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Impact of Municipal Solid Waste disposal on ground water quality near Mathuradaspura-Langadiyawas dumping sites, Jaipur City, India

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A B S T R A C T

Groundwater is a precious natural water resource considered as a readily available and safe source of water for domestic, agriculture and industrial uses. The quality of ground water is of paramount importance. But, many human activities like agricultural pollution, urbanization, industrialization, and improper solid waste management are major source of environmental pollution, deteriorating the quality of groundwater. In this view, present study was carried out to assess the impact of existing landfill sites on ground water quality at Mathuradaspura and Langadiya was at Jaipur, Rajasthan. In order to achieve this,24 well water samples around landfill site at different distance were collected and analyzed for physico-chemical parameters pH, EC, TDS, Total Hardness, Salinity, nitrate & Fluoride along with Heavy metals Zn, Mn, Ni, Fe, Pd, Cd and Cu. Results revealed that the study area is most affected by salinity, high Fluoride and high Nitrate problems. The heavy metal analysis for these samples showed that Ni & Fein some sampling sites are beyond the permissible limit of BIS whereas Pb& Cd were worst affected the quality of ground water in the study area.

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K E Y W O R D S

Groundwater | Municipal Solid Waste | Leachates | Heavy Metal | Environmental Pollution | Water Quality

C I T A T I O N

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Introduction

Water is the most essential thing for life. Though water covers majority of earth's surface but a very small percentage of it is available as fresh water that we can use. The quality of ground water is of paramount importance. In recent years, the risk of groundwater pollution has become one of the most important environment concerns.The improper Municipal solid waste (MSW) management is the major factor for deteriorating groundwater quality around landfill sites.In most of the developing countries, MSW are being dumped on land without adopting any acceptable sanitary land filling practices such as engineered liners, leachate interception and collection system etc. without such, leachate that seeps from a landfill usually percolates through the soil and reaches the groundwater (Mor et al., 2006).This leads to groundwater contamination almost immediately. The leachate generated in such a way has high concentration of toxic substances and pathogenic microorganisms. The concentration of these elements and compounds in leachate and the groundwater surrounding it depends on the composition of wastes dumped (Alker et al., 1995).

Purpose and Scope

During the month of April, 2017 a reference was received from Professor AlpanaKateja, Principal, Maharani College, Jaipur (University of Rajasthan) wherein a request was made to Central Ground Water Board, WR, Jaipur for collaborative studies to explore the impact of dumping of waste on the groundwater quality in Jaipur City under the aegis of UPE "Study of Ecology and Economy of Rajasthan". It was proposed to collect water samples from the nearby areas of two MSW dumping sites i.e. Mathuradaspura and Langadiyawas.

The objective of the study is to assess the impact of these landfill sites on the groundwater quality of surrounding areas. With the knowledge of hydrochemistry, it can be very well checked whether the ground water is suitable or not for domestic and irrigation uses. A total of 24 nos. of samples have been collected from the above sites and analysis has been carried out at CGWB, WR chemical lab.The present paper is based on the outcomes of this study.

Study Area

Jaipur is the capital city of Rajasthan covering geographical area of about 480 square kilometer (sq km) It is bounded by North latitudes 26º44'32" & 27º03'13"and East longitudes 73º35'34" & 73º56'55". The solid waste management of Jaipur city is done by Jaipur Municipal Corporation. The volume of solid waste generated in Jaipur City has increased significantly over time due to population growth and industrial & economic development.The disposal is done at two major disposal sites located outside of Jaipur city in Jamwa Ramgarh block. The Location of the study area is shown in Fig.1 and details are as follows:

A. **Mathuradaspura** This site is located 17 km away in the east direction from the city area at 26º57'10" North latitude and 75 º 55'54" East longitudes. The total area of the site is 0.445 sq km. It is the oldest site for dumping and approximately, 300 to 400 tones per day (TPD) of garbage are being dumped every day at this site.

B. Langadiyawas It is also located in the east direction of the city at 26º35'3" North latitude and 76 º 30'5" East longitudes. This site is about 3-4 km away from the Mathuradaspura. The total area of this landfill site is about 1.22 sq km.

