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IMPACT OF MUNICIPAL SOLID WASTE LEACHATE ON SOIL AND GROUND WATER QUALITY IN AND AROUND THE CHIDAMBARAM, TAMIL NADU, INDIA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

ABSTRACT

One of the most serious faced today by artificial pollution of an environment which includes soil and water pollution. Water and soil is an essential component for the survival organism. Due to rapid increase in population and industrialization there is increase in solid waste generation and it is disposed by dumping on land. Proper municipal solid waste management is not practiced in Chidambaram. Chidambaram municipality collects the MSW from 33 wards inclusive of village panchayats and dumps in open areas at Thandeswaranalur which is 3kms from the city. These dumping areas are close a fertile land.

This paper aims at study of polluted water and soil due to municipal solid waste in and around the Chidambaram. The quality of ground water and soil of different depths for several parameters of soil like pH, EC, N, P, K and water characteristics such as turbidity, total solids, electrical conductivity, pH, hardness, nitrate, chloride, fluoride and sulphate content estimated.

Keywords: pH; EC; MSW; Organic and inorganic content etc.

1. INTRODUCTION

Solid waste generation and its management has become a growing environmental and public health problem around the world, especially in developing countries where poverty, increased population growth, unplanned urbanization, industrialization and changing consumer habits produce huge amount of solid waste [1]. In most of the developing countries, solid waste is disposed unscientifically in open areas that result in risk to the surrounding environment and human population [2]. Open dumping is the oldest

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and the most common way of disposing solid waste. More than 90% of the Municipal Solid Waste (MSW) generated in India is directly dumped on land in an unsatisfactory manner [3]. During rainfall, precipitation infiltrates the solid wastes which are disposed off on land, mixes with the liquids (That from refuse piles of the waste and leach compounds from the solid waste). This leads to the formation of leachate [4]. Leachate contains innumerable organic and inorganic compounds. Dispersal of leachates poses potential threats to local ecosystems especially to soils and ground waters. The composition of leachate depends upon the nature of solid waste buried, chemical and biochemical processes responsible for the decomposition of waste materials, and water content in total waste. Leachates generated by the MSW in uncontrolled landfills have become a major environmental problem across the globe [5]. Areas near dumping site have a larger possibility of groundwater contamination because of the potential pollution source of leachate generating from the nearby dumping site. Such contamination of groundwater results in an extensive risk to local groundwater users. Once groundwater becomes contaminated, full restoration of its quality is not probably possible in some cases [6]. The continuous degradation of groundwater quality by anthropogenic activities particularly from waste dumpsites, especially nonscientific dumpsites will greatly affect its potability. Similarly, physicochemical, bacteriological and heavy metal pollution of groundwater has a direct impact on human health which leads water-borne diseases such as typhoid, cholera and dysentery [7]. A recent study shows that in most towns, municipal solid wastes are disposed of in open spaces without discriminating major residential areas, roadsides, drainage areas, rivers, riversides, and forests. This leads to the introduction of hazardous substances including heavy metals into water and soil ecology [8, 9]. Therefore, the present study was designed to assess the impact of dumpsites on groundwater quality in the nearby areas of the dumpsite.

2. METHODS

2.1 Study Area

Chidambaram town lies between 11º 23, 38.95''N and 79 º 41'12.88'' Elevation 34 ft and it has population around 56232 and it generates solid waste 16mt/day. Chidambaram municipal solid waste landfill site of about 5.5 acres is located near Thandeswaranalur area on view of 3kms from Chidambaram. It may constitute an environmental impact if the leachate transfers into the groundwater. The accumulation of the wastes at the dump yard includes both degradable (garbage or food waste and paper waste) and non-bio components (plastic, hazardous waste, and other metal containing substance). The arrangement of solid waste includes papers and cartons, food remnants, glass and bottles, plastic and polythene, metals and tins, textiles, rugs, and other minerals. In common municipal solid waste from the dumpsite consisted of 66.8% volatile solids, 14.2% fixed dumps, 20% liquid and 2.2% other compounds. The average biodegradability fraction is 0.92, carbon to nitrogen ratio of 27:1. The percentage composition of waste of contained of organic decomposable waste 33.5%, glass 24.5%, metals 10.9%, and textiles 7.0%, wood 7.6%, and sludge 5.6%. The presence of bore well at the landfill sites threatens to pollute the groundwater. People around the dump yard have reported that the dump yard has become a nuisances for their living. The study also focuses on the plastic impact of solid waste effect on groundwater quality on the physical-chemical parameters. The samples taken from a 500m radius around the dumpsite was collect for the groundwater sampling. Based on the groundwater flow direction 7 groundwater stations were recognized from this area for analysis.6 water samples were collected from the identified sampling locations. From each locations, their water samples were collected for analysis on a monthly basis. Source for water samples were hand pumps.

