ASSESSMENT OF GROUND WATER QUALITY AND THEIR DISTRIBUTION IN COASTAL AQUIFERS OF KAKINADA, EAST GODAVARI DISTRICT, A.P, INDIA

G.Vijayakumar[1], Dr.T.Vinoda Rao[2]
Department of Geology, Andhra University, Visakhapatnam, Andhra Pradesh, India

Abstract

Thirty two water samples were collected for research work in parts of Kakinada Urban and rural areas. In this paper, an application of the interpolation methods was used for predicting the spatial distribution of water quality and characteristics of the groundwater. The detailed hydrochemistry analysis such as pH, TDS, Total Hardness, Cl, NO_3, Ca^{+2}, Mg^{+2}, SAR, Na and K has been done. The Chlorite ranges from 78 to 955 mg/l, Sulphate in all the wells are ranging from 34 to 93 mg/l. High concentration of Nitrate in excess have been in many wells it indicates that higher in the urban and agricultural regions. The Physico-chemical parameters of water samples vary the permissible limits of standards in Kakianada rural areas. By using of geographical Information System (GIS) tools prepared different layered maps, IDW were used to understand the each and every parameter distribution in the study area.

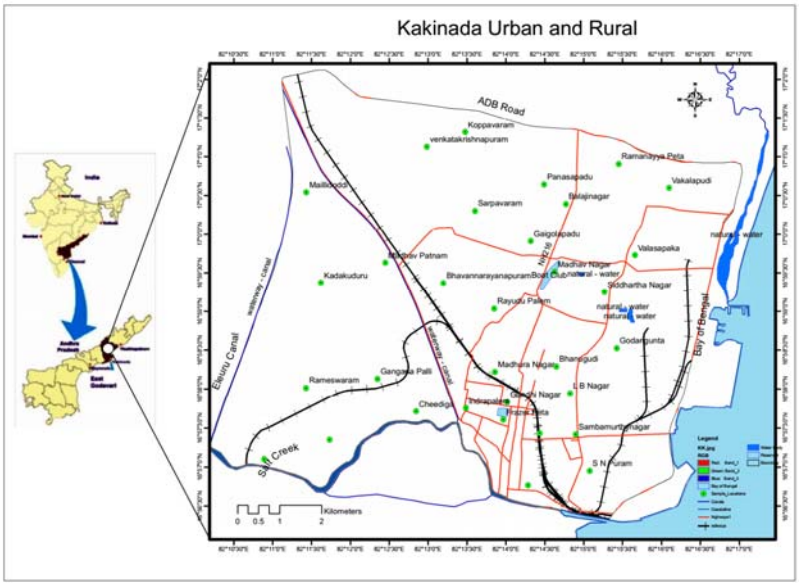
Keywords: groundwater quality, spatial distribution, contamination

Introduction:

Water is the essence of life and safe drinking is basic human need to all, however, many are not able to get sufficient potable drinking water supply to maintain basic hygiene. In developing countries infant mortality is mostly due to drinking of contaminated water (WHO, 1993; 200; 2002 and 2003). The chemical composition of groundwater is controlled by many factors that include the composition of precipitation, mineralogy of the watershed and aquifers climate and topography. The quality of groundwater in any area is controlled by the geology, vegetation and its location with respect to other surface water like streams, canals, tanks and also nearby industrial establishment (Back and Barnes, 1965 and Todd 1980), These factors can combine to from diverse water types that change in composition spatially and temporally water quality and quantity tends to be one of the most critical environmental issues Worldwide, especially in India. Groundwater absorbs gases of decomposition and degradable organic matter within the pores of the soil mantle through which they percolate. In groundwater studies, Geographical Information System is commonly used to contamination, groundwater flow modelling, groundwater quality assessment models with spatial data a case study of Yazd-Ardakan Plain. Handa (1986, a,b) studied the hydro geochemical zones in few places in India and indicated that the chemical composition of groundwater was affected by the land use practices. The present study aims at studying the chemistry of groundwater in relation to its pollution and evolves methods for its reclamation for regaining its original chemical composition.