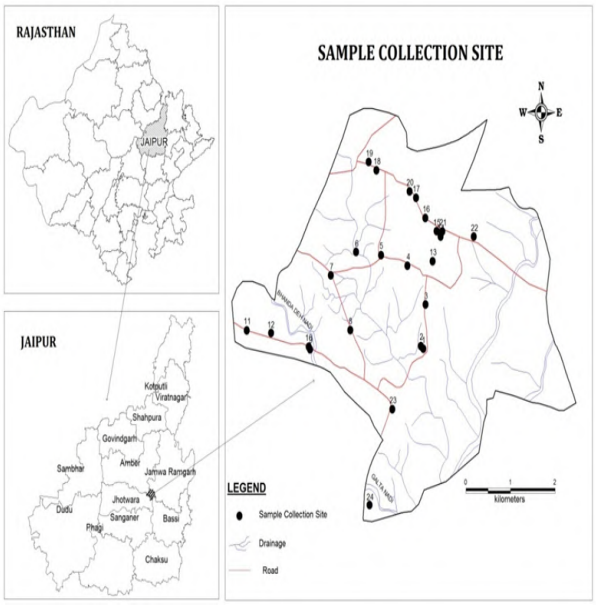


Fig.1 Location map showing sample collection site

Material and Method

Sampling and Analytical methods

A total number of 24 (S1 to S24) samples were collected from two dumping sites Mathuradaspura & Langadiyawas Taluka Jamwa Ramgarh of Jaipur district in April 2017. In same manner 24 (SH1 to SH24) samples also collected for Heavy metal analysis.These were analyzed in laboratory of Central Ground Water Board, Western Region, Jaipur. The water sampling has been carried out following the standard procedures. Good qualities, air tight plastic bottles with cover lock were used for sample collection and safely transfer to the laboratory for analysis.

Analysis were done forphysico-chemical parameters includes pH , EC and the major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^2, Cl^-, HCO_3^-,CO_3^{2-}, $F^-$and NO_3^-) using standard method (APHA, 2012) and Heavy metals i.e. Zn, Mn, Ni, Cu, Fe, Cd &Pb. Temperature, pH & EC was determined at the time of sampling at the site. Bicarbonate analysis was carried out using acid titration method, chloride concentration was measured by $AgNO_3$ titration method and calcium and magnesium by EDTA titration method. Sodium and potassium was analyzed using flame photometer, Nitrate and Fluoride by UV -Visible spectrophotometer. Heavy metals were analysed by Atomic absorption spectrophotometer.The data was subjected to various mathematical and statistical analyses. The ionic balance error for studied ions was within ±5%.The physico-chemical parameters of the analytical results of ground water samples were depicted (Table-1) and compared with standard guideline values recommended by WHO and BIS for drinking water.

Result and Discussion

Physico-chemical Parameters

1.pH

The pH value depicts the balance between acids and bases in water. It controls by carbon dioxide, carbonate and bicarbonate equilibrium. The combination of CO_2 with water forms carbonic acid, which affects the pH of the water. The acceptable limit of pH is 6.5-8.5. The pH values of the groundwater in the study area isvaries from7.05 to 8.46 with a mean value 7.68 indicating slightly alkaline in nature but suitable for drinking purposes.

Sample sites	pH	EC	HCO_3	Cl	SO_4	NO_3	TH	Ca	Mg	Na	K	F
S1	8.2	1600	500	227	60	4	110	20	15	320	2	1.6
S2	7.5	1790	781	192	50	5	200	28	32	356	1	2
S3	7.9	1810	842	192	15	6	130	28	15	400	1	3
S4	7.8	2510	500	532	100	18	260	68	22	470	4	2
S5	7.7	1840	378	362	30	18	420	68	61	208	3	1
S6	7.3	3620	512	987	50	69	950	148	141	450	4	0.8
S7	7.4	3470	976	660	250	7	380	44	66	750	2	1.1
S8	7.5	3310	891	639	220	3	240	28	41	755	2	1.6
S9	7.5	1700	403	305	5	92	650	116	88	85	4	0.6
S10	7.1	2070	378	405	50	115	650	148	68	176	2	0.5
S11	7.2	4527	354	1115	160	425	1190	340	83	550	5	0.8
S12	7.2	2065	220	563	20	95	790	220	58	132	3	0.8

Table 1A:. Physico-chemical parameters of ground water samples around Langariyawas & Mathuradaspura dumping sites

