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ENVIRONMENTAL DEGRADATION AND DETERIORATION OF GROUNDWATER QUALITY AROUND BHALSWA SOLID WASTE LANDFILL SITE, DELHI

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ABSTRACT
Groundwater samples were collected from Bhalswa solid waste landfill site from different locations (East, West, North and South) at less than 1.0 km and up to 2.0 km from the periphery of the landfill site. Leachate samples were also collected from the nearby drain. Entire work was completed in two phases i.e. Pre monsoon season and Post monsoon season. The physico-chemical parameters were analysed from the collected samples to determine the impact of landfill on the groundwater quality
WQI was determined using the values obtained from the following nine parameters i.e. pH, TDS, Hardness, Chlorine, Calcium, SO_4, Nitrate,Zinc, andIron. The study started with preliminary survey, reconnaissance survey, feasibility study, collection and analysis of the water samples and comparing experimental work with Water Quality Index (WQI).
Keywords: Landfill, leaching, groundwater contamination, seasonal variations, water quality parameters, WQI.

I. Introduction

Groundwater, the major source of freshwater in the world, are being overutilized for different uses like drinking, bathing, washing, cleansing, industry, irrigation, domestic, commercial etc. causing depletion of this precious resource. Besides, it is being polluted due to uncontrolled dumping of untreated domestic, industrial, and chemical wastes and percolation of pollutants into the subsurface. The quality of groundwater, consequently, in many parts of the country, particularly shallow subsurface water, is changing rapidly because of human activities. Although, groundwateris less polluted than the surface water because the soil and rocks through which water percolatefilters various bacteria and other pollutants,but still some bacterial and chemical pollutants reach groundwater.The presence of dissolved minerals, organic matters and heavy metals in the groundwater is the result of surface pollutants reaching subsurface soil. Most of them are harmful for human consumption and a few may even behighly toxic in concentration. Also, water dissolvesminerals from the soil and rocks and overground dumped material with which the percolating water comes in contact. Groundwater, therefore, may contain various dissolved minerals and gases that give badodour and are not good in taste as well. The most common dissolved mineral substances found in groundwater are sodium, iron, calcium, magnesium, potassium, chloride, bicarbonate, and sulfate. Contamination of groundwater with excessive amounts of heavy metals such as cadmium, lead, mercury, zinc, and chromium pose serious threat to every ecosystem, humans, and the all living organism.Excessive dissolved matters present in water causes corrosion of the materials thatcomes in contact. Solid waste landfill leachate that infiltrates in the subsurface and surrounding soil also percolates in to groundwater which is highly poisonous and causesadverse impact on living being and environment. So, preventing contamination of groundwater and environmental pollution, alongwith providing access to safe drinking water and sanitation is essential in reducing the spread of many diseases (WHO, 1994; 2001).

Picture: 1 Bhalswa Landfill Site **Picture: 2 Burning of waste at the site**

a) Need to Study

The changed lifestyle where indiscriminate industrialization and urbanization, together with rapid growth in population has brought a tremendous increase in the generation of municipal solid waste. Out of the total waste the inorganic constituents in the wastes have substantially increased, due to which the SWM has severely been affected and has become a global problem today [Khajuria A *et al*. 2011, Bhoyar SP et al. 2014]. Presently, the waste disposal scenario has become a considerable threat compared to earlier times when the waste was primarily organic and could be safely disposed-off in low-lying areas, assimilating into the natural biogeochemical cycles [Beede DN et al. 1995]. Moreover, the rapid increase in industrially-manufactured materials such as metals, glass, plastics, papers, rags, and polystyrene has enhanced the share of inorganic wastes [Mor S et al. 2006].

b) Problems/Limitations Identified

Solid waste landfills site adversely impact subsurface water quality and therefore there is a maximum possibility of poor water quality index. Our study of groundwater adjacent to the landfill sites in the capital city of India (Delhi) confirms this. Different parameters of Groundwater samples were tested and the result shows that almost every parameter is out of range, therefore to improve the groundwater quality it is essential to regularly monitor the quality of water and take necessary action required. Preventing pollution of the groundwater, a precious resource of fresh water, is absolutely crucial for the humanity. All steps should be taken at the government level (municipalties, civic bodies etc) and local population to prevent the damage to the environment.

c) Area of Study

In almost every metropolitan city over dumping of land fill sites are a regular practice and the Bhalswa landfill is no different. It is also an overfilled solid waste dumping site located in Delhi. This site is approximately over 60 m high and covers an area of around 78.5 acre. The site, located at 28°45′ N latitude and 77°11′54″ E longitude (Figure: 1), is a major source of environmental pollution.

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Landfill Location Map of Delhi