Study Area

Kakinada is the head quarter of East Godavari District In Andhra Pradesh and it is located on the central part of east coast of India, Kakinada is located between 82^0N to 82^0 N longitude 16^0 55' E to $17^0$5' E latitude located in Survey of India published Toposheet No. 65L . The area under the study is 33 Sq.km. Kakinada is one the smart city in the Nation.



Materials and Methods

The collected samples were analyzed for quality parameters like pH, EC, tds, ca, mg, k, No_3, SO4, Chlorites and Total Hardness.

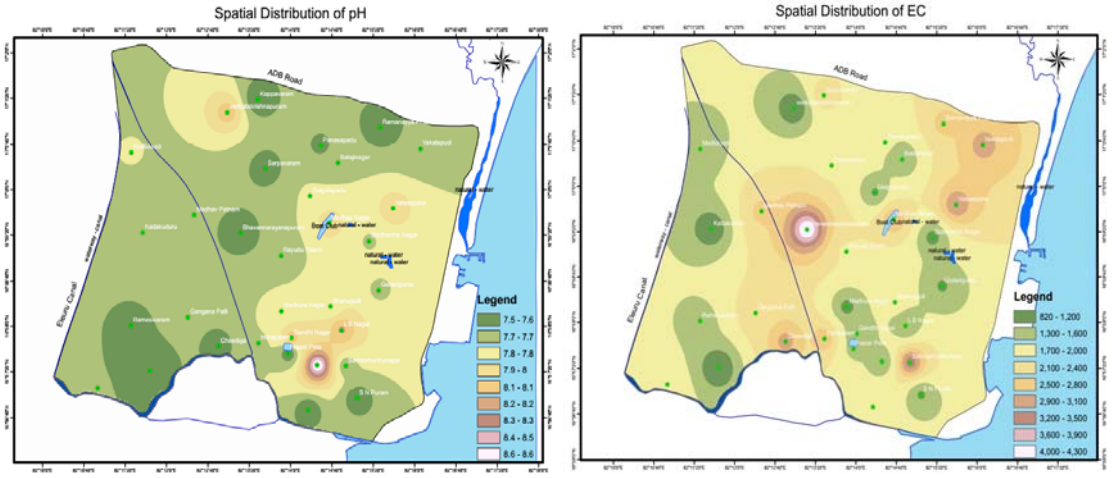
Geology and hydrogeology of the study area

The study area is composed mainly fine sand, silt and clay in proportionately. The average depth of groundwater table varies 0.6 m to 3.5 m from ground level. The general groundwater quality in Kakinada varies potable to saline the details of geology and land use/land cover is discussed by (*Satyaji Rao, Y.R et al 1997).* The geology of the Kakinada area is covered with alluvium about 90% of the soils in Godavari eastern delta re of silt plus clayey type, while the rest are found to be sandy soils (NIH 1997, Report).

Results and Discussion

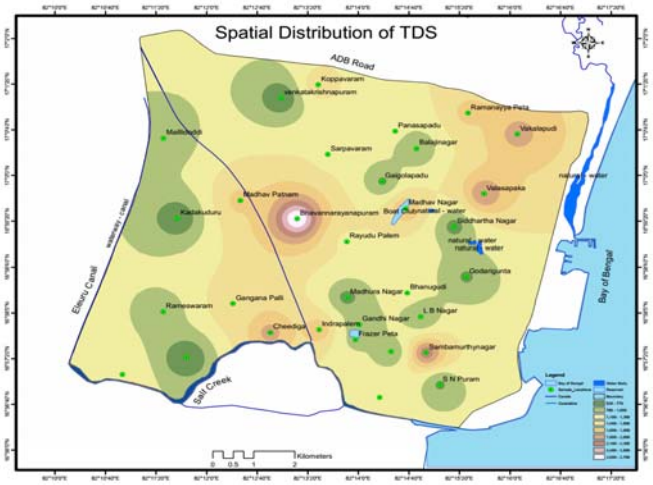
The results of study shows that the wells located nearby sea coast, salt creek and drains are exceeding the drinking water standards. High concentrations of NO_3 in excess of WHO recommended limit have been observed in many of the wells i.e. high in agriculture moderate in the urban regions and low concentration (bore wells) were found to decrease with increase well depth. Removal of nitrates from the water can be complicated and expensive. Some nitrates can be removed from the water through reverse osmosis, ion exchange and distillation units.

pH is a measurement of how acidic or basic a solution is, it is measured on a scale of 0-14. pH values higher than seven are revels of alkaline in normal water. in general permissible limit for pH is 6.5 to 8.5. Lower than four indicative sour taste and higher values above 8.5 indicative bitter tastes. The range of minimum and maximum ranges in study area is 7.45 to 8.5 (Table.3).



