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Collection and Treatment of Leachate from Solid Waste Dumps: A Study of Kidwainagar Muzaffarnagar Leachate Landfill Site

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ABSTRACT
Due to high urbanization and population growth, the municipal solid waste generation is also increasing with an alarming rate. In India, Uttar Pradesh is the largest populated state in which Muzaffarnagar is also a rapidly urbanizing and populated city. The annual population rate of Muzaffarnagar is almost double the national average. Muzaffarnagar isan agricultural and commercial hub as it is the Asia's largest supply market of jiggery and sugar. There are many sugar and paper mills and other industries producing large amount of solid waste. The increase on population producing about 2500 tones/ day of MSW out of which only 60-65% are collected by municipal authorities and rest of the municipal solid waste remains untreated and dumped at the empty spaces to form a pile of waste in open landfill Areas. Due to percolation of rain water and squeezing of waste, the leachate generated which causes the surrounding surface water, soil structure gets polluted. In this case study we have discussed about the characteristics of solid waste and leachate generation of Kidwai Nagar Muzaffarnagar landfill leachate site in different meteorological conditions so that the future planning and the proper management of surrounding water bodies and soil structure can be carried out.
Keywords leachate, landfill, Solid waste landfill, Treatment; Chemical coagulant.

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I. INTRODUCTION

Leachate generation is a series problem for municipal solid waste landfills and this leachate pollutes ground water and surface water drastically. Leachate generates due to percolation of rain water and precipitation into landfill sites [1]. The treatment of leachate can be divided into two broad categories: biological treatment techniques and chemical treatment techniques. In the larger systems the combination of these two methods is used. Leachate mainly contains high concentration of metals and hazardous organic chemicals as well as ammonia, nitrogen and chlorinated organic and inorganic salts which causes significant contamination to ground water, surface water and even surrounding soil [2].

II. METHODOLOGY TO BE USED

Landfill are the dumps yards which does not contain the impermeable layer at the top and bottom. All the types of wastes like – industrial, hazardous and bio medical waste are dumped in such kinds of yards. In India, the leachate is disposed at open land area and it is allowed to mix with water bodies and pollutes the surrounding significantly [3].Leachate with high COD ranges from 6000-20000 mg/L, Total solids 24000-50000 mg/L and with high concentration of metals should be disposed and treated properly [4].

In this study, we shall discuss about various leachate treatment processes as: Biological treatment includes aerobic, anaerobic bacteria, adsorption process on activated carbon, reverse osmosis and coagulation methods (with some modification) and their acceptability in Indian conditions will be discussed [5].

LEACHATE AND ITS CHARACTERISTICS

Leachate is a liquid which releases as a residue due to biological, physical and chemical process in the landfill sites. Excess amount of rain water enters in the landfill causes leachate. Leachate contains large amount of organic matter, ammonia, nitrogen, heavy metals, chlorinated organic and inorganic salts which severely contaminates surrounding soil, ground water and surface water [6].

The composition of leachate can be divided into four kinds of pollutants [7]:

i. Specific organic compounds
ii. Inorganic compounds and heavy metals
iii. COD (Chemical oxygen demand)
iv. TOC (Total organic carbon).

