Water Quality Assessment for Wells Located Near Municipal Waste Dumping Sites in Bhubaneswar City, India

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Abstract

Certain physicochemical and biological characteristics of well waters located near major solid waste disposal sites of Bhubaneswar city were studied in the dry and wet seasons of 2001 and 2002. Higher levels of NO_3^-, PO_4^{--}, Cl^-, SO_4^{--}, Fe, Ca, Mg, total hardness, and total and fecal coliform bacteria have been observed in the water samples in wet seasons relative to dry seasons. Most of the physicochemical and biological parameters exceeded the Indian drinking water standards prescribed by IS:10500:1991. The results indicated that in wet seasons, the well waters within 50 meters from municipal waste dumping sites were not suitable for drinking.

I. Introduction

Bhubaneswar, the capital city of Orissa state is located between 20°14′0″N and 20°15′40″N latitudes

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and 85°51′30″E longitude in the coastal plain of India. Bhubaneswar is one of the fastest growing cities in India and has a current population of 6,57,477(2001 Census). The rapid expansion of the city has not been matched by the corresponding strengthening of the civic amenities. A considerable number of people in the city consume water from dug wells. As the municipal corporation does not have proper solid waste disposal infrastructure, a considerable quantity of the refuse is disposed off in open dumps, often close to the dug wells. Since the wells are a sort of entrapped water sources, natural self purification does not take place and the wells often turn eutrophic. Contamination of well water due to effluents has been earlier reported by Bala *et al.*(1994), Pathak and Badre(1999), Mahapatra *et al.* (2001), and Bala *et al.*(1994). Water qualities of urban drinking water sources in India have been studied by Sarma *et al.*(2002); Reshma and Prakasam(2003), and others.

This study investigates seasonal variation in the quality of well waters located near nine major municipal solid waste disposal sites in Bhubaneswar, India.

II. Materials and Methods

Water samples were collected from the dug wells located at an average distance of 50m radius from nine major garbage dumping sites. Samples were collected at random in wide-mouth plastic bottles. For the measurements of dissolved oxygen(DO) and biological oxygen demand(BOD), samples were collected in 300ml BOD bottles. Temperature, pH, and DO(Winkler's method) were measured on the spot. For the analysis of physicochemical and biological parameters the samples were transported to the laboratory. Standard Methods prescribed by APHA(1995) were used for measurement of water quality parameters, such as pH, nitrate, phosphate, sulphate, potassium, iron, chloride, total dissolved solid (TDS), total hardness, calcium, magnesium, total coliform, and fecal coliform bacteria. The investigations were conducted in both dry and wet seasons of the years 2001 and 2002.

III. Results and Discussion

The analysis results of water samples for dry seasons and wet seasons of 2001 and 2002 are depicted in Tables 1~4. The standard values of drinking water as per Indian drinking water standard are presented in Table 5.

During both years of the study it was observed that pH of water in the wells shifted from an acidic condition to an alkaline from dry to wet season. Changes in pH occur as a result of depletion in readily biodegradable organics(Zafar *et al.*, 2002). The average pH values of water samples were within 7-8.5

Table 1. Average Well Water Quality During May 2001(Dry Season)