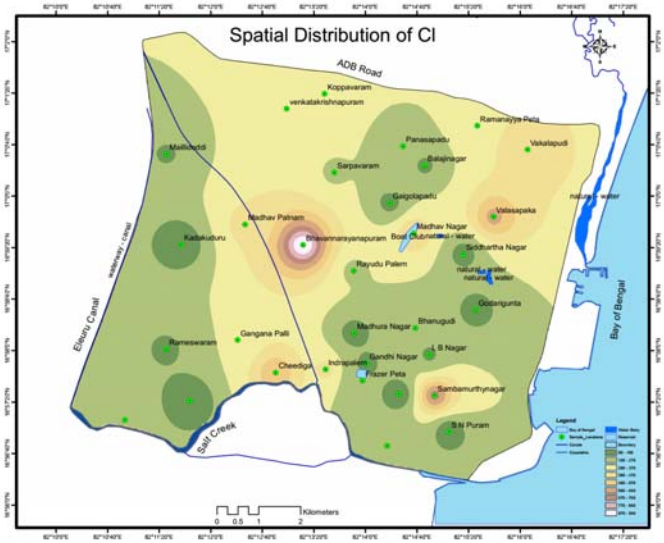
The EC values (umho/cm) of all samples were measured at 25^0C with portable water quality kits. The conductance of surface and ground water has wide range, of course and in some areas maybe as low as 50 umho/s where precipitation is low in solutes and rocks are resistant to attack. In other areas, conductance of 50,000 umho/s or more may be reached. This is approximately conductance of seawater. The electrical conductivity is ranging from 820 – 4300u mhos/cm. above 90% of samples are having high conductivity values above 1000u mhos/cm. the average EC value 1500u mhos/cm.

The potability of water in terms of Total Dissolved Solids is suggested that BIS (1984) less than 300 is excellent .i.e. many dissolved elements are adverse in water. The TDS of groundwater samples wide-ranging 524 to 2752 mg/l. The presence of high levels of TDS may also be repugnant to consumers, due to too much scaling in water pipes, TDS values exceeding the desirable limits

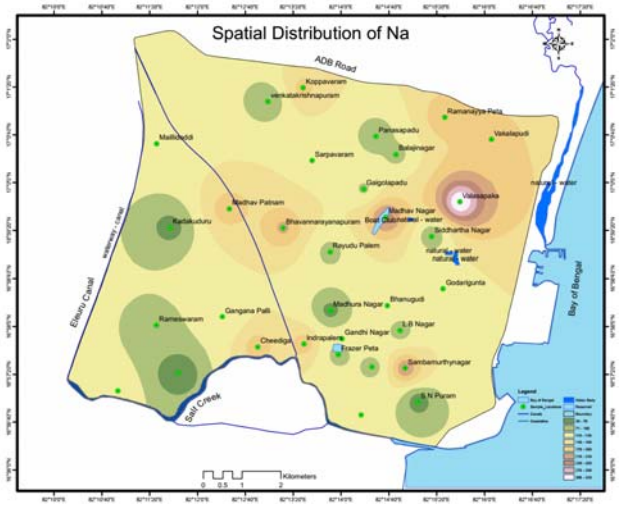


Carbonates in the study area are absent. Bicarbonates are I n between 48 – 195 mg/l(Table.1) according to ISI standards the highest desirable limits is 300 mg/l and maximum permissible limit is 600 mg/l. hence the bicarbonates concentration in groundwater of study area is within the desirable limits.

The most common type of water in which chloride is the dominant anion is one in which sodium is the predominant cation. As per ISI standards show that the maximum permissible limit of chloride in drinking water is 250 mg/l and maximum permissible limit is 1000mg/l. hence the chloride concentration is more than half of the wells is within the permissible limits according to WHO standards. Bhavannarayanapuram of the study area shows the highest concentration of 960 mg/l. the highest concentration is due to flour mill nearby wells.

