ASSESSMENT OF GROUNDWATER QUALITY IN AND AROUND JAMALPUR MUNICIPAL SOLID WASTE LANDFILL SITE AT LUDHIANA, PUNJAB, NORTHERN INDIA.

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Abstract: Increase in municipal solid waste at an alarming rate has complicated the health problems due to improper disposal in the context of Indian scenario. The purpose of the study is to assess the impact of landfill site on groundwater in Ludhiana region, occupied by Indo-Gangetic alluvium. Physico-chemical parameters (TDS, BOD, COD, TS, electrical conductivity, pH, chloride, hardness, alkalinity), of groundwater samples with their standard methods prescribed by APHA were analysed from different locations in Jamalpur region in Ludhiana. Presence of heavy metals (Cd, Pb, Cr and Ni) were also analysed. Result suggest that there was high concentration of heavy metal (Lead range 0.08 mg/L to 0.14 mg/L, Cadmium range 0.0033 mg/L to 0.0037 mg/L and Chromium range 0.0197 mg/L to 0.0653 mg/L for all the site samples) such as cadmium, lead and chromium. Hardness (263 mg/L to 582.56 mg/L for all the site samples) was also above the permissible limit as per WHO. Slight amount (2.79 mg/L to 6.26 mg/L) of BOD was also present in the samples and considerable amount (70 mg/L to 160 mg/L) of COD was present in the samples. The study emphasise on the proper management of landfill site so as to reduce the further contamination of groundwater.

Keywords: Groundwater, Indo-Gangetic alluvium, Landfill site, Leachate, Municipal Waste.

Introduction: Rapid urbanization and industrialization in India lead to an increase in the waste generation rate becoming major threat to the human health and surrounding environment (Central Public Health and Environmental Engineering Organisation 2013 Report). The generation of waste in urban area is more as compared to the rural area due to changing life style. Generation of municipal solid waste per day for the major cities in India (CPCB report 2004-2005 with the assistance of NEERI) is shown in fig 1. The annual generation of municipal solid waste estimated to be 150000 MT in the country (Indian Ministry of Urban Development, Central Public Health and Environmental Engineering Organisation 2013 Report). Presently 1000 tonnes/day is dumped in Jamalpur region of Ludhiana. Very few areas are equipped with door to door collection facility even by municipal corporation in India and most of the waste is thrown on the open land or unused plots. Land dumps are commonly being used by the municipal corporation to throw the waste. Moreover the country has very few properly working engineered landfills [1]. Lack of proper disposal methods lead to the contamination problem in all spheres including water, air and soil [2]. The major effect of the land dump is on the groundwater due to the infiltration of the leachate produced by the municipal solid waste contaminating the groundwater [3-5]. The study is being carried out to analysis of ground water quality which is being used for drinking purpose which can cause the major health problems in the surrounding area.

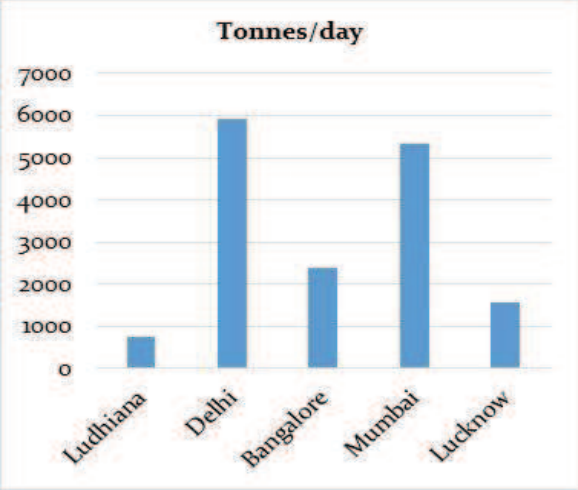


Fig 1. Municipal Solid Waste generation rate of major cities in India

Material and Methodology: Study Area: Ludhiana, a major industrial area of Punjab with high population and area is selected. The municipal corporation limit of city is spread over an area of 141 sq. Km. with population estimated as 34,87,882 in 2011 [6].The land of Ludhiana region is occupied by Indo-Gangetic alluvium with latitude 30°55',longitude 75°54' and height AMSL as 247 m [7]. The maximum and minimum mean temperature is 29.8°C ± 0.57°C, and 16.5°C ± 0.83°C respectively while the annual rainfall is 750 ± 236.8 [8]. The city is divided into four zones with respect to waste collection and dumping. The waste was dumped in jainpur for zone 1, 2 and 3 while zone 4 waste was dumped in jamalpur landfill site however currently jainpur landfill site is exceeded from its capacity so the waste from all the four zone is dumped in jamalpur region [9].