TABLE - TYPICAL CONSTITUENTS OF LEACHATE FROM LANDFILLS

TYPE	CONSTITUENT	RANGE (MG/I)	RANGE (MG/I)
	PARAMETER	**MINIMUM**	**MAXIMUM**
Physical	Conductivity	480 mho/cm	72500 mho/cm
	pH	3.7	8.9
Biological	BOD	0	195000
	Fecal Coli form bacteria	0	10
	Total Coli form bacteria	0	100
Organic	TOC	0	45000
	COD	50	99000
	Benzene	2	410
	Chloroform	2	1300
	Methyl ethyl ketone	110	28000
	Delta	0	5
	Toluene	2	16000
	Acetone	170	11000
	Phenol	10	28800
	1,2 dichloromethane	0	11000
	Vinyl Chloride	0	100
	Naphthalene	4	19
Inorganic	Total Dissolved Solids	725	55000
	Total Suspended Solids	2	170900
	Alkalinity	0	20350
	Sulphate	0	1850
	Hardness	300	225000
	Total Kjeldal Nitrogen	2	3320
	Chloride	2	11375
	Magnesium	4	1500
	Potassium	0	3200
	Arsenic	0	70.2
	Sodium	2	6010
	Cyanide	0	6.0
	Lead	0	17.2
	Copper	0	9.0
	Calcium	3	3000
	Mercury	0	3.0

TABLE - CHEMICAL CONCENTRATIONS IN OLD AND YOUNG LANDFILL LEACHATES COMPARING WITH TYPICAL SEWAGE CONCENTRATION [8]

Parameters	Old leachate concentration	Young leachate Concentration	Typical sewage concentration
BOD_5	50-100mg/L	10,000-20,000mg/L	250mg/L
COD	500-3,000mg/L	20,000-40,000mg/L	350mg/L
TOC	100-1,000mg/L	9,000-25,000mg/L	100mg/L
Volatile fatty acids	50-100mg/L	9,000-25,000mg/L	50mg/L

TABLE – VARIOUS PRAMETER OF LEACHATE AT DIFFERENT AGES OF LANDFILL[9]

Parameter	Old	Intermediate	Young
Age (years)	More than 10 years	Ranges 5 to 10 years	Less than 5 years
COD (mg/l)	< 4,000 mg/L	4,000-10,000 mg/L	> 10,000 mg/L
pH	>7.5	6.5-7.5	6.5
BOD_5/COD	< 0.1 mg/L	0.1-0.3 mg/L	> 0.3 mg/L
Heavy metals	Low	Low	Low medium
Organic Compounds	Humic and fulvic acids	5-30% VFA+ humic and fulvic acids	80% Volatile fat acids (VFA)
Biodegradability	Low	Medium	Important

NEED FOR MONITORING

The monitoring of leachate is necessary due to the following reasons:

i. To identify and measure the negative impacts of leachate on environment.
ii. To enquiry and ensure that the landfill is performing according to the designed parameters or not [10].
iii. To know that is a requirement of further investigation or not.
iv. To fulfill the control and monitoring requirements.
v. To identify that the site, threating thehuman health or causes a significant risk of pollution [11].
vi. Compliance of ground water control and trigger level requirements standard should be followed.

LEACHATE TREATMENT TECHNIQUES

Most Commonly landfill leachate treatment methods are as follows:

Physical and Chemical Methods:

Some of the treatment methods used worldwide are discussed as under:

i. Advanced Oxidation Process (AOP).
ii. Adsorption and ion exchange.
iii. Membrane technology.
iv. Coagulation and flocculation.

Biological Treatment Methods:

To eliminate the biological substances as BOD_5 and the part of COD, the biological treatment techniques are very effective in the case where BOD5/COD ratio is less than 0.2, for low organic substances waste the removal efficiency of biological waste up to 50%[12].Biological treatment methods can be briefly classified as follows:

i. Aerobic Bioreactors.
ii. Anaerobic Bioreactors.
iii. Bioremediation.
iv. Phytoremediation.

Combined Treatment Methods

Various Combination of above methods also used for the optimum results for the treatment of highly toxic and hazardous substances described as under [13]:

i. Combined physical/chemical with biological methods.
ii. Combined physical and chemical methods together.
iii. Combined Biological methods together.

Co-treatment of urban waste water and landfill leachate with biological treatment method

To increase the BOD/COD ratio and biodegradability of leachate the treatment authorities mix the domestic water with landfill leachate before treatment and uses a SBR for the co-treatment of a mixture of both landfill leachate and Urban waste water [14].

