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Effect of Industrial Effluents on Surface Water Quality - A Case Study of Patancheru, Andhra Pradesh, India

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ABSTRACT

In order to assess the surface water quality a total of forty two surface water samples were collected in pre-monsoon and post-monsoon seasons of 2008, 2009, 2010 and were analyzed for electrical conductivity, pH, total dissolved solid, Na, K, Ca, Mg, HCO_3, Cl, and SO_4. The chemical classification of surface water has been studied using L-L diagram, given by Langelier and Ludwig (1942)[1], surface water of both the seasons belongs to sodium Cl+SO4 type. The results show that surface water is affected by industrial effluents which have high concentration of BOD, COD, Na, Ca, Mg, K, Cl, SO_4 and HCO_3. However the three years of study shows that the surface water pollution in Bolaram and patancheru industrial development areas has significantly reduced, due to fact that the emission of effluents are treated regularly for the last few years.

Key words: Surface water, Industrial effluents, Three years, Water pollution, Electrical conductivity.

INTRODUCTION

Surface water is usually rain water that collects in surface water bodies, like oceans, lakes, or streams. Surface water can become contaminated in many ways, one of which is direct recharge can come from industries sources. A change in the water chemistry due to surface water contamination can negatively affect all levels of an ecosystem. It can impact the health of lower food chain organism and consequently the contaminated surface water can also affect the health of animals and humans when they drink or bathe in contaminated water or for aquatic organism when they ingest contaminated sediments. Degradation of water quality or depletion of water resources and loss of aquatic biodiversity are prominent features of the environmental landscape requiring urgent attention at global and national level1. The effluents of the industries gave a great deal of influence on the pollution of the water bodies, these effluents can alter the physical, chemical and biological nature of the receiving water body[2]. In the present study area there are about 400 (large and small) industries, and since 1977 these have been engaged in the manufacture, production, and processing of pharmaceuticals, paints and pigments, metal treatment and steel rolling, cotton and synthetic yarn, and engineering products. Most of them use various inorganic and organic chemicals as raw materials. These industries discharging their waste effluents directly into the streams.

The Study Area

The Patancheru and Bolaram Industrial Development Areas (IDA) (78°08'-78°23' east longitude and 17°30'-17°42' north latitude) of the Medak district are located about 35 km from Hyderabad, Andhra Pradesh (A.P.), India; the location is shown in Fig. 1. The study area form the part of the Nakkavagu watershed.

Surface water sampling

1. Kazipally lake
2. Gandigudem lake

3. Asanikunta
4. Kistareddy pet lake
5. Palma vagu
6. Pedda vagu
7. Nakka vagu

The Pamulavagu, Peddavagu and Nakkavagu streams, while carrying industrial effluents also acts as diffuse sources of contamination along their courses to the confluence with the Manjira River. Apart from this, streams tanks both of medium and small size form the other surface water bodies of patancheru and bolaram industrial areas.

METHODOLOGY

Hydrochemical sampling procedure

The objective of sampling is to collect a portion of material small enough in volume to be transported conveniently and handled in the laboratory while still accurately representing the material being sampled (APHA, 1992)[3]. Samples, however, have to be handled in such a way that no significant change in composition occurs before the tests are made.

A total number of 42 surface water samples were collected for physico-chemical analysis in two successive pre-and post-monsoon seasons of 2008, 2009, 2010.

The water samples were collected and stored in 1 liter capacity clean plastic bottles. Before collection of samples, the bottles were properly washed. Prior to collecting the samples, the containers were rinsed by the water to be sampled. The major ion analyses were carried out at National Geophysical Research Institute, (NGRI) Hyderabad.

Analytical techniques for major ions

The water samples were analyzed as per the standard methods of APHA (1992). Values of pH were measured by a portable digital water analyses kit with electrodes. The instrument was calibrated with buffer solutions having pH values of 4 and 9. Total dissolved solids (TDS) were calculated by summing up the concentrations of all the major cations and anions. The values of electrical conductivity (EC) were measured by portable kit with electrodes.

