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Characterization of Leachate and its Effects on Ground Water Quality Around Jawaharnagar Municipal Open Dumpsite, Rangareddy, Telangana

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ABSTRACT

In the present work, characterization of leachate from an open dumpsite, Jawaharnagar, Rangareddy district, Telangana and its effects on surrounding ground water was investigated. A total of one leachate sample and twelve ground water samples were collected during pre-monsoon and post-monsoon seasons (2015) for monitoring purpose. All the samples were analyzed for physico-chemical parameters (pH, TDS, TH, CH, Cl^-, SO_4^{-2}, NO_3^- and F^-) as per standard procedures (APHA). Results indicate that, only pH and sulphates were found to be within the permissible limits in ground water recommended by WHO:2006. Total dissolved solids, Chlorides and Nitrate levels were found to be alarming in both pre and post monsoon. Water quality index (WQI) study also showed that most of the water samples fall in “Poor” and “Unsuitable” category. It is evident that the leachate from the municipal dumpsite is polluting the ground water at greater extent making them unsuitable for drinking purpose. Therefore, immediate measures should be taken to control the leachate contamination in the ground water.

Key words: Jawaharnagar Dumpsite, Water Quality Index (WQI), Physico-chemical parameters, WHO (2006).

INTRODUCTION

Management of solid waste and related environmental impacts presents a challenge to both developing and developed countries. Rapid industrialization, growing population and changing lifestyle are the root causes for increasing rate of solid waste generation. The quantum of municipal solid waste generated in India is about 0.15 million tons per day. This is approximately 50 million tons annually. Out of the total municipal waste collected, on an average 94% is dumped on land and 5% is composted. However, the average rate of MSW generation in India (0.35 to 0.60 kg/ person/day) is very low as compared to developed countries[1]. The most widely used method for disposal of municipal solid waste is land filling. Landfills or open dumps are tremendously used for disposal of solid waste because they have capacity to accumulate large amounts of wastes offering very low cost as compared to incineration. For a long time, land filling was the most common waste management option for Municipal Solid Wastes (MSW). Not only is it a waste of resources but landfills as such constitute a health hazard and an environmental burden[2]. Unconditional dumping of municipal solid wastes results in generation of toxic leachate, which percolates through the soil and finally reaches the water table affecting the ground waters. As the ground water is an important part of the hydrological cycle, it is more prone to various sources of contamination. Amongst the drawbacks, landfills have been identified as one of the major threats to ground water resources[3]. Not only ground water resources, it equally affects the surface water bodies through the lateral movement of surface run-off as a result of precipitation. The toxic leachate may consists of large amounts of organic and inorganic compounds[4]. In countries like India, where ground water is a major source of water supply for drinking and domestic purpose if leachate is not controlled it can contaminate the surrounding soils, vegetation, livestock, surface waters and ultimately the ground water. Ground water treatment of polluted aquifers is inefficient in terms of economy and is time consuming. Further, the contaminants may still remain in aquifers even after prolonged process of remediation. Therefore regular monitoring of the wells in terms of quality assessment is mandatory to control the pollution to the earliest either experimentally or through mathematical modeling. Therefore, a seasonal evaluation of groundwater quality was carried out in order to determine the status of the water for human consumption as well as to provide overall scenario of ground water contamination around the dumpsites which opens an avenue for establishment of well engineered landfill to achieve ground water sustainability. WQI is an important technique for demarcating water quality and its suitability for drinking purposes. It is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption[5]. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of water quality characteristics. Higher value of WQI indicates better quality of water and lower value shows poor water quality. WQI helps us to translate multifaceted water quality data into simple information that is comprehensible and useable by the public. Several studies were carried out in order to estimate the water quality of ground waters around dumpsites during pre-monsoon and post monsoon seasons using WQI index[6, 7 8,9,10]. The main focus of this study was to assess the physical and chemical parameters of ground waters during pre and post monsoon, 2015.

