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Determination of Water Quality Index in Industrial areas of Kakinada, Andhra Pradesh, INDIA

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Abstract

The present study intended to calculate Water Quality Index (WQI) of industrial areas of well water samples in Kakinada, Andhra Pradesh, India were monitored. The quality of bore waters was assessed by comparing with existing standards for important parameters. Water Quality Index calculated from thirteen parameters of physico-chemical parameters taken together varied from 49.52 - 123.54 ppm indicating level of nutrient load and pollution in the bore waters. Results of this study indicate that all the bore well waters of the study area are Permissible limit except S3, S4 and S6 (Valasapakala, Vakalapudi, and Nagarjuna nagar). The water was not conforming to drinking standards, and hence it is suggested to take all the necessary precautions before the waters are sent into public distribution system. It is concluded that WQI can be used as a tool in comparing the water quality of different source.

Keywords: Andhra Pradesh, chemical properties, industrial areas, India, Kakinada, WQI.

Introduction

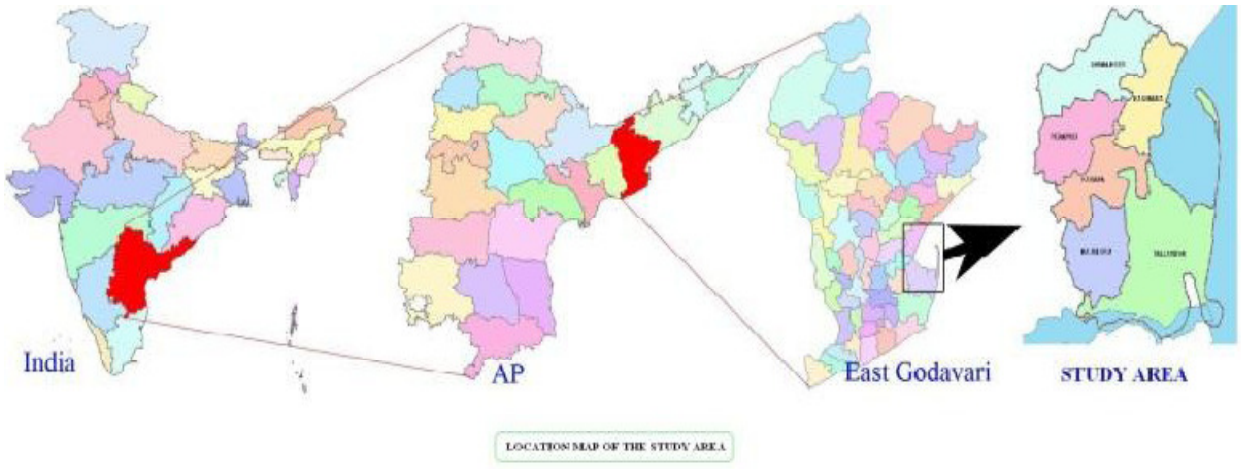
Water is one of the most important factor for every living organism on this planet. The three percent of global fresh water is large enough to meet the requirements of man for million of years etc., Water pollution ia a phenomenon that is characterized by the deterioration of its quality as a result of various human activities. Water is generally used for drinking, fisheries and other domestic purposes in this area. The available fresh water to man is hardly 0.3 to 0.5% of the total water available on the earth and therefore its judicious use in imperative. Kakinada is a city and a municipal corporation in the Indian state of Andhra Pradesh. Kakinada is a special economic zone. The problem of industrial wastes has been considerably serious in India. Due to the extremely rapid rate of industrial development which is providing one of the major sources of employment for the growing population of the country. This promotes the leaching of chemicals and contaminates the ground water. As of 2011 census, Kakinada Municipal Corporation had a population of 4,42,936.

The 1/3rd of the inhabitant people depends on mainly ground water in residential and industrial areas. In industrial belt having several major industries such as fertilizers, power, oil and gas etc., the industries discharge their treated effluents into unlined canals through drains and some store in ash ponds or slurry ponds. Water quality index (W.Q.I.) provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters[1-11]. The WQI was first developed by Horton in the early $1970_{s,}$ is basically a mathematical means of calculating a single value from multiple test results. The index results represents the level of water quality in a given water basin, such as ponds, lake, river or stream[12,13,14,15].