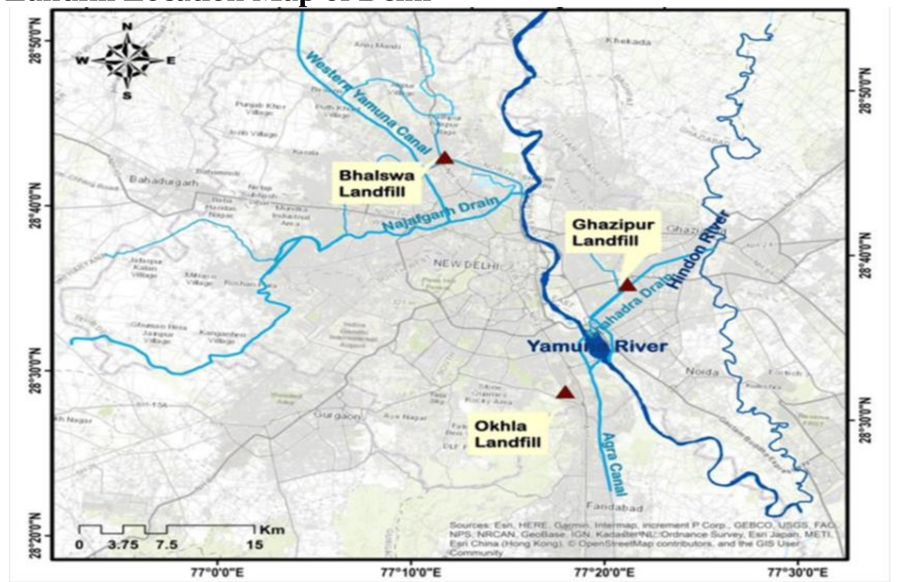

Figure: 1 Solid WasteLandfill Site at Delhi

II. Literature Review

The enormous waste generated in the cities and towns today is a major problem for the civic bodies and the current practice of dumping it in the identified landfill site, a common practice in the modern solid waste management system, still poses threat to environment. The landfill site should be developed considering primarily its impact on environment and the geology of the area. The main geological factors that need to be considered are thickness of the soil cover, lithology of the area, and the depth of groundwater so that the leachate developed at the landfills do not percolate into the water bearing strata [Pipkin, B et al. 2011, Jacobson, G et al. 1981, Tchobanoglous, G et al. 1993, Kungolos, A et al. 2006]. Therefore, proper selection of waste landfill site in accordance with the standard guidelines is the most important aspect in the management of urban solid waste. But the landfills developed generally do not strictly follow the guidelines and the only criteria that isfollowed is a low-laying area away from habitable zone, forest, waterbodies, national parks, and places of important cultural, historical, or religious importance are considered suitable for its development. Where whatever wastes comes from the city is dumped indiscreetly without considering the essential procedure of segregation of wastes. This is badly affecting the environment in the vicinity of the landfill site, besides polluting groundwater by the percolation of leachate into the subsurface [Mallick, J et al.2021]. It is essential therefore that priorto planning and designing of landfill sites environmental issues should be taken care off because landfills badly affect whole environment. In addition, education and awareness are crucial for household waste management and sustainable development [Pérez LE et al. 2021]. There are several papers highlighting problems of waste disposal and developing mechanism of proper solid waste management system. The fuzzy Delphi method identified 146 barriers to attaining sustainable SWM. The most significant ones are household hazardous waste, inadequate research capital, local architecture, lack of staff capability, and standard processes [Bui TD et al.2020]. A strong correlation exists between geographical position and economic status with waste characteristics. It also undertakes LCA models to select appropriate waste management algorithms to evaluate and find a sustainable solution [Das S et al.2019]. The rapid increase of solid waste is due to population increase, urbanization, rapid industrialization, and economic sustainability [Adipah S et al. 2018]. The model was generated utilizing TOPSIS in the GIS environment to develop a suitability indicator for siting the units to minimize fixed and transportation costs and maximize the system's suitability [Asefi H et al. 2017].

Management of municipal solid waste (MSW) is a major environmental concern in India. Appropriate Solid Waste Management System (SWM) involving actions such as waste handling, collection, storage, transport, treatment, and disposal is not followed [CPCB, 2004]. The treatment of waste before its dumping at site is usually not done and therefore the disposed-off untreated solid waste is an environmental hazard. Proper waste collection and transportation is also lacking that results accumulation of waste everywhere in the cities and towns in India. Although Indian Government has taken many steps in this regard but stillfacilities for the treatment of municipal solid waste are insufficient, which adversely impact all components of the environment and human health. The rapid industrialization along with uncontrolled urbanization is aggravating the problem many folds in handling MSW as the system could not cope up with the waste generated. Municipal solid waste management system should include proper collection (prohibiting littering or burning of the waste), segregation, storage (establishing storage facility in accordance with the waste generated), transportation (wastes should be transported in a covered containers to prevent scattering), processing (adoption of technologies to recycle waste to minimize burden on landfills), and disposal of waste (biodegradable waste should be stabilized by composting and other techniques and non-biodegradable waste should only be dumped at the landfill sites to avoid environmental pollution). The efficient management of MSW requires appropriate infrastructure, maintenance, and regular upgrade of all activities as the continuous and unplanned growth of urban centres put tremendous pressure on the existing facilities [Chang N-B et al.2015]. But financial status of the municipal corporations is not stable, hence providing desired level of public service is difficult in the urban centres. In the presentresearch, an attempt has been made to provide a comprehensive assessment of the groundwater condition around a landfill site due to infiltration and percolation of waste and leachate into the subsurface and forecasting projected future status of the problems of MSW landfill sites in major Indian cities.
World Health Organization (WHO) includes domestic refuse, construction debris and street sweepings, non-hazardous institutional and commercial wastes as solid wastes (WHO 2013). The handling and disposal of the solid waste is a major issuefor the WHO world over.It is a common practice since a long time that the biodegradable waste isneutralized by the methods such as composting and decomposing. The use of non-biodegradable materials and manifold increase in the amount of waste generated has amplified the problem. The National Capital of India is inhabited by approximately 16.75 million people [Census of India 2011], which are collectively producing more than 8000 tons of solid waste per day. The solid waste generated is disposed off in three major sanitary landfills in and around Delhi every day namely, Bhalswa Landfill site, Ghazipur and Okhla which were commissioned in 1994, 1984 and 1996, respectively [CPCB, 2004]. These landfill sites are still being used even after being completely saturated that adversely affects environment and hence the concept of sustainable landfill should be implemented.
Greenhouse gas emissions, a major problem today, can be reduced by proper implementation of SWM framework, such as waste-to-energy and material recovery, instead of landfilling [Chen Y-C et al. 2016]. Systems engineering approaches such as systems engineering, industrial ecology, integrated solid waste management strategies, integrated systems planning, design and management, and uncertainty analysis shall be applied to SWM [Allesch A et al. 2014]. Multiple methods for decision-making regarding waste management suggest direction by mass-balance approach, goal-oriented evaluation, and transparent and reproducible presentation of the methodology, data, and results [Marshall RE et al. 2013].
The physico-chemical characteristics of the groundwater near Bhalsawa solid waste landfills has been studied extensively by various government and non-government research groups [Chandrappa R et al. 2012]. The groundwater near the solid waste disposal sites in Delhi, has been found to be heavily contaminated by various heavy metals and inorganic elements [P. Kumari et al.2017, P. Babbar et al. 2017]. It is interesting to note that the biological and especially, microbiological quality of the groundwater in this region has not yet been analyzed adequately. The presence of

microorganisms in drinking water has been correlated with numerous gastrointestinal infections in the population [N. Kamboj et al. 2013].

