8.3	16.5	19.3
1998	0.0	12.0	0.0	0.0	0.0	53.9	158.9	114.4	140.0	250.1	20.6	0.0
1999	0.0	0.0	0.0	0.0	31.2	94.1	156.8	113.8	133.2	203.4	0.0	0.0

22. Machilipatnam

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0.0	0.0	28.2	0.0	37.0	117.2	449.4	209.4	182.6	80.4	46.8	5.6
1990	0.0	95.5	43.9	0.1	492.1	110.1	104.0	189.1	184.1	177.1	60.9	2.4
1991	42.9	0.0	0.0	0.0	22.7	218.7	86.2	180.4	295.8	175.0	300.0	0.0
1992	0.0	0.0	0.0	0.0	1.3	41.2	93.5	201.4	235.3	205.4	247.7	0.0
1993	0.0	0.0	0.0	0.0	21.5	37.4	118.9	91.8	103.9	251.3	14.5	18.7
1994	21.2	18.7	0.0	0.0	0.3	56.1	376.8	130.5	83.3	445.9	550.2	0.0
1995	23.6	0.0	0.0	0.0	232.1	77.9	239.4	200.9	246.0	393.4	43.5	0.0
1996	0.0	8.9	0.0	1.8	3.3	299.8	284.6	141.3	154.5	428.0	13.2	43.4
1997	9.4	0.0	9.6	7.7	0.0	56.9	247.9	135.0	49.4	125.4	186.4	87.1
1998	17.8	0.0	0.4	18.5	0.0	78.0	164.3	181.5	208.1	310.4	46.7	0.0
1999	0.0	0.0	0.0	3.2	40.6	69.6	187.8	83.9	108.9	280.6	0.0	0.0

23. Gudivada

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0.0	0.0	81.5	0.0	76.0	159.3	313.0	263.7	236.4	61.5	30.6	0.0
1990	0.0	74.0	54.8	6.6	399.6	94.8	102.2	113.8	225.0	223.0	22.2	4.2
1991	0.0	0.0	0.0	0.0	35.2	157.8	100.2	212.2	434.6	60.6	157.6	0.0
1992	0.0	0.0	0.0	0.0	19.6	26.0	135.2	182.8	96.4	195.0	121.2	0.0
1993	0.0	0.0	6.0	0.2	33.4	103.2	162.2	50.0	99.8	263.7	0.0	19.6
1994	5.4	9.2	0.0	0.0	2.6	65.8	278.0	171.2	121.0	206.8	278.4	0.0
1995	1.6	0.0	0.0	0.0	162.6	137.8	270.6	238.4	119.4	429.8	13.2	43.4
1996	0.0	7.6	0.0	0.0	0.0	284.0	306.8	223.8	143.6	228.2	76.8	9.4
1997	13.3	0.0	13.2	9.8	28.2	47.4	213.8	91.2	251.2	100.2	91.4	72.8
1998	2.2	0.0	0.0	0.0	26.4	69.0	245.2	284.2	232.8	361.4	41.4	0.0
1999	0.0	0.0	0.0	0.0	86.2	114.8	243.2	171.2	127.4	197.4	4.8	0.0

24. Gudlavalleru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	0.0	0.0	0.0	30.4	0.0	36.0	227.0	189.4	309.8	74.4	68.6	50.8
1998	2.0	0.0	0.0	0.0	0.0	44.6	291.8	295.4	275.7	300.2	45.6	0.0
1999	0.0	0.0	0.0	0.0	69.6	48.6	148.6	134.8	95.8	195.6	0.0	0.0

25.Mandavalli

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0.0	0.0	47.6	0.0	6.9	64.6	306.5	428.6	178.6	49.8	14.4	0.0
1990	0.0	69.2	110.2	8.2	469.2	61.4	39.0	151.3	282.6	174.7	19.8	15.0
1991	31.0	0.0	0.0	0.0	59.2	197.0	96.3	283.2	671.1	138.8	104.8	0.0
1992	0.0	0.0	0.0	0.0	35.0	32.0	148.3	199.2	207.1	170.2	140.0	0.0
1993	0.0	0.0	12.4	10.8	32.4	65.0	143.0	115.4	101.2	151.8	9.0	42.8
1994	0.0	14.6	0.0	0.0	4.6	39.6	263.1	117.6	108.8	142.0	183.3	0.0
1995	27.8	0.0	0.0	0.0	147.2	141.2	230.6	204.7	215.4	400.7	2.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	238.3	267.6	245.8	276.4	166.0	49.8	20.6
1997	31.6	0.0	0.0	28.6	0.0	84.0	225.2	95.8	252.6	119.8	33.4	68.2
1998	0.6	0.0	0.0	0.0	0.0	101.0	211.8	332.2	325.8	344.4	39.2	0.0
1999	0.0	0.0	0.0	0.0	124.0	57.0	177.3	198.6	72.4	183.0	6.2	0.0

26.Thotlavalluru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	60.4	0.0	12.2	44.4	0.0	55.4	194.0	171.0	312.8	65.4	36.4	20.2
1998	0.0	0.0	0.0	0.0	5.2	81.2	224.2	140.8	218.6	300.8	108.2	0.0
1999	0.0	0.0	0.0	0.0	112.8	79.0	169.0	119.0	181.4	244.0	2.4	0.0

27.Pedana

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	0.0	0.0	24.6	0.0	68.3	177.6	428.0	240.5	160.3	33.9	15.7	0.0
1990	0.0	110.4	49.6	15.2	312.1	86.4	128.4	155.4	131.5	220.4	62.1	7.2
1991	10.1	0.0	0.0	0.0	73.0	166.9	64.3	189.2	265.1	192.2	252.1	0.0
1992	8.3	0.0	0.0	0.0	15.8	32.9	94.2	138.4	186.6	198.1	291.6	0.0
1993	0.0	0.0	0.0	0.0	31.6	66.1	121.2	10.4	127.4	233.5	1.2	20.2
1994	0.0	10.2	0.0	0.0	0.0	66.1	405.7	111.7	36.6	296.3	388.3	0.0
1995	16.4	0.0	0.0	0.0	175.9	122.3	224.9	171.1	297.9	428.8	16.5	0.0
1996	0.0	10.2	0.0	3.5	0.0	369.2	274.1	174.9	162.2	342.9	15.7	24.3
1997	28.5	0.0	10.3	8.4	0.0	47.7	167.8	252.0	259.3	83.2	79.8	118.7
1998	25.5	0.0	8.3	28.2	0.0	26.0	140.2	247.3	223.8	321.5	50.5	0.0
1999	0.0	0.0	0.0	5.2	65.6	62.4	159.8	57.1	42.0	160.9	0.0	0.0

28. Pamidimukkala

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	131.9	196.5	46.6	00.0
1989	0.0	0.0	62.5	00.0	4.5	51.5	458.6	202.8	202.3	28.2	21.6	00.0
1990	0.0	30.0	72.6	00.0	325.6	114.7	118.5	186.5	208.8	167.2	28.6	4.8
1991	0.0	0.0	00.0	00.0	47.4	125.5	61.9	181.7	212.2	89.7	191.0	00.0
1992	3.5	7.6	00.0	00.0	6.3	53.1	111.5	189.0	176.4	123.3	119.0	00.0
1993	4.2	0.0	00.0	5.6	29.0	95.1	234.6	34.8	66.0	176.8	00.0	36.6
1994	0.0	23.6	00.0	4.2	0.0	48.9	344.0	181.2	59.4	241.8	358.7	00.0
1995	30.4	0.0	00.0	00.0	157.8	76.1	187.2	225.0	128.3	532.1	23.4	00.0
1996	0.0	0.0	00.0	00.0	24.4	205.9	180.2	314.5	246.6	--	17.2	8.6
1997	41.1	6.8	1.8	84.2	0.0	52.6	184.3	163.8	428.0	61.5	55.4	55.6
1998	0.0	0.0	3.0	0.0	45.0	42.9	182.2	149.9	143.7	264.4	61.6	0.0
1999	0.0	0.0	0.0	0.0	33.2	52.6	136.8	107.4	61.9	317.2	0.0	0.0

29. Guduru

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	4.0	0.0	20.2	10.2	3.2	35.2	126.8	87.0	275.3	96.5	89.0	63.0
1998	16.2	7.1	0.0	14.2	0.0	92.0	181.7	221.4	151.8	302.0	30.2	0.0
1999	0.0	0.0	0.0	0.0	65.2	70.8	104.6	117.0	96.8	317.8	0.0	0.0

30. Cherakupalli [Gundlapalli]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	0	0	0	0	0	30.4	221.2	320.2	137.6	26.4	9.2	136.4
1989	0	0	38	0	29.8	158.1	312.8	83.8	229.2	10	31.2	12.6
1990	4	93	11	0	414.6	111.2	79.8	151.8	153.4	183.1	47	0
1991	2.8	0	0	0	10.2	319.6	96	114.2	224	122.4	287.7	8.2
1992	2	0	0	32	6.4	38.6	140	138.5	166.2	69	161.1	0
1993	0	0	1.2	3.8	101.8	44.8	128.2	87.2	180.4	238.2	18.8	36
1994	4.8	12.8	0	0	7.6	65.6	199	78	42.6	299	344	0
1995	105	0	0	0	192.4	42.2	138.8	242.8	116.8	270.2	25.4	0
1996	0	0	0	3.8	16.8	90	153.2	240.8	106.6	356	38.2	12.4
1997	14.8	0	0	16.2	22.6	61.4	74.2	54.2	400.8	60.4	63	34
1998	1.4	0	0	0	0	47.4	92.4	171.2	48.9	365.2	63.6	0
1999	0	0	0	0	0	76.4	100.8	180.5	140.1	152.8	0	0