MATERIALS AND METHODS

Study Location

Jawaharnagar village dumpsite is located just outside the limits of GHMC (Greater Hyderabad Municipal Corporation) and inside the HMDA (New limits of Hyderabad). The site is 35km from Hyderabad city and 105km away from the state highway connecting Hyderabad and Nagpur in west direction from boundary of project site. It is an open dumpsite where unconditionally the solid wastes are dumped on a terraneous site called IrlaGutta (Gutta=Hill). The total area of Jawaharnagar dumpsite is 350 acres. The site receives Municipal Solid Waste of 5000 metric tons per day. It is located between 17Ú29^{1} 21^{11} N to 17Ú31^{1}39^{11}N latitude and 78Ú34’13" E to 78Ú37’47"E longitude (Fig:1). It has a tropical wet and dry climate bordering on a hot semi-arid climate. The annual mean temperature is 26 °C (78.8 °F). Summers (March–June) are hot and humid. Maximum temperatures often exceed 40 °C (104 °F) between April and June. Winter lasts for only about 2 ^{1}D $_{2}$ months, during which the lowest temperature occasionally dips to 10 °C (50 °F) in December and January. May, the hottest has temperatures ranging from 26 to 38.8 °C. January, the coldest, has temperatures varying from 14 to 28 °C. Heavy rain from the south-west summer monsoon falls between June and September, supplying Rangareddy with most of its annual rainfall of 812.5 mm (32 in). Monthly rainfall distribution of the sampling year (2015) in Rangareddy district is presented in (Fig:2).Geology of area comprises of pink and grey granite rock formations.

Sample Collection

Leachate sample was collected in 1 litre pre-cleaned high density polyethylene bottle (HDPE) with diluted HNO_3 during pre-monsoon and post monsoon (2015) and was stored in the laboratory at 4 C for monitoring purpose within 2 days. Similarly, ground water samples were collected from 12 stations during pre and post-monsoon within 5km radius from the dumpsite employing random sampling method. Geographic locations, latitude, longitude of the sampling points were collected with the help of GARMIN GPS and the details are given in (Table:1). Each of the leachate and ground water samples were analyzed for 8 parameters viz., pH, TDS, TH, CH, Cl^-, SO_4^{-2}, NO_3^- and F^- using standard procedures recommended by[11]. The pH was recorded on site at the time of sampling with digital pH meter (HANNA Inst. Italy). The physico-chemical parameters like Total Dissolved Solids (TDS), Total Hardness (TH),Calcium hardness (CH) and Chlorides (Cl^-) of leachate, and ground water