The review presented in this paper tends to addresses current issues in solid waste handling and management in India and points out areas for further research [M. Zafar et al. 2004, J.P.S. Cabral 2010, Tambekar DH et val. 2005, Hafsa N et al. 2019]. The study identifies numerous barriers to effective management of municipal solid waste. It shows that implementing a systematic approach in MSWM will significantly improve the scenario.

III. Material and Method

The methodology of the study comprises collection and analysis of environmental indicators that gives information regarding potential environmental problems associated with the solid waste landfills sites and its impact on all environmental elements. Besides, it suggests the proper location of landfill sites from city population, its designing aspects as per environmental guidelines, and its maximum capacity to accept the solid waste to be disposed.

a) Various Instruments Used

Experimental setups were used as per BIS:3025 and APHA standardsfor analyzing groundwater quality to ensure best results. Prepared reagents for experimental work and used pH meter, EC meter, Turbidity meter etc.

b) Sample Collection

Water sample were collected at different points and directions and also leachate samples were collected near drain. Collection and transportation of the sample to the laboratory was done following the procedure of the BIS:3025 (Part I) and APHA. Representative samples of leachate were taken from the Drain. The analysis of the collected samples was done at the Environmental Engineering laboratory of the Civil Engineering department of the Rama University, Kanpur, (UP) India and Environmental Engineering laboratory of the Civil Engineering department of the Al-Falah University, Faridabad, (Haryana) India.

c) Permissible limit as per BIS, Indian Standard for Drinking water

In the following Table: 2 and Table: 3 the recommended and the acceptable limit for drinking water quality (as per BIS, Indian Standard code IS:10500:2012) is depicted. The Table: 1 enlists Organoleptic and Physico-Chemical Parameters where as Table: 2 lists out parameters for heavy metals. The values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under ‘permissible limit in the absence of alternate source’, above which the sources will have to be rejected.

Table: 1 Organoleptic and Physico-Chemical Parameters

S. No	Parameter	BIS, Indian standards (1S 10600:1991)		Method of Test
		Desirable limit	Permissible limit	
1.	Colour, Hazen units	5	15	IS 3025 (Part 4)
2.	Turbidity, NTU	1.0	5.0	IS 3025 (Part 10)
3.	pH	6.5-8.5	No relaxation	IS 3025 (Part 11)
4.	Total Hardness (as $CaCO_3$), mg/l	200	600	IS 3025 (Part 21)
5.	Chlorides (as Cl) , mg/l	250	1000	IS 3025 (Part 32)
6.	Free residual chlorine, mg/l	0.2	1.0	IS 3025 (Part 26)
7.	Total dissolved solids, mg/l	500	2000	IS 3025 (Part 16)
8.	Calcium (as Ca), mg/l	75	200	IS 3025 (Part 40)
9.	Sulphate (as SO_4), mg/l	200	400	IS 3025 (Part 24)
10.	Nitrate (as NO_3), mg/l	45	No relaxation	IS 3025 (Part 34)
11.	Fluoride (as F) mg/l	1.0	1.5	IS 3025 (Part 60)
12.	Phenolic compounds (as C_6H_5OH), mg/l	0.001	0.002	IS 3025 (Part 43)
13.	Anionic detergents (as MBAS), mg/l	0.2	1.0	Annex. K IS 13428
14.	Mineral oil, mg/l	0.5	No relaxation	Clause 6 of IS 3025 (Part 39) Infrared
15.	Total alkalinity, mg/l	200	600	IS 3025 (Part 23)
16.	Boron (as B), mg/l	0.5	1.0	IS 3025 (Part 57)

Table: 2 Heavy Metals and Pesticides

S. No.	Parameter	BIS, Indian standards (1S 10600:1991)		Method of Test
		Desirable limit	Permissible limit	
1.	Zinc (as Zn), mg/l	5.0	15.0	IS 3025 (Part 49)
2.	Iron (as Fe), mg/l	0.3	No relaxation	IS 3025 (Part 53)
3.	Manganese (as Mn), mg/l	0.01	0.05	IS 3025 (Part 37)
4.	Copper (as Cu), mg/l	0.05	1.5	IS 3025 (Part 42)
5.	Arsenic (as As), mg/l	0.5	No relaxation	
6.	Cyanide (as CN), mg/l	0.05	No relaxation	IS 3025 (Part 27)
7.	Lead (as Pb), mg/l	0.01	No relaxation	IS 3025 (Part 47)
8.	Chromium (as Cr), mg/l	0.05	No relaxation	IS 3025 (Part 52)
9.	Aluminium (as Al), mg/l	0.03	0.2	IS 3025 (Part 55)
10.	Cadmium (as Cd), mg/l	0.003	No relaxation	IS 3025 (Part 41)
11.	Selenium, (as Se), mg/l	0.01	No relaxation	IS 3025 (Part 56) or IS 15303
12.	Mercury (as Mg), mg/l	0.001	No relaxation	IS 3025 (Part 48)/ Mercury analyser
13.	Total Pesticide, µg/l	Absent	0.001	

IV. Result and Discussion

Different parameters and their dimension for experimental analysis of groundwater were conducted at different interval of time like pre monsoon and post monsoon season and water sample were collect ed at one and two kilometers from the periphery of the land fill site.