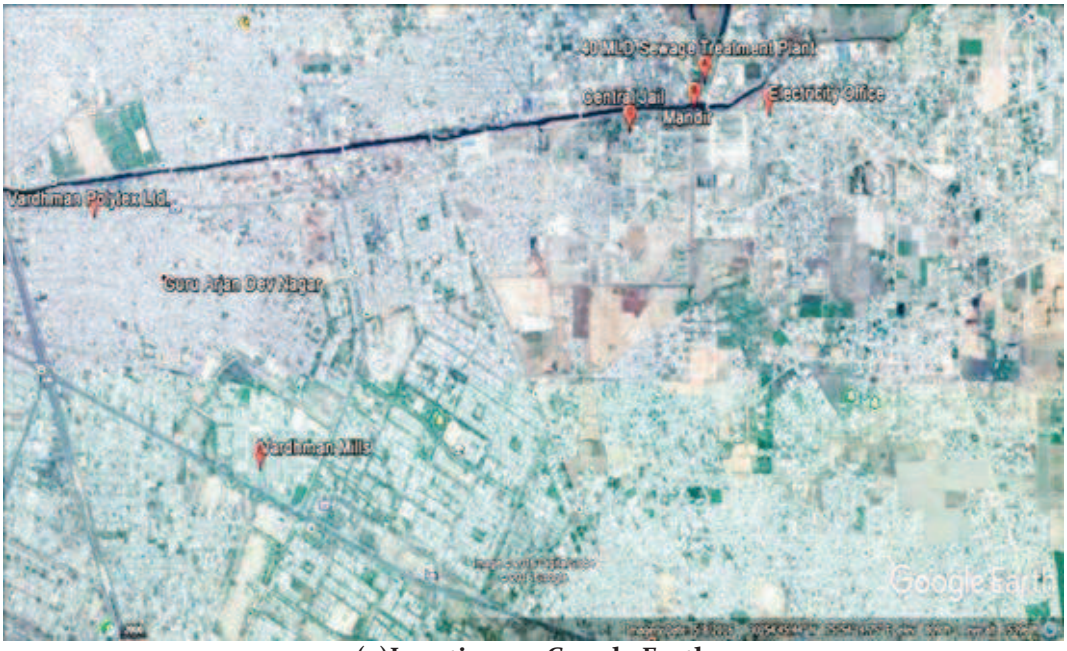
Jamalpur region has the waste reducing facilities being installed by A2Z Infrastructure Pvt Ltd Company (Official Website of Punjab Pollution Control Board www.ppcb.gov.in/municipalsolidwaste.aspx) in 2011 but now JBR Technologies Pvt Ltd is working for A2Z Infrastructure Pvt Ltd Company. The plant was established in 2013 but started operation in 2015. Presently total waste generation in Ludhiana is estimated to be 1000 Tonnes/day.

Detail of land dump site

Location	Land Area (acres)	Average depth (ft)
Jamalpur landfill site	64	8 to 10

(1)

Fig 2. Jamalpur Landfill site



(4)Location on Google Earth

Table 1. Description of sampling site

Sampling Site	Description
Ga 1.	40 MLD Treatment Plant
Ga 2.	Electricity Office
Ga 3.	Temple
Ga 4.	Ludhiana Central Jail
Ga 5.	Vardhman Mills

Sampling: Groundwater samples were taken from five different places near Jamalpur landfill site as described in Table 1. The samples were collected in polythene bottles from five sampling site. The location of the sampling points was recorded using google map. The water samples were taken from bore wells of the respective site from November 2016 to January 2017 [1], [10] and [11].

Sampling was done during the winter season from November 2016 to January 2017. The area selected is the major industrial zone in Punjab. All the procedure for various parameters are followed from standard method for examination of water and wastewater APHA [12]. Physio-chemical Analysis: TDS, pH and EC by multi parameter analyser (Agilent technologies 3200M Multi Parameter Analyser), Hardness and chloride by titrimetric method, Total Solids by gravimetric method, BOD is carried by winkler's method, COD is carried in closed reflux digester (Hach model no 2895805) Heavy metals (Cd, Pb, Cr, Ni) presence were determined through AAS (Model no Agilent 240AA, In Environment Laboratory Civil department, Guru Nank Dev Engineering College Ludhiana.