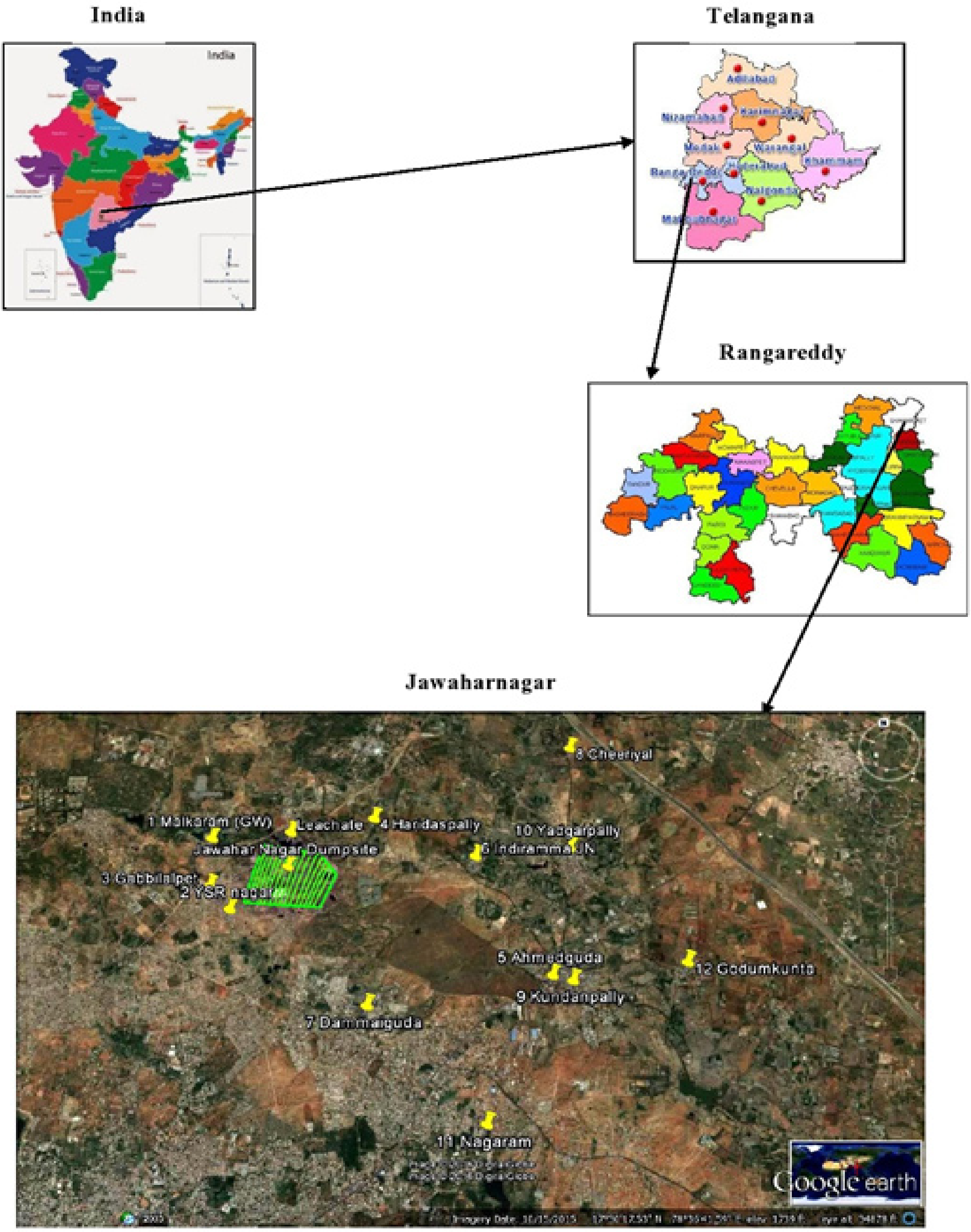


Fig. 1: Location Map of Study Area

samples were analyzed titrimetrically. Chloride was included in the water quality assessment because of its measure of extent of dispersion of leachates in groundwater body[12]. Nitrates and Fluoride determination was carried out using Ion-Selective Electrode (Orion). Sulfates (SO_4^{-2}) in the groundwater samples were analyzed by nephelometric turbidity method.

Calculation of Water Quality Index

In this study, for the calculation of WQI, eight important parameters were chosen. The WQI

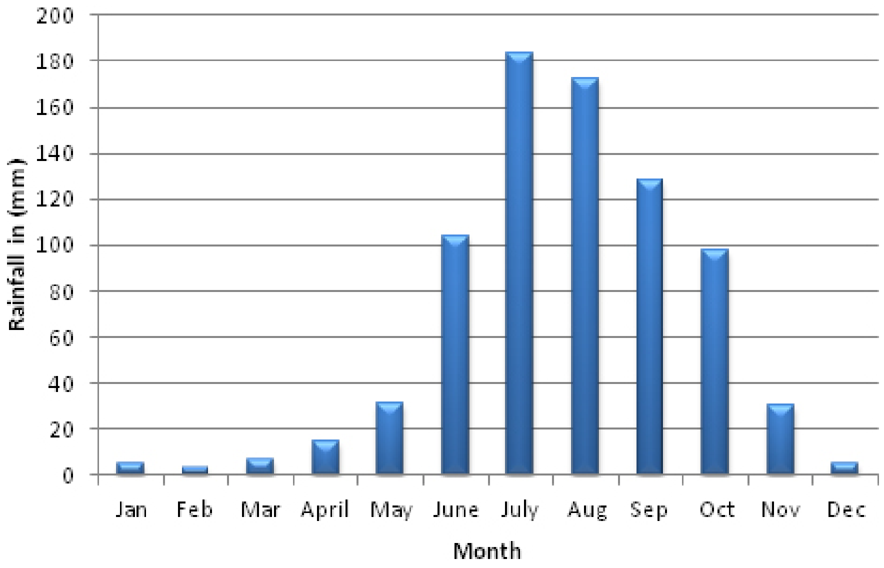
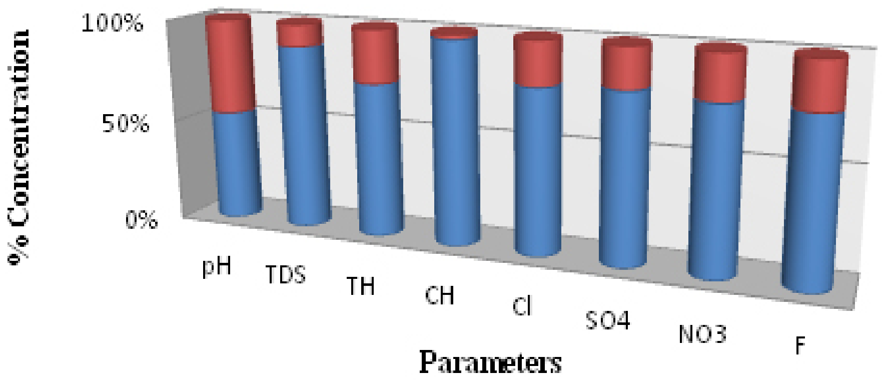


Fig. 2: Monthly Rainfall Distribution of Ranga Reddy District
Source: Ground Water Department, Telangana State (2015)



	pH	TDS	TH	CH	Cl	SO4	NO3	F
Post	8.2	4128	1000	29.4	12266	122	280	0.2
Pre	9.6	35200	2900	1179	45319	500	1012	0.7

Fig. 3: Leachate Characteristics of Jawaharnagar Municipal Open Dumpsite

has been calculated by using the standards of drinking water quality recommended by[13]. The WAI (Weighted Arithmetic Index) method has been used for calculation of WQI of the water samples. Further, quality rating or sub index (q_n) was calculated using the following expression.