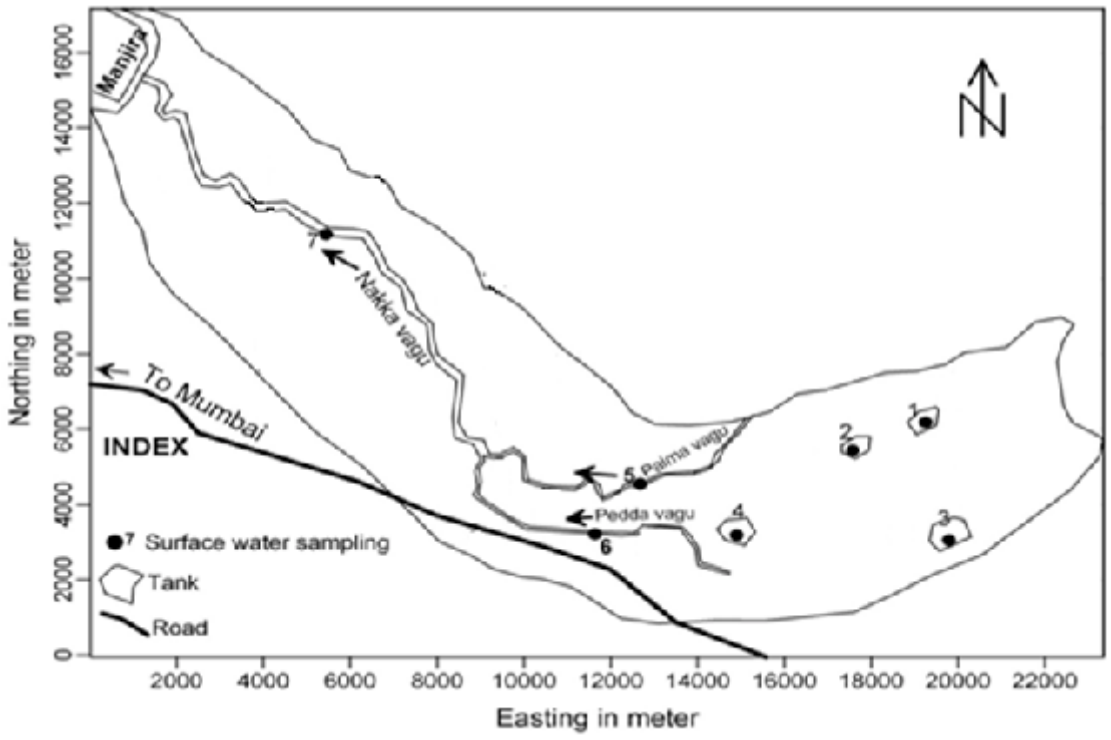


Table 1: Physico-chemical characterization of surface water of pre-monsoon 2008 IN mg/L

S.No	Sample	PH	EC	TDS	TH	HCO_3	Cl	SO_4	Na	K	Ca	Mg
1	Kazipally Tank	8.14	27400	17810	3593	890	6704.9	3983.3	4001.9	575.3	1005	263
2	Gandigudem	7.25	20500	13100	4613	551	6200	1700	2856	204	1300	331.8
3	Asanikunta	8.39	33800	21600	4110	757	11214.2	1767.3	6183.9	395.9	915.8	444.9
4	Kistareddy Pet	8.3	17000	11050	1590	459	5593	679	3361	249	329.3	188
5	Palma Vagu	7.85	26700	17200	3630	564	7213	3219	4563	275	816	388
6	Pedda Vagu	8.21	26700	15870	2290	489	6633	2756	5006	213	516	245
7	Nakka Vagu	8.41	30100	20150	4350	445	7570	4950	4990	362	990	458

EC in µs/cm all other parameters in mg/L Except pH

Table 2:Physico-chemical characterization of surface water of post-monsoon 2008 IN mg/L