Result and Discussion: The average ± standard deviation of various physico-chemical groundwater quality parameters are shown in Table 2. pH is an indicative parameter for hydrogen ion concentration. There is no such impact of pH found over health [13]. But highly alkaline water may cause skin and eye irritation. The prescribed range of pH in potable water is 6.5 to 8.5 as per BIS 2012 [3] and is 6.5 to 9.5 as per WHO 2006 [13]. The pH for groundwater sample of study area was found to be in the range of 7.17 to 7.67 thus it is safe for drinking as far as pH is concerned. High value of electrical conductivity shows the presence of inorganic compounds mainly in the form of anion and salts [14]. The value of electrical conductivity varies between 541.98 µS/cm to 989.95 µS/cm which within the permissible limit i.e 1000 µS/cm as per WHO[15]. The range of total dissolved solid was found to be in the range 352.87 mg/L to 767.53 mg/L for all the sampling sites. All the samples are within the permissible limit followed by BIS 2012 [3] but the value of TDS in four out of five sampling sites are above the acceptable limit. High value of TDS lower the palletability of water as well as causes gastro intestinal irritation in humans and laxative effect particularly upon transits (WHO 1997) [11].High value of TDS results to the colour, taste and odor in water [14].Electrical conductivity cannot be used for the measurement of TDS as it only gives the approximation but not exact result [16]. Total solid is collective parameter of total dissolved solids, total suspended solids and total fixed solids. Total solid of the sampling site was in the range of 763.68 mg/L to 4138.57 mg/L. Total solid of four sites were more than 1500 mg/L which is not acceptable according to WHO 2006 [13].

Table 2. Physico-Chemical Parameters of the samples

Sr No.	Parameters	Sampling Points					BIS*Ref(3) Drinking Water Specification IS:10500:2012		WHO* Drinking Water Specification Ref(13)
		Ga 1	Ga 2	Ga 3	Ga 4	Ga 5	Acceptable Limit	Permissible Limit in the absence of alternative source	
1.	pH	7.36±0.02	7.26±0.09	7.41±0.14	7.66±0.10	7.45±0.03	6.5-8.5	No relaxation	6.5-9.5
2.	EC[a]	785.56±40.3	944.22±45.73	839.67±15.97	548.67±6.69	872.44±85.47			
3.	TDS[b]	622.11±49.29	749.67±17.86	658.11±5.71	403.44±50.57	679.33±56.64	500		1200
4.	Total	1612.78±79.92	4051.56±85.98	1521.67±134.76	860.67±96.99	1389.67±297.04		2000	
5.	Solids	3.56±0.17	2.95±0.39	3.13±0.28	0.89±0.43	6.82±0.46	250		250
6.	Chloride	4.33±1.54	4.41±1.61	4.54±1.79	4.57±1.69	4.37±1.61		1000	
7.	BOD[c]	93.33±23.09	133.33±23.09	160±0	120±40	120±40			
8.	COD[d]	414.44±107.95	484.44±98.12	443.33±109.77	370±107	397.78±122.66	200		500
9.	TH[e]	255.56±117.06	281.11±92.12	252.22±93.65	193.33±86.89	203.33±85.44		600	
	CH[f]								

EC[a] - Electrical Conductivity in µS/cm; TDS[b] - Total Dissolved Solids in mg/L; BOD[c] - Biological Oxygen Demand in mg/L; COD[d] - Chemical Oxygen Demand in mg/L; Chloride in mg/L of Cl^-; TH[e] - Total Hardness in mg/L as $CaCO_3$; CH[f] - Calcium Hardness in mg/L as $CaCO_3$.