Chaterjee et al. (2002)[7] carried out the Determination of water quality index (WQI) of a degraded river in asanol Industrial area, Raniganj, Burdwan, West Bengal and also determined the Water quality of Nandakanan lake, India[16]. This promotes the leaching of chemicals and contaminates the ground water. Water Quality Monitoring of Groundwater Resources Studied[17-20].

The objective of water quality index is to turn complex water quality data into information that is understandable and used by the public. A single number cannot tell the whole story of water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a single indicator of water quality[12,13]. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a lake and river with number[21].

Study area: The Kakinada city is the capital of East Godavari District of Andhra Pradesh on the central east coast of India. The present study deals with the assessment of the quality of ground water in industrial areas of Kakinada, Andhra Pradesh, India. Kakinada is situated between the latitude 16˚57’ North and longitude 82˚15’ East. The study was carried out at the 10 sampling locations of industrial areas of Kakinada. It is rich in small water bodies and most of all agricultural lands are dependent on these water source.



Location Map of the Study area

Material and Methods

The water sample were collected in satirized polythene air tight containers and were analysed for water quality parameters like pH, electrical conductivity, total dissolved solids, total solids, dissolved oxygen, biological oxygen demand, total alkalinity, total hardness, sulphates, phosphates, nitrates and chlorides as per standard method (1 - American Public Health Association – 1995)[22,23]. All the chemicals and reagents were of analytical grade. D.D. water was used for the preparation of solutions.

The study was carried out at the 10 locations of industrial areas of Kakinada. The sampling stations selected for the analysis of ground waters are - S1 – Atcham Peta, S2 – Ramanayya Peta, S3 – Valasapakala, S4 – Vakalapudi, S5 – Gudarigunta, S6 – Nagarjuna Nagar, S7 – Sarpavaram, S8 – Rangarao Nagar, S9 – Muralidhar Nagar, S10 – Burma colony.

Bore water samples were collected in the all sampling stations.

In this study, for the calculation of water quality index, thirteen important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Indian council of Medical Research (ICMR)[24] and Bureau of Indian Standards (BIS)[10] has been used for the calculation of WQI of the water body[25,26].

Further, quality rating or sub index (*qn*) was calculated using the following expression.

$$qn = 100\,(V_n - V_{io}) / (S_n - V_{io})$$

(Let there be *n* water quality parameters and quality rating or sub index *(qn)* corresponding to n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value).

qn=Quality rating for the n^{th} Water quality parameter. V_n=Estimated value of the n^{th} parameter at a given sampling station. S_n =Standard permissible value of the n^{th} parameter. V_{io} = Ideal value of nth parameter in pure water, (i.e.,0 for all other parameters except the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/L respectively).

Unit weight was calculated by a value inversely proportional to the recommended standard value *Sn* of the corresponding parameter.

$$W_n = K / S_n$$

W_n = Unit weight for the n^{th} parameters. S_n= Standard value for n^{th} parameters. K= Constant for proportionality.

The overall Water Quality Index calculated by aggregating the quality rating with the unit weight linearly.

$$\text{WQI} = \sum qn\, Wn \,/ \sum wn$$

Table 1
Status and Index level (WQI) of water quality[3,7]

Water quality status	Water Quality Index Level
Excellent water quality	0 – 25
Good water quality	26 – 50
Poor water quality	51 – 75
Very Poor water quality	76 – 100
Unsuitable for drinking	>100

Results and Discussions

The results of physico-chemical parameters of bore water at various points are given in table 3.

The pH of the bore well waters in all the stations are acceptable and varies from 6.71-7.99. Though, pH has no direct effect on human health, all biochemical reactions are sensitive to the variation of pH. The permissible limits of pH value for drinking water ICMR (1975) is specified as 6.5-8.5. If pH is less, algae die, fish cannot reproduce and it cause acidity, corrosion, irritation of mucous membranes, tuberculosis and other health problems in humans.