3. RESULTS AND DISCUSSION

The sampling stations are located around the dump site as shown in Figs. 1, 2, 3, and 4 The dumping area but within the city. The soil and water samples were reported in Table-1. Before collecting the samples bottles were cleaned with sulphuric acid , potassium dichromate and thoroughly rinsed with distilled water and sterilized immediately. The soil collection preservation and analysis were done as per standard methods. The top soil was cleaned and samples were collected from depth up to 0.7m depth and were transferred into polythene bags and transported to environmental engineering laboratory of Annamalai University in Annamalai nagar for physical – chemical analysis.

The study revealed an increase in water temperature along the course of leachate, downstream, and the point near to dump sites. This might be due to differences in altitude and the presence of the effluent released from the open dump site. Higher pH (8.5 ± 0.11) was recorded from the leachate sample as shown in Table 1. This shows that the leachate was alkaline, and this was typical of the sample from aged wastes [10, 11, 12, and 13]. Lower pH was recorded near to dump site and downstream sample sites (8.1 ± 0.11 and 8 ± 0.1), respectively. The higher range of pH indicates higher productivity of water. Other studies conducted in the solid waste dump sites of Nigeria, South Sudan, Sri Lanka, and Ethiopia substantiate this finding which shows slightly basic pH in the nearby stream [9, 13, 14]. However, the mean values of pH in water samples varied between 7.5 ± 0.21 and 8.5 ± 0.1. The limit value prescribed by WHO was between 6.5 and 8.5. (e sample points of leachate and near to dump sites showed higher TDS values than the limit prescribed by the WHO standard (500 mg/l). On the other hand, the sample point of the upper stream recorded lower TDS values. This might be due to the effect of the dump site. The lowest mean value of turbidity was observed in the upper stream sample site (61.6 ± 0.01 NTU) as presented in Table-6 although it was above the limit prescribed by WHO standard value (25 NTU). It might be due to indiscriminate disposal of waste into the water bodies. The higher turbidity in the other sites might be due to the influence of open dump site. The highest turbidity values were observed than those investigated in Jordan dump sites that revealed values between 13.4 and 4.7 NTU and between 40 and 160 NTU, respectively, in the nearby stream and leachate water [15, 16]. A high EC value was observed in leachate sample (391.35 μS/cm) as presented in Table 1 which is indicative of the presence of high amount of dissolved inorganic substances in ionized form in and around solid waste dump site [17]. In addition, the higher value of EC is a good indicator of the presence of contaminants such as potassium and sulfate [11, 18]. When considering the average value of conductivity in the leachate sample, it was concluded that leachate had the high amount of ionizable material.

Box 1. Index-water samples

BORE WATER SAMPLE	DISTANCE FROM YARD in ‘ M ’	DEPTH IN 'FEET'	DURATION BETWEEN MONTHS (2021-2022)
1	13	30	AUGUST' 21
2	20	18	SEPTEMBER' 21
3	45	30	OCTOBER' 21
4	120	100	NOVEMBER' 21
5	109	30	DECEMBER' 21
6	50	50	JANUARY' 22