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Material and Accessories to Be Used: All apparatus and salts (reagent) were used for conducting water tests as per BIS:3025 and APHA i.e. TDS meter, pH meter, Turbidity meter, Electrical conductivity meter, Chemical analysis by titrimetric methods and Atomic Absorption Spectrometer for heavy metals etc.

a) Pre- Monsoon Season Analysys, Calculation And Result

Site:Bhalswa landfill site at Delhi April, 2023: Analysis and monitoring report (Table: 3) of subsurface water in the vicinity of the solid waste landfill site at different radial distances. Experimental value of the leachate concentration is given in Table: 2. Pie-chart (Figure: 2) of the water quality parameters and Graph (Figure: 3) of the leachate concentration represent the percentile of each parameter.Analysis and monitoring report of underground water in the viscinity of the solid waste landfill site at different radial distances.

Table: 3 Analysis and monitoring report

S.No	Parameters	Less than 1.0 km SL	At 2.0 km SL (sample location)	Desirable limit (IS)
1	pH	7.95	7.60	6.5-8.5
2	TDS (mg/l)	1970	3685	500
3	Turbidity (NTU)	Nil	Nil	5
4	Hardness (mg/l)	465	1210	300
5	Cl (mg/l)	650	2720	250
6	Ca (mg/l)	90	95	75
7	SO_4 (mg/l)	460	915	200
8	Nitrate (mg/l)	38	57	45
9	Fluoride (mg/l)	NF	NF	1
10	Zn (mg/l)	0.91	1.5	5
11	Fe (mg/l)	0.28	0.95	0.3
12	Pb (mg/l)	NF	NF	0.05
13	Cu (mg/l)	NF	NF	0.05
14	Cr (mg/l)	NF	NF	0.05
15	Ni (mg/l)	NF	NF	0.1
16	Cd (mg/l)	NF	NF	0.01

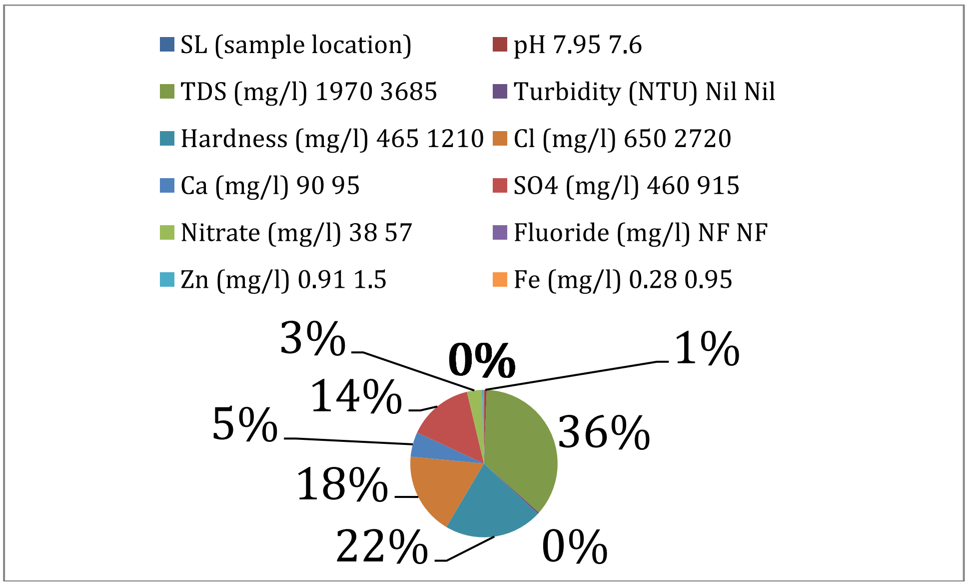

Figure:2 Parameters values

Table: 4 Leachate concentration at Bhalswa landfill site, waste water collected from nearby pond (drain)

S.No.	Parameter	Experimental Value	Typical value (IS)	Remarks
1.	TDS (mg/l)	27300	250-850	Above typical value
2.	pH	7.36	6.5-8.5	Above typical value
3.	EC (MHO/cm)	1492	2250	Above typical value
4.	Alkalinity (mg/l)	2385	50-200	Above typical value
5.	Chloride (mg/l)	1888	30-100	Above typical value
6.	Sulphate(mg/l)	336	200	Above typical value
7.	Nitrate (mg/l)	172	20-40	Above typical value
8.	BOD_5 (mg/l)	1192	50-100	Above typical value
9.	COD (mg/l)	7514	250-1000	Above typical value
10.	Iron (mg/l)	61.5	0.05-0.1	Above typical value
11.	Hardness (mg/l)	6742	50-100	Above typical value
12.	Temp (Celsius)	23°C	------------	------------------------