$q_n = 100[V_n - V_{io}]/[S - V_{io}]$ ...(1)

q_n = Quality rating for the n^{th} water quality parameter

V_n = Estimated value of the n^{th} parameter t a given sampling station

S_n = Standards permissible value of the n^{th} parameter

V_{io} = Ideal value of the n^{th} parameter in pure water (i.e.,0 for all other parameters except the parameter pH, where it is 7.0).

Unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter,

$W_n = K/S_n$ ...(2)

W_n = Unit weight for the n^{th} parameter

S_n = Standard value for n^{th} parameter

K = Constant for proportionality

Table 1. GEographical Details of the Study Area

S.No.	Sampling Station	Latitude	Longitude	Altitude	Dist (km)
1	Malkaram	17 31 38	78 34 52	1858	1
2	Y.S.R. Nagar	17 31 02	78 34 57	1859	1
3	Gabbilalpet	17 31 01	78 34 45	1877	2
4	Haridaspally	17 31 39	78 35 49	1796	1
5	Ahmedguda	17 30 04	78 37 13	1703	1
6	IndirammaJn	17 31 05	78 36 52	1722	2
7	Dammaiguda	17 30 12	78 35 27	1763	2
8	Cheeriyal	17 31 52	78 37 49	1770	4
9	Kundanpally	17 29 56	78 38 16	1701	4
10	Yadgarpally	17 32 56	78 37 49	1735	4
11	Nagaram	17 29 21	78 36 00	1703	5
12	Godumkunta	17 29 32	78 38 52	1688	5

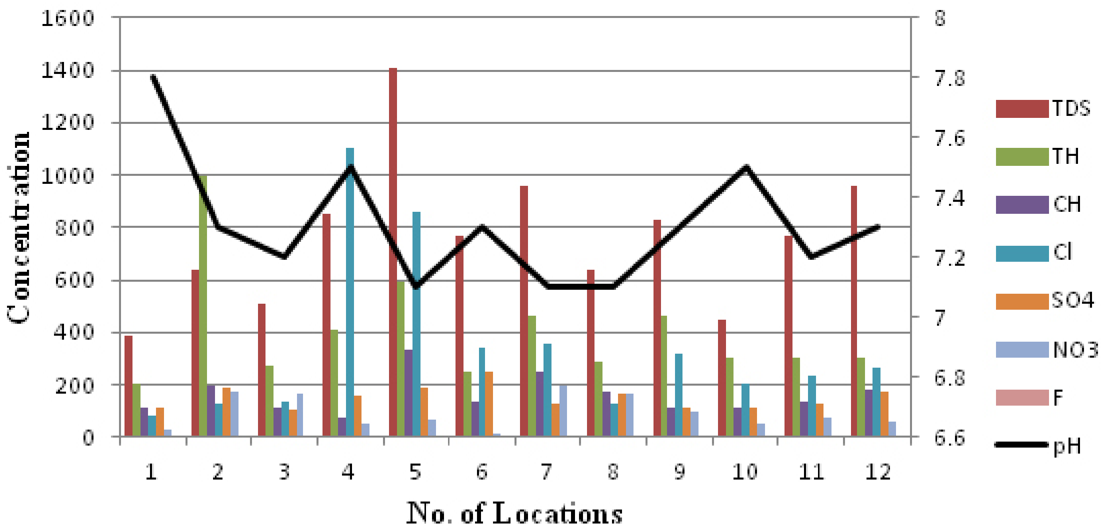


Fig. 4: Physico-Chemical Parameters of Pre-Monsoon Ground Water

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

$$WQI = \Sigma q_n W_n / \Sigma W_n \quad ...(3)$$

The maximum weight of 5 has assigned to the parameters like NO_3^-, TDS, Cl^-, F^-, and SO_4^{-2}, due to their major importance in water quality assessment[14].