Electrical conductivity is very important parameter for determining the water quality for drinking arid agricultural purpose. The value in the study area is from 177-400 millimhos. The ideal value of electrical conductivity is <2.4 millimhos.

The total dissolved solids (TDS) in the study area varied from 222-511 mg/L. The high value of TDS (above 500mg/L) recorded at S2, S6, and S8, may be due to their proximity to the industrial area and seacoast. If TDS is more, water cannot be used for drinking as well as construction purposes. TDS affects palatability of food cooked and also causes gastro intestinal irritation.

Total alkalinity of all the sampling stations is high and varied from 63-88 mg/L. The large amount of alkalinity imparts a bitter taste to water. Total hardness of water is characterized by contents of calcium and magnesium salts. The total hardness in the study area varied from 160-288 mg/L. The within standard values were observed in all the sampling points.

The total magnesium in the study area varied from 47-108 mg/L. The magnesium content is higher than the calcium in the samples indicates the occurrence of magnesium salts is all samples.

Table 2
Drinking Water standards recommending Agencies and unit weights
(All values except pH and Electrical Conductivity are in mg/L)

S. No.	Parameters	Standards	Units	Recommended	Unit Weight
1	pH	6.5 – 8.5	-	ICMR / BIS	0.2190
2	Dissolved oxygen	300	mg/lit	ICMR	0.0037
3	Electrical Conductivity	500	millimols	ICMR / BIS	0.0037
4	Total Dissolved Solids	120	mg/lit	ICMR / BIS	0.0155
5	Total Alkalinity	300	mg/lit	ICMR / BIS	0.0062
6	Total hardness	500	mg/lit	WHO	0.0037
7	Total suspended solids	75	mg/lit	ICMR / BIS	0.025
8	Calcium	30	mg/lit	ICMR / BIS	0.061
9	Magnesium	250	mg/lit	ICMR	0.0074
10	Chlorides	45	mg/lit	ICMR / BIS	0.0412
11	Nitrates	150	mg/lit	ICMR / BIS	0.01236
12	Sulphates	5.99	mg/lit	ICMR	0.3723
13	Biological oxygen demand	5.00	mg/lit	ICMR	0.3723

Table – 3
Physico - chemical parameters of water bodies in Kakinada

S. No	Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	pH	7.3	7.61	7.92	6.71	7.36	7.99	6.98	6.82	7.2	7.67
2	Dissolved oxygen (mg/lit)	3.9	4	3	3	4	3.5	3.6	3	3.1	2.9
3	Electrical Conductivity (millimols)	177	400	388	302	266	376	332	200	287	222
4	Total Dissolved Solids (mg/lit)	222	505	498	449	355	511	440	502	456	412
5	Total Alkalinity (mg/lit)	66	88	87	70	87	77	69	63	86	75
6	Total hardness (mg/lit)	288	200	178	168	160	167	276	182	188	186
7	Total suspended Solids	333	234	335	409	387	377	310	310	411	345
8	Calcium (mg/lit)	180	130	133	112	110	120	189	95	100	111
9	Magnesium (mg/lit)	108	70	45	56	50	47	87	87	88	75
10	Chlorides (mg/lit)	22	121	133	200	122	186	88	132	174	98
11	Nitrates (mg/lit)	30	35	44	49	40	40	28	31	38	33
12	Sulphates (mg/lit)	133	130	120	143	122	141	94.6	132	132	100.1
13	Biological oxygen demand (mg/lit)	6	5	12	14	3	16	2.5	4.1	3.5	3