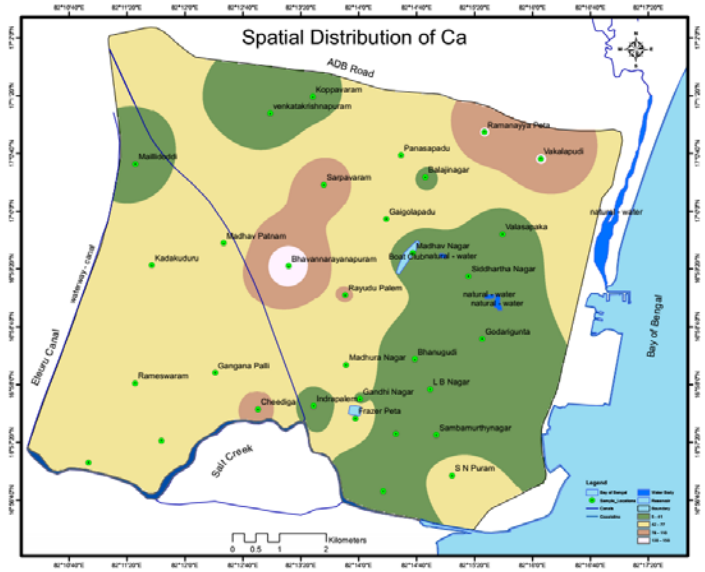


The sodium concentration in the study area in between 39 to 322 mg/l (Table 4). The maximum permissible limit of Na in drinking water according to W.H.O is 200mg/l and according to Bureau of Indian standards it 50 mg/l. content of sodium is exceeding the maximum permissible limits at Valasapakala, Madhavanagar, Sambamurthynagar more than 200 mg/l. From the observation it is noted that all the other wells are below the maximum permissible limits.



The potassium levels in the study area ranging in between 7 to 192 mg/l (Table 4). The permissible limits of the potassium based on Indian standards in drinking water is 10 mg/l, where the recorded observations of 32 wells in the study area it is noticed that potassium is exceeding largely in concentrations specified according to Bureau of Indian Standards. Only two areas siddarthanagar and Koppavaram are within the permissible limits and all the remaining well are exceeding the maximum permissible limits.

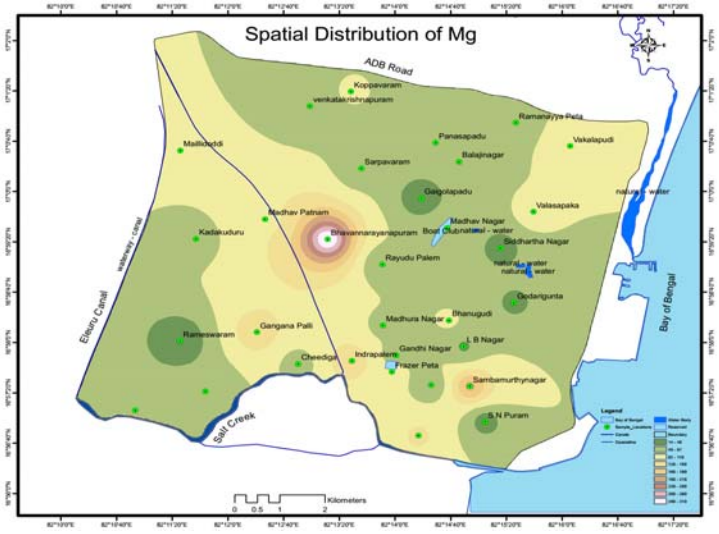
Calcium is an essential constituent of many igneous rock minerals, especially of the chain silicates and amphibole, and the feldspars, Magnesium is common element and is essential in plant and animal nutrition. In some aspects of water chemistry, calcium and magnesium may be considered as having similar as in their contributions to the property of hardness.



Calcium concentrations in the ground waters of study area is ranging from 5 to 150 mg/l (Table 4). According to ISI standards it is 200 mg/l. Hence the calcium concentrations of the ground water is within the permissible limits.

Magnesium concentration in the study area is ranging from 14 to 315 mg/l (Table 1).