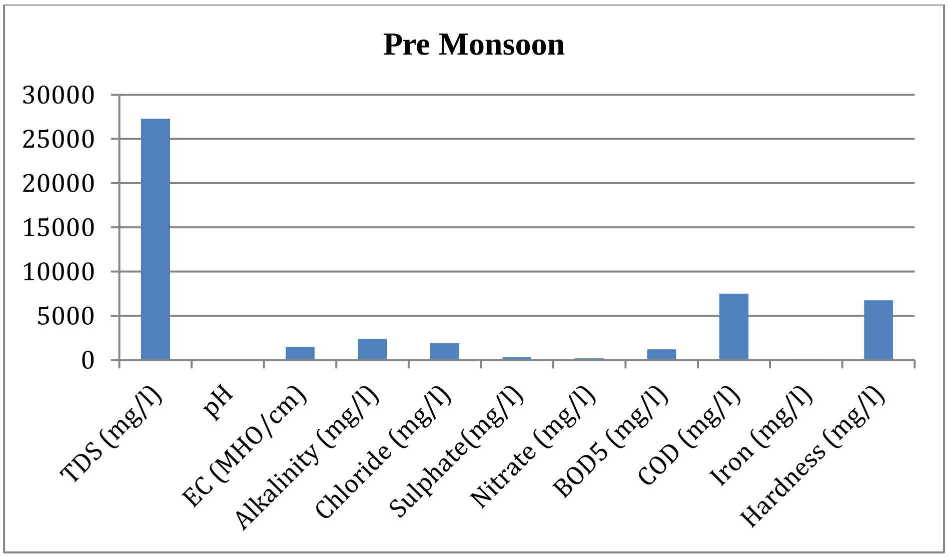

Figure: 3 Graphical representation of leachate

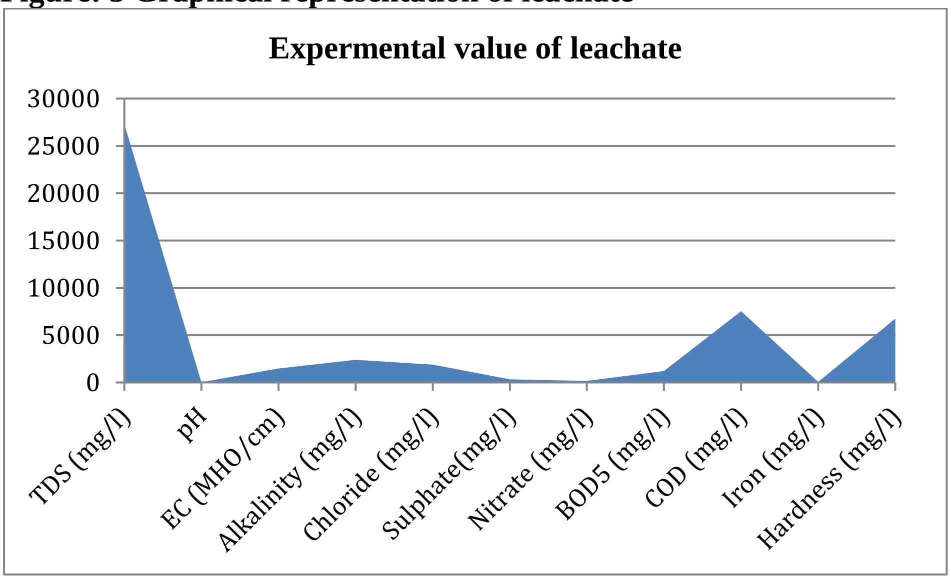

Figure: 4 Pre monsoon Leachate Concentration

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Table: 5 Calculation for Water Quality Index Eastern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.96	8.5	93.65	0.031764706	2.97467128
2	TDS (mg/l)	2120	500	424	0.00054	0.22896
3	Hardness(mg/l)	459	300	153	0.0009	0.1377
4	Chlorine (mg/l)	654	250	261.60	0.00108	0.282528
5	Calcium (mg/l)	92	75	122.67	0.0036	0.4416
6	SO4 (mg/l)	469	200	234.50	0.00135	0.316575
7	Nitrate (mg/l)	38	45	84.44	0.006	0.506666667
8	Zinc (mg/l)	0.91	5	18.20	0.054	0.9828
9	Iron (mg/l)	0.29	0.3	96.67	0.9	87
					Total = 0.999	Total = 92.871
						WQI = 92.94

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 92.94 Very Poor Water Quality

Table: 6 Calculation for Water Quality Index Western side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.95	8.5	93.53	0.031764706	2.970934256
2	TDS (mg/l)	1989	500	397.80	0.00054	0.214812
3	Hardness(mg/l)	445	300	148.33	0.0009	0.1335
4	Chlorine (mg/l)	645	250	258	0.00108	0.27864
5	Calcium (mg/l)	91	75	121.33	0.0036	0.4368
6	SO4 (mg/l)	469	200	234.50	0.00135	0.316575
7	Nitrate (mg/l)	38	45	84.44	0.006	0.506666667
8	Zinc (mg/l)	0.91	5	18.20	0.054	0.9828
9	Iron (mg/l)	0.28	0.3	93.33	0.9	84
					Total = 0.999	Total = 89.841
						WQI = 89.91

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 89.91 Very Poor Water Quality

Table: 7 Calculation for Water Quality Index Northern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	8	8.5	94.12	0.031764706	2.989619377
2	TDS (mg/l)	2120	500	424	0.00054	0.22896
3	Hardness(mg/l)	440	300	146.67	0.0009	0.132
4	Chlorine (mg/l)	635	250	254	0.00108	0.27432
5	Calcium (mg/l)	90	75	120	0.0036	0.432
6	SO4 (mg/l)	463	200	231.50	0.00135	0.312525
7	Nitrate (mg/l)	38	45	84.44	0.006	0.506666667
8	Zinc (mg/l)	0.91	5	18.20	0.054	0.9828
9	Iron (mg/l)	0.29	0.3	96.67	0.9	87
					Total = 0.999	Total = 92.86
						WQI = 92.93

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 92.93 Very Poor Water Quality

Table: 8 Calculation for Water Quality Index Southern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.97	8.5	93.76	0.031764706	2.978408304
2	TDS (mg/l)	2000	500	400	0.00054	0.216
3	Hardness(mg/l)	450	300	150	0.0009	0.135
4	Chlorine (mg/l)	650	250	260	0.00108	0.2808
5	Calcium (mg/l)	89	75	118.67	0.0036	0.4272
6	SO4 (mg/l)	463	200	231.50	0.00135	0.312525
7	Nitrate (mg/l)	38	45	84.44	0.006	0.506666667
8	Zinc (mg/l)	0.91	5	18.20	0.054	0.9828
9	Iron (mg/l)	0.28	0.3	93.33	0.9	84
					Total = 0.999	Total = 89.84
						WQI = 89.91

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 89.91 Very Poor Water Quality