S.No	Sample	PH	EC	TDS	TH	HCO_3	Cl	SO_4	Na	K	Ca	Mg
1	Kazipally Tank	7.67	24200	15500	3070	645	5700.3	3456.2	3956	431	878	215
2	Gandigudem	7.35	16700	10735	3550	458	5008.1	1423	2311	187	997	258
3	Asanikunta	8.5	29300	18900	3610	615	9900	1545	5432	307	787	400
4	Kistareddy Pet	7.64	14900	9500	1460	412	4907.1	520.3	2902.5	210	311.9	165.2
5	Palma Vagu	7.8	22700	14400	2590	544	5643	2759	4090	255.1	528	309.6
6	Pedda Vagu	8.5	19400	12450	1980	521	4903	2458	3631	186	428	223
7	Nakka Vagu	8.6	23800	15250	3490	414	6023	3679	4067	307	760	389

Table 3:Physico-chemical characterization of surface water of pre-monsoon 2009 IN mg/L

S.No	Sample	PH	EC	TDS	TH	HCO_3	Cl	SO_4	Na	K	Mg	Ca
1	Kazipally Tank	7.98	22600	14500	3693	458	6200	2750	3300	275	350	900
2	Gandigudem	7.76	14900	9600	3940	506	4690	875.4	1932	180	290.8	1100
3	Asanikunta	7.01	25300	16250	3720	654	8734	1434	4320	304	405	823
4	Kistareddy Pet	7.54	15600	10005	1250	601	4991	579	3041	202	120.1	304.9
5	Palma Vagu	7.58	19300	12521	2450	745	4300	3110	3418	115	279	523
6	Pedda Vagu	7.85	18200	11650	2060	711	4519	1956	3601	179	205	489
7	Nakka Vagu	7.83	26800	17050	3730	487	5680	4250	4563	275	387	856

Table 4: Physico-chemical characterization of surface water of post-monsoon 2009 in mg/L

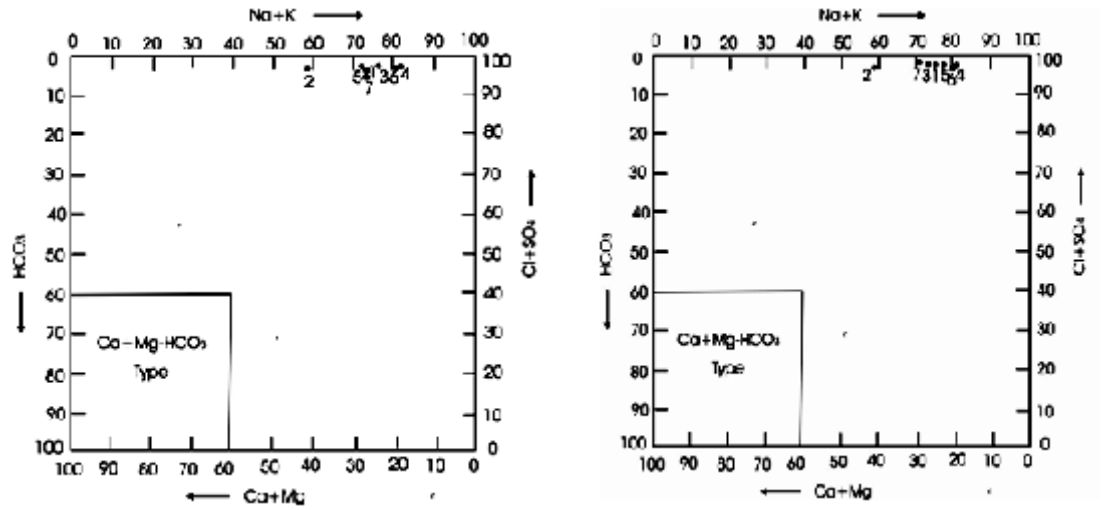
Sample	PH	EC	TDS	TH	HCO_3	CL	SO_4	Na	K	Mg	Ca
Kazipally Tank	7.65	21100	13400	2760	798	4989	2536.4	3546	376	201	775
Gandigudem	7.85	10000	6350	1920	429	3012	654	1472.5	105	197	445
Asanikunta	6.94	21800	13902	2670	550	7021	1342	4031	254	232	686
Kistareddy Pet	7.98	12800	8150	1230	512	4121	432.3	2409.1	159	132.5	276.1
Palma Vagu	7.94	15000	9750	2160	678	3852	1784	2511	221	298	375
Pedda Vagu	7.91	12300	7900	1710	751	2889.1	1347	2039.1	139	218	328
Nakka Vagu	7.43	19800	14001	2880	425	5720	3100	3500	250	309	645