Sl. No.	Station Name	Ward No.	pH	NO_3^- mg/l	PO_4^{---} mg/l	SO_4^{--} mg/l	K mg/l	Fe mg/l	Cl mg/l	TDS mg/l	Total Hardness mg/l	Ca mg/l	Mg mg/l	TC MPN/ 100ml	FC MPN/ 100ml
1	Palasuni Village	3	7.9 ±0.1	10.4 ±1.2	0.034 ±0.002	300 ±13.8	0.4 ±0.2	1.9 ±0.01	69 ±4.5	200 ±10.1	100 ±10.2	29 ±2.5	5.4 ±1.2	30 ±2.8	12 ±1.2
2	Sainik School	2	6.8 ±.12	3.9 ±0.12	0.062 ±0.003	320 ±14.5	0.49 ±0.31	0.5 ±.01	81 ±5.6	300 ±11.2	100 ±10.2	35 ±2.8	4.9 ±1.3	10 ±2.5	5 ±1.1
3	Baramunda Village	16	7.0 ±0.01	26.5 ±3.4	0.011 ±0.001	300 ±12.5	0.5 ±0.21	0.6 ±0.02	75 ±4.9	350 ±12.12	90 ±11.1	25 ±2.5	2.6 ±0.5	25 ±1.2	15 ±1.1
4	Khandagiri	19	7.5 ±0.21	4.2 ±0.31	0.021 ±0.001	270 ±10.5	0.59 ±0.13	0.8 ±0.01	51 ±5.6	250 ±12.12	102 ±10.1	32 ±2.8	5.1 ±1.1	60 ±2.2	32 ±1.1
5	Niladri Vihar	1	6.9 ±0.01	9.0 ±0.23	0.031 ±0.001	280 ±11.5	0.7 ±0.23	0.99 ±0.02	49 ±4.9	290 ±11.24	87 ±10.1	33 ±2.5	4.9 ±1.2	15 ±1.1	8 ±1.2
6	Satya Nagar	10	6.8 ±0.12	6.2 ±0.14	0.022 ±0.001	325 ±13.8	0.65 ±0.31	0.98 ±0.01	120 ±6.9	200 ±10.12	90 ±11.12	20 ±2.4	3.5 ±1.3	25 ±1.2	13 ±1.1
7	Sundarpada Village	29	6.5 ±0.23	6.6 ±0.34	0.35 ±0.02	210 ±11.5	0.75 ±0.21	0.29 ±0.01	50 ±5.6	300 ±11.12	100 ±12.1	30 ±2.9	4.2 ±1.5	60 ±2.3	30 ±2.1
8	Bargarh Village	25	7.4 ±0.02	9.5 ±0.34	0.01 ±0.001	290 ±12.5	0.8 ±0.32	0.59 ±0.01	190 ±8.5	300 ±12.12	89 ±11.1	35 ±2.5	4.5 ±1.9	15 ±1.2	8 ±2.1
9	Vani Vihar West Gate (Near RRL Gate)	6	6.21 ±0.03	10.9 ±1.01	0.35 ±0.02	250 ±11.9	0.72 ±0.21	0.09 ±0.01	50 ±4.5	250 ±11.12	90 ±10.11	30 ±2.9	5.0 ±1.6	15 ±1.2	8 ±2.1
	Mean		7.001	9.689	0.099	282.778	0.622	0.749	81.667	271.111	94.222	29.889	4.456	28.333	14.556
	Std. Dev.		0.523	6.805	0.143	35.978	0.136	0.524	46.669	50.111	6.058	4.859	0.896	19.039	9.825

Table 2. Average Well Water Quality During August 2001(Wet Season)