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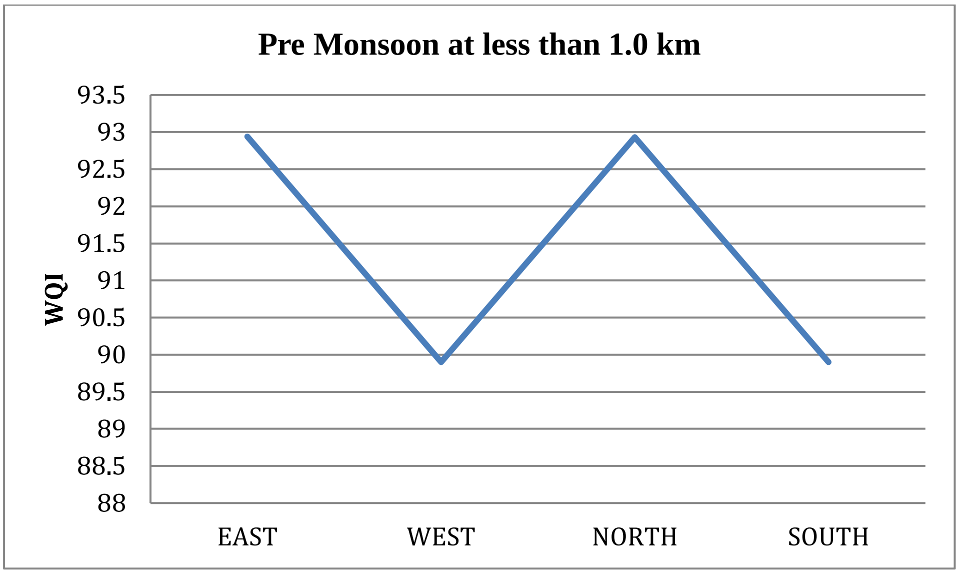

Figure:5 Graphical representation of WQI

Table: 9 Calculation for Water Quality Index Eastern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	PH	7.76	8.5	91.29	0.031764706	2.899930796
2	TDS (mg/l)	3700	500	740	0.00054	0.3996
3	Hardness(mg/l)	1280	300	426.67	0.0009	0.384
4	Chlorine (mg/l)	2720	250	1088	0.00108	1.17504
5	Calcium (mg/l)	93	75	124	0.0036	0.4464
6	SO4 (mg/l)	920	200	460	0.00135	0.621
7	Nitrate (mg/l)	38	45	84.44	0.006	0.506666667
8	Zinc (mg/l)	1.5	5	30	0.054	1.62
9	Iron (mg/l)	0.96	0.3	320	0.9	288
					Total = 0.999	Total = 296.052
						WQI = 296.28

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 296.28 Not fit for drinking

Table: 10 Calculation for Water Quality Index Western side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.8	8.5	91.76	0.031764706	2.914878893
2	TDS (mg/l)	3650	500	730	0.00054	0.3942
3	Hardness(mg/l)	1215	300	405	0.0009	0.3645
4	Chlorine (mg/l)	2715	250	1086	0.00108	1.17288
5	Calcium (mg/l)	90	75	120	0.0036	0.432
6	SO4 (mg/l)	920	200	460	0.00135	0.621
7	Nitrate (mg/l)	42	45	93.33	0.006	0.56
8	Zinc (mg/l)	1.3	5	26	0.054	1.404
9	Iron (mg/l)	0.96	0.3	320	0.9	288
					Total = 0.999	Total = 295.863
						WQI = 296.09

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 296.09 Not fit for drinking

Table: 11 Calculation for Water Quality Index Nortern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.9	8.5	92.94	0.031764706	2.952249135
2	TDS (mg/l)	2000	500	400	0.00054	0.216
3	Hardness(mg/l)	1220	300	406.67	0.0009	0.366
4	Chlorine (mg/l)	2720	250	1088	0.00108	1.17504
5	Calcium (mg/l)	92	75	122.67	0.0036	0.4416
6	SO4 (mg/l)	925	200	462.50	0.00135	0.624375
7	Nitrate (mg/l)	44	45	97.78	0.006	0.586666667
8	Zinc (mg/l)	1.5	5	30	0.054	1.62
9	Iron (mg/l)	0.95	0.3	316.67	0.9	285
					Total = 0.999	Total = 292.982
						WQI = 293.21

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 293.21Not fit for drinking

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Table: 12 Calculation for Water Quality Index Southern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.75	8.5	91.18	0.031764706	2.896193772
2	TDS (mg/l)	3655	500	731	0.00054	0.39474
3	Hardness(mg/l)	1225	300	408.33	0.0009	0.3675
4	Chlorine (mg/l)	2800	250	1120	0.00108	1.2096
5	Calcium (mg/l)	92	75	122.67	0.0036	0.4416
6	SO4 (mg/l)	917	200	458.50	0.00135	0.618975
7	Nitrate (mg/l)	42	45	93.33	0.006	0.56
8	Zinc (mg/l)	1.3	5	26	0.054	1.404
9	Iron (mg/l)	0.94	0.3	313.33	0.9	282
					Total = 0.999	Total = 289.893
						WQI = 290.11

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 290.11 Not fit for drinking

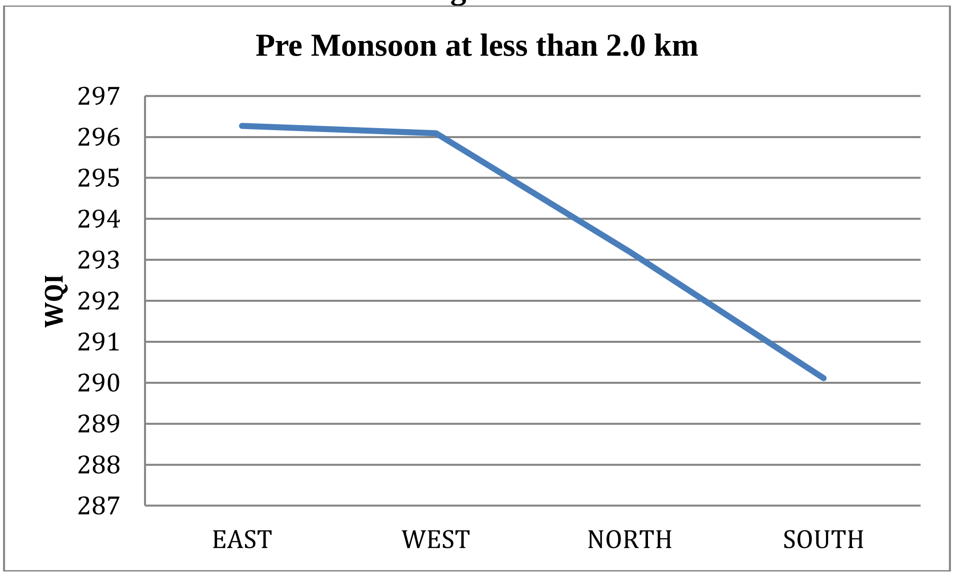

Figure:6 Graphical representation of WQI

b) Post Monsoon Season Analysys, Calculation And Result

Site: Bhalswa landfill site at Delhi,October 2023,Analysis and monitoring report (Table: 13) of subsurface water in the vicinity of the solid waste landfill site at different radial distances. Experimental value of the leachate concentration is given in Table: 14. Pie-chart (Figure: 7) of the water quality parameters and Graph (Figure: 8) of the leachate concentration represent the percentile of each parameter. Analysis and monitoring report of underground water in the locality nearby solid waste landfill site at different radial distances.