31.Vijayawada

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	0.0	0.0	0.0	0.0	34.4	211.2	113.0	254.2	368.0	58.6	110.2	0.0
1992	0.0	0.0	0.0	0.0	12.2	45.0	84.9	230.8	104.4	135.2	63.4	0.0
1993	0.0	0.0	1.0	40.2	208.0	51.8	134.1	22.5	161.3	204.3	80.2	34.4
1994	8.6	8.4	0.0	14.8	15.6	79.0	230.2	138.6	47.4	311.4	226.0	0.0
1995	25.8	0.0	0.0	0.0	53.6	217.0	265.8	88.4	312.4	8.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	207.2	209.8	189.9	192.4	164.2	6.0	4.2
1997	13.2	0.0	27.5	30.2	49.5	35.0	189.9	88.8	224.0	85.4	56.8	45.4
1998	0.0	0.0	0.0	0.0	0.0	133.8	231.4	259.4	130.0	227.2	29.2	0.0
1999	0.0	0.0	0.0	0.0	76.9	138.1	275.0	75.8	186.8	96.6	17.6	0.0

32.Telaprolu

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	0.0	0.0	0.0	0.0	34.2	153.7	64.5	242.0	398.8	52.4	72.6	0.0
1992	0.0	0.0	0.0	0.0	6.3	41.5	80.0	180.1	129.2	156.2	106.0	0.0
1993	0.0	2.4	0.0	21.9	65.0	63.4	149.0	8.4	79.1	167.8	28.0	18.3
1994	0.0	40.8	0.0	0.0	0.0	52.8	230.0	154.6	122.8	236.1	241.0	0.0
1995	54.6	0.0	0.0	0.0	125.0	68.0	245.8	103.2	53.2	319.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	153.0	233.8	159.2	161.6	172.6	29.4	2.4
1997	5.0	0.0	0.0	7.8	0.0	57.0	128.6	95.6	241.4	84.2	74.0	24.8
1998	3.0	0.0	16.4	0.0	4.0	57.4	210.2	282.0	183.4	256.6	25.0	0.0
1999	0.0	0.0	0.0	0.0	49.0	57.8	132.6	122.9	128.4	179.0	0.0	0.0

ANNEXURE II
(1 to 15) Groundwater quality parameters of shallow observation wells in Krishna delta(Analysed by State Groundwater Department, A.P)

Location & Year	pH	EC µmho/cm	TDS mg/l	HCO ₃ mg/l	CO ₃ mg/l	Cl mg/l	F mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	TH as CaCO ₃ mg/l	SAR	%Na	RSC
May-82															
B.D.PALLI (16)	7.85	24425	15632	931	NA	7410	NA	468	244	24	83	401	10.17	76.86	-0.10
CHALLAPALLI (17)	8.12	3634	2326	395	0	642	NA	630	267	32	151	701	10.36	71.00	-6.66
CHINAMUTTEVI (20)	7.83	4826	3089	366	0	924	NA	155	35	32	49	282	4.02	57.61	1.14
VUYURU (21)	8.28	1177	753	338	0	114	NA								
Nov-82															
B.D.PALLI (16)	8.42	14950	9568	349	58	3634	NA	505	311	24	73	360	11.59	80.63	0.46
CHALLAPALLI (17)	8.46	3680	2355	332	50	534	NA								
CHINAMUTTEVI (20)	8.87	5120	3277	216	0	856	NA	144	50	48	29	239	4.05	61.21	1.20
VUYURU (21)	8.18	1240	794	299	0	120	NA								
May-83															
B.D.PALLI (16)	8.11	22700	14528	384	NA	7178	NA	666	23	40	97	499	12.98	74.81	-6.11
CHALLAPALLI (17)	8.18	3920	2509	192	0	503	NA	540	400	48	136	679	9.02	71.33	-8.37
CHINAMUTTEVI (20)	7.86	4880	3123	259	0	913	NA	146	40	24	29	179	4.75	67.33	2.36
VUYURU (21)	8.48	1127	721	259	38	110	NA								
Nov-83															
B.D.PALLI (16)	7.85	15080	9651	608	NA	3933	NA	306	299	56	63	399	6.67	72.46	3.02
CHALLAPALLI (17)	7.80	2970	1901	549	0	341	NA	537	380	60	136	709	8.78	70.04	-2.97
CHINAMUTTEVI (20)	7.58	4570	2926	559	0	625	NA	238	45	56	49	341	5.61	62.78	1.62
VUYURU (21)	8.65	1843	1180	304	118	165	NA								
May-84															
B.D.PALLI (16)	8.61	18400	11776	660	160	5600	NA	2934	311	96	459	2128	27.70	76.16	-26.02
CHALLAPALLI (17)	8.97	3553	2274	320	60	512	NA	500	289	20	85	400	10.89	78.52	-0.37
CHINAMUTTEVI (20)	8.64	5513	3528	135	60	972	NA	934	356	36	143	678	15.62	78.62	-9.62
VUYURU (21)	8.54	1208	773	355	50	112	NA	145	14	32	41	249	4.00	57.32	3.14
Nov-84															
B.D.PALLI (16)	7.50	22300	14272	350	NA	7200	NA	3714	400	176	476	2398	33.02	78.22	-
CHALLAPALLI (17)	7.60	3700	2368	330	0	557	NA	500	333	24	83	401	10.87	79.08	-1.40
CHINAMUTTEVI (20)	7.81	3800	2432	360	0	787	NA	475	289	40	88	462	9.62	75.27	-2.01
VUYURU (21)	7.69	2000	1280	550	0	230	NA	250	88	72	58	418	5.32	61.10	2.65

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Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
May-85															
B.D.PALLI (16)	7.82	28500	18240	950	NA	9025	NA	4821	378	64	690	2999	38.35	78.58	-
CHALLAPALLI (17)	8.31	3120	1997	399	19	665	NA	400	333	8	92	399	8.73	76.54	0.42
CHINAMUTTEVI (20)	7.93	4240	2714	238	0	1074	NA	563	378	40	131	639	9.70	72.83	-7.98
VUYYURU (21)	8.20	1208	773	276	0	247	NA	158	22	16	53	258	4.28	59.10	0.38
Nov-85															
B.D.PALLI (16)	7.34	19800	12672	772	NA	7320	NA	3750	400	320	428	2560	32.26	77.23	-
CHALLAPALLI (17)	7.56	3280	2099	497	0	560	NA	388	311	48	83	461	7.86	72.95	0.74
CHINAMUTTEVI (20)	7.86	5510	3526	524	0	1200	NA	575	422	120	146	900	8.34	66.58	-7.49
VUYYURU (21)	8.32	2300	1472	469	110	350	NA	221	78	104	66	531	4.17	52.24	0.97
May-86															
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B.D.PALLI (16)	7.63	3620	2317	582	0	632	NA	400	333	64	97	559	7.37	69.91	0.49
CHALLAPALLI (17)	7.84	4480	2867	466	0	546	NA	500	377	96	107	680	8.35	69.81	-4.25
CHINAMUTTEVI (20)	7.32	5350	3424	602	0	1284	NA	663	178	160	165	1078	8.79	60.80	-9.48
VUYYURU (21)															
Nov-86															
B.D.PALLI (16)	7.13	1208	773	270	0	182	NA	135	13	48	39	4	3.51	52.57	-0.20
CHALLAPALLI (17)	7.34	3770	2413	473	0	700	NA	476	343	56	78	10	9.65	76.22	0.27
CHINAMUTTEVI (20)	7.30	5020	3213	459	0	1037	NA	538	371	88	136	8	8.39	67.90	-6.37
VUYYURU (21)	7.33	2605	1667	446	0	415	NA	292	111	64	78	6	5.80	61.82	-0.67
May-87															
B.D.PALLI (16)	8.10	786	503	202	0	120	0.7	122	11	16	15	102	5.27	73.35	2.01
CHALLAPALLI (17)	8.20	3690	2362	308	0	680	0.1	492	350	16	112	501	9.58	75.25	-3.82
CHINAMUTTEVI (20)	7.20	4230	2707	282	0	790	0.1	538	350	48	92	498	10.49	76.49	-4.30
VUYYURU (21)	7.30	2140	1370	326	0	470	0.1	246	350	16	58	279	6.42	77.96	0.97
Nov-87															
B.D.PALLI (16)	7.51	1290	826	323	0	166	0.4	151	12	64	39	320	3.67	51.79	0.06
CHALLAPALLI (17)	7.86	4380	2803	617	0	780	0.1	571	275	88	78	541	10.69	74.69	1.55
CHINAMUTTEVI (20)	7.45	5630	3603	647	0	1061	0.1	681	368	144	107	800	10.48	70.96	-3.03
VUYYURU (21)	7.46	1385	886	196	0	312	0.2	206	38	32	53	298	5.20	62.55	-2.02
May-88															
B.D.PALLI (16)	7.60	1204	771	214	0	220	0.2	166	31	32	39	240	4.66	62.55	-0.52
CHALLAPALLI (17)	7.40	572	366	130	0	50	0.3	75	11	32	10	121	2.96	59.41	0.18
CHINAMUTTEVI (20)	7.20	4290	2746	651	0	660	0.1	538	300	152	92	758	8.50	67.23	-2.12
VUYYURU (21)	7.60	3960	2534	493	0	410	0.1	640	102	73	88	544	11.94	73.70	-1.00