RESULTS AND DISCUSSION

Leachate

The physico-chemical characteristics of collected leachate around the dumpsite during pre-monsoon and post-monsoon were analyzed and presented in the (Fig:3). From the figure, it can be observed that pH is highly alkaline in nature. Alkaline pH is normally encountered at landfills, 10 years after disposal[15]. Other analyzed parameters like TDS, TH, CH, Cl^-, SO_4^{2-}, NO_3^- and F^- were found to have higher concentrations in the leachate collected during pre-monsoon season when compared to post monsoon leachate sample. The results were consistent with[16].

Major Cations and Anions

The results of physico-chemical analyses of ground water samples collected during pre-monsoon and post-monsoon of 2015 were shown in (Fig:4) and (Fig:5) and were compared with the World Health Organization (WHO:2006) as shown in (Table:2). The pH values of all the ground water samples collected during pre-monsoon and post-monsoon around dumpsite fall within the WHO (2006) limits indicating the alkaline nature. The TDS value of the ground water samples ranged from 384-1408mg/l during pre-monsoon season and from 528-1280mg/l which exceeded the permissible limits of WHO(2006). Concentration of TDS was maximum during pre-monsoon and reduced during post-monsoon which may be due to the dilution of the ions due to precipitation. Total hardness values of water samples ranged from 205-1000mg/l during pre-monsoon and 199-664mg/l during post-monsoon which were also above the permissible levels of WHO(2006). The calcium hardness ranged from 75-335mg/l during pre-monsoon and 110-499mg/l which were above the permissible levels according to WHO (2006). The chloride values ranged from 78-1100mg/l during pre-monsoon and 50-998mg/l during post-monsoon which were above the permissible levels of WHO (2006). Highest chloride concentration was observed in GW4 station collected during post-monsoon. The high chloride content in groundwater is from pollution sources such as domestic effluents, fertilizers, septic tanks, and leachates[17]. Sulphates of water samples ranged from 16-250mg/l during pre-monsoon and 49-155mg/l during post-monsoon. All samples fall within permissible limits of WHO (2006) Nitrate values ranged from 13-196mg/l during pre-

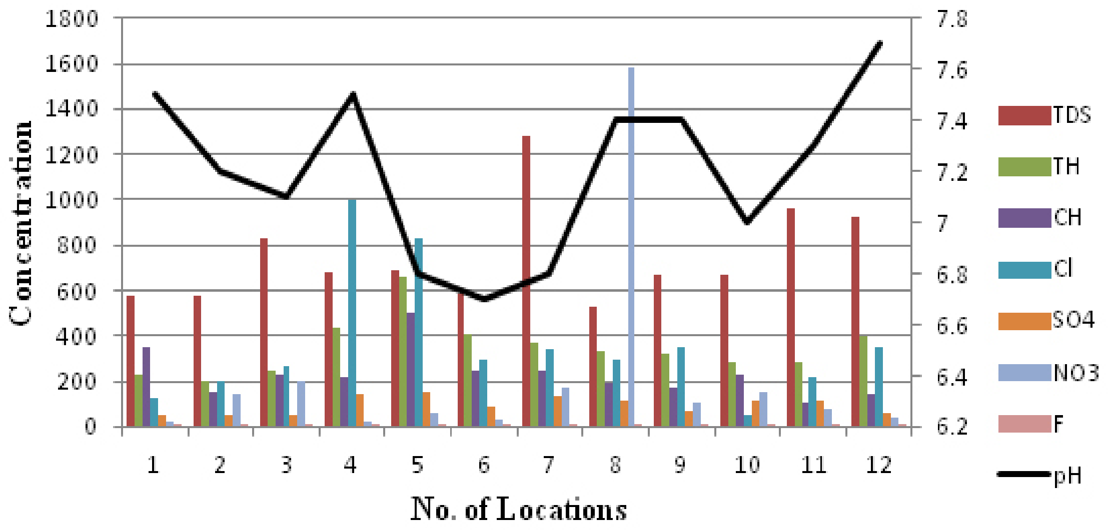


Fig. 5: Physico-Chemical Parameter of Post-Monsoon Ground Water

Table 2: Physico-Chemical & WQI Analysis Of Ground Water (Pre Monsoon & Post Monsoon) And Its Comparison With WHO: 2006