Sl. No.	Station Name	Ward No.	pH	NO_3^- mg/l	PO_4^{---} mg/l	SO_4^{--} mg/l	K mg/l	Fe mg/l	Cl mg/l	TDS mg/l	Total Hardness mg/l	Ca mg/l	Mg mg/l	TC MPN/ 100ml	FC MPN/ 100ml
1	Palasuni Village	3	8.1 ±0.1	30 ±2.4	0.085 ±0.001	250 ±12.5	0.9 ±0.2	1.5 ±0.01	250 ±10.12	550 ±10.11	320 ±12.58	30 ±2.8	9 ±1.5	100 ±10.5	19 ±1.8
2	Sainik School	2	7.1 ±0.01	25 ±2.1	0.095 ±0.002	210 ±11.5	0.91 ±0.81	1.2 ±0.01	290 ±10.21	540 ±12.11	300 ±11.21	38 ±2.4	8 ±1.5	110 ±10.4	15 ±1.5
3	Baramunda Village	16	8.2 ±0.1	50 ±3.2	0.055 ±0.002	250 ±12.9	0.6 ±0.11	1.1 ±0.01	280 ±10.35	600 ±11.12	340 ±12.12	30 ±2.4	5.4 ±1.6	125 ±11.5	22 ±1.5
4	Khandagiri	19	8 ±0.12	15.9 ±2.1	0.095 ±0.002	300 ±13.8	0.81 ±0.12	1.2 ±0.11	200 ±10.51	550 ±12.12	350 ±11.12	40 ±3.5	9.8 ±1.5	150 ±12.5	35 ±1.8
5	Niladri Vihar	1	7.8 ±0.13	18 ±1.3	0.098 ±0.001	290 ±12.9	0.9 ±0.12	1.1 ±0.012	250 ±11.56	650 ±12.11	390 ±12.12	45 ±2.8	10.2 ±1.4	110 ±1105	20 ±1.3
6	Satya Nagar	10	7.5 ±0.11	15.5 ±1.4	0.056 ±0.001	280 ±12.5	0.81 ±0.22	1.9 ±0.02	300 ±12.12	600 ±12.12	380 ±11.12	30 ±1.9	10.5 ±1.2	120 ±10.5	25 ±1.5
7	Sundarpada Village	29	7.8 ±0.21	20.5 ±1.5	0.895 ±0.011	310 ±13.9	0.81 ±0.12	0.59 ±0.01	220 ±10.15	560 ±11.12	290 ±11.12	40 ±2.5	9.8 ±1.3	150 ±10.5	40 ±1.9
8	Bargarh Village	25	7.9 ±0.12	22.4 ±1.9	0.05 ±0.01	320 ±14.5	0.9 ±0.21	1.2 ±0.02	290 ±11.15	590 ±12.15	300 ±12.12	45 ±2.4	9.7 ±1.2	120 ±10.5	25 ±1.8
9	Vani Vihar West Gate (Near RRL Gate)	6	7.3 ±0.13	18.5 ±1.8	0.89 ±0.12	250 ±12.8	0.85 ±0.21	0.19 ±0.01	200 ±10.25	580 ±11.12	300 ±11.12	35 ±2.5	9 ±1.6	150 ±11.5	30 ±1.5
	Mean		7.744	23.978	0.258	273.333	0.832	1.109	253.333	580.000	330.000	37.000	9.044	126.111	25.667
	Std. Dev.		0.371	10.793	0.360	35.707	0.097	0.490	39.370	34.641	37.081	6.103	1.557	19.329	8.031

Table 3. Average Well Water Quality During May 2002 (Dry Season)