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Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
Nov-88															
B.D.PALLI (16)	8.06	1403	898	317	0	240	0.1	148	14	80	34	340	3.49	50.02	-0.45
CHALLAPALLI (17)	7.76	3580	2291	898	0	440	0.1	379	300	80	78	521	7.23	69.91	7.57
CHINAMUTTEVI (20)	7.90	3750	2400	458	0	830	0.1	395	350	72	83	521	7.53	71.52	-1.24
VUYYURU (21)	7.56	3360	2150	678	0	660	0.1	436	79	112	88	642	7.49	62.08	0.75
May-89															
B.D.PALLI (16)	7.85	1974	1263	240	0	221	0.4	241	18	64	68	440	5.00	55.49	-3.97
CHALLAPALLI (17)	8.17	2980	1907	458	0	691	0.1	410	262	24	73	360	9.41	77.35	1.98
CHINAMUTTEVI (20)	8.13	4230	2707	315	0	864	0.1	554	262	32	102	500	10.79	75.56	-3.66
TELAPROLU (32)	7.75	6450	4128	480		1536	0.1	724	30	192	204	1319	8.68	55.06	-16.72
VUYYURU (21)	7.92	3280	2099	285	0	749	0.2	410	21	56	112	601	7.28	60.52	-6.28
Nov-89															
AVANIGADDA (18)	7.94	1593	1020	501	0	207	0.5	220	11	48	53	338	5.21	59.35	3.28
B.D.PALLI (16)	7.88	1776	1137	455	0	103	1.0	129	188	64	63	419	2.74	55.47	0.74
CHALLAPALLI (17)	8.17	2960	1894	683	0	395	0.1	357	250	80	68	480	7.09	69.60	4.09
CHINAMUTHEVI (20)	8.16	3710	2374	655	0	658	0.1	429	250	112	78	601	7.62	67.62	1.11
GHANTASALA (19)	8.33	6100	3904	254	18	1203	0.5	593	750	80	140	776	9.27	74.40	-10.04
GUDIVADA (23)	7.80	2800	1792	464	0	150	0.5	486	12	72	49	381	10.83	73.79	1.66
GUDLAVALLERU (24)	8.39	5400	3456	728	109	921	0.1	948	49	128	78	641	16.30	76.85	3.95
PAMIDIMUKKALA (28)	8.39	3680	2355	345	91	714	0.5	600	33	96	68	520	11.45	72.19	-1.65
TELAPROLU (32)	7.94	6600	4224	619	NA	1354	0.1	919	375	96	165	919	13.20	73.00	-
THOTLAVALLURU (26)	7.62	1150	736	364	0	85	0.5	93	140	32	39	240	2.61	61.38	2.48
VIJAYAWADA (31)	7.61	492	827	437	nil	132	0.5	136	12	80	49	401	2.95	43.69	-
VUYYURU (21)	7.60	4350	2784	737	0	959	0.1	667	77	128	92	698	10.98	68.96	0.80
May-90															
CHINAMUTTEVI (20)	8.04	3290	2106	588	0	488	0.1	418	267	88	73	520	7.98	70.66	1.38
GHANTASALA (19)	8.39	4050	2392	294	53	848	0.1	614	150	32	136	640	10.57	70.55	-5.81
GUDIVADA (23)	8.52	2890	1850	294	63	350	0.5	538	10	56	53	358	12.38	76.80	0.00
GUDLAVALLERU (24)	8.50	5260	3366	399	84	1336	0.1	861	62	176	53	658	14.60	74.80	-3.48
GUDURU (29)	8.40	2130	1363	252	63	254	0.1	213	75	112	53	498	4.15	52.92	-3.64
MANDAYALI (25)	8.36	3540	2266	525	63	486	0.1	554	150	168	15	481	10.98	74.36	2.13
PAMIDIMUKKALA (28)	7.09	4630	2963	368	0	1007	0.5	800	29	88	92	598	14.23	74.84	-4.58
TELAPROLU (32)	8.13	6120	3917	515	NA	1484	0.1	842	500	112	117	761	13.28	76.48	-
THOTLAVALLURU (26)	8.60	1300	832	221	42	138	0.1	101	145	56	34	280	2.63	59.18	-0.33
VIJAYAWADA (31)	7.99	1425	912	410	nil	138	0.1	127	10	88	58	458	2.58	38.69	-
VUYYURU (21)	8.13	2000	1280	252	0	324	0.1	300	50	72	19	258	8.12	73.52	-0.12

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Location & Year

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Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
AMRUTALURU (04)	7.48	1506	964	173	0	245	0.1	175	21	40	58	339	4.14	54.67	-3.29
AVANIGADDA (18)	8.42	1814	1161	285	95	208	0.1	300	14	8	49	222	8.78	75.21	3.18
BHATTIPROLU (08)	7.65	2180	3095	202	0	294	0.1	292	77	40	58	339	6.91	68.47	-2.71
B.D.PALLI (16)	7.78	1672	1070	238	0	225	0.5	233	14	72	34	320	5.67	62.15	-1.63
CHALLAPALLI (17)	7.78	3200	2048	684	0	392	0.1	419	250	48	73	420	8.90	74.59	5.30
CHINAMUTHEVI (20)	8.30	2950	1888	428	57	333	0.1	442	250	40	58	339	10.46	79.13	2.95
DUGGIRALA (05)	8.03	2900	1856	586	0	451	0.1	357	178	56	107	580	6.45	63.44	0.15
GHANTASALA (19)	7.62	7000	4480	323	0	1180	0.1	714	675	136	185	1101	9.37	68.74	-15.50
GUDIVADA (23)	8.11	3600	2304	285	0	450	0.5	696	16	40	58	339	16.47	81.95	-1.05
GUDLAVALLERU (24)	8.18	5150	3296	513	0	1019	0.1	1000	63	48	68	400	21.77	84.97	2.29
GUDURU (29)	8.35	2000	1280	241	38	218	0.1	271	75	56	53	358	6.23	65.73	-1.56
MACHILIPATNAM (22)	8.41	2440	1562	247	95	248	0.1	277	125	80	63	459	5.63	62.45	-2.32
MANDAVALLI (25)	8.12	3340	2138	422	0	416	0.1	514	150	16	83	381	11.46	77.50	0.84
NAGARAM (09)	8.42	2770	1773	211	77	441	0.1	354	55	176	49	641	6.08	56.72	-7.06
NAMBURU (14)	7.70	5620	3597	298	0	951	0.1	473	955	24	112	521	9.03	81.25	-4.42
P.V.PALEM (115)	7.48	2860	1830	173	NA	510	0.1	467	17	56	68	420	9.92	71.24	-
PAMIDIMUKKALA (28)	7.94	5200	3328	295	0	1109	0.5	914	30	80	92	578	16.54	77.83	-5.64
PEDANA (27)	8.46	4350	2784	285	38	673	0.1	651	150	80	83	541	12.18	74.84	-4.34
REPALLE (07)	8.73	5720	3661	336	0	1127	0.1	1008	222	24	112	521	19.24	82.67	-3.66
TELAPROLU (32)	8.42	6280	4019	380	76	1156	0.1	883	375	104	117	741	14.12	76.44	-5.67
THOTLAVALLURU (26)	8.03	1363	872	285	0	119	0.5	129	188	24	29	179	4.19	74.44	2.12
VEMURU (02)	7.42	1552	993	186	NA	235	0.1	223	20	48	53	338	5.28	60.21	-
VIJAYAWADA (31)	7.88	1380	883	390	nil	108	0.1	130	10	80	58	438	2.70	40.29	-
VUYYURU (21)	8.01	3500	2240	627	0	490	0.1	581	69	64	58	398	12.67	77.26	4.59

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Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
AVANIGADDA (18)	7.62	1395	893	422	0	166	0.1	216	14	32	44	261	5.82	65.19	3.23
BAPATLA (12)	8.92	1245	797	248	40	78	0.1	120	65	72	34	320	2.92	51.86	-0.63
B.D.PALLI (16)	7.83	1534	982	346	0	274	0.1	184	14	80	44	381	4.10	52.35	-0.69
CHALLAPALLI (17)	8.28	2890	1850	634	0	372	0.1	353	250	72	58	418	7.51	72.24	4.35
CHEBROLU (11)	8.37	5140	3290	257	79	764	0.1	437	127	40	78	421	9.27	83.58	-1.67
CHINAMUTHEVI (20)	8.39	2340	1498	413	38	274	0.1	277	200	24	63	319	6.75	72.95	2.66
GHANTASALA (18)	8.38	5800	3712	470	96	902	0.1	529	778	136	122	842	7.94	71.86	-5.48
GUDIVADA (23)	8.19	3670	2349	336	0	529	0.2	647	14	48	63	379	14.46	79.02	-0.84
GUDLAVALLERU (24)	7.83	4600	2944	893	0	931	0.1	825	28	120	58	538	15.47	77.28	7.11
GULLAPALLI (30)	7.92	1720	1101	238	0	299	0.1	225	26	64	44	341	5.30	60.55	-2.05
KOLLIPARA (06)	8.88	3920	2509	535	139	745	0.1	500	550	16	49	242	14.01	88.14	8.66
KOLLURU (3)	8.72	3900	2496	663	119	588	0.1	575	275	72	83	521	10.96	75.49	5.24
NAGARAM (09)	8.57	1897	1214	277	20	255	0.1	238	100	48	44	301	5.97	68.24	-0.07