AN ANALYSIS OF KIDWAINAGAR MUZAFFARNAGAR LEACHATE LANDFILL SITE

INTRODUCTION OF SITE

In India, Uttar Pradesh is the largest populated state in which Muzaffarnagar in a rapidly Urbanizing and populated City. Muzaffarnagar is an agricultural and commercial hub as it is Asia's largest sale market jaggery and Sugar. The vast increase in population and urbanization produces about 2500 tones/day of MSW. Out of which only 60-65% are collected by municipal authorities and rest of the municipal waste remains untreated and dumped at the empty spaces to form a pile of waste in open landfill areas. Due to the percolation of rain water and squeezing of waste, the leachate generated which causes the surrounding surface water, soil structure polluted.

In this study we have discussed about the characteristics of solid waste and leachate

generation of Kidwai Nagar Muzaffarnagar landfill leachate site [15].

LEACHATE SAMPLING

Kidwai Nagar Muzaffarnagar is an open dumping site which does not have any barricading around it. It is a non-engineered low-lying open dump. It does not contain any bottom liner nor any leachate lying collection and treatment system [16]. Leachate collection are not installed at the landfall site. Hence the sampling of leachate from the base landfill is not a big problem. The first phase of case study is performed for eight consecutive days. In each day near about 15-20 kg of waste collected from 16 different vehicles as a source which collects MSW from 10 different locations of Muzaffarnagar. Hence, per day 100 kg of Mixed waste analyzed and, in each day, the composition of Constituents is tabulated. In second phase of this study, the analysis of the waste is conducted in different Meteorological Conditions[17].

FIRST PHASE OBSERVATIONS:

Day wise composition of waste of Kidwai Nager Muzaffarnagar landfill site

Composition of waste	% by mass of weight								
	On 10.02.22	On 12.02.22	On 19.02.22	On 24.02.22	On 28.02.22	On 02.03.22	On 04.03.22	On 12.03.22	Average
Food waste	35.30	27.60	38.15	12.50	19.75	25.25	28.65	16.85	**25.506**
Paper	12.35	11.20	8.40	10.50	6.85	7.45	9.25	10.35	9.544
Plastic	7.00	10.00	6.25	8.55	11.25	5.50	6.25	3.55	7.294
Garden wastes	9.50	7.20	11.50	9.00	15.15	10.50	12.40	19.10	11.794
Wood	1.20	0.60	2.10	0.50	0.35	1.25	0.75	0.65	0.925
Rubber	0.25	0.10	1.40	0.60	0.15	1.35	0.15	1.15	0.644
Leather	0.25	0.15	0.50	0.55	1.35	0.65	0.85	0.60	0.613
Glass	0.50	0.65	2.25	1.45	0.55	0.85	3.25	2.10	1.450
Tin cans	3.45	2.20	1.50	6.25	2.30	4.50	1.75	2.50	3.056
Demolition wastes	11.70	24.30	6.10	16.30	23.40	27.45	15.50	16.00	**17.594**
Textile	2.00	1.90	0.75	2.80	1.75	1.20	5.35	1.40	2.144
Ferrous materials	1.20	2.00	0.50	1.50	2.80	0.65	1.30	1.90	1.481
Special waste*	14.50	11.70	19.50	28.75	12.45	13.25	10.90	23.35	**16.800**
Other misc.	0.80	0.40	1.10	0.75	1.90	0.15	3.65	0.50	1.16
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100.00**

Table- : Average Typical Composition of Solid Waste of Kidwai Nagar Landfill Site