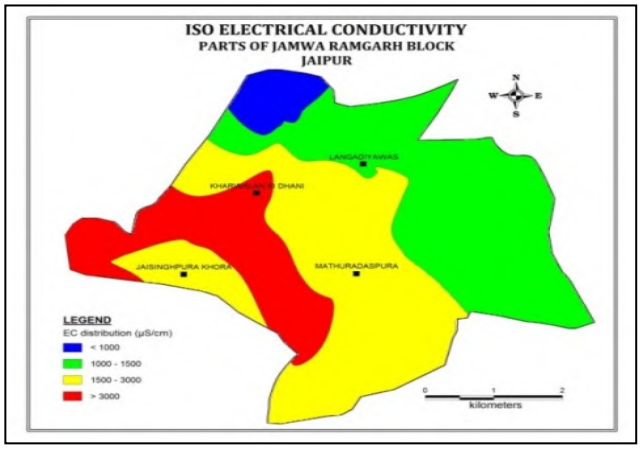
Sample sites	pH	EC	HCO_3	Cl	SO_4	NO_3	TH	Ca	Mg	Na	K	F
S13	8	1688	708	170	10	6	220	32	34	290	1	1.8
S14	7.8	2348	598	461	100	0	380	56	58	395	11	1.3
S15	8.2	1522	683	156	10	30	100	20	13	335	1	1.6
S16	8.1	1391	647	114	5	5	90	16	13	282	1	2
S17	7.9	1287	573	99	40	1	130	20	20	240	2	1.3
S18	7.6	1039	464	64	20	32	140	32	15	174	4	1.3
S19	7.5	850	451	50	25	27	230	36	34	120	2	1
S20	7.9	1410	549	192	15	7	130	28	15	284	2	2.5
S21	8.1	1596	732	142	10	4	120	16	19	322	2	2
S22	8.5	1323	720	71	15	4	90	16	12	290	1	3
S23	7.5	3807	647	859	150	10	390	52	63	705	2	2
S24	7.2	2331	622	355	10	75	530	96	71	255	1	0.9

Table 1B:. Physico-chemical parameters of ground water samples around Langariyawas & Mathuradaspura dumping sites

2. Electrical Conductivity (EC)

Electrical Conductivity is a measure of capacity of water to convey the electrical current and is a function of temperature, type of ions present and concentration of various ions (Walton, 1970). The ground water samples having EC values less than 2000 µS/cm at 25°C is generally considered as fresh water. In the present study, EC values ranged between 850µS/cm to 4527µS/cm with average mean value 2121µS/cm.Highest value of conductivity(4527µS/cm) was found at the sampling sites S11(Annapurna mahadev temple) while the minimum value found at the sampling site S19. Sampling sites S23 (3807µS/cm) at LMNIT university &S6 (3620 µS/cm) Kharwalan ki dhani is somewhat saline in nature, indicate the effect of dumping of solid in the study area as the groundwater quality is slowly deteriorating.From the perusal of the map, the western part of the study area near by locations Annapurna Mahadev Temple & Jaisinghpura Khor quality of groundwater is somewhat saline in nature (Fig. 2).

Fig.2



3. Total Dissolved Solids (TDS)

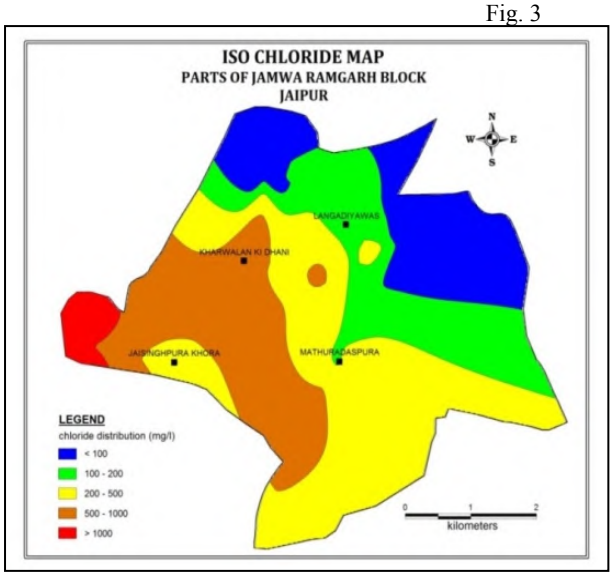
The Total dissolved solids refers to matter suspended or dissolved in water with high content is inferior and may be polluted.In the present study, TDS of study area ranged from 544mg/l to 2897mg/l with an average value 1357.4mg/l. All samples were beyond the acceptable limit (500mg/l) of BIS, which indicate the downward transfer of leachate, that impact, the groundw-

ater quality.