From the ISI standards the desirable limit of magnesium limit is 75 mg/l. almost all the wells are exceeding the maximum permissible limit. The Highest concentration is found at Bhavannarayanapuram is due to near by the flour mill.



Classification of Groundwater Samples

Groundwater water samples collected in the year 2017 have been classified according to pipers trilinear (1953). SAR, %Na and comparison with drinking water standards characterize the groundwater samples for drinking water purposes.

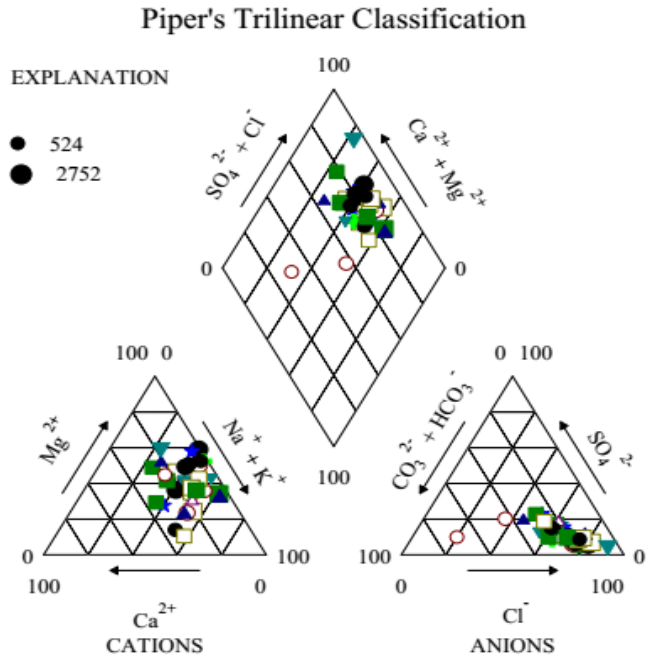
Sodium concentration is important criteria in irrigation water classification and sodium reacts with soil to create hazards by replacing cations. The percentage of sodium and SAR values has been calculated in each well during the study period. The variation in %Na and SAR in each well has been observed in the study area. The following equations are being used to calculated %Na and SAR.

$$\%Na = ((Na^{+}+k^{+})/(Ca^{2+}+ Mg^{2+}+K^{+})*100$$

$$SAR = (Na^{+})/((Ca^{2+}+Mg^{2+})/2)^{0.5}$$

Piper's Trilinear Classification

The chemical analysis data of the groundwater samples of Kakinada have been plotted on trilinear diagrams



different type of groundwater can be distinguished by the position their plotting occupy in certain subareas of the diamond shaped file (Table 1)

SNo	Description
1	$Ca+Mg+Cl+SO_4$
2	$Na+K+Cl+ SO_4$
3	$Na+K+CO_3+HCO_3$
4	$Ca+Mg+CO_3+HCO_3$

Table 1

Area	Description of Piper's Classification	Name of the Well no occupying area
1	Alkaline earths exceed alkalies	--
2	Alkalies exceed alkaline earths	--
3	Weak acids exceeds strong acids	--
4	Strong acids exceed weak acids	--
5	Carbonate hardness exceeds 50% i.e. chemical properties of the water are dominated by alkaline earths and weak acids	--
6	Non carbonate hardness exceeds 50%	1,7,11,12,13,15,19,22,24,26,29,30,31
7	Non corbonate alkali exceeds 50% i.e. chemical properties are dominated by alkalies and strong acids ocean water and many brines plot near the right –hand vertex of the sub area.	2,3,4,5,14,16,17,18,20,2127,28,
8	Carbonate alkali exceeds 50% here plot the waters which are in ordinately soft in proportion to their content of dissolved solids	--
9	No one cation – anion pair exceed 50%	6,8,9,10,23,25,32

Table.2

Suitability of Groundwater

The suitability of groundwater drinking purpose is examined based on the quality standards recommended by WHO (1984) and ISI (1983) are identified (Table 3). Groundwater quality parameters of pH, TDS, Ca, Mg, HCO_3, SO_4 and Cl were compared for WHO (1984) and ISI (1983) drinking standards. The range of parameters of the wells exceeding the maximum permissible limits are given in the table.3 the wells located near sea coast, salt creek, drains are exceeded the desirable limits

.