Table – 4
Water Quality Index Calculation of S1 – Atcham peta

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.3	6.5 - 8.5	0.2190	21	4.59
2	Dissolved oxygen (mg/lit)	3.9	300	0.0037	111.45	41.49
3	Electrical Conductivity (millimols)	177	500	0.0037	59	21.88
4	Total Dissolved Solids (mg/lit)	222	120	0.0155	44.4	0.16
5	Total Alkalinity (mg/lit)	66	300	0.0062	55	0.85
6	Total hardness (mg/lit)	288	500	0.0037	96	0.59
7	Total suspended Solids	333	75	0.025	66.6	0.24
8	Calcium (mg/lit)	180	30	0.061	240	6
9	Magnesium (mg/lit)	108	250	0.0074	360	21.96
10	Chlorides (mg/lit)	22	45	0.0412	8.8	0.06
11	Nitrates (mg/lit)	30	150	0.01236	66.66	2.74
12	Sulphates (mg/lit)	133	5.99	0.3723	88.66	1.09
13	Biological oxygen demand (mg/lit)	6	5.00	0.3723	120	44.67
				$\sum \mathbf{Wn}$ = 1.51	$\sum \mathbf{qn}$ =1337.58	$\sum \mathbf{Wnqn}$ = 100.29
Water Quality Index = $\sum \boldsymbol{qn\ wn} / \sum \boldsymbol{wn}$= 66.45						

Table – 5
Water Quality Index Calculation of S2 – Ramanayya peta

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.61	6.5 – 8.5	0.2190	52	11.38
2	Dissolved oxygen (mg/lit)	4	300	0.0037	110.4	41.1
3	Electrical Conductivity (millimols)	400	500	0.0037	133.33	49.46
4	Total Dissolved Solids (mg/lit)	505	120	0.0155	101	0.37
5	Total Alkalinity (mg/lit)	88	300	0.0062	73.33	1.13
6	Total hardness (mg/lit)	200	500	0.0037	66.66	0.41
7	Total suspended Solids	234	75	0.025	46.8	0.17
8	Calcium (mg/lit)	130	30	0.061	173.33	4.33
9	Magnesium (mg/lit)	70	250	0.0074	233.33	14.23
10	Chlorides (mg/lit)	121	45	0.0412	48.4	0.35
11	Nitrates (mg/lit)	35	150	0.01236	77.77	3.2
12	Sulphates (mg/lit)	130	5.99	0.3723	86.66	1.07
13	Biological oxygen demand (mg/lit)	5	5.00	0.3723	100	37.23
				$\sum \mathbf{wn}$= 1.51	$\sum \mathbf{qn}$ = 1303.04	$\sum \mathbf{Wnqn}$ = 111.99
Water Quality Index = $\sum \boldsymbol{qn\ wn} / \sum \boldsymbol{wn}$ = 74.16						

Table – 6
Water Quality Index Calculation of S3 – Valasapakala

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.92	6.5 – 8.5	0.2190	83	18.17
2	Dissolved oxygen (mg/lit)	3	300	0.0037	120.83	44.98
3	Electrical Conductivity (millimols)	388	500	0.0037	129.33	47.98
4	Total Dissolved Solids (mg/lit)	498	120	0.0155	99.6	0.36
5	Total Alkalinity (mg/lit)	87	300	0.0062	72.5	1.12
6	Total hardness (mg/lit)	178	500	0.0037	59.33	0.36
7	Total suspended Solids	335	75	0.025	67	0.24
8	Calcium (mg/lit)	133	30	0.061	177.33	4.43
9	Magnesium (mg/lit)	45	250	0.0074	150	9.15
10	Chlorides (mg/lit)	133	45	0.0412	53.2	0.39
11	Nitrates (mg/lit)	44	150	0.01236	97.77	4.02
12	Sulphates (mg/lit)	120	5.99	0.3723	80	0.98
13	Biological oxygen demand (mg/lit)	12	5.00	0.3723	240	89.35
				$\sum \mathbf{wn}$ = 1.51	$\sum \mathbf{qn}$ = 1337.58	$\sum \mathbf{Wnqn}$ = 158.43
Water Quality Index = $\sum \boldsymbol{qn\ wn} / \sum \boldsymbol{wn}$ = 104.92						