4. Chloride (Cl)

The chloride in ground water may be from diverse sources such as weathering, leaching of sedimentary rocks, domestic & municipal waste and lack of underground drainage system.In drinking water, the acceptable limit of Chloride is 250 mg/l and permissible limit in the absence of alternative source of water is 1000 mg/l as per BIS (2012). The chloride ion in the ground water samples of the study area varied between 50.0 mg/l to 1115.0mg/l with an average value 371.0 mg/l. The map showing distribution of Chloride in study area is represented in Fig.3

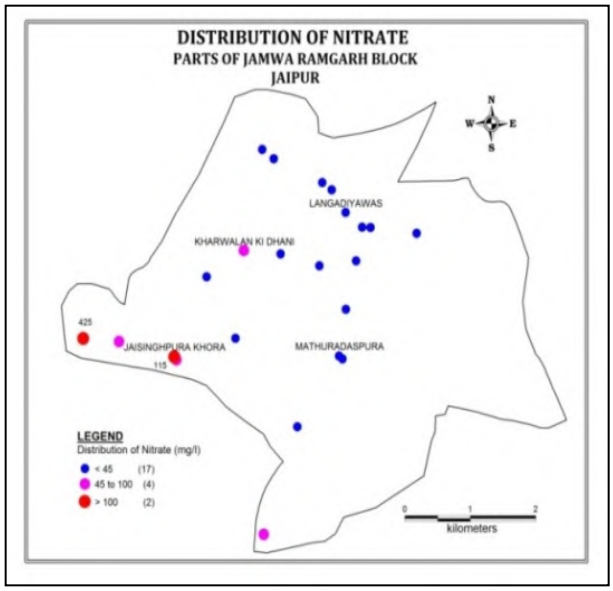
Fig. 3



5. Nitrate (NO3)

Nitrogen compounds are the most widespread contaminant in subsurface environment, mainly originating from non-point and multipoint agricultural sources. Excessive concentrations of nitrate in drinking water cause several diseases, such as methemoglobinemia (blue baby syndrome), gastric cancer, thyroid disease and diabetes. The value of nitrate in the groundwater is observed between S14 (0.0mg/l) (Balayionka Mohalla) to S11 (425mg/l) (Annapurna Mahadev Temple) with average value of 44.0mg/l. To demarcate the pollution by nitrate in ground water a nitrate distribution map was prepared in the following range (i)<45ppm (ii) 45-100 ppm & (iii)>100ppm. From the map it is observed that the high nitrate in study area 45 -100 mg/l&greater than 100 mg/l found in west- southern part, indicating the effect of dumping of municipal solid waste in the study area as the ground water quality is slowly deteriorating (Fig.4)

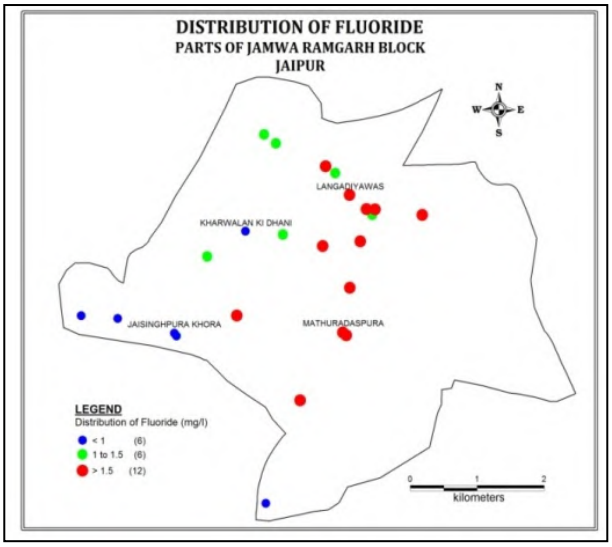
Fig.4



6. Fluoride (F)

Occurrence of Fluoride in ground water is due to geogenic sources but it is also contributed through anthropogenic activities. Higher concentration of Fluoride causes molting of teeth. In study area the value of Fluoride ranges from (0.5mg/l)S10 to (3.0mg/l)S22with average value 1.5mg/l. Out of 24 samples, 16 samples were beyond the acceptable limit (1.0mg/l)of BIS. In Fig. 5

Fig. 5



7. Hardness (TH)

In the present study Total Hardness was found in range of 90 to 1190 mg/l, with an average value 355mg/l. It is observed that total hardness in

ground water in vicinity of landfill sites was higher in concentration. Highest value of hardness (1190mg/l) was recorded at the sampling site S11 same location Annapurna Mahadev Temple while the minimum value (90mg/l) was recorded at the sampling site S22 (Table-1)

8. Calcium and Magnesium (Ca and Mg)

Calcium and magnesium are directly related to hardness of the water and exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride.