Sl. No.	Station Name	Ward No.	pH	NO_3^- mg/l	PO_4^{---} mg/l	SO_4^{--} mg/l	K mg/l	Fe mg/l	Cl mg/l	TDS mg/l	Total Hardness mg/l	Ca mg/l	Mg mg/l	TC MPN/ 100ml	FC MPN/ 100ml
1 Village	Palasuni	3 ±0.1	7.8 ±1.2	11.2 ±0.002	0.045 ±12.8	280 ±0.2	0.5 ±0.02	2 ±4.8	70 ±10.2	250 ±8.12	110 ±2.8	30 ±1.2	5.9 ±2.4	35 ±2.8	15
2	Sainik School	2	6.9 ±0.11	5.1 ±0.12	0.084 ±0.004	300 ±15.2	0.52 ±0.21	0.8 ±0.01	90 ±5.7	350 ±12.1	120 ±9.24	40 ±2.9	5.4 ±1.2	15 ±2.4	10 ±1.1
3	Baramunda Village	16	6.85 ±0.02	30.8 ±3.8	0.045 ±0.001	250 ±10.5	0.9 ±0.21	0.9 ±0.02	85 ±5.2	390 ±10.11	110 ±10.12	30 ±2.5	4.5 ±0.4	30 ±1.2	15 ±1.2
4	Khandagiri	19	7.6 ±0.21	5.6 ±0.42	0.031 ±0.002	310 ±11.6	0.99 ±0.14	1.2 ±0.02	60 ±5.4	300 ±11.12	130 ±10.12	35 ±2.9	6.8 ±1.2	65 ±2.1	33 ±1.3
5	Niladri Vihar	1	6.5 ±0.02	10.2 ±0.24	0.042 ±0.002	290 ±12.5	0.9 ±0.24	0.89 ±0.03	75 ±3.2	310 ±12.12	100 ±10.11	34 ±2.4	5.9 ±1.3	20 ±1.1	10 ±1.2
6	Satya Nagar	10	6.5 ±0.11	9.8 ±0.14	0.034 ±0.002	250 ±11.9	0.96 ±0.32	0.98 ±0.02	130 ±6.8	280 ±10.11	110 ±10.12	25 ±2.3	4.5 ±1.2	30 ±1.3	18 ±1.2
7	Sundarpada Village	29	6.8 ±0.21	6.9 ±0.35	0.39 ±0.03	210 ±21.8	0.98 ±0.21	0.59 ±0.03	53 ±5.7	350 ±11.11	130 ±11.12	32 ±2.8	5.8 ±1.4	65 ±1.5	32 ±2.1
8	Bargarh Village	25	7.1 ±0.03	10.8 ±0.35	0.02 ±0.001	250 ±12.5	0.95 ±0.34	0.84 ±0.01	200 ±7.4	320 ±12.12	120 ±10.12	40 ±2.4	8.2 ±1.2	20 ±1.3	10 ±1.2
9	Vani Vihar West Gate (Near RRL Gate)	6	6.1 ±0.02	11.5 ±1.02	0.42 ±0.12	300 ±13.3	0.78 ±0.22	0.88 ±0.02	59 ±3.4	310 ±10.12	110 ±10.12	35 ±2.8	9 ±1.7	20 ±1.4	9 ±1.2
Mean			6.906	11.322	0.123	271.111	0.831	1.009	91.333	317.778	115.556	33.444	6.222	33.333	16.889
Std. Dev.			0.538	7.700	0.161	32.956	0.193	0.405	46.856	41.466	10.138	4.851	1.539	19.039	9.360

Table 4. Average Well Water Quality During August 2002 (Wet Season)