NIZAMPATNAM (10)	8.90	5400	3456	455	119	1196	0.1	911	48	64	107	600	16.19	77.33	-0.49
PAMIDIMUKKALA (28)	7.82	3800	2432	413	0	804	0.1	643	33	56	83	481	12.76	74.99	-1.34
PONNURU (13)	8.56	1700	1088	257	99	147	0.1	288	3	8	53	238	8.13	72.64	2.38
REPALLE (07)	8.04	2200	1408	307	0	363	0.1	263	44	88	63	479	5.23	56.77	-3.42
TELAPROLU (32)	7.84	5580	3571	614	NA	1176	0.1	775	300	96	146	841	11.64	71.16	-
THOTLAVALLURU (26)	7.82	754	483	250	0	49	0.1	49	48	40	34	240	1.38	41.23	0.21
VIJAYAWADA (31)	7.76	1400	896	451	nil	167	0.1	141	11	56	83	481	2.80	40.04	-
VUYYURU (21)	7.68	3580	2291	653	0	764	0.1	565	86	40	92	478	11.25	73.72	3.52

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AVANIGADDA (18)	8.65	1566	1002	322	83	194	0.1	250	19	56	39	300	6.28	65.44	2.10
BAPATLA (12)	8.29	545	349	136	0	54	0.1	69	20	24	10	101	2.99	63.49	0.70
BHATTIPROLU (08)	7.90	1875	1200	310	0	302	0.1	236	38	64	58	398	5.15	58.54	-1.75
B.D.PALLI (16)	8.45	1413	904	312	21	238	0.5	205	15	48	44	301	5.14	60.75	0.65
CHALLAPALLI (17)	9.00	2300	1472	458	104	356	0.1	275	250	24	49	262	7.40	77.87	6.02
CHEBROLU (11)	8.14	5200	3328	407	0	896	0.5	457	950	64	97	559	8.41	79.84	-3.01
CHINAMUTHEVI (20)	8.94	2030	1299	458	62	270	0.1	208	233	32	53	298	5.25	71.62	4.46
GHANTASALA (19)	8.52	5620	3597	385	42	1048	0.5	560	629	160	102	819	8.51	71.19	-7.82
GUDIVADA (23)	9.00	1760	1126	218	62	238	0.5	300	17	56	24	239	8.45	73.61	0.83
GUDLAVALLERU (24)	8.86	4400	2816	707	104	875	0.5	673	100	152	63	639	11.58	71.37	3.46
GULLAPALLI (30)	8.34	1422	910	291	38	216	0.1	225	63	40	34	240	6.32	70.42	1.79
KOLLIPARA (06)	8.43	3120	1997	417	58	400	0.1	457	375	16	39	200	14.06	88.05	5.50
KOLLURU (3)	8.63	4700	3008	611	175	940	0.1	628	450	32	122	582	11.34	76.99	4.12
NAGARAM (09)	8.23	1462	936	340	0	194	0.1	212	65	32	39	240	5.95	69.40	2.00
NIZAMPATNAM (10)	8.70	2200	1408	155	78	367	0.5	377	16	24	44	241	10.57	77.75	-0.15
PAMIDIMUKKALA (28)	7.66	7900	5056	146	42	1814	0.1	1360	26	128	146	920	19.51	76.50	-14.61
PONNURU (13)	8.72	896	573	291	38	76	0.1	154	20	24	15	122	6.08	74.79	4.15
REPALLE (07)	8.00	4890	3130	243	0	1123	0.1	908	175	24	863	3611	6.58	37.93	-67.08
TELAPROLU (32)	8.83	6300	4032	448	187	1274	0.1	764	433	112	146	880	11.21	71.60	-4.87
TENALI (01)	8.17	1300	832	310	0	140	0.1	150	57	112	19	358	3.45	52.72	-0.96
THOTLAVALLURU (26)	7.95	1135	765	229	42	86	0.1	112	116	40	29	219	3.29	61.16	1.04
VIJAYAWADA (31)	8.52	1038	664	166	62	214	0.1	108	8	80	44	381	2.41	39.18	-3.05
VUYYURU (21)	8.96	3000	1920	508	104	562	0.1	417	70	96	68	520	7.96	65.76	1.87

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AVANIGADDA (18)	8.63	1778	1138	349	78	194	0.5	156	150	72	44	361	3.57	59.57	1.33
BAPATLA (12)	7.43	1380	883	369	0	126	0.1	145	42	104	19	338	3.43	52.20	0.62
BHATTIPROLU (08)	7.78	2020	1293	446	NA	310	0.1	242	27	136	29	459	4.91	54.99	-
B.D.PALLI (16)	8.40	2160	1382	320	39	378	0.1	300	19	64	63	419	6.38	61.80	-1.18
CHALLAPALLI (17)	8.50	2200	1408	514	58	272	0.1	354	113	40	34	240	9.95	79.25	6.65
CHEBROLU (11)	7.70	4950	3168	485	0	611	0.1	520	933	80	63	459	10.56	83.53	0.54

CHINAMUTHEVI (20)	8.42	2680	1715	281	58	340	0.1	338	175	88	63	479	6.72	66.72	-2.78
GHANTASALA (19)	7.92	5010	3206	456	0	844	0.1	525	650	72	107	620	9.18	76.13	-3.25
GUDIVADA (23)	8.54	2960	1894	320	58	437	0.5	600	12	40	53	318	14.65	80.62	1.22
GUDLAVALLERU (24)	7.70	4600	2944	718	0	951	0.1	971	6	64	63	419	20.64	83.51	6.00
GULLAPALLI (30)	7.47	3180	2035	330	0	475	0.1	509	30	144	58	598	9.05	65.70	-5.35
KOLLIPARA (06)	7.68	3800	2432	679	0	417	0.1	527	533	64	49	361	12.06	83.51	6.36
KOLLURU (3)	7.60	4500	2880	922	0	621	0.1	740	333	120	34	440	15.35	82.24	9.65
NIZAMPATNAM (10)	7.65	5850	3744	737	0	999	0.1	1055	47	96	107	680	17.61	77.62	1.17
PAMIDIMUKKALA (28)	8.05	5060	3238	369	0	1251	0.1	1000	21	80	102	619	17.49	78.07	-4.98
REPALLE (07)	7.32	5830	3731	388	0	970	0.1	945	233	120	83	641	16.24	78.61	-5.04
TELAPROLU (32)	7.42	6080	3891	417	NA	1426	0.1	927	240	240	112	1060	12.39	68.68	-
THOTLAVALLURU (26)	8.45	546	349	184	39	39	0.1	51	54	24	15	122	2.01	59.70	2.03
VIJAYAWADA (31)	7.42	1406	900	485	nil	146	0.1	114	11	96	49	441	2.36	37.27	-
VUYYURU (21)	8.25	2650	696	291	0	553	0.1	463	75	32	73	380	10.34	74.41	-1.76

Nov-92

AVANIGADDA (18)	8.30	1231	788	350	55	137	0.5	169	17	24	58	299	4.26	56.66	2.15
BHATTIPROLU (08)	7.90	7810	5998	600	NA	1463	0.5	825	700	248	156	1261	10.11	68.10	-
B.D.PALLI (16)	8.65	3210	2054	534	74	376	0.1	367	367	64	49	361	8.40	77.84	4.94
CHALLAPALLI (17)	7.95	2650	1696	552	0	308	0.1	343	200	48	44	301	8.61	76.93	5.03
CHINAMUTHEVI (20)	8.38	3150	2016	515	74	399	0.1	429	267	80	53	418	9.13	75.33	3.44
DUGGIRALA (05)	8.47	590	378	138	378	438	0.1	69	1	32	15	142	2.52	51.67	7.49
GHANTASALA (19)	8.16	4640	2970	469	0	684	0.1	500	533	80	88	562	9.18	75.93	-1.83
GUDIVADA (23)	7.91	3150	2016	350	0	399	0.1	600	14	64	19	238	16.91	84.75	2.24
GUDLAVALLERU (24)	7.90	4420	2829	662	0	662	0.5	757	55	112	63	539	14.19	76.12	2.48
KOLLURU (3)	8.15	5980	3827	828	0	770	0.1	757	425	144	122	862	11.22	71.80	-0.64
NAGARAM (09)	8.09	3100	1984	460	0	437	0.1	453	55	176	63	699	7.45	60.18	-4.76
PAMIDIMUKKALA (28)	8.29	940	602	276	0	34	0.5	74	120	32	24	179	2.41	63.80	1.95
REPALLE (07)	7.52	5570	3565	460	0	950	0.1	914	200	112	88	642	15.70	77.78	-3.61
TELAPROLU (32)	8.14	6080	3891	370	NA	1300	0.1	892	400	32	126	598	15.88	80.43	-
THOTLAVALLURU (26)	3.12	905	579	265	0	80	0.1	80	93	48	10	161	2.74	64.53	2.48
VEMURU (02)	8.11	1221	781	340	0	133	0.5	154	2	56	29	259	4.16	56.58	1.62
VIJAYAWADA (31)	7.97	1280	819	370	nil	137	0.5	120	10	96	39	400	2.61	40.63	-
VUYYURU (21)	7.85	5020	3213	718	0	1072	0.5	711	133	144	97	759	11.23	69.37	-0.79

Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
May-93															
AMRUTALURU (04)	8.28	652	417	NA	0	74	0.1	84	3	32	75	389	1.86	32.49	-7.75
AVANIGADDA (18)	7.95	1602	1025	550	0	167	1	168	28	90	49	401	3.65	50.01	2.98
BAPATLA (12)	8.51	1300	832	320	60	121	0.1	135	83	88	34	360	3.10	52.65	0.41
BHATTIPROLU (08)	8.13	1379	883	250	0	251	0.1	188	25	32	44	261	5.07	62.86	-0.21
B.D.PALLI (16)	8.32	685	438	160	40	84	0.5	92	10	16	24	139	3.40	60.60	1.23
CHALLAPALLI (17)	8.33	1920	1229	520	60	260	0.1	250	250	32	24	179	8.14	82.88	8.03
CHINAMUTHEVI (20)	8.42	3000	1920	390	80	288	0.1	283	367	24	92	439	5.89	71.28	0.66
DUGGIRALA (05)	8.20	516	330	320	0	47	0.5	54	3	32	19	158	1.87	43.44	3.24
GHANTASALA (19)	7.87	4100	2624	560	0	688	0.1	417	600	56	83	481	8.27	77.71	1.60
GUDIVADA (23)	8.37	4800	3072	360	80	744	0.5	854	28	80	88	562	15.68	77.14	-2.41
GUDLAVALLERU (24)	8.34	3300	2112	620	120	465	0.1	538	30	88	53	438	11.19	73.42	6.06
GULLAPALLI (30)	8.31	2900	1856	180	60	484	0.5	369	48	144	58	598	6.56	59.10	-7.15
KOLLIPARA (06)	8.62	3200	2048	400	100	447	0.1	415	400	16	44	221	12.16	86.52	5.59
KOLLURU (3)	8.01	5200	3328	950	NA	316	0.1	676	307	136	107	780	10.53	70.52	-
NAGARAM (09)	7.68	3360	2150	400	0	539	0.1	450	45	184	68	739	7.20	58.37	-6.77
NAMBURU (14)	8.34	4720	3021	230	100	826	0.1	400	920	24	107	500	7.79	80.41	-3.37
NIZAMPATNAM (10)	8.39	3800	2432	670	60	651	0.1	700	33	40	73	400	15.23	79.67	6.62
P.V.PALEM (15)	7.50	2200	1408	300	NA	391	0.1	336	17	48	63	379	7.51	66.54	-
PAMIDIMUKKALA (28)	7.85	4500	2880	520	0	800	0.1	733	40	96	107	680	12.23	70.79	-3.17
PONNURU (13)	7.92	1425	912	390	NA	142	0.1	232	18	32	34	220	6.81	70.63	-
REPALLE (07)	7.62	5800	3712	820	0	1153	0.1	917	167	156	97	789	14.21	73.70	0.65
TELAPROLU (32)	7.67	6780	4288	649	NA	1568	0.1	871	323	192	170	1179	11.04	66.22	-
THOTLAVALLURU (26)	8.35	685	438	210	40	56	0.5	52	73	24	24	159	1.80	56.58	1.83
VEMURU (02)	8.81	1257	804	NA	40	195	0.1	200	5	24	39	220	5.86	66.74	-
VIJAYAWADA (31)	8.27	1480	947	1164	nil	176	0.1	137	13	72	63	439	2.85	41.78	-
VUYYURU (21)	8.40	3900	2496	730	120	735	0.1	517	88	144	117	841	7.76	59.56	0.21
Nov-93															
AMRUTALURU (04)	8.03	5900	3776	160	0	1218	1.0	1175	15	40	68	380	26.25	87.17	-4.37
AVANIGADDA (18)	8.74	1480	947	319	36	132	0.5	192	17	48	39	280	4.99	61.08	1.50
BAPATLA (12)	NA	870	557	220	20	58	0.1	83	28	56	24	239	2.34	47.57	0.03
BHATTIPROLU (08)	8.70	1554	1014	330	0	250	0.2	273	42	40	15	162	9.34	80.03	3.37
B.D.PALLI (16)	8.46	841	538	255	36	85	0.1	94	10	48	29	239	2.64	47.62	1.04
CHALLAPALLI (17)	8.31	2600	1664	573	36	291	0.1	384	267	72	29	299	9.66	79.74	6.20
CHEBROLU (11)	8.38	4840	3098	220	80	654	0.1	550	720	16	92	419	11.71	83.54	-2.34
CHINAMUTHEVI (20)	8.30	3280	2099	382	55	320	0.1	415	267	40	73	400	9.03	75.70	0.76
DUGGIRALA (05)	8.39	1980	1267	210	40	269	0.5	285	140	16	39	200	8.77	79.98	1.00
GHANTASALA (19)	8.59	1300	832	319	36	103	0.5	225	33	40	15	162	7.70	76.69	3.87
GUDIVADA (23)	8.06	3800	2432	364	0	508	0.5	680	13	80	53	418	14.47	78.18	-1.06

GUDLAVALLERU (24)	8.85	3960	2534	382	72	639	0.1	720	40	80	53	418	15.33	79.48	0.74
GULLAPALLI (30)	8.29	585	374	170	0	38	0.2	42	3	64	10	201	1.29	32.13	-0.62
KOLLIPARA (06)	8.42	4020	2573	350	100	432	0.1	688	240	24	49	262	18.52	87.36	3.78
KOLLURU (3)	8.41	1030	659	270	60	67	0.5	225	4	16	5	61	12.58	89.10	5.39
NAGARAM (09)	8.40	2700	1728	330	20	202	0.2	292	42	160	73	700	4.80	49.61	-6.98
NIZAMPATNAM (10)	8.86	4400	2816	610	40	883	0.5	733	40	88	83	561	13.47	74.59	1.80
P.V.PALEM (15)	8.14	2680	1715	180	NA	595	1.0	400	17	40	83	441	8.29	66.94	-
PAMIDIMUKKALA (28)	8.16	4650	2976	319	0	902	0.5	784	40	96	78	561	14.41	75.83	-4.81
PONNURU (13)	8.23	1300	832	360	NA	144	0.2	180	32	56	24	239	5.07	64.45	-
REPALLE (07)	8.09	4780	3059	500	0	816	0.1	900	144	40	73	400	19.59	84.28	2.02
TELAPROLU (32)	8.14	6780	4339	419	NA	1372	0.1	982	333	88	170	919	14.10	73.64	-
TENALI (01)	8.30	1460	934	240	60	154	1.0	250	5	24	29	179	8.13	75.46	2.42
THOTLAVALLURU (26)	8.06	1020	653	219	36	56	0.5	98	160	NA	NA	-	-	-	5.10
VEMURU (02)	8.39	838	536	160	40	96	0.1	144	4	32	10	121	5.69	72.45	1.58
VIJAYAWADA (31)	8.31	1121	717	255	36	94	0.5	96	6	80	34	340	2.27	38.94	-0.97
VUYURU (21)	8.58	2960	1894	328	36	432	0.1	492	82	64	63	419	10.46	73.74	-1.08
May-94															
AVANIGADDA (18)	7.89	3320	2125	760	0	518	0.1	509	11	56	102	560	9.37	66.76	4.04
B.D.PALLI (16)	8.12	3710	2374	580	0	672	0.1	636	19	32	102	500	12.39	73.86	1.64
CHALLAPALLI (17)	8.32	1962	1256	520	40	240	0.1	370	16	32	39	240	10.39	77.47	6.40
CHINAMUTHEVI (20)	8.21	3350	2144	610	0	499	0.1	509	143	104	53	478	10.13	72.99	2.66
GHANTASALA (19)	8.12	1600	1024	490	0	221	0.1	227	4	32	83	421	4.81	54.27	1.40
GUDIVADA (23)	8.60	4200	2688	420	60	538	0.5	800	23	48	78	441	16.59	80.09	0.81
GUDLAVALLERU (24)	8.52	2640	1690	630	100	384	0.1	517	18	64	34	300	12.99	79.30	8.61
PAMIDIMUKKALA (28)	8.04	3840	2522	500	0	806	0.1	673	39	88	97	619	11.77	71.01	-2.35
TELAPROLU (32)	8.78	4540	2906	NA	NA	957	0.1	994	10	48	34	260	26.84	89.34	-
THOTLAVALLURU (26)	8.22	676	433	240	0	38	0.1	47	51	56	19	218	1.38	43.45	0.44
VIJAYAWADA (31)	8.02	1190	762	200	nil	115	0.1	113	4	48	53	338	2.68	42.65	-
VUYURU (21)	8.15	2980	1907	590	0	538	0.1	473	100	56	78	461	9.59	71.55	2.61
Nov-94															
AMRUTALURU (04)	7.53	5630	3603	320	0	1220	0.5	933	12	120	122	802	14.34	71.87	-9.60
AVANIGADDA (18)	8.14	2470	1581	658	0	338	0.1	329	13	56	112	601	5.84	54.99	1.18
BAPATLA (12)	8.46	2700	1728	280	80	400	0.1	371	34	112	58	518	7.09	62.15	-3.15
BHATTIPROLU (08)	8.50	4200	2688	480	112	692	0.1	671	200	32	73	380	14.98	81.89	4.26
B.D.PALLI (16)	8.03	775	496	263	0	56	0.1	NA	NA	NA	NA	-	-	-	5.26
CHALLAPALLI (17)	8.24	2860	1830	470	0	470	0.1	NA	NA	NA	NA	-	-	-	9.40
CHEBROLU (11)	7.60	5230	3347	496	0	746	0.5	446	880	56	92	518	8.53	80.20	-0.42
CHINAMUTHEVI (20)	7.90	4130	2643	536	0	752	0.1	NA	NA	NA	NA	-	-	-	10.72
DUGGIRALA (05)	7.79	1104	707	232	0	137	1.0	148	1	32	39	240	4.16	57.39	-0.16