Comparison of chemical parameters of wells WHO (1984) and ISO (1983) Table .3

Parameters	Range in the study area	WHO (1984)	ISI (1983)		Well no exceeded the ISI maximum permissible limits
			Highest Desirable	Maximum permissible	
pH	7.45 – 8.10	6.5 – 8.5	7 – 8.5	6.5 – 9.2	
TDS	524 – 2752	1000	500	1500	3, 5, 7, 13, 14,18, 25, 31
Ca^{2+}	5- 150	500	75	200	

Mg^{2+}	14 – 315	-	30	100	7, 11, 13, 17, 25, 27, 31
Na^{+}	39 – 322	200	-	-	
$HCO3^{-}$	73 – 483	-	300	600	
$SO4^{-}$	36 – 96	400	150	400	
Cl^{-}	86 – 960	250	250	1000	

Units – $mg/^{-1}$

References

1. Surekha Gangavarapu, *et al.,* Groundwater Quality Mapping of East Godavari District, AP, India Using Remote Sensing and Geostatistics. *Intl .J.RSR, vol. 6,(4), pp.3602-3608, April, 2015.*
2. Handa B.K (1986a),Hydrochemical zones of India Proc.of seminar on Groundwater Development, Roorkee, pp 439 -450
3. Handa B.K (1986 b) water quality and water quality problems in India, seminar on environmental pollution control and Monitoring CSW, Chandigargh, pp 473-492
4. ISO drinking water standards (1983)
5. NIH, Kakinada, 1997 Seasonal Changes in Groundwater Hydrogeochemistry of Kakinada town AP,1997
6. Sankaran, N Sundarajan, and S.Khaida , Geochemical analysis of Groundwater Samples in Vicinity of Lakes and Drainage Network *J.GSI, vol.86, 2015, pp 459-467*
7. *BACK, W. barnes, I, (1965) Relation of electrochemical potential and iron content of groundwater flow patterns. USGS Professional paper 498-C, Reston, Virgineia;USGS.*
8. *TODD, D.K.(1980) Groundwater Hydrology. 2nd edition John Wiley and Son, pp.535*
9. *WHO(1993) and (1984) Guidelines for drinking water quality. Second Edition. Vol.1,*
10. *WHO, (2002) Managing water in the home: Accelerated health grains from improved water supply. Document WHO/SDE/WDE/WSH/02, Geneva.*
11. *WHO (2003) World Health Report, 2003, Shaping our future, WHO. 229, ISBN 924156249*
12. *Satyaji Rao, Y.R, Vijay T and Mohan Rangan (1197). Seasonal Changes in Groundwater Hydrochemistry of Kakinada town A.P during the year 1997.NIHRoorkee report.*
13. *Seasonal Changes in Groundwater Hydrochemistry, NIH report 1997*