Table – 7
Water Quality Index Calculation of S4 – Vakalapudi

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	6.71	6.5 – 8.5	0.2190	20	4.38
2	Dissolved oxygen (mg/lit)	3	300	0.0037	120.83	44.98
3	Electrical Conductivity (millimols)	302	500	0.0037	100.66	37.34
4	Total Dissolved Solids (mg/lit)	449	120	0.0155	89.8	0.33
5	Total Alkalinity (mg/lit)	70	300	0.0062	58.33	0.9
6	Total hardness (mg/lit)	168	500	0.0037	56	0.34
7	Total suspended Solids	409	75	0.025	81.8	0.3
8	Calcium (mg/lit)	112	30	0.061	149.33	3.73
9	Magnesium (mg/lit)	56	250	0.0074	186.66	11.38
10	Chlorides (mg/lit)	200	45	0.0412	80	0.59
11	Nitrates (mg/lit)	49	150	0.01236	108.88	4.48
12	Sulphates (mg/lit)	143	5.99	0.3723	95.33	1.17
13	Biological oxygen demand (mg/lit)	14	5.00	0.3723	280	104.24
				$\sum$ **wn** = 1.51	$\sum$ **qn** = 1427.65	$\sum$ **Wnqn** = 164.85
Water Quality Index = $\sum qn\ wn\ /\ \sum wn$ = 109.17						

Table – 8
Water Quality Index Calculation of S5 – Gudarigunta

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.36	6.5 – 8.5	0.2190	27	5.91
2	Dissolved oxygen (mg/lit)	4	300	0.0037	110.4	41.1
3	Electrical Conductivity (millimols)	266	500	0.0037	88.66	32.89
4	Total Dissolved Solids (mg/lit)	355	120	0.0155	71	0.26
5	Total Alkalinity (mg/lit)	87	300	0.0062	72.5	1.12
6	Total hardness (mg/lit)	160	500	0.0037	53.33	0.33
7	Total suspended Solids	387	75	0.025	77.4	0.28
8	Calcium (mg/lit)	110	30	0.061	146.66	3.66
9	Magnesium (mg/lit)	50	250	0.0074	166.66	10.16
10	Chlorides (mg/lit)	122	45	0.0412	48.8	0.36
11	Nitrates (mg/lit)	40	150	0.01236	88.88	3.66
12	Sulphates (mg/lit)	122	5.99	0.3723	81.33	1
13	Biological oxygen demand (mg/lit)	3	5.00	0.3723	60	22.33
				$\sum$ **wn** = 1.51	$\sum$ **qn** = 1092.65	$\sum$ **Wnqn** = 76.09
Water Quality Index = $\sum qn\ wn\ /\ \sum wn$ = 50.39						

Table – 9
Water Quality Index Calculation of S6 – Nagarjuna Nagar

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.99	6.5 – 8.5	0.2190	90	19.71
2	Dissolved oxygen (mg/lit)	3.5	300	0.0037	115.62	43.04
3	Electrical Conductivity (millimols)	376	500	0.0037	125.33	46.49
4	Total Dissolved Solids (mg/lit)	511	120	0.0155	102.2	0.37
5	Total Alkalinity (mg/lit)	77	300	0.0062	64.16	0.99
6	Total hardness (mg/lit)	167	500	0.0037	55.66	0.34
7	Total suspended Solids	377	75	0.025	75.4	0.27
8	Calcium (mg/lit)	120	30	0.061	160	4
9	Magnesium (mg/lit)	47	250	0.0074	156.66	9.55
10	Chlorides (mg/lit)	186	45	0.0412	74.4	0.55
11	Nitrates (mg/lit)	40	150	0.01236	88.88	3.66
12	Sulphates (mg/lit)	141	5.99	0.3723	94	1.16
13	Biological oxygen demand (mg/lit)	16	5.00	0.3723	320	119.13
				$\sum$ **wn** = 1.51	$\sum$ **qn** = 1522.34	$\sum$ **Wnqn** = 186.56
Water Quality Index = $\sum qn\ wn\ /\ \sum wn$ = 123.54						