During the course of study, Calcium was recorded minimum (16.0 mg/l) at S16 to maximum (340.0 mg/l) at S11 with average value 69.8 mg/l, except two locations (S11) Annapurna Mahadev Temple (340.0 mg/l) &(S12) Block-B JDA building (220.0mg/l) all samples are within permissible limit (200mg/l) of BIS. In case of magnesium, It is observed that, all the samples are within permissible limit (100mg/l) of BIS except one location (S6) Kharwalnki dhani (141mg/l) in the study of Calcium and magnesium are directly related to hardness of the water and exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride. During the course of study, Calcium was recorded minimum (16.0 mg/l) at S16 to maximum (340.0 mg/l) at S11 with average value 69.8 mg/l, except two locations (S11) Annapurna Mahadev Temple (340.0 mg/l) &(S12) Block-B JDA building (220.0mg/l) all samples are within permissible limit (200mg/l) of BIS. In case of magnesium, It is observed that, all the samples are within permissible limit (100mg/l) of BIS except one location (S6) Kharwalnki dhani (141mg/l) in the study area.

9. Sodium and Potassium (Na and K)

The most significant and important source of sodium in groundwater are the precipitates of sodium salts impregnating the soil in shallow water tract, particularly in arid and semi-arid regions. BIS (2012) and WHO have not given any guideline limit for sodium and potassium in drinking water. The value of sodium in present study area ranges from 85mg/l to 755mg/l with average value 347.7mg/l. The occurrence of sodium above the WHO tolerance levels in wells closest to the landfill is an indication of possible leachate flow into groundwater. BIS also has not recommended any norm for potassium. Excessive intake of potassium may have laxative effect. As per the study, potassium concentrations in samples were found in the range of 1mg/l - 11 mg/l. Maximum value of potassium 11 mg/l was found in sampling site (S14) Balaiyonka Mohallah.

Statistical Summary of Results

Basic statistics of the analyzed water quality parameter are summarized in Table 2

The statistical summary of the groundwater hydrochemical parameters of study area Langadiyawas & Mathuradaspura shows that pH of groundwater was alkaline. However, EC was not much high, but few locations have high EC may be due to leachate from landfills. Because of strong correlation between EC and chloride about these locations salinityis also high. The coefficient variance of Nitrate is much high that represents the distribution of nitrate in groundwater was randomand that particular location which have high nitrate was contaminated from a point source. The order of abundance for the cations was found to be Na > Ca > Mg > K and for anions was HCO_3 > Cl > NO_3 > F.

Correlation of Major Ions with EC

The correlation coefficient is commonly used to measure the relationship between two variables. It is simply a measure how well one variable predicts the behavior of the other.The correlation coefficients were computed between all the ions and the correlation matrix is given below in Table3.

S. No	Parameters	Minimum	Maximum	Average	SD	CV%	Acceptable Limit (BIS)	Permissible Limit (BIS)	WHO Permissi-ble Limit
1	pH	7.05	8.5	7.7	0.4	4.9	6.5-8.5	No relaxation	6.5-8.5
2	EC (µS/cm)	850	4527.0	2121.0	957.3	45.1	-	-	1000
3	TH (mg/l)	90	1190.0	355.0	298.6	84.1	300	600	500
4	Cl (mg/l)	50	1115.0	371.3	301.2	81.1	250	1000	200
5	NO3 (mg/l)	0	425.0	44.1	88.2	200.0	45	No relaxation	45
6	HCO3(mg/l)	220	976.0	588.7	184.6	31.4	-	-	-
7	F (mg/l)	0.5	3.0	1.5	0.7	47.0	1.0	1.5	1.5
8	Ca (mg/l)	16	340.0	69.8	77.7	111.3	75	200	75-
9	Mg (mg/l)	12	141.0	44.0	32.3	73.4	30	100	50
10	Na (mg/l)	85	755.0	347.7	187.7	54.0	-	-	200
11	K (mg/l)	1	11.0	2.6	2.1	81.6	-	-	-

Table 2: Statistical parameters of the different chemical constituents of groundwater samples