Table 5: Physico-chemical characterization of surface water of pre-monsoon 2010 in mg/L

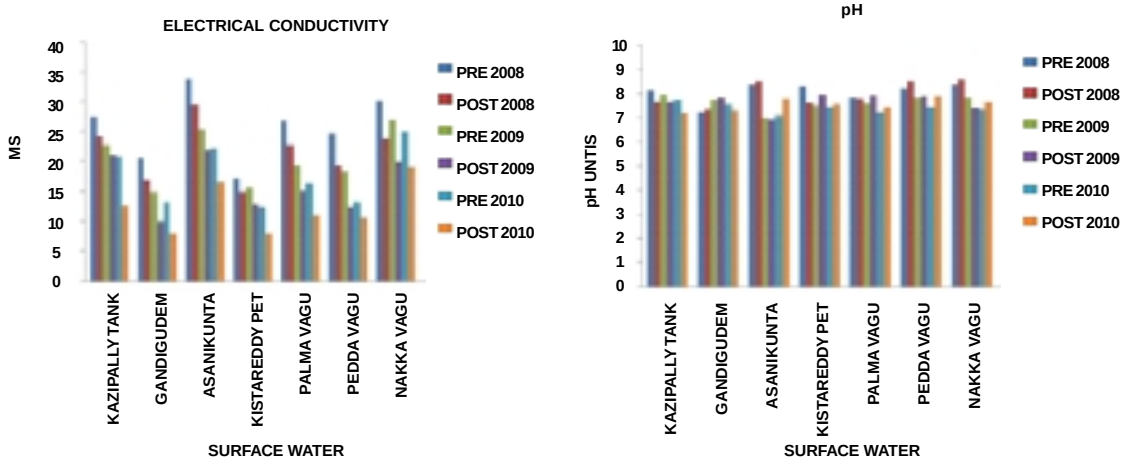
	PH	EC	TDS	TH	HCO_3	CL	SO_4	Na	K	Mg	Ca
Kazipally Tank	7.77	20800	13300	4403	550	5963.4	1871.3	2600	750	463.6	1600
Gandigudem	7.56	13200	8518	3330	489	4290	722.4	1600	150	250.8	920
Asanikunta	7.11	22100	14000	3210	858	6560	1350	3815	235	320	770
Kistareddy Pet	7.47	12300	7850	1000	650	3453	868.5	2300	120	97.6	240
Palma Vagu	7.23	16300	10420	2050	547	4110	2019	3063	79	239	428
Pedda Vagu	7.45	13200	8450	1700	540	3100	1839	2234	89.9	193	365
Nakka Vagu	7.35	24900	15180	3410	415	5880	3550	3909	289	375	750

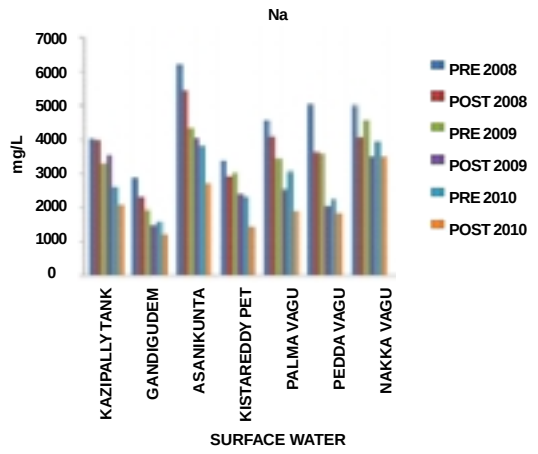
Table 6: Physico-chemical characterization of surface water of post-monsoon 2010 in mg/L