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Table: 13 Analysis and monitoring report

S.No	Parameters	Less than 1.0 km SL	At 2.0 km SL (sample location)	Desirable limit (IS)
1	pH	7.93	7.54	6.5-8.5
2	TDS (mg/l)	1960	3680	500
3	Turbidity (NTU)	Nil	Nil	5
4	Hardness (mg/l)	450	1200	300
5	Cl (mg/l)	640	2715	250
6	Ca (mg/l)	88	92	75
7	SO_4 (mg/l)	460	915	200
8	Nitrate (mg/l)	38	57	45
9	Fluoride (mg/l)	NF	NF	1
10	Zn (mg/l)	0.91	1.5	5
11	Fe (mg/l)	0.28	0.95	0.3
12	Pb (mg/l)	NF	NF	0.05
13	Cu (mg/l)	NF	NF	0.05
14	Cr (mg/l)	NF	NF	0.05
15	Ni (mg/l)	NF	NF	0.1
16	Cd (mg/l)	NF	NF	0.01

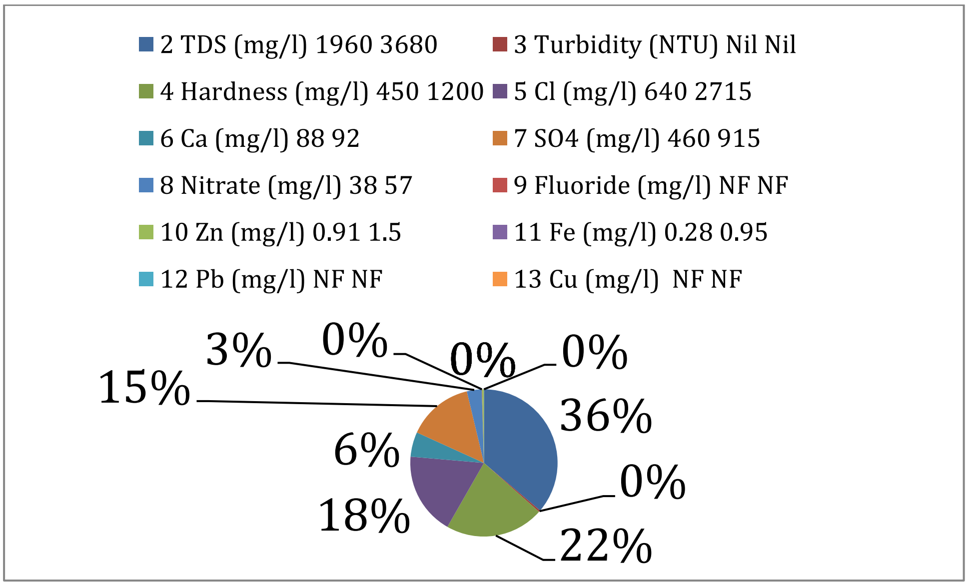

Figure:7 Parameters values

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Table:14 Leachate concentration at Bhalswa landfill site, waste water collected from nearby pond (drain)

S.No.	Parameter	Experimental Value	Typical value (IS)	Remarks
1.	TDS (mg/l)	24200	250-850	Above typical value
2.	pH	6.8	6.5-8.5	Above typical value
3.	EC (MHO/cm)	1513	2250	Above typical value
4.	Alkalinity (mg/l)	2321	50-200	Above typical value
5.	Chloride (mg/l)	1933	30-100	Above typical value
6.	Sulphate(mg/l)	287	200	Above typical value
7.	Nitrate (mg/l)	98	20-40	Above typical value
8.	BOD5 (mg/l)	1756	50-100	Above typical value
9.	COD (mg/l)	9011	250-1000	Above typical value
10.	Iron (mg/l)	59.7	0.05-0.1	Above typical value
11.	Hardness (mg/l)	7234	50-100	Above typical value
12.	Temp (Celsius)	27^{o}C	----------------	--------------------------