Table – 10
Water Quality Index Calculation of S7 – Sarpavaram

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	6.98	6.5 – 8.5	0.2190	-7	-1.53
2	Dissolved oxygen (mg/lit)	3.6	300	0.0037	114.58	42.65
3	Electrical Conductivity (millimols)	332	500	0.0037	110.66	41.05
4	Total Dissolved Solids (mg/lit)	440	120	0.0155	88	0.32
5	Total Alkalinity (mg/lit)	69	300	0.0062	57.5	0.89
6	Total hardness (mg/lit)	276	500	0.0037	92	0.57
7	Total suspended Solids	310	75	0.025	62	0.22
8	Calcium (mg/lit)	189	30	0.061	252	6.3
9	Magnesium (mg/lit)	87	250	0.0074	290	17.69
10	Chlorides (mg/lit)	88	45	0.0412	35.2	0.26
11	Nitrates (mg/lit)	28	150	0.01236	62.22	2.56
12	Sulphates (mg/lit)	94.6	5.99	0.3723	63.06	0.77
13	Biological oxygen demand (mg/lit)	2.5	5.00	0.3723	50	18.61
				$\sum$ **wn** = 1.51	$\sum$ **qn** = 1270.23	$\sum$ **Wnqn** = 89.28
Water Quality Index == $\sum qn\, wn \,/\, \sum wn$ = 59.12						

Table – 11
Water Quality Index Calculation of S8 – Rangarao Nagar

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	6.82	6.5 – 8.5	0.2190	9	1.97
2	Dissolved oxygen (mg/lit)	3	300	0.0037	120.83	44.98
3	Electrical Conductivity (millimols)	200	500	0.0037	66.66	24.73
4	Total Dissolved Solids (mg/lit)	502	120	0.0155	100.4	0.37
5	Total Alkalinity (mg/lit)	63	300	0.0062	52.5	0.81
6	Total hardness (mg/lit)	182	500	0.0037	60.66	0.37
7	Total suspended Solids	310	75	0.025	62	0.22
8	Calcium (mg/lit)	95	30	0.061	126.66	3.16
9	Magnesium (mg/lit)	87	250	0.0074	290	17.69
10	Chlorides (mg/lit)	132	45	0.0412	52.8	0.39
11	Nitrates (mg/lit)	31	150	0.01236	68.88	2.83
12	Sulphates (mg/lit)	132	5.99	0.3723	88	1.08
13	Biological oxygen demand (mg/lit)	4.1	5.00	0.3723	82	30.52
				$\sum$ **wn** =1.51	$\sum$ **qn** = 1180.41	$\sum$ **Wnqn** = 82.22
Water Quality Index == $\sum qn\, wn \,/\, \sum wn$ = 54.45						

Table – 12
Water Quality Index Calculation of S9 – Muralidhar Nagar

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.2	6.5 – 8.5	0.2190	11	2.4
2	Dissolved oxygen (mg/lit)	3.1	300	0.0037	119.79	44.59
3	Electrical Conductivity (millimols)	287	500	0.0037	95.66	35.49
4	Total Dissolved Solids (mg/lit)	456	120	0.0155	91.2	0.33
5	Total Alkalinity (mg/lit)	86	300	0.0062	71.66	1.11
6	Total hardness (mg/lit)	188	500	0.0037	62.66	0.38
7	Total suspended Solids	411	75	0.025	82.2	0.3
8	Calcium (mg/lit)	100	30	0.061	133.33	3.33
9	Magnesium (mg/lit)	88	250	0.0074	293.33	17.89
10	Chlorides (mg/lit)	174	45	0.0412	69.6	0.51
11	Nitrates (mg/lit)	38	150	0.01236	84.44	3.47
12	Sulphates (mg/lit)	132	5.99	0.3723	88	1.08
13	Biological oxygen demand (mg/lit)	3.5	5.00	0.3723	70	26.061
				$\sum$ **wn** = 1.51	$\sum$ **qn** = 1272.90	$\sum$ **Wnqn** = 90.00
Water Quality Index == $\sum qn\, wn \,/\, \sum wn$ = 59.60						