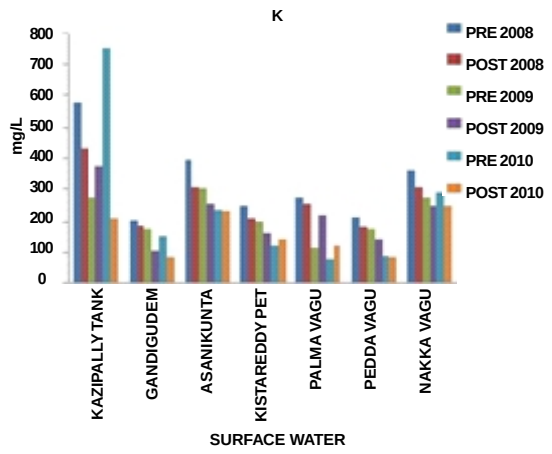
	PH	EC	TDS	TH	HCO_3	CL	SO_4	Na	K	Mg	Ca
Kazipally Tank	7.21	12600	8150	1530	575	2976	1645.3	2078.5	210	156	356
Gandigudem	7.31	8000	5050	1400	358	2434.2	401	1198	87	134.2	341.9
Asanikunta	7.81	16400	10500	2250	560	5112	1018	2711	231.1	190.2	587.4
Kistareddy Pet	7.56	8000	5200	974	505	2401.9	319.2	1410.1	141	111.9	205.9
Palma Vagu	7.44	11000	7050	1450	682	2625	1214	1921.3	121	217	225
Pedda Vagu	7.91	10600	6750	1390	510	2743	1058	1831.4	87	176	267
Nakka Vagu	7.65	19100	12500	2880	425	5720	3100	3500	250	309	645

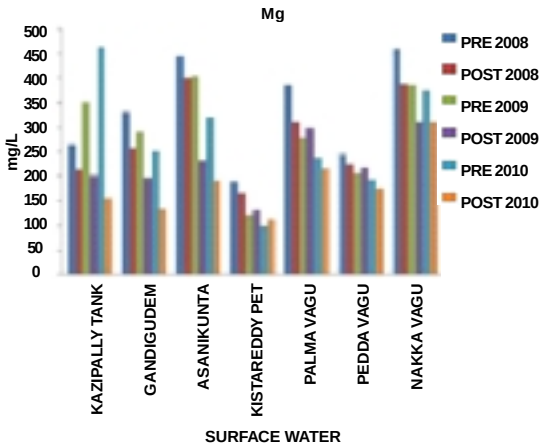


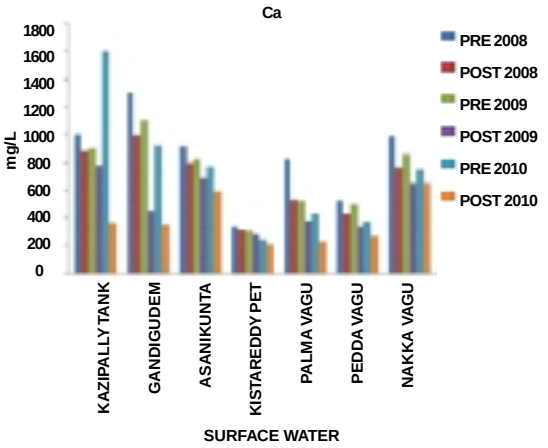
Langelier and Ludwig (L-L) diagram of pre-monsoon and post-monsoon 2008