	E.C.	HCO3	Cl	NO3	TH	Ca	Mg	Na	K	F
E.C.	**1.000**									
HCO3	0.091	**1.000**								
Cl	**0.964**	-0.143	**1.000**							
NO3	**0.522**	-0.484	**0.573**	**1.000**						
TH	**0.670**	-0.532	**0.790**	**0.800**	**1.000**					
Ca	**0.577**	-0.611	**0.696**	**0.911**	**0.941**	**1.000**				
Mg	**0.659**	-0.300	**0.753**	0.465	**0.869**	**0.649**	**1.000**			
Na	**0.781**	**0.598**	**0.634**	0.041	0.074	0.000	0.165	**1.000**		
K	0.269	-0.333	0.362	0.234	0.375	0.328	0.359	0.052	**1.000**	
F	-0.265	**0.557**	-0.388	-0.466	-0.679	-0.581	-0.676	0.198	-0.350	**1.000**

Table 3: Correlation Matrix of the hydrochemical parameters.

It shows the interrelationship between variables, a very high positive correlation exists between EC-Cl (r=0.964), TH-Ca (r=0.941) & Ca- NO3 (r = 0.911)and high positive correlation exists betweenTH-Mg (r=0.869), TH-NO3 (r =0.800), TH-Cl (r =0.790), Mg-Cl (r = 0.753) & EC-Na (r = 0.781). A moderate positive correlation exist between Ca-Cl (r = 0.696), EC-TH (r =0.670), EC-Mg(r = 0.659), Ca-Mg (r = 0.649) Na-Cl (r = 0.634), Na-HCO3 (r = 0.598), EC-Ca (r = 0.577), Cl-NO3 (r = 0.573), HCO3-F (R = 0.557) & EC-NO3 (r = 0.522). This suggests that EC, salinity& TDS are controlled by these ions Ca, Mg, Na and Cl are the most abundant ion in water.

Heavy Metal

A brief discussion on Heavy metals of Langadiyawas & Mathuradaspura dumping sites: 24 groundwater samples (SH1 to SH24) were collected from the study area for seven major heavy metal analysis and their results have been presented in Table 4.

Zn & Mn: In present study area, the value of Zn & Mn varied from .0033mg/l to 3.724mg/l with mean value 0.232 mg/l and 0.0 mg/l to 0.1744 mg/l with mean value 0.014mg/l respectively. However, no one groundwater sample have Zn & Mn value beyond the permissible limit of BIS (Table 3)but, spatial distribution of metal can't be ignored, which showed the impact of leachate from landfills in groundwater.

Cu: During the study Cu fluctuated from 0.0005mg/l to 0.200mg/l with mean value 0.012mg/l. The maximum value was observed at sampling site S11 (Annapurna Mahadev Temple) which is beyond the permissible limit (0.05mg/l) of BIS.

Ni: Nickel concentrations in the groundwater of study area varied from 0.0014mg/l to 0.341mg/l with mean value 0.0289mg/l. From the perusal of map out of 24 samples 08 samples SH6, 7, 8, 9,10,11,12 & 23 were beyond the BIS limit (0.02mg/l). These all locations were situated in west-southern part of study area.

Fe: Iron is the most commonly available metal on earth. During study iron content in ground water samples varied from 0.0mg/L to 1.16mg/L wi-

Parameters (Value expressed in mg/l)							
	Cu	**Zn**	**Ni**	**Fe**	**Mn**	**Cd**	**Pb**
Acceptable limit (BIS:2012)	**0.05**	**5.0**	**0.02**	**0.3**	**0.1**	**0.003**	**0.01**
Permissible limit (BIS:2012)	**1.5**	**15**	**No relaxation**	**No relaxation**	**0.3**	**No relaxation**	**No relaxation**
Sample sites							
SH1	0.0018	0.0042	0.0094	0.0049	0.0017	**0.0036**	**0.0248**
SH2	0.0023	0.0067	0.0127	0.004	0.0016	**0.0037**	**0.0263**
SH3	0.0021	0.0049	0.0139	0.007	0.0013	**0.0047**	**0.0287**
SH4	0.008	0.0034	0.0055	0.0014	0.0005	**0.0034**	**0.0133**
SH5	0.0021	0.0058	0.0137	0.00852	0.0031	**0.0058**	**0.0346**
SH6	0.0048	0.0195	**0.0296**	0.0262	0.0248	**0.0095**	**0.0542**
SH7	0.0051	0.0099	**0.0252**	0.0177	0.0035	**0.0075**	**0.0424**
SH8	0.0049	0.0086	**0.0223**	0.0144	0.004	**0.0074**	**0.0363**