Table – 13
Water Quality Index Calculation of S10 – Burma Colony

S. No	Parameter	Observed Value	Standard values (S_n)	Unit Weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.67	6.5 – 8.5	0.2190	58	12.7
2	Dissolved oxygen (mg/lit)	2.9	300	0.0037	121.87	45.37
3	Electrical Conductivity (millimols)	222	500	0.0037	74	27.45
4	Total Dissolved Solids (mg/lit)	412	120	0.0155	82.4	0.3
5	Total Alkalinity (mg/lit)	75	300	0.0062	62.5	0.96
6	Total hardness (mg/lit)	186	500	0.0037	62	0.38
7	Total suspended Solids	345	75	0.025	69	0.25
8	Calcium (mg/lit)	111	30	0.061	148	3.7
9	Magnesium (mg/lit)	75	250	0.0074	250	15.25
10	Chlorides (mg/lit)	98	45	0.0412	39.2	0.29
11	Nitrates (mg/lit)	33	150	0.01236	73.33	3.02
12	Sulphates (mg/lit)	100.1	5.99	0.3723	66.73	0.82
13	Biological oxygen demand (mg/lit)	3	5.00	0.3723	60	22.33
				$\sum$ **wn**= 1.51	$\sum$ **qn** =1167.03	$\sum$ **Wnqn** = 74.79
						Water Quality Index = $\sum qn\, wn \,/\, \sum wn$ = 49.52

Dissolved oxygen (DO), and biochemical oxygen demand (BOD) are very important pollution parameters. The values of DO, and BOD in the study area are 3.0-4.0, and 2.5-16mg/L (S7-S6) respectively. Hence the water treatment is required before it is sent into the public distribution system. The sulphate ion concentration in the entire study area varied from 94.6-143mg/L. High concentration of sulphates at S7, S6 and might be due to heavy industrial activity and seepage of sewage water.

The chlorides are also corrosive and impart permanent hardness to water. The chlorides impart a salty taste and sometimes high concentration causes laxative effect in human beings. The chloride content in the study area ranged from 22 – 200 (S1 – S4) mg/L. Chloride content observed within the standard value in all samples.

The nitrate is used to assess the self purification properties of water bodies and nutrient balance in surface waters and soil and the state of determination of organic matter present in waste waters. The nitrate ion concentration is very important in public water supplies, because it causes methemoglobinemia in children The nitrate concentration in the study area varied between 28 and 49 (S4 and S7) mg/L with all the values well below the permissible levels (ICMR, 1975) except S4.

Conclusion

The Water Quality Index (WQI) of waters in industrial areas of Kakinada is given in table 4 to 13. The report prepared by the WHO the importance of safe water supply and sanitation in the control of waterborne diseases.

The value of WQI in water sampling areas was reported to be less than 100, and greater than 100, indicating that the water is suitable for human use except at S3, S4 and S6. The value of WQI at S6 site is 123.54 mg/L and the reason may be due to seepage of saline, sewage waters and heavy industrial activity.