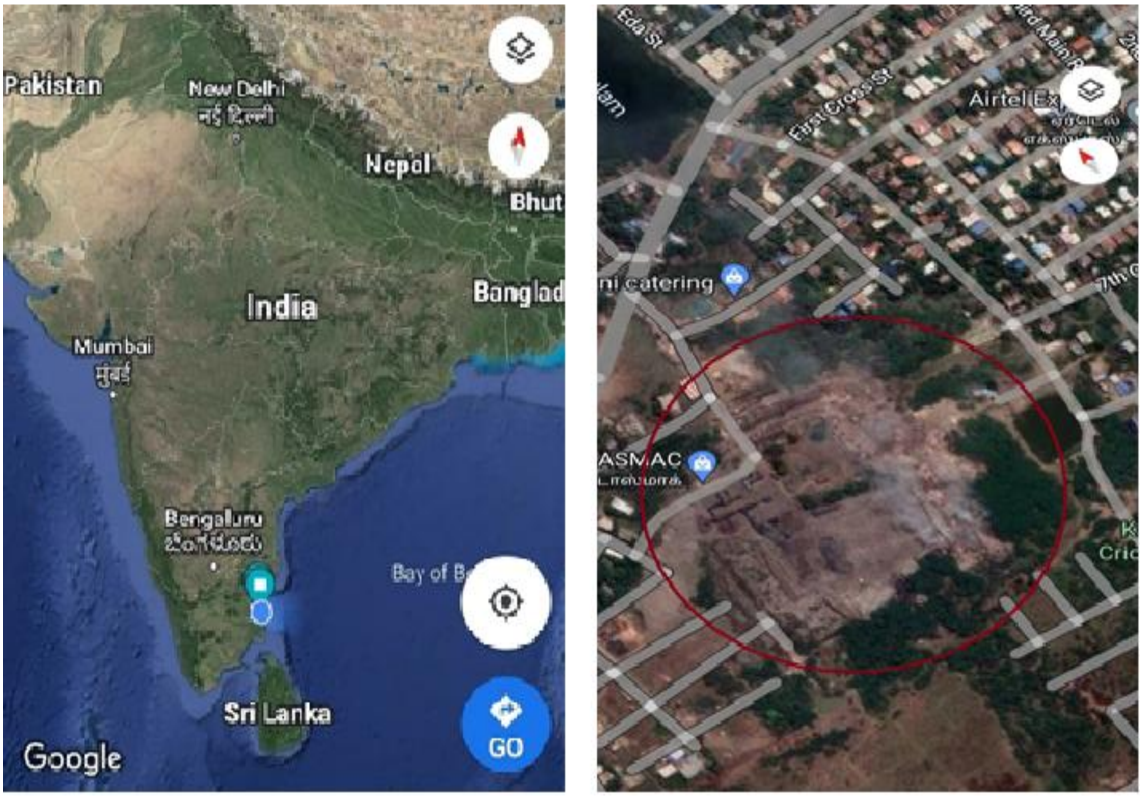

Fig. 1. Map showing study area

Fig. 2. Place of dump site

Fig. 3. Collection of samples

Fig. 4. Collection of samples

Table 1. Soil pH

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	7.7	7.7	7.7	7.7	7.5	7.7
September' 21	7.8	8.2	8.4	8.2	8.6	8.7
October' 21	8.1	8.4	8.3	8.6	8.2	8.4
November' 21	7.7	8.6	8.2	8.4	8.5	8.1
December' 21	7.6	7.8	8.1	8.4	7.5	7.9
January' 22	8.5	8.1	8.2	8.4	7.8	8.7

Table 2. Soil EC (dS/m)

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	0.6	0.4	0.24	0.24	0.4	0.5
September' 21	0.2	0.2	0.29	0.23	0.30	0.32
October ' 21	0.4	0.24	0.40	0.31	0.20	0.36
November' 21	0.23	0.6	0.26	0.29	0.33	0.35
December' 21	0.21	0.43	0.28	0.36	0.33	0.34
January' 22	0.37	0.56	0.48	0.44	0.52	0.58

Table 3. Soil Nitrogen (N) kg/ha

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	45	31	29	46	52	56
September '21	81	56	71	78	56	84
October' 21	62	75	66	60	70	72
November' 21	70	66	47	52	56	72
December' 21	42	56	25	73	66	68
January' 22	79	82	58	78	54	73

Table 4. Soil Phosphorus (P) kg/ha

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	17	14	8	15	15	18
September' 21	15	22	14	23	15	23
October' 21	14	22	17	21	15	25
November'21	21	14	9	11	13	20
December' 21	20	18	10	16	14	24
January' 22	20	13	21	17	12	22

Table 5. Soil Potassium (K) kg/ha

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August’ 21	120	195	85	85	148	188
September’ 21	140	175	200	190	215	219
October’ 21	70	98	110	139	217	200
November’ 21	178	184	160	174	179	196
December’ 21	114	120	75	132	164	172
January’ 22	118	174	112	178	212	206

Table 6. Water Turbidity (NTU)

Months	samples					
	1	**2**	**3**	**4**	**5**	**6**
August’ 21	0	1	1	1	1	1
September’21	0	0	0	0	0	0
October’ 21	0	0	0	0	0	1
November’ 21	0	0	0	1	0	0
December’ 21	0	0	1	1	0	0
January’ 22	0	1	0	0	1	1

Table 7. Total solids mg/l in Water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August’ 21	3100	3400	3100	1644	3360	3184
September’21	3290	3250	3560	3000	3525	3156
October’ 21	2790	1543	3260	1752	2800	2642
November’ 21	2756	2241	3358	1984	3114	2864
December’ 21	3000	3421	3480	1874	3342	3298
January’ 22	2652	2411	3350	1662	2765	3185

Table 8. Electrical conductivity in Water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	2170	2380	2170	1151	2253	2096
September'21	2303	2275	2282	2100	2224	2026
October' 21	1953	1080	2352	1226	2527	2061
November' 21	1980	1884	1972	1201	1760	1765
December' 21	1593	1488	1978	1200	1562	1612
January' 22	2520	1786	2622	1316	2526	2421