Table 4A: Heavy metal parameters of ground water samples around Langariyawas & Mathuradaspura dumping sites

Parameters (Value expressed in mg/l)							
	Cu	**Zn**	**Ni**	**Fe**	**Mn**	**Cd**	**Pb**
Acceptable limit (BIS:2012)	**0.05**	**5.0**	**0.02**	**0.3**	**0.1**	**0.003**	**0.01**
Permissible limit (BIS:2012)	**1.5**	**15**	**No relaxation**	**No relaxation**	**0.3**	**No relaxation**	**No relaxation**
Sample sites							
SH9	0.0129	1.644	**0.032**	0.2065	**0.1744**	**0.0082**	**0.0727**
SH10	0.0035	0.0137	**0.0206**	0.0146	0.0058	**0.0077**	**0.045**
SH11	**0.2002**	3.724	**0.051**	**1.1645**	0.0761	**0.0142**	**0.1037**
SH12	0.0122	0.0049	**0.0241**	**0.609**	0.013	**0.0033**	**0.0493**
SH13	0.0018	0.0077	0.0063	0.0034	0.0	**0.0063**	**0.0302**
SH14	0.0063	0.0054	0.0136	0.0089	0.0024	**0.0041**	**0.0387**
SH15	0.0014	0.0042	0.0045	0.0028	0.0003	0.0025	**0.0179**
SH16	0.0014	0.0033	0.0069	0.003	0.0019	0.0013	**0.0252**

Table 4B: Heavy metal parameters of ground water samples around Langariyawas & Mathuradaspura dumping sites.

Parameters (Value expressed in mg/l)							
	Cu	**Zn**	**Ni**	**Fe**	**Mn**	**Cd**	**Pb**
Acceptable limit (BIS:2012)	**0.05**	**5.0**	**0.02**	**0.3**	**0.1**	**0.003**	**0.01**
Permissible limit (BIS:2012)	**1.5**	**15**	**No relaxation**	**No relaxation**	**0.3**	**No relaxation**	**No relaxation**
Sample sites							
SH17	0.0013	0.0482	0.0071	0.0002	0.0021	**0.0042**	**0.0263**
SH18	0.0102	0.0054	0.0138	0.0529	0.0111	**0.0058**	**0.045**
SH19	0.0005	0.0067	0.0014	0.0	0.0024	0.002	**0.0227**
SH20	0.0015	0.0064	0.0081	0.0027	0.0013	**0.004**	**0.0281**
SH21	0.0012	0.0055	0.0099	0.0026	0.0011	**0.0042**	**0.0309**
SH22	0.0006	0.0131	0.0069	0.0	0.0016	**0.0037**	**0.0269**
SH23	0.0046	0.011	**0.341**	0.0179	0.0029	**0.0098**	**0.0502**
SH24	0.0025	0.0094	0.014	0.0102	0.004	**0.0058**	**0.0437**

Table 4C: Heavy metal parameters of ground water samples around Langariyawas & Mathuradaspura dumping sites.

h average value 0.0909mg/l.

From the perusal of map, out of 24 groundwater samples 22 samples were within the limit, one sample(SH12) from Block-B, JDA Building have iron 609 µg/l is beyond the acceptable limit of BIS(0.3mg/l), another one water sample(SH11) from Annapurna Mahadev Temple (1.1645mg/l) is beyond the permissible limit of WHO(1.0mg/l).

Fig. 6

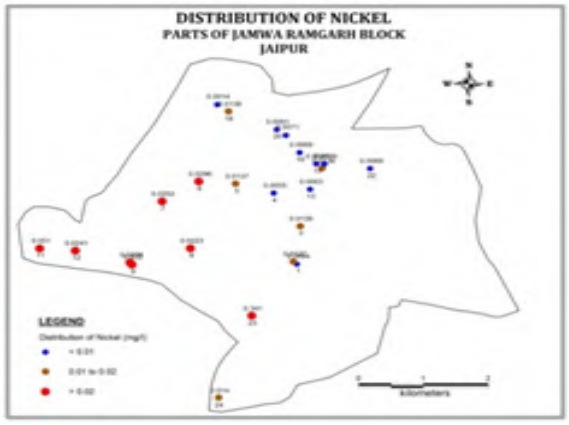
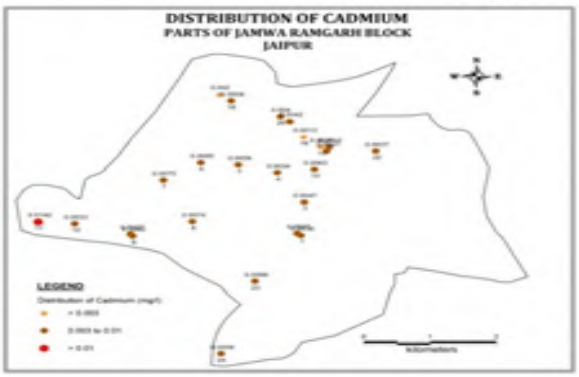