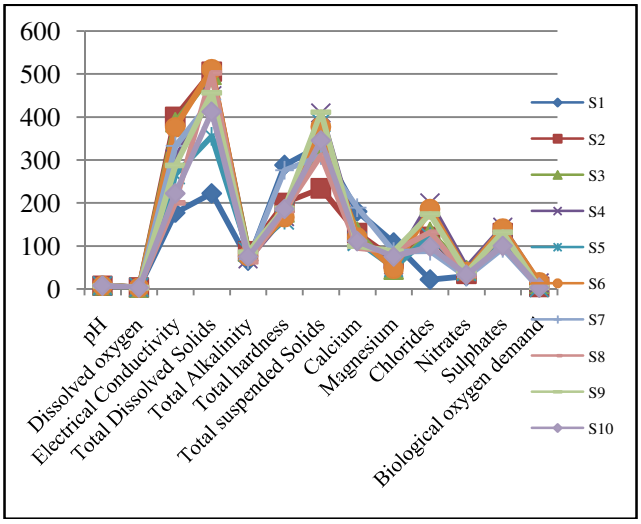


Figure: 1
S_1 to S_{10} Sampling station values showing

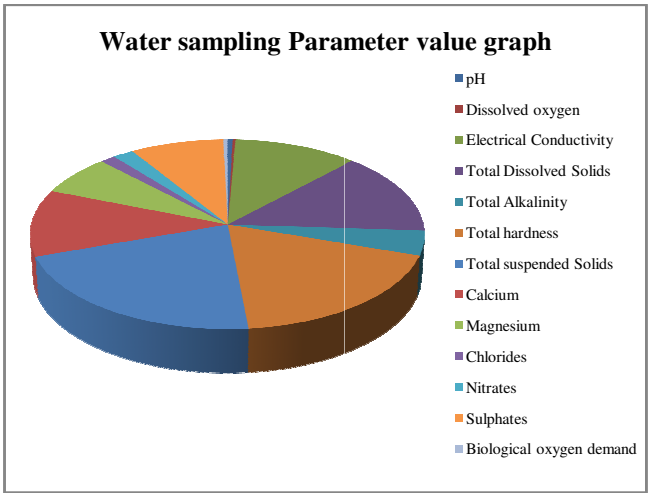


Figure: 2
S_1 to S_{10} Sampling station values showing

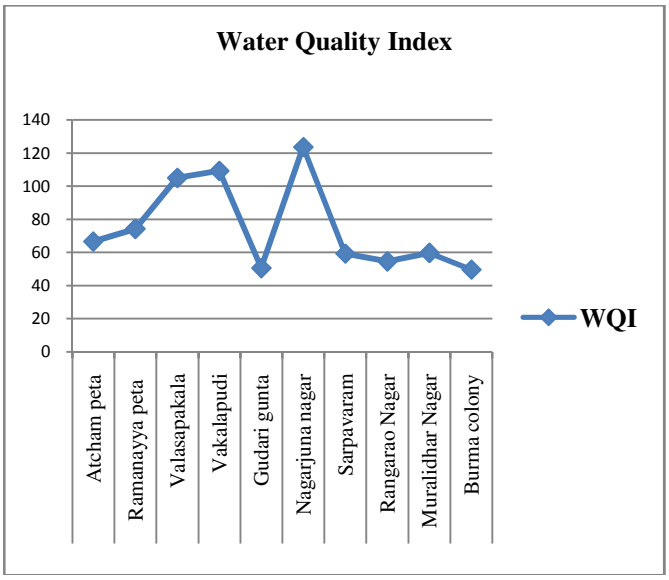


Figure-3
S_1 to S_{10} Water Quality Index Rating showing

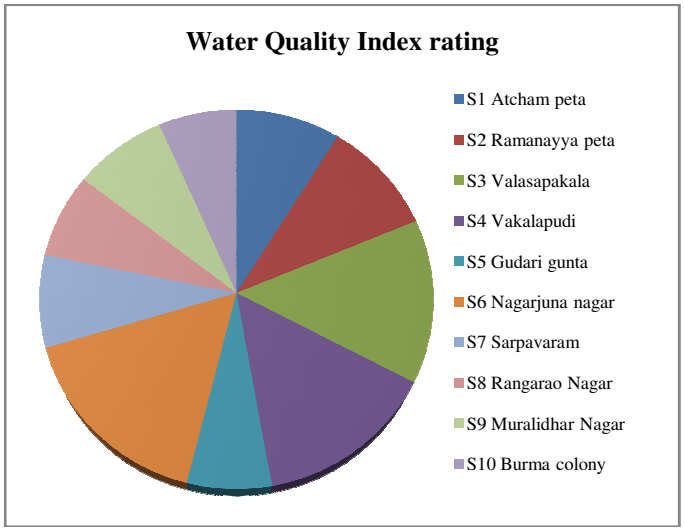


Figure-4
S_1 to S_{10} Water Quality Index Rating showing

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