S.No	Longitude	Latitude		WELL NO	Temp	pH	EC	TDS	TA	TH	Ca	Mg	Na	K	Co3	Hco3	Cl	NO3	So4	SAR	Na%	RSC
1	82.23	17.01	Sarpavaram	1	29	7.5	1920	1228	440	513	110	57	119	65	12	97	260	172	57	2.28	44	-8.25
2	82.25	17.01	Anjaneyanagar	2	29.1	7.69	1240	793	410	321	35	56	93	22	12	109	160	68	96	2.25	41	-4.21
3	82.26	17	valasapakala	3	29.5	7.92	3090	1977	710	460	20	99	322	29	12	195	600	0	62	65.44	61	-5.59
4	82.25	16.99	Sasikanth Nagar	4*	29.3	7.69	1070	684	340	192	25	31	79	7	0	97	130	27	36	2.47	48	-2.24
5	82.24	16.99	Veg Market St	5	29.8	7.92	2750	1760	580	374	20	78	244	80	24	146	480	64	82	5.49	62	-4.22
6	82.25	16.97	Shanthinagar	6	29.1	8.1	1200	768	320	192	5	43	89	20	0	85	160	12	56	2.79	53	-2.44
7	82.25	16.96	Dolphins Colony	7	29.2	7.62	3380	2163	610	791	5	189	222	37	12	170	700	7	66	3.44	40	-12.62
8	82.24	16.97	Dwarkanagar	8*	30	7.73	1750	1120	500	363	5	85	130	19	12	134	210	65	38	2.9	45	-4.66
9	82.24	16.96	Venkataratnapuram	9	29.8	8.58	1260	806	530	288	25	55	91	114	12	158	90	3	67	2.33	54	-2.77
10	82.25	16.95	Sanjaynagar PHC	10	29.1	7.47	1160	742	460	299	65	33	55	36	0	109	110	15	69	1.38	35	-4.18
11	82.24	16.95	S. Puram	11*	29.6	7.46	1830	1171	670	535	15	120	105	72	12	73	190	11	61	1.98	37	-9.02
12	82.23	16.96	Kulai cheruvu	12	29.9	7.45	1520	972	340	513	55	91	91	69	12	97	180	135	40	1.75	35	-8.23
13	82.22	16.96	Chidilpora Road	13	30	7.68	2680	1715	660	684	25	151	184	116	0	183	400	135	45	3.05	44	-10.6
14	82.21	16.96	Cheediga	14	29.3	7.5	2910	1862	370	513	95	67	182	180	12	109	570	145	65	3.49	54	-8.06
15	82.23	16.97	Kondayapalem	15	29.7	7.72	1060	678	240	460	65	72	57	19	0	73	120	114	46	1.15	24	-7.99
16	82.23	16.98	Vidyutnagar	16	29.4	7.58	1930	1235	320	-	80	48	91	192	0	85	250	243	42	1.98	52	-6.58

17	82.27	17.01	FCI Colony	17	29.1	7.6	2910	1862	600	749	115	112	170	122	12	170	450	227	57	2.7	41	-11.77
18	82.26	17.02	Teachers Colony	18	29.3	7.47	2450	1568	570	545	115	62	186	140	0	97	360	134	68	3.46	51	-9.3
19	82.26	16.98	Suresh Nagar	19	29.5	7.68	1160	742	310	267	40	40	104	45	0	73	130	45	52	2.76	51	-4.14
20	82.23	16.96	Prabhakar St	20	29.9	8.03	1310	838	410	363	40	64	110	17	12	122	150	51	48	2.5	41	-4.86
21	82.24	17	Sundar Nagar	21	29.8	7.72	1160	742	340	224	60	15	98	14	0	97	140	52	45	2.92	51	-2.63
22	82.24	17.01	Maruthi Nagar	22	29.4	7.54	1640	1049	520	449	65	69	79	50	12	146	210	51	46	1.62	34	-6.17
23	82.22	17.02	Panasapadu	23	29.1	7.46	2170	1388	510	428	30	85	172	19	0	134	360	22	53	3.63	48	-6.28
24	82.19	17.01	VenkataK.Puram	24	29.7	7.71	1260	806	410	406	25	83	110	24	0	122	170	4	58	2.37	39	-6.12
25	82.21	16.99	Madhavapalem	25	29.3	7.58	2450	1568	470	620	70	108	184	128	0	122	400	89	66	3.21	47	-10.4
26	82.2	16.96	Repuru	26	29.2	7.46	820	524	170	331	45	53	39	56	0	483	80	93	54	0.93	32	-5.8
27	82.21	16.97	Ganganapalle	27	29.5	7.6	2240	1433	330	716	55	140	106	177	12	109	280	315	55	1.72	39	-12.06
28	82.19	16.97	Rameswaram	28	29.1	7.54	1420	908	380	235	70	14	92	94	12	109	160	102	74	2.61	42	-2.5
29	82.18	16.95	Atchutapuram	29	29.9	7.58	1950	1248	460	424	45	75	121	132	0	134	260	68	48	2.57	50	-6.21
30	82.19	16.99	Mamilladoddi	30	30	7.63	910	582	480	385	45	66	58	12	0	122	90	1	52	1.28	26	-5.69
31	82.22	16.99	Incometax colony	31	29.1	7.46	4300	2752	220	1412	150	315	202	39	0	85	960	167	74	2.14	22	-32.06
32	82.22	17.02	P.Vemavaram	32	29.3	8.02	880	563	460	321	5	50	76	7	0	109	310	1	48	2.13	43	-2.62