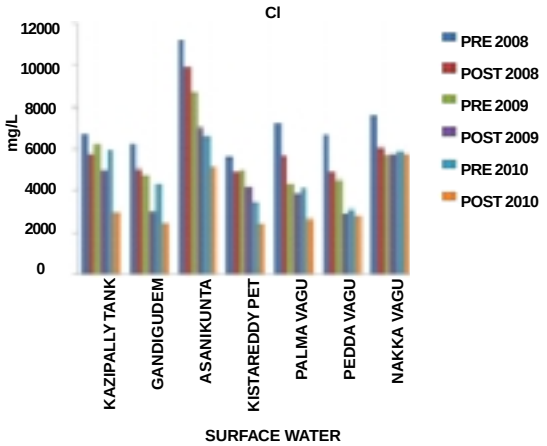


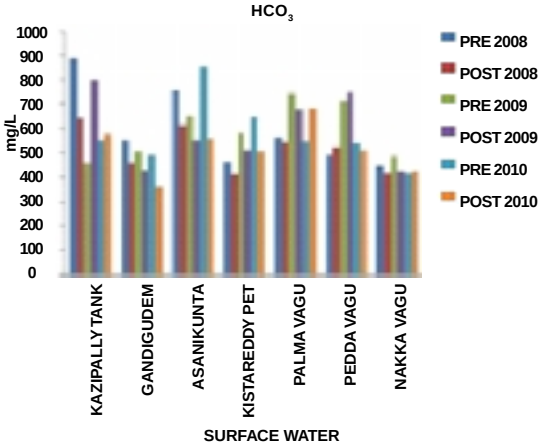


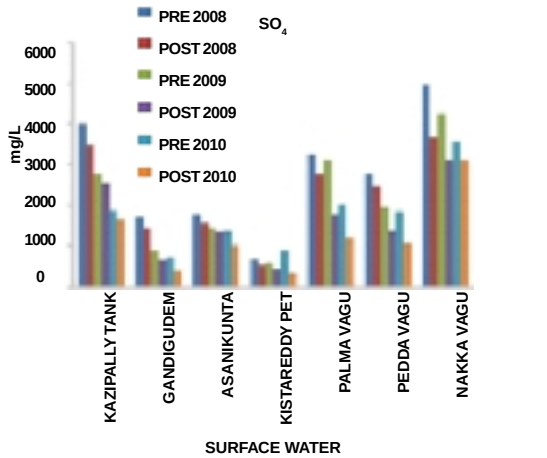


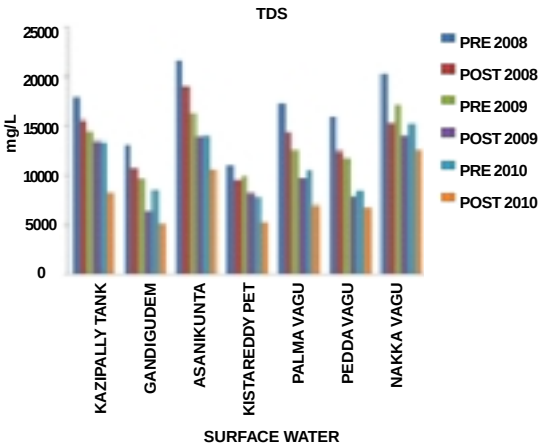

Mg
mg/L
500
450
400
350
300
250
200
150
100
50
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER

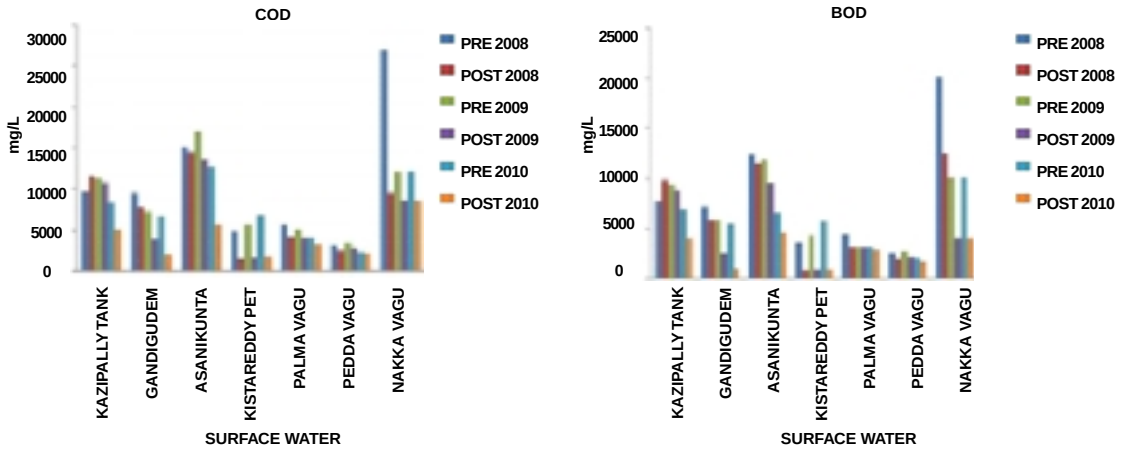

Ca
mg/L
1800
1600
1400
1200
1000
800
600
400
200
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER


Cl
mg/L
12000
10000
8000
6000
4000
2000
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER


HCO3
mg/L
1000
900
800
700
600
500
400
300
200
100
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER


SO4
mg/L
6000
5000
4000
3000
2000
1000
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER


TDS
mg/L
25000
20000
15000
10000
5000
0
PRE 2008
POST 2008
PRE 2009
POST 2009
PRE 2010
POST 2010
KAZIPALLY TANK
GANDIGUDEM
ASANIKUNTA
KISTAREDDY PET
PALMA VAGU
PEDDA VAGU
NAKKA VAGU
SURFACE WATER



Variation of various parameters are graphically represented as

The concentrations of Ca^{++}, Mg^{++}, Cl^{-}, HCO_3^{-} and total hardness were determined by volumetric method. Ca^{++} and Mg^{++} were determined by EDTA titration. For HCO_3^{-}, HCl titration to a methyl orange point was used. Chloride was determined by titration with $AgNO_3$ solution. Flame emission photometry has been used for the determination of Na^{+} and K^{+}. In this method water sample is atomized and sprayed into a burner. The intensity of the light emitted by a particular spectral line is measured with the help of a photoelectric cell and a galvanometer. Sulphate was determined by gravimetric method.

RESULTS AND DISCUSSION

The analytical data of successive pre-and post-monsoon seasons for surface water sample corresponding to June 2008 and November 2008, June 2009 and November 2009 June 2010 and November 2010 are given in table 1, 2, 3,4,5,6.

Classification of surface water

The chemical classification of surface water has been studied using L-L diagram, given by Langelier and Ludwig (1942)[4] for both, pre-monsoon and post-monsoon of 2008 seasons. Surface water samples have been plotted to discern any conspicuous changes in the overall chemical behavior of surface water during the two major seasons of the year. Both the plot belongs to pre and post-monsoons of 2008 indicate there are no major changes in the chemistry of surface water samples. Surface water of both the seasons belongs to sodium $Cl+SO_4$ type.

Physico-chemical attributes of surface water

The properties of surface water of the area under study, in terms of fundamental parameters, such as, pH, total dissolved solids, Electric Conductivity, COD and BOD are given below.

Hydrogen Ion Concentration (pH)

The pH values were measured at well sites, are lies in the range of 7.25 to 8.41 and 7.35 to 8.0 during pre-monsoon 2008 and post-monsoon 2008, respectively .The surface water thus is mildly acidic to slightly alkaline in nature.

Electrical Conductivity

Seasonal variations showed higher value of EC in pre-monsoon 2008 and lower value in post-monsoon due to dilution with rain water. The values obtained were very much higher than the permissible limits. The conductivity was recorded in different seasons from minimum of 17 mS Cm^{-1} to a maximum of 33 mS Cm^{-1} in pre- monsoon 2008 season and from minimum of 14.9 mS Cm^{-1} to a maximum of 29.3 mS Cm^{-1} in post- monsoon 2008 season..

Total Dissolved Solids (TDS)

In water, total dissolved solids are composed mainly of carbonates, bicarbonates,

chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles[5]. At high flows, the TDS values tend to be diluted by surface runoff and for most rivers there are an inverse correlation between discharge rate and TDS[6]. As expected, the maximum total dissolved solids were observed during the pre-monsoon season of 2008 (21600 mg/l) than the post-monsoon (18900 mg/l), this is due to dilution factor during the rainy season. Higher level of TDS during pre-monsoon season is more likely due to the influence of industrial activities such as effluent addition to the surface water. Waters with high total dissolved solids (TDS) are unpalatable and potentially unhealthy.