Table 9. pH in water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	7.46	7.39	7.50	7.12	7.41	7.36
September'21	7.36	7.52	7.47	7.39	7.46	7.21
October' 21	7.28	7.25	7.38	7.19	7.24	7.53
November' 21	7.27	7.48	7.36	7.12	7.31	7.19
December' 21	7.50	7.42	7.37	7.11	7.37	7.29
January' 22	7.31	7.47	7.52	7.29	7.43	7.46

Table 10. Water Hardness CaCo3 mg/l

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	768	848	764	448	824	798
September'21	888	848	860	756	861	742
October' 21	688	464	852	460	716	569
November' 21	674	453	786	524	732	792
December' 21	681	693	702	647	653	689
January' 22	874	446	789	742	734	886

Table 11. Nitrate in water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	5	8	12	0	6	20
September'21	3	2	5	14	9	8
October' 21	19	3	6	5	14	12
November' 21	16	13	9	6	22	19
December' 21	21	18	11	7	7	6
January' 22	26	19	8	13	23	11

Table 12. Chloride in water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	760	788	872	376	456	723
September'21	728	784	820	448	596	561
October' 21	192	236	800	224	368	416
November' 21	800	452	642	242	712	632
December' 21	729	641	272	464	643	800
January' 22	842	608	481	724	702	750

Table 13. Fluoride in water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	0.2	0.2	0.2	0.0	0.2	0.0
September'21	0.2	0.2	0.2	0.0	0.0	0.2
October' 21	0.2	0.2	0.2	0.0	0.2	0.0
November' 21	0.2	0.2	0.2	0.2	0.0	0.2
December' 21	0.2	0.2	0.2	0.0	0.0	0.0
January' 22	0.2	0.2	0.2	0.0	0.2	0.0

Table 14. Sulphate in water

Months	Samples					
	1	**2**	**3**	**4**	**5**	**6**
August' 21	65	97	94	34	56	74
September'21	36	32	32	52	62	28
October' 21	48	22	112	56	76	86
November' 21	168	46	72	86	116	132
December' 21	141	32	66	94	129	85
January' 22	73	29	181	64	62	43

Chart 1. Comparison samples with soil standards

Samples parameters	1	2	3	4	5	6	Soil standards
pH	W	W	W	W	W	W	6.5 – 7.5
EC	W	W	W	W	W	W	110 – 570 (ms/m)
N	W	W	W	W	W	W	<240 Kg/ha
P	W	W	W	W	W	E	< 22 Kg/ha
K	E	E	E	E	E	E	< 110 Kg/ha

Chart 2. Comparison samples with drinking water standards

Samples parameters	1	2	3	4	5	6	Drinking water standers
Turbidity	W	W	W	W	W	W	5 NTU
Total solids	E	E	E	E	E	E	< 500 mg/l
EC	E	E	E	E	E	E	100-2000 US
pH	W	W	W	W	W	W	6.5 - 8.5
Hardness	E	E	E	E	E	E	600 mg/l
Nitrate	W	W	W	W	W	W	45mg/l
Chloride	E	E	E	E	E	E	250 mg/l
Fluoride	W	W	W	W	W	W	< 1 mg/l
Sulphate	W	W	W	W	W	W	200 mg/l

W - indicates the value within the drinking water standards; E - indicates the value exceeding the drinking water standards

All the six samples collected from different depths of water sources were analyzed and tabulated as shown in Table no (1 to 3) and by no. (1to5) five parameters over a period of six months. The comparison of soil samples with soil standards are shown in chart I. The pH, electrical conductivity and nitrogen obtained from all the soil samples (six) are within permissible limit and potassium values obtained from all samples are exceed permissible limit. The phosphorus values obtained the permissible limit except the samples six and five respectively in the month of October'21 where they exceed permissible value.

All the six samples collected from different depths of water sources were analyzed and tabulated as shown in Table no (6 to 14) and by no (6-14) nine parameters over a period of six months. The comparison of water samples with water quality standards are shown in chart II. The Total solids, electrical conductivity hardness and chloride obtained from all the samples are exceeds limit and drinking standards. The pH, turbidity, nitrate, fluoride and sulphate within permissible limit.

4. CONCLUSION

The soil and ground water quality of Chidambaram was investigated and the results were compared with BIS 10500 and WHO soil characteristics and drinking water quality and standards. the various physicochemical parameters of soil viz, pH, electrical conductivity, nitrogen, phosphorus and potassium, water characteristics viz were reported higher at the all the sampling sites around the dumping yard at the same time few parameters within limit permissible limit the quality water and soil in deep bore wall is not affected by the solid waste leaded from the dump yard and the dump side. The water quality in shallow depth bore walls are affected by one (or) more parameters tested in the laboratory. The quality of water in this deep bore wells is not affected by the effluent discharges from the industries in and around the dump site. The water quality in shallow depth bore wells are affected by one or more parameters tested in the laboratory.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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