Sl. No.	Station Name	Ward No.	pH	NO_3^- mg/l	PO_4^{---} mg/l	SO_4^{--} mg/l	K mg/l	Fe mg/l	Cl mg/l	TDS mg/l	Total Hardness mg/l	Ca mg/l	Mg mg/l	TC MPN/ 100ml	FC MPN/ 100ml
1	Palasuni Village	3	8.11 ±0.12	32 ±2.5	0.091 ±0.002	250 ±12.5	1.12 ±0.2	1.9 ±0.02	300 ±11.12	350 ±10.12	325 ±11.25	31 ±2.5	10 ±1.4	110 ±10.2	20 ±1.9
2	Sainik School	2	7.81 ±0.21	30 ±2.2	0.098 ±0.002	300 ±13.6	0.98 ±0.91	1.3 ±0.01	300 ±10.21	500 ±12.11	300 ±10.25	40 ±2.5	9 ±1.2	120 ±10.2	25 ±1.8
3	Baramunda Village	16	7.91 ±0.02	55 ±3.2	0.098 ±0.003	310 ±14.5	0.9 ±0.19	1.5 ±0.01	310 ±10.32	620 ±10.12	350 ±11.15	32 ±2.5	5.9 ±1.3	150 ±10.25	30 ±1.9
4	Khandagiri	19	8 ±0.23	25 ±2.5	0.098 ±0.001	280 ±12.6	0.99 ±0.21	1.4 ±0.12	210 ±10.25	560 ±10.15	390 ±10.25	42 ±3.2	10.2 ±1.4	190 ±11.5	40 ±1.9
5	Niladri Vihar	1	7.2 ±0.03	20 ±1.4	0.099 ±0.001	210 ±11.9	1.2 ±0.12	1.3 ±0.012	250 ±12.50	620 ±11.12	380 ±11.12	48 ±2.7	11.5 ±1.2	170 ±10.5	30 ±1.8
6	Satya Nagar	10	7.5 ±0.02	16 ±1.5	0.059 ±0.001	200 ±10.6	0.99 ±0.24	1.9 ±0.02	290 ±12.12	610 ±10.12	390 ±10.15	32 ±1.9	12.2 ±1.3	140 ±1.45	45 ±2.8
7	Sundarpada Village	29	7.8 ±0.01	25 ±1.5	0.998 ±0.012	310 ±14.	0.99 ±0.24	0.99 ±0.01	250 ±10.15	570 ±10.13	300 ±12.1	42 ±2.9	10.5 ±1.2	180 ±10.50	30 ±1.9
8	Bargarh Village	25	7.9 ±0.03	29 ±1.9	0.09 ±0.02	300 ±12.9	1.8 ±0.24	1.5 ±0.02	300 ±10.15	600 ±11.12	320 ±10.1	48 ±2.5	10 ±1.3	140 ±10.5	35 ±1.9
9	Vani Vihar West Gate (Near RRL Gate)	6	6.9 ±0.01	20 ±1.8	0.99 ±0.22	290 ±11.6	0.89 ±0.29	0.29 ±0.02	210 ±10.25	610 ±11.25	310 ±10.12	40 ±2.9	12 ±1.6	190 ±11.5	40 ±2.8
Mean			7.681	28.0	0.291	272.222	1.096	1.342	268.889	560.0	340.556	39.444	10.144	154.444	32.778
Std. Dev.			0.402	11.402	0.399	42.361	0.282	0.489	39.826	87.75	37.786	6.540	1.904	29.627	7.949

Table-5. Indian Drinking Water Standard Values(IS 10500: 1991)

Sl. No.	Substance or, Characteristic	Requirement(Desirable Limit)
1	PH	6.5 to8.5
2	No_3^-(mg/l)	45
3	SO_4^{--}(mg/l)	200
4	Fe(mg/l)	0.3
5	Cl(mg/l)	250
6	TDS(mg/l)	500
7	Total Hardness(mg/l)	300
8	Ca(mg/l)	75
9	TC MPN/100ml	<10/100ml and Should not be detectable in 100ml of any two consecutive samples.
10	FC MPN/100ml	<10/100ml and Should not be detectable in 100ml of any two consecutive samples

prescribed for drinking water IS:10500: 1991. During both years of the study, the concentrations of NO_3^-, PO_4^{---}, and Cl^- were found to be considerably higher in the well water in wet seasons relative to dry seasons. Since water-soluble organic matter of the solid wastes contained considerable amount of the above constituents(Panda *et al.*, 2003), during rains a significant amount of the leachate might have contaminated the well waters, resulting in considerable increase in the above parameters during the wet seasons(Tables 2 & 4). It has earlier been observed(Heckman *et al.*, 1997) that high amount of nitrate and nitrite as well as low pH in the wells in Brazil were dangerous for human intake. It has also been reported(Tripathy *et al.*, 2000) that the concentration of NO_3^- in water above 45mg/l could cause methemoglobin in children. Sarma *et al.*(2002) and Mahendran and Arunachalam(2002) have reported high values of the above parameters in well waters located close to waste disposal sites at various locations.

Increased amount of iron during the wet seasons might be due to the presence of laterites in the soil which percolated along with rain water into the wells. It has been reported earlier(Israile *et al.*, 1990; Goverdhan, 1990; Rowe *et al.*, 1995 and Tripathy *et al.*, 2000) that high iron content in well waters might discolour clothes and cause greater bacterial contamination in drinking water. High iron content in drinking water is known to cause skin and stomach diseases.