COD and BOD

COD pointing to a deterioration of the water quality caused by the discharge of industrial effluents[7]. The COD in the surface water ranges from 3100-27000 mg/l in pre-monsoon 2008 and from 1450-14500 mg/l in post monsoon 2008. High BOD level indicates decline in DO, because the oxygen that is available in the water is being consumed by the bacteria leading to the inability of fish and other aquatic organism to survive in the river[8]. The BOD in the surface water ranges from 2400-20200 mg/l in pre-monsoon 2008 and from 660-12500 mg/l in post monsoon 2008.

Temporal variation trends of major ions in surface water

Data of concentration of major ions of pre- and post-monsoon 2008, pre-and post-monsoon 2009, and pre-and post-monsoon 2010 are given in Table. The concentration values of all the samples are discussed in detail.

- In pre-monsoon seasons of 2008, 2009 and 2010, the concentration of Na ranges from 2856 to 6183.9 mg/l, 1932 to 4563 mg/l and 1600 to 3909 mg/l, respectively. In post-monsoon seasons of years 2008, 2009 and 2010 the observed ranges are 2311 to 5432 mg/l, 1472 to 4031 mg/l and 1198 to 3500 mg/l respectively.
- Potassium ranges from 204 to 575.3 mg/l, 115 to 304 mg/l and 79 to 750 mg/l in pre-monsoon samples whereas in post-monsoon seasons it ranges from 186 to 431 mg/l, 105 to 376 mg/l and 27 to 250 mg/l, respectively.
- Concentration of Ca ranges from 329.3 to 1300 mg/l, 304.9 to 1100 mg/l and 240 to 1600 mg/l in pre-monsoon samples and from 311.9 to 997 mg/l, 276.1 to 775 mg/l and 205.9 to 645 mg/l in post-monsoon samples.
- Magnesium values range from 188 to 458 mg/l, 120.1 to 405 mg/l and 97.6 to 463.6 mg/l in pre-monsoon periods and from 165.2 to 400 mg/l , 132.5 to 309 mg/l and 111.9 to 309 mg/l in post-monsoon.
- Bicarbonate ranges from 445 to 890 mg/l, 458 to 745 mg/l and 415 to 858 mg/l in pre-monsoon seasons of years 2008, 2009 and 2010, whereas in post-monsoon seasons of above years it ranges from 412 to 645 mg/l, 425 to 798 mg/l and 358 to 682 mg/l respectively.
- Chloride, in corresponding sampling periods, ranges from 5593 to 11214 mg/l, 4300 to 8734 mg/l, 3100 to 6560 mg/l and 4903 to 9900 mg/l, 2899 to 7021 mg/l, 2401 to 5720 mg/l respectively.
- The concentration of SO_4 in corresponding seasons ranges from 679 to 4950 mg/l, 579 to 4250 mg/l, 722 to 3550 mg/l and 520 to 3679 mg/l, 432 to 3100 mg/l, 319 to 3100 mg/l, respectively.

CONCLUSIONS

Surface water has the highest concentration of cations and anions. Surface water is affected by industrial effluents which have high concentration of Na, Ca, Mg, K, Cl, SO_4 and HCO_3. These parameters are in more than desirable limits which could be the result of direct dumping of effluents into the water bodies. The industrial effluents are let into the stream directly during rainy days thus leading to accumulation of elements in surface water, which together with rain water, flow down to Nakkavagu stream and join the major drainage system and these water in due course percolate down to join ground water reservoir. The effect of industrial pollution thus can be seen along Nakkavagu and its adjourning areas.

The three years of study shows that the surface water pollution in Bolaram and patancheru

industrial development areas has significantly reduced, due to fact that the emission of effluents are treated regularly for the last few years. The low reduction in surface water pollution may be due to rainfall dilution.

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