Fig. 7

Pb & Cd: Both Lead & Cadmium are highly toxic metals and they should normally be present only in traces. In the present study the levels of lead and cadmium in all collected sample were found to be very high than their maximum permissible limits of BIS, i.e. (0.01mg/l) & Cd (0.003.0mg/l) respectively. The concentrations of lead in groundwater samples ranged from 0.0133mg/l to 0.1037mg/l with mean value 0.0382mg/l. The maximum concentration of lead was found at Annapurna MahadevTemple(SH11) Similarly, the cadmium value ranged between 0.0013mg/l to 0.0142mg/l with mean value 0.0055mg/l. The maximum concentration was found again at same location Annapurna Mahadev Temple. From the perusal of both maps the distribution of concentrations of lead and cadmium is almost similar that showed that sources of contamination of both heavy metals are same. This could be as a result of disposal of solid waste containing garbage of lead- cadmium batteries, industrial effluents & old plumbing at this dumping site.

Fig. 8

Fig. 9



Correlation of Heavy Metals

The correlation coefficients were computed between all the heavy metals and the correlation matrix is given below in Table 5.

A fairly very high positive correlation was exist between Cu-Zn (r = 0.923) & Cu-Fe (r = 0.899). A high positive correlation exist between Cd-Pb (r = 0.854), Fe-Zn (r = 0.851), Zn-Pb (r = 0.832), Fe -Pb (r = 0.785) and Cu-Pb (r = 0.762). A moderate positive correlation exist between Zn-Mn (r = 0.699), Pb-Mn (r = 0.693), Zn-Cd (r = 0.668), Cu-

Cd (r = 0.650) & Fe-Cd (r = 0.540). The results showed that the influx of leachates through the water flow is gradually affecting the groundwater particularly that of Pb, Cd, Fe & Zn. Specially Pb and Cd is extremely high. Inter-elemental analysis of the metals showed the strong and positive correlation with all the metals are from the same source which may be coming from the dumpsite.

Zn-Pb (r = 0.832), Fe-Pb (r = 0.785) and Cu-Pb (r = 0.762). A moderate positive correlation exist between Zn-Mn (r = 0.699), Pb-Mn (r = 0.693), Zn-Cd (r = 0.668), Cu-Cd (r = 0.650) & Fe-Cd (r = 0.540). The results showed that the influx of leachates through the water flow is gradually affecting the groundwater particularly that of Pb, Cd, Fe & Zn. Specially Pb and Cd is extremely high. Inter-elemental analysis of the metals showed the strong and positive correlation with all the metals are from the same source which may be coming from the dumpsite.

	Cu	Zn	Ni	Fe	Mn	Cd	Pb
Cu	1.000						
Zn	0.928	1.000					
Ni	0.079	0.069	1.000				
Fe	0.899	0.851	0.066	1.000			
Mn	0.399	0.699	0.040	0.457	1.000		
Cd	0.650	0.668	0.445	0.540	0.475	1.000	
Pb	0.762	0.832	0.285	0.785	0.693	0.854	1.000

Table 5: Correlation Matrix of the heavy metal parameters

Conclusion

Based on the results, it can be concluded that Municipal solid waste dump-site at Mathuradaspura and Langariyawas, Jaipur has adversely affected the groundwater. The concentrations of physico-chemical parameters i.e. EC, TDS, TH, F, NO3, Na and Cl were very high in concentration in some sampling sites (S6, S11, S16, S22, & S23).Similarly many of the sampling sites were contaminated by Ni and Fe heavy metals, whereas about all sampling sites having Pb, & Cd beyond the acceptable limit and there is no relaxation as per BIS norms. Hence, in the vicinity of landfills ground water is found to be not suitable for drinking and other domestic purposes. Therefore there is aneed to have an effective management program of existing open dumping site and the landfill to control the environmental pollution.

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