BOD and COD are important parameters to check the contamination of water due to organic matter which can provide active site for microorganism and pathogens which harms the human health [13]. Value of BOD and COD for the sampling site were 2.79 mg/L to 6.26 mg/L and 70 mg/L to 160 mg/L respectively. So the BOD to COD ratio is varies from 0.03 to 0.07 which indicates the high nonbiodegradable organic matter which may found its way from leachate of landfill site [17] since no other potential cause is identified in the study area. Excess amount of Cl^- in water is taken as an index of pollution and it is tracer for groundwater contamination [10]. The permissible value for chloride as Cl^- is 1000 mg/L while the acceptable limit is 250 mg/L. High amount of Cl^- is problematic for people suffering from cardiovascular and kidney diseases. The chloride as Cl^- was found to be 0.49 mg/L to 7.26 mg/L as Cl^- which insignificant with respect to acceptable limit. The permissible and acceptable limit of total hardness is 600 mg/L as [$CaCO_3$ and 200mg/L as $CaCO_3$ respectively according to BIS 2012 (3]. Higher amount of hardness causes cardiovascular disease while very soft water causes lack of mineral in human [13]. The range of hardness in groundwater site sample was 263 mg/L as $CaCO_3$ to 582.56 mg/L as $CaCO_3$ which is higher than acceptable limit but lower than permissible limit. It should be noted that calcium hardness was in the range of 106.44 mg/L as $CaCO_3$ to 373.23 mg/L as $CaCO_3$ which indicates the temporary hardness hence if water is used after boiling the hardness of water can be bring well within the acceptable limit. The mean ± standard deviation of selected heavy metals in groundwater for different sampling site are shown in Table 3. Based on the cross-sectional epidemiological studies conducted by WHO [13] it was found that there is significant relationship between lead level in blood and intelligence quotient of children and also have harm effect on nervous system. It was also revealed that four to five times more lead is absorbed by infants and children. The acceptable limit without any relaxation is 0.01 mg/L as per BIS 2012 [3] and WHO [13]. The groundwater sample from different site was having the lead content 0.08 mg/L to 0.14 mg/L which is approximately ten times higher than acceptable limit which may be due to the disposal of batteries, lead based paints and a variety of food waste [11]. Cadmium have 10-35 years half-life in human thus it get accumulate in kidney and causes problem in the functioning of renal cortex [13]. The suggest acceptable limit below 0.003 mg/L without any relaxation which is slightly less than the range of cadmium in the groundwater sample of different sites i.e 0.0033 mg/L to 0.0037 mg/L. In future slight high cadmium value can be reported if more e-waste is thrown at landfill site. Epidemiological studies shows an association between exposure to chromium if exposed to respiratory system and it is also active in genotoxicity test either invitro or invivo [13]. BIS recommends the acceptable limit of 0.05 mg/L with no relaxation. Out of five site sample one site sample has higher value than acceptable limit i.e 0.065 mg/L and two site sample have nearby value to acceptable limit i.e 0.0443 mg/L and 0.047 mg/L and two site sample have significantly less value i.e 0.019mg/L and 0.025 mg/L.

Table 3. Heavy Metals of the samples

Sr No.	Heavy Metals (mg/L)	Sampling Points					BIS*Ref(3) Drinking Water Specification IS:10500:2012		WHO* Drinking Water Specification Ref(13)
		Ga 1	Ga 2	Ga 3	Ga 4	Ga 5	Acceptable Limit	Permissible Limit in the absence of alternative source	
1.	Lead (Pb)	0.0807±0.0005	0.113±0.0011	0.1313±0.0011	0.1407±0.0005	0.1303±0.0005	0.01	No relaxation	0.01
2.	Cadmium (Cd)	0.0033±0.0005	0.0037±0.0005	0.0033±0.0005	0.0037±0.0005	0.0033±0.0005	0.003	No relaxation	0.003
3.	Chromium (Cr)	0.0197±0.0025	0.0653±0.0021	0.0443±0.0005	0.0257±0.0021	0.047±0.0020	0.05	No relaxation	0.05
4.	Nickel (Ni)	0	0	0	0	0	0.02	No relaxation	0.02

Remedial Measures for landfill site: The assessment of groundwater clearly indicates the contamination of water in terms of hardness and heavy metals in the nearby can be carried out which can be achieved by the proper management of municipal solid waste vicinity of municipal solid waste site. To prevent the further contamination some remedial measures. The landfill site should be

installed with liner and some collection system for leachate which infiltrate into the soil [10]. Ludhiana landfill is non-engineered landfill and is not equipped with liner and any collection facility for the leachate and also the plant installed is dealing with 1000 Tonne/day waste which is the waste generation in Ludhiana per day from 2015 but the waste which being dumped before 2015 is being not touched by the plant which is the major cause for leachate generation which further contaminate the water. The waste is reduced by the plant in three categories i.e 65% is being used for composting, 25% is used for RDF and 10% is of no use. Further the second plant will be installed by the end of 2017. The feasible measure which can be taken are: The leachate can collected from the heaps of the landfill site and can be recycled so the less amount of leachate infiltrate into the site. By providing the vegetation cover over the landfill so that the evapo-transpiration rate increases which can reduce the leachate generation [10]

Conclusion: Groundwater quality assessment studies was carried out near the landfill site in Jamalpur region of Ludhiana which indicates the contamination of groundwater due to industries waste in landfill as some heavy metals were above the permissible limit of drinking water guidelines values. The study further suggests that the soil and sediments should be monitored near the landfill site for the diseases which are caused by groundwater in that region. The study of leachate should also be carried out as there is agricultural land in the nearby region.

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