Location	pH		TDS		TH		CH		Cl^-		SO_4^{-2}		NO_3^-		F^-		WQI	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
GW 1	7.8	7.5	384	573	205	225	115	349	78	121	110	49	28	19	1.1	1.5	70.5	92
GW 2	7.3	7.2	640	576	1000	199	195	150	126	202	187	50	174	142	0.9	0.7	165	106
GW 3	7.2	7.1	512	832	275	250	110	225	138	266	106	51	165	204	1.6	1.3	125.8	152
GW 4	7.5	7.5	854	677	410	434	75	222	1100	998	160	146	54	25	1.2	0.9	145	138.2
GW 5	7.1	7.1	1408	690	590	664	335	499	859	827	190	155	70	64	0.9	1	181.2	168.8
GW 6	7.3	7.1	768	582	250	408	135	250	340	295	250	86	13	35	1	0.8	95.5	94.4
GW 7	7.1	7.1	960	1280	465	365	250	250	355	344	124	135	196	168	0.7	0.6	164	159
GW 8	7.1	7.4	640	528	290	335	175	190	128	294	168	114	162	1580	1.6	1.3	135.3	580.7
GW 9	7.3	7.4	832	672	465	323	115	175	319	355	111	65	95	110	1.2	0.7	127	116.3
GW 10	7.5	7.1	448	672	300	285	115	230	202	50	110	115	49	150	0.9	1.9	84.1	134
GW 11	7.2	7.3	768	960	300	285	135	110	231	223	130	117	73	77	1.3	1.1	109	110.7
GW 12	7.3	7.7	960	928	306	400	180	140	263	355	173	56	59	40	1.7	1.6	124.5	120
Min	7.1	7.1	384	528	205	199	75	110	78	50	106	49	13	19	0.7	0.6	70.5	92
Max	7.8	7.7	1408	1280	1000	664	335	499	1100	998	250	155	196	1580	1.7	1.9	181.2	580.7
Mean	7.3	7.3	764.5	747.5	404.7	347.8	161.3	232.5	344.9	360.8	151.6	94.9	94.8	217.8	1.2	1.1	127.2	164.3
WHO:2006	7-8.5	500	200	100	250	250	50	1										

Note: All parameters are in mg/L, except pH monsoon and 19-1580mg/l during post-monsoon. Most of the water samples exceeded the WHO (2006) limits. Alarmingly, highest value was observed in GW8 (1580mg/l) collected in poultry farm present within the study area during post-monsoon which is a point source of pollution. About 50-80% of nitrogen is excreted[18] by the livestock which can be easily leached to the ground water table posing threat to the groundwater resources. In general, other major sources for nitrate in ground-water include domestic sewage, runoff from agricultural fields, and leachate from landfill sites. Higher concentration of NO_3^- in water causes a disease called "Methaemoglobinaemia" also known as "Blue-baby Syndrome". This disease particularly affects infants that are up to 6 months old[19]. Fluoride values of waters ranged from 1.2-1.7mg/l during pre-monsoon and 1.1-1.9mg/l during post-monsoon season. Most of the samples are slightly higher than the permissible (WHO:2006).

Table 3: Computed Average WQI Values Of Pre-Monsoon Ground Waters Around Jawaharnagar Dumpsite

Parameter	WHO: 2006 (Sn)	Weight (Wi)	Relative Weight (Wn)	Observed Value	Standard Value (Sn)	Unit Weight (Wn)	Quality Rating (qn)	Wn*qn
pH	7-8.5	4	0.125	7.3	8.5	0.125	20	2.5
TDS	500	5	0.156	765	500	0.156	153	23.8
TH	200	3	0.093	405	200	0.093	203	18.8
CH	100	2	0.062	161	100	0.062	161	9.9
Cl^-	250	4	0.125	345	250	0.125	138	17.2
SO_4^{-2}	250	4	0.125	152	250	0.125	61	7.6
NO_3^-	50	5	0.156	95	50	0.156	190	29.6
F^-	1	1	0.156	1.2	1	0.156	120	18.7
Total		32	0.998					
						ΣWn=0.998		ΣWn* qn = 136.5

All parameters are in mg/L, except for pH & TDS.

Table 4. Computed Average WQI Values of Post-Monsoon Ground Waters Around Jawaharnagar Dumpsite

Parameter	WHO: 2006 (Sn)	Weight (Wi)	Relative Weight (Wn)	Observed Value	Standard Value (Sn)	Unit Weight (Wn)	Quality Rating (qn)	Wn*qn
pH	7-8.5	4	0.125	7.3	85	0.125	20	2.5
TDS	500	5	0.156	748	500	0.156	150	23.4
TH	200	3	0.093	348	200	0.093	174	16.1
CH	100	2	0.062	233	100	0.062	233	14.4
Cl^-	250	4	0.125	361	250	0.125	144	18
SO_4^{-2}	250	4	0.125	95	250	0.125	38	4.75
NO_3^-	50	5	0.156	218	50	0.156	436	68
F^-	1	1	0.156	1.1	1	0.156	110	17.1
Total		32	0.998			ΣWn=0.998		ΣWn* qn = 164.4

Water Quality Index (WQI)

Water quality index developed for the groundwater samples collected during pre-monsoon and post-monsoon indicated that there is a wide variation from station to station. In this study, WQI values were 136.5 and 164.4 in pre and post monsoon respectively (Table:3) and (Table:4). According to[20], 75% of water samples fall in "Poor" category, 25% fall in "Good" category collected during pre-monsoon. Similarly, 75% of water samples fall in "Poor" category, 16.9% of water samples fall in "Good" category and 18.3% of water samples fall in "Unsuitable" category collected during post-monsoon season (Table:5).