It was further observed that calcium and magnesium levels of well water were considerably higher in wet seasons compared to dry seasons irrespective of the disposal sites. The values of calcium and magnesium levels in wet seasons are higher than the standard values prescribed for drinking water by IS:10500:1991. The rise in the levels of calcium and magnesium during wet seasons might be due to the contamination of water by the leachates from the waste disposal sites. High values of calcium and

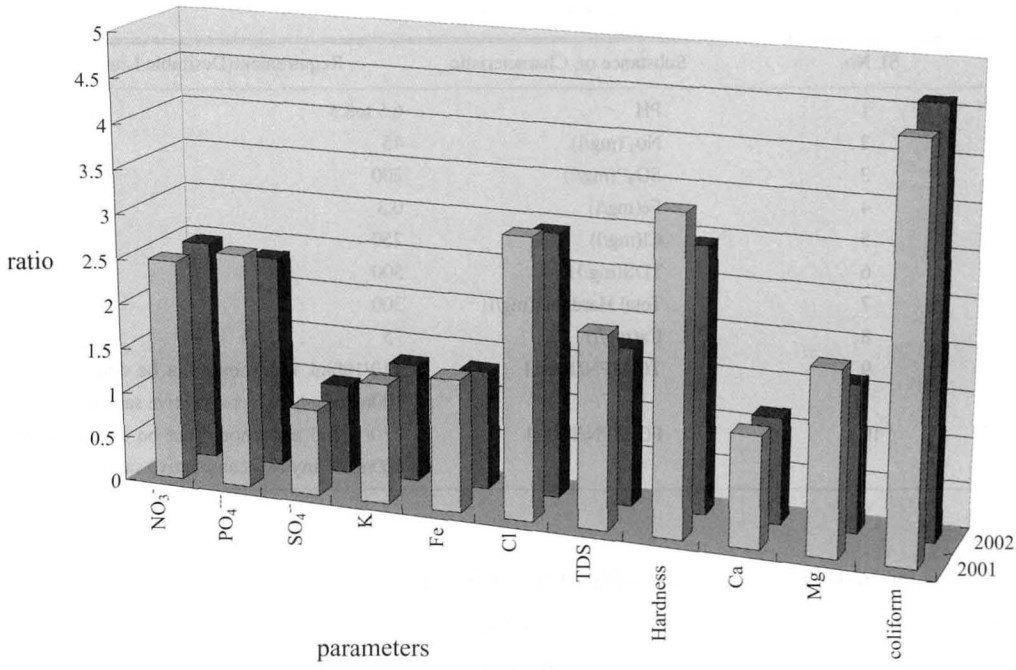

Figure 1. The Ratio of Average Concentration in Wet Season to That in Dry Season

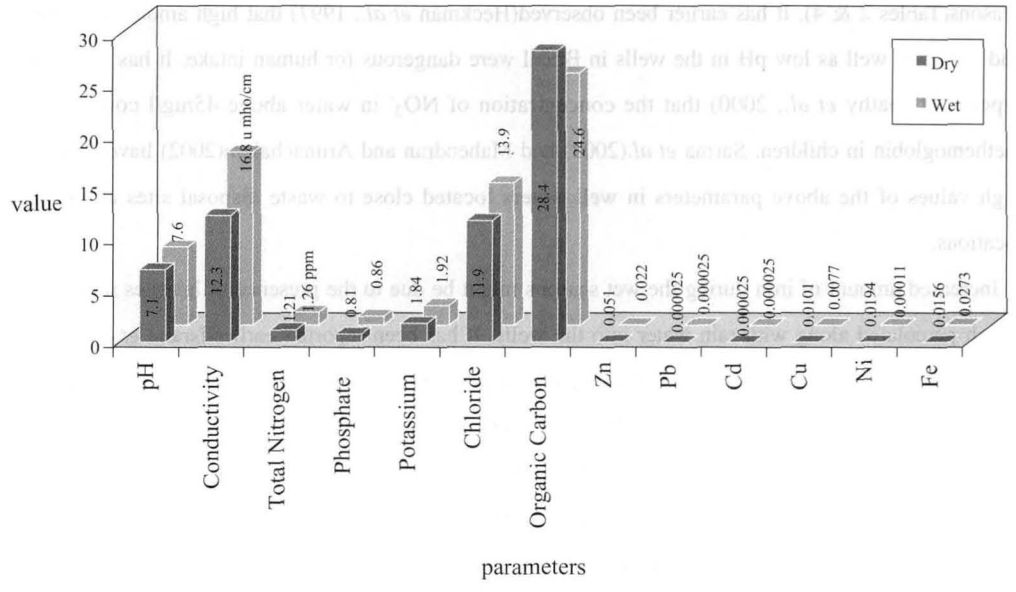

Figure 2. Average Physico Chemical Parameters of Urban Solid Waste in Dry and Wet Season 2001

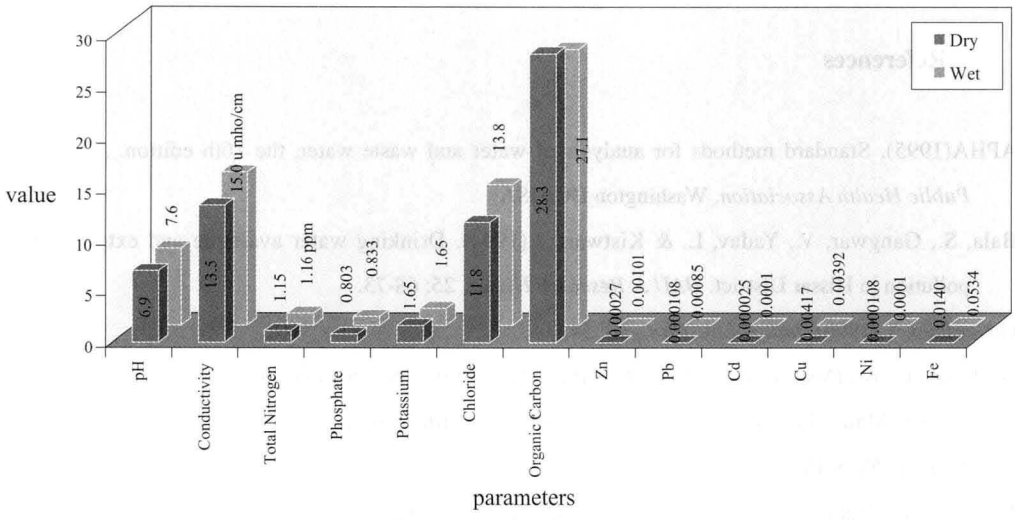

Figure 3. Average Physico Chemical Parameters of Urban Solid Waste in Dry and Wet Season 2002

magnesium generally are known to have positive impacts on eutrophication in well water(Subba Rao, 1998).

Considerable increase in total hardness during wet seasons might be due to the impact of carbonates of calcium and magnesium. The sources of these elements might be from the leachate of both solid waste and soil.

As per the bacteriological standards of IS:10500:1991, the maximum range for the coliform bacteria in drinking water before purification process should be 10/100ml. However, irrespective of the year and season the well water contained considerably higher numbers of both total and fecal coliforms. The increase in both TC and FC during wet seasons might be correlated to higher input of water-soluble organic constituents from nearby waste disposal sites during rains which is likely to accelerate bacterial growth.

Overall, the water quality deteriorated badly in wet seasons due to the leachate from the solid waste dumps. As shown in Figure 1, all the parameters except sulphate increased up to about 4.5 times during wet seasons. Among those the coliform bacterial count increased the most. The average physico-chemical characteristics of urban solid wastes in Bhubaneswar City in dry and wet seasons of the study period are shown in Figures 2 and 3.

Hence the results of the investigation indicated that the waters in the wells located close to municipal waste disposal sites in Bhubaneswar are not suitable for human drinking at the present state.

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