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GHANTASALA (19)	8.48	4520	2893	470	38	677	0.1	400	566	144	83	701	6.57	69.47	-3.84
GUDIVADA (23)	8.57	1887	1203	235	38	235	0.1	NA	NA	NA	NA	-	-	-	5.46
GUDLAVALLERU (24)	8.69	2100	1344	338	56	263	0.1	NA	NA	NA	NA	-	-	-	7.88
GULLAPALLI (30)	8.35	2970	1901	288	48	655	0.1	428	16	88	73	520	8.17	64.68	-3.66
KOLLURU (3)	8.31	1836	1175	272	32	291	0.5	315	2	32	34	220	9.25	75.81	1.69
NAGARAM (09)	8.35	1130	723	216	32	182	0.1	164	20	24	44	241	4.60	61.39	0.15
NIZAMPATNAM (10)	8.31	3000	1920	304	48	437	0.1	357	40	192	49	681	5.95	54.85	-6.58
PAMIDIMUKKALA (28)	8.09	5620	3597	545	0	1119	0.1	969	45	144	97	759	15.31	74.07	-4.25
REPALLE (07)	8.33	2450	1568	432	48	291	0.5	214	200	64	78	481	4.25	60.05	0.01
TELAPROLU (32)	8.22	7000	4480	801	NA	1363	0.1	889	366	158	180	1135	11.48	67.94	-
TENALI (01)	7.97	1254	803	334	0	118	0.5	213	4	16	29	159	7.35	74.67	3.50
THOTLAVALLURU (26)	8.53	1534	982	320	56	132	0.1	157	167	64	15	222	4.59	71.47	3.09
VENURU (02)	8.10	433	277	176	0	9	0.5	40	3	40	5	120	1.58	42.97	1.11
VIJAYAWADA (31)	11.9	16.1	1030	357	nil	150	0.1	123	5	104	68	540	2.30	33.70	-
VUYYURU (21)	8.36	1103	706	282	19	132	0.1	129	40	48	19	198	3.99	62.63	2.06

May-95

AMRUTALURU (04)	7.18	8200	5248	1600	0	1700	0.3	500	9	400	490	3015	3.96	26.75	-28.16
AVANIGADDA (18)	7.75	3010	1926	359	0	900	0.1	482	20	40	92	478	9.59	69.23	-2.36
BAPATLA (12)	7.73	827	529	270	0	80	0.8	47	10	128	15	381	1.05	23.16	-2.23
BHATTIPROLU (08)	7.20	1255	803	440	0	140	0.3	139	38	40	54	322	3.37	52.19	2.37
B.D.PALLI (16)	7.28	1150	736	258	0	135	0.5	134	20	64	34	300	3.37	51.42	-0.83
CHALLAPALLI (17)	7.66	2220	1421	276	0	450	0.5	364	50	40	49	302	9.12	73.98	-0.50
CHEBROLU (11)	7.35	4480	2867	1180	0	590	0.3	453	200	64	58	398	9.88	82.54	15.65
CHINAMUTHEVI (20)	7.86	3070	1965	368	0	522	0.1	459	260	16	73	340	10.84	79.68	0.58
DUGGIRALA (05)	6.84	1345	861	390	0	180	0.3	130	2	64	58	398	2.83	41.76	-0.15
GHANTASALA (19)	6.92	7050	4512	819	0	1368	0.5	1050	40	136	214	1220	13.09	65.72	-7.96
GUDIVADA (23)	7.26	3730	2387	414	0	522	0.5	647	40	72	78	501	12.58	74.47	-1.71
GUDLAVALLERU (24)	7.70	2960	1888	524	0	414	0.1	470	88	96	39	400	10.22	73.94	2.48
GUDURU (29)	7.30	2390	1530	377	0	306	0.1	253	100	144	58	598	4.50	53.14	-4.41
GULLAPALLI (30)	7.97	2600	1664	600	0	382	0.8	253	250	136	34	480	5.02	64.47	2.41
KOLLIPARA (06)	7.25	3230	2080	880	0	370	0.3	975	50	32	58	319	1.22	81.01	11.25
KOLLURU (3)	7.59	1450	928	370	0	250	0.8	224	3	56	29	259	6.05	65.47	2.22
MACHILIPATNAM (22)	7.35	4040	2586	488	0	504	0.5	467	267	152	78	701	7.68	65.97	-4.23
MANDAVALLI (25)	7.80	2330	1491	580	0	261	0.1	329	133	72	58	418	7.00	67.94	3.25
NAGARAM (09)	7.50	2620	1677	510	0	360	0.8	236	225	168	39	580	4.26	58.00	-1.40
NAMBURU (14)	7.79	4800	3072	1000	0	800	0.3	727	260	40	102	520	13.89	78.69	9.64
NIZAMPATNAM (10)	7.92	2370	1517	520	0	420	0.8	318	108	56	54	362	7.27	69.66	3.17
P.V.PALEM (15)	7.58	1910	1222	450	NA	390	0.8	209	125	64	63	419	4.44	59.49	-
PAMIDIMUKKALA (28)	7.15	5044	3228	460	0	900	0.5	800	60	152	107	820	12.16	68.93	7.17
PEDANA (27)	7.49	4040	2586	506	0	576	0.1	541	178	56	112	601	9.61	70.09	-1.86

REPALLE (07)	7.67	3720	2381	900	0	660	0.5	682	100	40	49	302	17.10	84.26	11.98
TELAPROLU (32)	8.00	5450	3488	540	NA	1480	0.3	750	179	208	97	919	10.77	66.96	-
TENALI (01)	7.16	1230	787	400	0	130	0.5	172	4	32	44	261	4.63	59.28	2.79
THOTLAVALLURU (26)	7.70	608	389	202	0	54	0.5	47	6	32	29	199	1.45	35.58	0.06
VEMURU (02)	7.88	682	436	240	0	70	0.8	87	5	32	24	179	2.83	52.30	1.23
VIJAYAWADA (31)	7.84	1185	758	175	nil	108	0.1	130	8	40	49	302	3.26	49.33	-
VUYURU (21)	7.25	2460	1574	524	0	396	0.1	329	100	98	58	483	6.51	63.59	0.83
Nov-95															
AMRUTALURU (04)	7.92	8100	5184	640	NA	2300	NA	494	175	640	290	2791	4.07	31.76	-
AVANIGADDA (18)	8.10	4300	2752	684	0	534	0.1	614	26	104	131	799	9.46	63.19	-2.26
BAPATLA (12)	8.12	1268	812	390	NA	130	NA	NA	NA	96	63	499	-	-	-
BHATTIPROLU (08)	8.27	2820	1805	720	NA	430	NA	312	58	128	92	698	5.14	51.91	-
B.D.PALLI (16)	8.30	1500	960	410	23	205	0.1	179	52	80	49	401	3.89	53.20	0.64
CHALLAPALLI (17)	8.03	2960	1894	752	0	481	0.1	429	78	96	53	458	8.72	69.31	5.90
CHEBROLU (11)	8.23	5620	3597	1100	0	1000	NA	300	150	320	290	1992	2.93	29.80	-17.77
CHINAMUTHEVI (20)	8.19	3880	2483	673	0	676	0.1	600	234	72	44	361	13.74	81.65	6.25
DUGGIRALA (05)	8.18	3320	2125	900	20	410	NA	500	67	80	78	521	9.54	69.29	8.01
GHANTASALA (19)	7.82	6440	4122	741	0	668	0.1	753	573	176	126	958	8.06	69.78	-4.31
GUDIVADA (23)	8.42	2100	1344	274	23	285	0.1	350	5	48	44	301	8.78	71.87	-0.07
GUDLAVALLERU (24)	8.62	2300	1472	410	68	320	0.1	429	13	32	34	220	12.59	81.23	5.17
GUDURU (29)	8.50	2500	1600	524	NA	142	0.1	314	104	144	49	561	5.76	59.26	-
GULLAPALLI (30)	7.96	692	443	190	NA	90	NA	21	53	88	39	380	0.47	23.00	-
KOLLIPARA (06)	7.62	4550	2912	900	NA	820	NA	545	458	40	97	499	10.62	78.06	-
KOLLURU (3)	7.10	1780	1139	310	NA	350	NA	164	9	80	88	562	3.01	39.63	-
MACHILIPATNAM (22)	8.08	4600	2944	502	0	534	0.1	600	260	192	78	800	9.23	67.18	-5.95
MANDAVALLI (25)	8.27	620	397	205	0	53	0.1	61	14	24	24	159	2.11	48.73	0.93
NAGARAM (09)	8.18	3010	1926	260	NA	820	NA	359	217	48	88	482	7.12	68.76	-
NAMBURU (14)	7.28	2611	1671	210	NA	700	NA	286	150	44	88	472	5.73	63.35	-
NIZAMPATNAM (10)	8.05	2620	1677	690	NA	390	NA	335	75	40	63	359	7.70	69.71	-
P.V.PALEM (15)	8.03	1595	1021	410	0	200	NA	186	108	32	49	282	4.83	65.89	2.58
PAMIDIMUKKALA (28)	7.92	6250	4000	718	0	1308	0.5	1000	52	176	126	958	14.06	70.08	-4.77
PEDANA (27)	8.50	4200	2688	798	46	676	0.1	600	182	168	58	658	10.17	70.03	3.73
REPALLE (07)	7.87	1536	983	360	NA	270	NA	118	79	104	44	441	2.44	44.81	-
TELAPROLU (32)	7.50	6790	4346	650	NA	1388	0.1	853	390	136	170	1039	11.52	69.42	-
TENALI (01)	8.25	1425	912	410	NA	160	NA	118	4	64	39	320	2.87	45.00	-
THOTLAVALLURU (26)	8.18	1874	1199	388	0	169	0.5	107	145	88	58	458	2.17	51.29	-1.39
VEMURU (02)	7.83	1135	726	180	NA	250	NA	132	2	56	39	300	3.31	49.12	-
VIJAYAWADA (31)	8.05	1509	966	422	nil	53	0.1	129	5	112	58	518	2.47	35.65	-
VUYURU (21)	7.87	2100	1344	673	0	249	0.5	269	52	80	53	418	5.73	60.95	5.12

Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
May-96															
AMRUTALURU (04)	7.76	12640	8090	500	0	4000	NA	1364	2	480	520	3338	10.28	47.12	-56.62
AVANIGADDA (18)	8.80	3170	2029	750	40	490	NA	494	2	64	83	501	9.60	68.28	5.80
BAPATLA (12)	8.24	1035	662	310	NA	130	NA	87	6	88	29	339	2.05	36.74	-
BHATTIPROLU (08)	8.03	1286	823	280	NA	250	NA	57	2	96	73	540	1.07	19.00	-
B.D.PALLI (16)	8.70	1045	669	210	20	200	NA	106	1	72	34	320	2.58	42.05	-1.79
CHALLAPALLI (17)	8.66	2920	1869	640	20	530	NA	482	3	72	53	398	10.51	72.58	5.26
CHEBROLU (11)	8.72	4730	3027	1140	40	750	NA	773	133	40	107	540	14.48	77.46	12.83
CHINAMUTHEVI (20)	8.64	3980	2547	750	40	790	NA	636	8	40	117	581	11.49	70.62	4.21
DUGGIRALA (05)	8.35	540	346	80	20	120	NA	26	Traces	64	19	238	0.73	-	-2.76
GHANTASALA (19)	8.58	5150	3296	940	40	1100	NA	73	50	400	340	2398	0.65	8.51	-28.27
GUDIVADA (23)	8.72	4320	2765	1000	40	680	NA	682	2	72	126	698	11.24	68.08	6.87
GUDLAVALLERU (24)	8.75	3260	2086	550	40	680	NA	494	3	56	49	341	11.63	75.97	4.98
GULLAPALLI (30)	8.13	3460	2214	680	NA	700	NA	591	8	80	63	459	12.00	73.87	-
KOLLIPARA (06)	8.35	1200	768	850	20	160	NA	74	Traces	112	44	461	1.50	-	8.19
KOLLURU (3)	8.26	1585	1014	310	NA	330	NA	214	1	40	63	359	4.92	56.57	-
NAGARAM (09)	7.73	2770	1773	510	NA	570	NA	282	5	120	122	802	4.33	43.64	-
NIZAMPATNAM (10)	9.24	3402	2176	680	40	700	NA	471	4	80	122	702	7.74	59.51	0.40
P.V.PALEM (15)	NA	2650	1696	590	NA	510	NA	382	2	56	92	518	7.30	61.70	-
PAMIDIMUKKALA (28)	8.58	3780	2419	510	40	840	NA	682	3	80	34	340	16.10	81.41	4.21
PONNURU (13)	8.66	1580	1011	390	40	240	NA	141	Traces	96	68	520	2.69	-	-1.77
REPALLE (07)	8.42	4280	2739	610	40	1000	NA	727	9	128	58	558	13.38	74.06	1.85
TELAPROLU (32)	7.80	6320	4045	160	NA	2100	NA	191	6	800	150	2615	1.62	13.92	-
TENALI (01)	8.31	1365	874	300	40	240	NA	141	1	80	49	401	3.06	43.44	-1.22
THOTLAVALLURU (26)	8.50	600	384	130	20	100	NA	13	5	72	24	279	0.34	11.07	-2.57
VEMURU (02)	8.36	1870	1197	370	40	370	NA	264	1	56	63	399	5.75	59.09	0.24
VIJAYAWADA (31)	8.55	1015	650	260	20	150	NA	69	1	48	63	379	1.54	28.57	-1.96
VUYURU (21)	8.60	2240	1434	390	40	470	NA	218	7	104	97	659	3.70	42.34	-4.55
Nov-96															
AMRUTALURU (04)	8.09	10280	6579	640	0	3100	NA	545	4	800	490	4014	3.74	22.89	-67.36
BAPATLA (12)	8.58	2250	1440	480	40	380	NA	295	3	80	73	500	5.74	56.38	0.42
BHATTIPROLU (08)	8.48	3100	1984	630	40	580	NA	335	3	112	136	839	5.03	46.65	-3.35
CHEBROLU (11)	8.24	4870	3117	810	NA	1100	NA	245	133	320	240	1787	2.52	28.26	-
DUGGIRALA (05)	8.68	540	346	130	20	80	NA	20	1	48	29	239	0.56	15.78	-1.78
GULLAPALLI (30)	8.66	3240	2074	900	40	430	NA	494	8	64	97	559	9.10	66.04	7.65
KOLLIPARA (06)	8.28	3320	2125	910	0	470	NA	300	75	128	146	920	4.30	44.89	-0.17
KOLLURU (3)	8.26	3770	2413	660	NA	820	NA	545	8	104	97	659	9.24	64.51	-
NAGARAM (09)	8.62	1375	880	230	20	300	NA	114	7	96	53	458	2.32	35.96	-4.14
NIZAMPATNAM (10)	7.62	2960	1869	450	NA	700	NA	335	3	96	122	742	5.35	49.73	-

P.V.PALEM (15)	8.36	1020	653	40	20	240	NA	148	2	48	19	198	4.57	62.11	-2.76
PONNURU (13)	8.68	1970	1261	520	40	280	NA	295	1	72	49	381	6.57	62.79	3.58
REPALLE (07)	8.16	2940	1882	350	NA	780	NA	365	3	80	122	702	6.00	53.25	-
TENALI (01)	7.88	1410	902	360	NA	230	NA	188	1	64	39	320	4.57	56.18	-
VEMURU (02)	8.28	620	397	170	NA	90	NA	29	1	48	34	260	0.78	19.87	-

May-97

AMRUTALURU (04)	NA	13000	8320	1200	0	3600	NA	494	400	720	780	5008	3.04	24.09	-75.93
BAPATLA (12)	NA	1285	822	270	NA	250	NA	69	3	96	68	520	1.32	22.87	-
BHATTIPROLU (08)	NA	1335	854	240	NA	290	NA	87	4	80	136	759	1.37	20.41	-
CHEBROLU (11)	NA	4600	2944	1000	NA	860	NA	545	175	144	136	919	7.82	60.56	-
DUGGIRALA (05)	NA	526	337	110	NA	100	NA	45	1	32	24	179	1.46	35.72	-
GULLAPALI (30)	NA	3310	2118	600	NA	700	NA	371	5	136	131	879	5.45	48.11	-
KOLLIPARA (06)	NA	3470	2221	800	NA	620	NA	545	2	64	97	559	10.04	68.05	-
KOLLURU (3)	NA	1545	989	320	NA	300	NA	136	2	72	78	501	2.65	37.38	-
NAGARAM (09)	NA	2970	1901	500	NA	660	NA	241	2	144	156	1002	3.31	34.50	-
NIZAMPATNAM (10)	NA	4030	2579	600	NA	950	NA	482	150	120	122	802	7.41	60.78	-
P.V.PALEM (15)	NA	3350	2144	700	NA	650	NA	500	4	72	102	600	8.89	64.62	-
PONNURU (13)	NA	1577	1009	270	NA	300	NA	145	1	64	83	501	2.82	38.75	-
REPALLE (07)	NA	4230	2707	640	NA	980	NA	727	8	112	126	798	11.20	66.64	-
TENALI (01)	NA	1230	787	180	NA	300	NA	100	10	48	73	420	2.12	35.45	-
VEMURU (02)	NA	1410	902	200	NA	240	NA	82	3	48	68	400	1.79	31.35	-