Correlation Analysis Of Pre-Monsoon And Post-Monsoon Ground Water Parameters

Correlation is a method used to evaluate the degree of interrelation and association between two variables[21]. A correlation of 1 indicates a perfect

Table 5: Classification Of Pre-Monsoon And Post-Monsoon Ground Water Quality Based On WQI Value

WQI Value	Water Quality	Percentage of GW Samples Pre Monsoon	Percentage of GW Samples Post Monsoon
<50	Excellent	Nil	Nil
50-100	Good	25%	16.9%
100-200	Poor	75%	75%
200-300	Very Poor	Nil	Nil
>300	Unsuitable	Nil	8.3%

Table 6. Correlation Matrix Of Pre-Monsoon Ground Water

	pH	TDS	TH	CH	Cl^-	SO_4^{-2}	NO_3^-	F^-
pH	1							
TDS	-0.56239	1						
TH	-0.24759	0.297768	1					
TH	-0.59079	0.730952	0.452917	1				
Cl^-	-0.05663	0.66473	0.144608	0.188295	1			
SO_4^{-2}	-0.2597	0.413605	0.242431	0.322037	0.27596066	1		
NO_3^-	-0.59171	-0.01683	0.454436	0.309294	-0.2714739	-0.2306	1	
F^-	-0.10585	-0.17716	-0.43997	-0.3552	-0.2200465	-0.09241	0.021369	1

Table 7. Correlation Matrix Of Post-Monsoon Ground Water

	pH	TDS	TH	CH	Cl^-	SO_4^{-2}	NO_3^-	`F^-
pH	1							
TDS	-0.1574	1						
TH	-0.31802	0.064187	1					
TH	-0.45206	-0.1743	0.617686	1				
Cl^-	0.013082	-0.00072	0.766779	0.38716907	1			
SO_4^{-2}	-0.37461	0.228926	0.658442	0.35664521	0.596911	1		
NO_3^-	0.142199	-0.26452	-0.08622	-0.1554513	-0.12873	0.132874	1	
F^-	0.331722	-0.16816	-0.18182	0.01231033	-0.37028	-0.16887	0.130479	1

positive relationship between two variables. A correlation of -1 indicates that one variable changes inversely with relation to the other. A correlation of zero indicates that there is no relationship between the two variables. Correlation matrix of pre and post monsoon ground water parameters of the study area are represented in (Table:6) and (Table:7). In pre-monsoon season, the influence of TDS on CH and Cl^- were observed to have positive correlation. The positive correlation between TDS and CH(r=0.730) is normal and is responsible to a large extent of calcium hardness of water. Positive correlation of TDS with Cl(r=0.66) is shown in (Fig:6). In post-monsoon season, TH was positively correlated with Cl^-(r=0.766) CH(r=0.617), and SO_4^{-2}(r=0.658) (Fig:7) and (Fig:8). This result indicates that there was great reliance of hardness on calcium, chlorides and sulphates.

CONCLUSION

Municipal landfills and open dumps have been posing a threat to a greater extent by contaminating the surroundings especially the ground water resources. The study reveals that the unconditional dumping of the wastes in Jawaharnagar dumpsite and establishment of inappropriate leachate collecting systems has