Composition of Waste	**Average % by mass of weight**		
Food wastes	**25.506**	Biodegradable	
Paper	9.544	Biodegradable	
Plastic	7.294	Non-Biodegradable	**Total Biodegradable Wastes = 58.464 %**
Garden Trimmining	11.794	Biodegradable	
Wood	0.925	Biodegradable	
Rubber	0.644	Biodegradable	**Total Non-Biodegradable Wastes = 41.536 %**
Leather	0.613	Biodegradable	
Glass	1.450	Non-Biodegradable	
Tin cans	3.056	Non-Biodegradable	
Demolition wastes	**17.594**	Non-Biodegradable	
Textile	2.144	Biodegradable	
Ferrous materials	1.481	Non-Biodegradable	
Special waste*	**16.800**	Non-Biodegradable	
Other misc.	1.16	Non-Biodegradable	
Total	**100.00**		

SECOND PHASE CONDITIONS:

In the second phase of the case study the study of leachate characteristics is done under the following four Conditions:

i. In first condition, the sample of leachate is taken directly from land fill site, without occurrence of any rainfall condition [18].
ii. In second conditions, the sample of leachate in taken directly from landfill site, with occurrence of rainfall condition [19].
iii. In third condition, the sample of leachate generated in laboratory of without occurrence of rainfall condition [20].
iv. In fourth condition, the sample of leachate generated in laboratory with Occurrence of artificial rainfall is maintained [21].

In laboratory, the artificial rainfall is maintained as under.

Date	**Rainfall in mm/hr.**
12/03/2022	35
28/03/2022	20
02/04/2022	10
14/04/2022	12
22/04/2022	08

SECOND PHASE OBSERVATIONS

1. The results observed in laboratory, When the sample of leachate is taken directly from land fill site, without occurrence of any rainfall condition.

Table-3: Characteristics of raw leachate

Parameters	**Value**
pH	7.47 mg/l
BOD_3 (27 °C)	6500 mg/l
COD	17300 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.375	
TKN	180 mg/l
TS	19220 mg/l
SS	57 mg/l
DS	19,163 mg/l
Total Coliform (E-coli)	3.6×10^5 / 100 ml

2. The results observed in laboratory, when the sample of leachate in taken directly from landfill site, with occurrence of rainfall condition.

Table- : COD-Removal after Alum Treatment

Alum – dosing mg/l	pH	COD mg/l	% removal
100	7.41	16,200	6.36
200	7.38	15,500	10.40
250	7.35	15100	12.72
300	7.33	14600	15.61
350	7.31	13800	20.23

Table- : COD-Removal after Lime Treatment

Lime – dosing mg/l	pH	COD mg/l	% removal
100	7.47	16900	2.31
200	7.58	16300	5.78
250	7.66	15800	8.67
300	7.79	15200	12.14
350	7.83	14800	14.45

Table- : COD-Removal after Lime - Alum Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.43	15,100	12.72
200	200	7.49	14,700	15.03
250	250	7.52	13900	19.65
300	300	7.56	13200	23.70
350	350	7.58	12800	26.01

Table- : COD-Removal after Lime - Alum with Biological Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.43	12,300	28.90
200	200	7.49	11,900	31.21
250	250	7.52	11400	34.10
300	300	7.56	10800	37.57
350	350	7.58	10600	38.73

Table-8 : Characteristics for raw leachates

Parameters	Value
pH	8.30 mg/l
BOD_3 (27 ^{0}C)	1135 mg/l
COD	4432 mg/l
$\frac{BOD_3}{COD}$ ratio $= 0.256$	
TKN	26 mg/l
TS	2535 mg/l
SS	72 mg/l
DS	2463 mg/l
E-coli	3.6 x 10^5 / 100 ml

3. The results observed in laboratory, when the sample of leachate generated in laboratory of without occurrence of rainfall condition.