12

Nov-97

AMRUTALURU (04)	7.14	4030	2579	600	NA	950	NA	482	150	120	122	802	7.41	60.78	-
BAPATLA (12)	7.85	915	586	160	NA	200	NA	57	1	56	53	358	1.31	25.95	-
BHATTIPROLU (08)	6.89	2450	1568	400	NA	550	NA	241	2	96	117	721	3.91	42.25	-
CHEBROLU (11)	7.73	1784	1142	250	NA	430	NA	59	4	80	146	801	0.91	14.31	-
DUGGIRALA (05)	8.12	1110	710	320	NA	300	NA	136	2	72	78	501	2.65	37.38	-
KOLLIPARA (06)	8.10	1545	989	1200	NA	3600	NA	494	400	720	780	5008	3.04	24.09	-
KOLLURU (3)	8.60	2970	1900	500	NA	660	NA	241	2	144	156	1002	3.31	34.50	-
NAGARAM (09)	7.54	4600	2944	900	NA	750	NA	500	150	136	122	842	7.50	60.35	-
NAMBURU (14)	7.28	8430	5395	600	NA	2500	NA	435	267	400	490	3015	3.45	29.97	-
NIZAMPATNAM (10)	NA	4200	2688	900	NA	750	NA	482	83	160	136	959	6.77	54.66	-
P.V.PALEM (15)	7.95	9250	5920	700	NA	2700	NA	312	183	640	530	3779	2.21	19.47	-
PONNURU (13)	7.75	1650	1056	300	NA	350	NA	145	1	72	92	558	2.67	36.23	-
REPALLE (07)	6.25	13000	8320	1000	NA	860	NA	545	175	144	136	919	7.82	60.56	-
TENALI (01)	8.13	34.7	2220	800	NA	620	NA	545	2	64	97	559	10.04	68.05	-
VEMURU (02)	7.91	4230	2707	640	NA	980	NA	727	8	112	126	798	11.20	66.64	-

Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
May-98															
AMRUTALURU (04)	8.02	10250	6560	500	NA	3200	NA	498	200	600	530	3679	3.57	26.71	-
BAPATLA (12)	8.48	1369	876	250	20	260	NA	143	4	32	63	339	3.38	48.30	-1.36
BHATTIPROLU (08)	8.48	1192	762	180	20	200	NA	107	2	80	34	340	2.53	40.93	-2.79
CHEBROLU (11)	7.94	4530	2899	1000	NA	860	NA	523	175	144	136	919	7.51	59.73	-
DUGGIRALA (05)	8.45	506	323	80	10	90	NA	45	1	32	24	179	1.46	35.72	-1.77
GULLAPALLI (30)	8.06	2710	1794	520	NA	560	NA	295	2	160	83	741	4.71	46.52	-
KOLLIPARA (06)	8.04	1222	782	250	NA	230	NA	70	1	80	63	459	1.42	25.09	-
KOLLURU (3)	8.53	1623	1038	350	20	300	NA	132	2	96	73	540	2.47	34.94	-3.38
NAGARAM (09)	8.02	2998	1918	640	NA	520	NA	494	4	64	68	440	10.25	71.10	-
NAMBURU (14)	8.03	7300	4672	370	NA	2230	NA	308	2	560	390	3003	2.45	18.31	-
NIZAMPATNAM (10)	8.01	4880	3123	810	NA	1070	NA	597	247	112	126	798	9.20	66.96	-
P.V.PALEM (15)	7.80	1841	1178	360	NA	350	NA	213	2	64	68	440	4.42	51.49	-
PONNURU (13)	8.64	1444	924	300	20	240	NA	137	4	104	44	441	2.84	40.76	-2.41
REPALLE (07)	8.49	3790	2387	510	40	870	NA	591	1	80	83	541	11.06	70.42	0.20
TELAPROLU (32)	8.53	3250	2080	380	30	800	NA	144	54	168	195	1222	1.79	23.86	-16.18
TENALI (01)	8.02	1322	846	290	NA	240	NA	128	4	104	34	400	2.78	41.51	-
VEMURU (02)	8.46	1693	1083	320	20	270	NA	158	7	46	86	469	3.18	42.99	-2.55
Nov-98															
AMRUTALURU (04)	7.68	7710	4934	1600	0	1680	NA	194	43	560	487	3402	1.45	12.31	-35.92
AVANIGADDA (18)	7.77	2390	1530	460	NA	460	NA	145	4	184	102	879	2.13	26.73	-
B.D.PALLI (16)	8.02	1111	711	200	NA	210	NA	54	1	80	68	480	1.07	19.87	-
BAPATLA (12)	7.88	530	339	90	0	110	NA	34	1	40	24	199	1.05	27.49	-2.17
BHATTIPROLU (08)	7.91	1630	1043	290	0	330	NA	173	1	80	68	480	3.44	44.08	-3.77
CHALLAPALLI (17)	7.45	2520	1613	490	NA	520	NA	289	87	32	117	561	5.31	56.93	-
CHEBROLU (11)	8.18	5440	3482	450	0	1500	NA	162	4	400	340	2398	1.44	12.99	-38.87
CHINAMUTHEVI (20)	7.82	5510	3526	210	NA	1750	NA	164	1	320	389	2400	1.46	13.00	-
DUGGIRALA (05)	7.18	700	448	110	0	160	NA	46	1	40	39	260	1.24	28.05	-3.00
GHANTASALA (19)	7.57	5020	3213	950	NA	1020	NA	376	119	72	341	1583	4.12	38.07	-
GUDIVADA (23)	7.50	2480	1587	400	NA	500	NA	367	6	64	63	419	7.80	65.83	-
GUDURU (29)	8.20	1895	1213	360	NA	380	NA	139	76	64	97	559	2.56	41.73	-
GUDLAVALLERU (24)	7.52	1261	807	120	NA	270	NA	73	1	72	73	480	1.45	25.03	-
GULLAPALLI (30)	7.68	2480	1587	460	0	500	NA	277	1	96	102	659	4.69	47.84	-3.96
KOLLIPARA (06)	7.80	3310	2118	480	0	800	NA	376	2	120	146	900	5.45	47.72	-8.37
KOLLURU (3)	8.16	910	582	180	0	180	NA	71	2	40	53	318	1.73	33.09	-2.74
MACHILIPATNAM (22)	7.35	2660	1702	500	NA	560	NA	256	123	40	117	581	4.62	55.19	-
MANDAVALLI (25)	7.55	1345	861	280	NA	250	NA	62	8	40	107	540	1.16	21.22	-
NAGARAM (09)	7.75	730	467	110	0	170	NA	33	1	40	49	302	0.83	19.53	-3.82
NIZAMPATNAM (10)	7.44	4730	3027	620	0	120	NA	200	6	400	240	1986	1.95	18.24	-27.27

Location & Year	pH	EC	TDS	HCO ₃	CO ₃	Cl	F	Na	K	Ca	Mg	TH	SAR	%Na	RSC
Nov-99															
AMRUTALURU (04)	9.17	9300	5952	900	40	2600	NA	144	10	640	680	4396	0.95	6.91	-68.94
BAPATLA (12)	8.90	743	476	160	10	160	NA	56	1	40	39	260	1.51	32.13	-1.80
BHATTIPROLU (08)	7.10	1570	1005	250	0	360	NA	75	8	144	68	639	1.29	21.34	-7.77
CHEBROLU (11)															Water leaked out
DUGGIRALA (05)	6.95	491	314	80	0	110	NA	34	2	40	24	199	1.05	27.82	-2.37
GULLAPALLI (30)	8.08	1429	915	300	0	300	NA	147	3	64	58	398	3.20	44.85	-1.95
KOLLIPARA (06)	7.01	4250	2720	900	0	840	NA	398	4	248	156	1261	4.88	40.87	-7.19
KOLLURU (3)	8.42	1836	1175	380	20	350	NA	124	6	112	92	658	2.10	29.67	-5.14
NAGARAM (09)	7.43	3130	2003	600	0	660	NA	426	1	96	97	639	7.34	59.26	-0.75
NIZAMPATNAM (10)	7.84	4690	3002	860	0	860	NA	531	8	200	170	1199	6.67	49.32	-6.73
P.V.PALEM (15)	8.35	1397	894	200	10	200	NA	150	1	72	49	381	3.34	46.23	-3.42
PONNURU (13)	7.31	1644	1052	230	0	230	NA	144	2	112	63	539	2.70	36.96	-6.16
REPALLE (07)	7.17	4350	2784	800	0	950	NA	364	3	240	194	1398	4.24	36.30	-11.90
VEMURU (02)	9.66	886	567	160	10	180	NA	184	1	40	34	240	5.17	62.64	-1.39

Source - Andhra Pradesh State Groundwater Department, Vijayawada and Guntur.

All Chemical parameters are in mg/l.

T.H - Total hardness as CaCO₃

SAR - Sodium Absorption Ratio

%Na - Percentage Sodium

RSC - Residual Sodium Carbonate

NA - Data Not Available