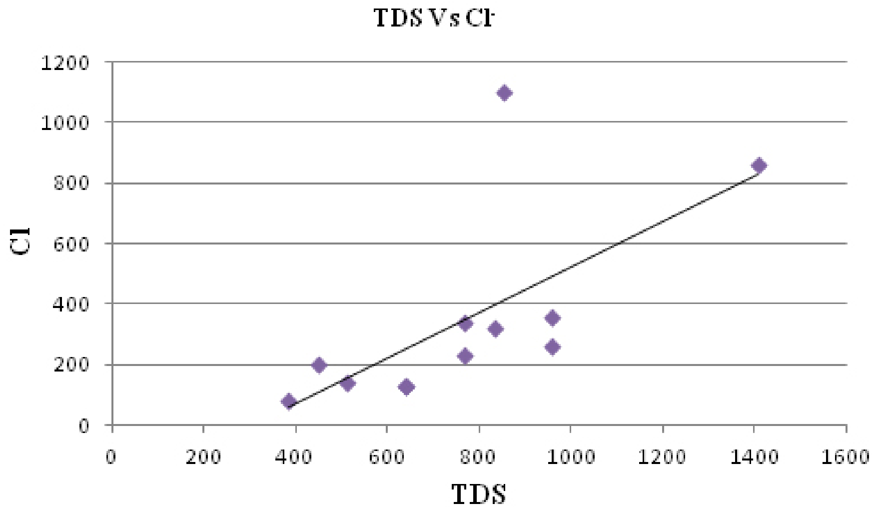


Fig. 6: Correlation between TDS and Cl^- (mg/l) Parameters of Pre-Monsoon Ground Water

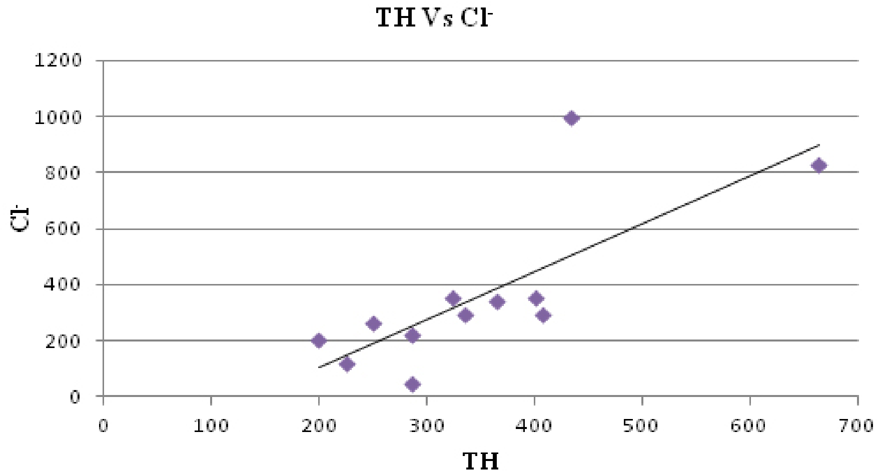


Fig. 7: Correlation between TH and Cl^- (mg/l) Parameters of Post-Monsoon Ground Water

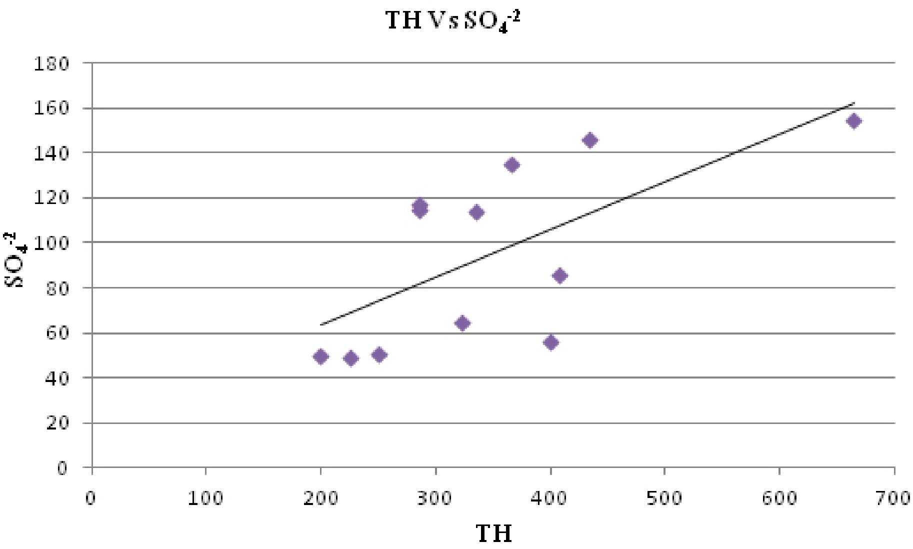


Fig. 8: Correlation between TH and SO_4^{-2} (mg/l) Parameters of Post-Monsoon Ground Water

extremely polluted the ground waters over time. The findings conclude that, most of the water samples were found to be unsuitable for drinking purpose except for few and therefore puts emphasis on enforcement of governmental policies on waste disposal and management, citing of dumpsites far away from residential areas to minimize pollution, waste sorting and treatment before disposal and constructing well engineered landfills to avoid the leachate percolation into the ground waters.

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