Table-9: Characteristics for raw leachates

Parameters	Value
pH	7.48 mg/l
BOD_3 (27 ^{0}C)	62 mg/l
COD	320 mg/l
$\frac{BOD_3}{COD}$ ratio $= 0.193$	
TKN	11.3 mg/l
TS	6021 mg/l
SS	895 mg/l
DS	5126 mg/l
E-coli	3.6 x 10^5 / 100 ml

Table-10: COD – removal after Alum Treatment

Alum – dosing mg/l	pH	COD mg/l	% removal
100	7.44	275	14.06
150	7.33	240	25.00
175	7.25	180	43.75
200	7.09	115	64.06

Table-11: COD – removal after Lime Treatment

Lime – dosing mg/l	pH	COD mg/l	% removal
100	7.61	305	4.68
150	7.69	292	8.75
175	7.76	287	10.31
200	7.88	282	11.88

Table-12: COD – removal after Lime – Alum Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.55	245	23.43
150	150	7.57	220	31.25
175	175	7.68	160	50.00
200	200	7.74	93	70.94

Table-13: COD-Removal after Lime - Alum with Biological Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.53	227	29.06
150	150	7.55	196	38.75
175	175	7.61	132	58.75
200	200	7.69	51	84.06

Table-14: Characteristics for raw leachates

Parameters	Value
pH	7.31 mg/l
BOD_3 (27 ^{0}C)	56 mg/l
COD	218 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.193	
TKN	9.5 mg/l
TS	5238 mg/l
SS	998 mg/l
DS	4240 mg/l
E-coli	3.6 x 10^5 / 100 ml

4. The results observed in laboratory, When the sample of leachate generated in laboratory with Occurrence of artificial rainfall is maintained.

III. DISCUSSION OF EXPERMENTAL RESULTS:

After analysis of percentage of compositions of Kidwai Nagar Muzaffarnagar, leachate landfill, we found that the component food waste has highest percentage of waste. The second highest Components isdemolition wastes Thecomponent with minimum percentage is leather.

Some materials like glass, plastic tin, paper and iron are not found in large quantity which indicate that before dumping of waste in landfill the segregation of these items may be done.

It was found this the color of at leachate in each condition is almost same likely to be blackish. From the Observations we found that, without rainfall condition, the BOD, COD, TS, TSS concentration is always high. But, due to rainfall, the concentrations reduces. Only pH increases due to rainfall. By the study of Microbial characteristics, in all type of leachate the Coliform organism count is more than 3.6 X10^5 / 100mL.

IV. CONCLUSION

By the Analysis of above Observation, we conclude that the in leachate treatment, the Anaerobic treatment, performs better than physico-chemical treatments, and also in physico-chemical treatment,the Alum perform better than lime [22].

In Kidwai Nagar Muzaffarnagar leachate landfill site, the characteristics and composition of decomposable waste are approximately 58.464%And for non-decomposable it is 41.536% Which indicates that there is a shortage of land area in future. It is suggested the generation of inorganic waste should be minimum and better to use in any Constructional Projects. After rainfall, the contamination of leachate is low except Coliform count [23].

The Landfill leachate site of Kidwai Nagar Muzaffarnagar is a non-engineered low-lying open dump. It does not have any bottom liner nor any leachate collection system. The age of landfill has a significant effect on leachate Composition. In older landfills, the Biodegradable fraction of organic pollutants in the leachate decreases as an Outcome of the anaerobic decomposition occurring in the landfill.

It has been concluded that leachate samples contains high concentration of organic and inorganic constituents beyond the permissible limits. The measured leachate Samples would need an appropriate treatment strategy to reduce the pollutants to a satisfactory level prior to discharge into receiving system.

Indiscriminate dumping of municipal Solid waste without proper waste solid managementpractices should be stopped or some remedial measures were required to be adopted to prevent contamination.

V. SUGGESTED REMEDIAL MEASURES

At the Base of landfill site, the impermeable linear and proper drainage system should be provided. So that the leachate does not mix with subsoil and does not contaminate it. Also, the leachate collected at the base should be properly recycled, treated or disposed so that it does not pollute the surrounding water bodies [24].

The Leachate generated should be collected and spread over the waste so that some of water present in it will evaporated and reduce the volume leachate for ultimate treatment. Be the effective control on generation, treatment and recycling of leachate, the optimum leachate management can be achieved [25].

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