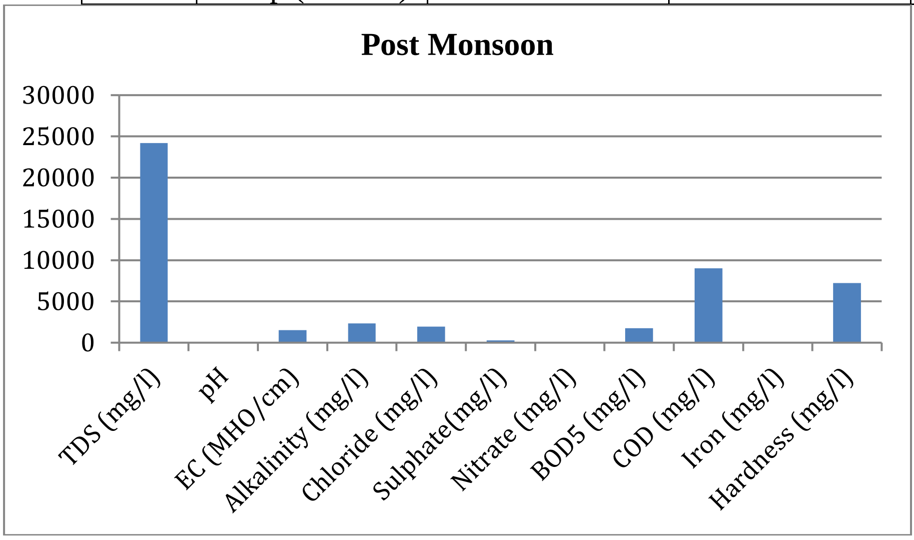

Figure: 8 Graphical representation of leachate

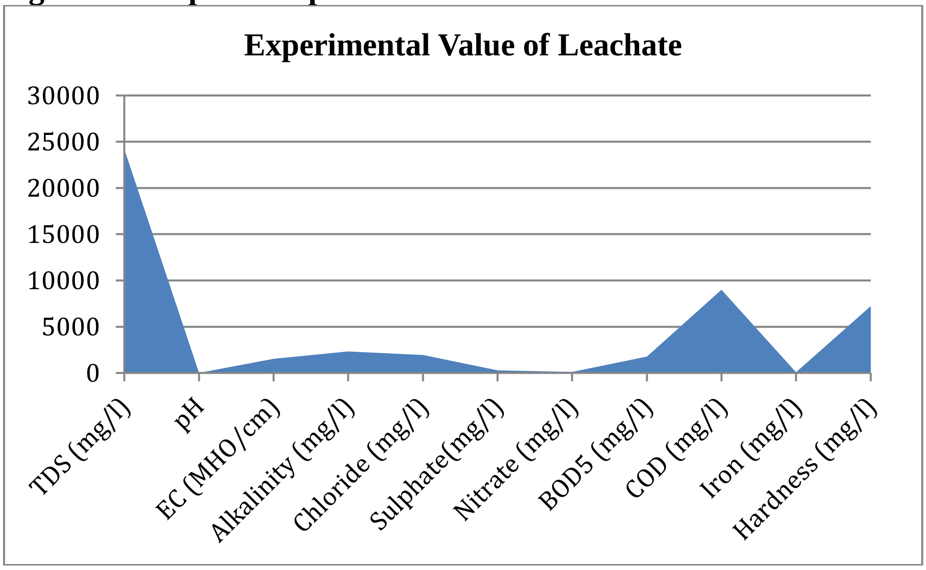

Figure: 9 Post monsoon Leachate Concentration

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Table: 14 WQI Range and water quality on the basis of range

Water Quality Index Range	Water Quality
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Not fit for drinking

Table: 15 Various methods and instruments used for determination of physicochemical parameters of ground waterSamples.

S.No	Parameters	Methods	Instruments/Equipments
1.	pH	Electrometric	pH meter
2.	EC	Electrometric	Conductivity meter
3.	TDS	Electrometric	Conductivity meter/TDS meter
4.	Alkalinity	Titrimetric	-
5.	Hardness	EDTA	-
6.	Chloride	Silver Nitrate	-
7.	Sulphate	-	UV Spectrophotometer
8.	Nitrate	-	UV Spectrophotometer
9.	Phosphate	-	UV Spectrophotometer

Water Quality Index (WQI) is avery populartool by which water quality data is evaluated for reporting to the public in a scientific manner. The WQI is similar to the UV index or an air quality index, and it expresses in simple terms the quality of drinking water at the source of drinking water supply. OR It is an index showing the quality of water on a scale in the range of 0-100. Water Quality Index is a compound index decided by different parameters. There are various formulae to calculate the WQI, but the most widely used formula is the National Sanitation Foundation Water Quality Index (NSFWQI).ORThe WQI measures the scope, frequency, and amplitude of water quality exceedances and then combines the three measures into one score. This calculation produces a score between 0 and 100.

a) Observed value(V_n) =Practical value
b) Standard value(S_n) = Set by agencies
c) Quality Rating$(Q_n) = \frac{V_n}{S_n} \times 100$
d) Unit weight $(W_n) = \frac{K}{S_n}$
e) Proportionality constant(K)
f) Water Quality Index $(WQI) = Q_n \times W_n$

Table: 16 Calculation for Water Quality Index Eastern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.93	8.5	93.3	0.032	2.99
2	TDS (mg/l)	1960	500	392	0.00054	0.211
3	Hardness(mg/l)	450	300	150	0.0009	0.135
4	Chlorine (mg/l)	640	250	256	0.0011	0.281
5	Calcium (mg/l)	88	75	117	0.0036	0.42
6	SO4 (mg/l)	460	200	230	0.0013	0.3
7	Nitrate (mg/l)	38	45	84.5	0.006	0.507
8	Zinc (mg/l)	0.91	5	18.2	0.054	0.98
9	Iron (mg/l)	0.28	0.3	93.3	0.9	83.97
					Total = 0.999	Total = 89.8
						WQI = 90.70

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 90.70 Very Poor Water Quality

Table: 17 Calculation for Water Quality Index Western side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.90	8.5	92.9	0.032	2.97
2	TDS (mg/l)	1965	500	393	0.00054	0.211
3	Hardness(mg/l)	440	300	147	0.0009	0.132
4	Chlorine (mg/l)	640	250	256	0.0011	0.281
5	Calcium (mg/l)	88	75	117	0.0036	0.42
6	SO4 (mg/l)	463	200	231	0.0013	0.3
7	Nitrate (mg/l)	38	45	84.5	0.006	0.507
8	Zinc (mg/l)	0.91	5	18.2	0.054	0.98
9	Iron (mg/l)	0.28	0.3	93.3	0.9	83.97
					Total = 0.999	Total = 89.771
						WQI = 89.90

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 89.90 Very Poor Water Quality

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Table: 18 Calculation for Water Quality Index Northern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.95	8.5	93.5	0.032	2.98
2	TDS (mg/l)	1968	500	393	0.00054	0.211
3	Hardness(mg/l)	445	300	148	0.0009	0.133
4	Chlorine (mg/l)	640	250	256	0.0011	0.281
5	Calcium (mg/l)	88	75	117	0.0036	0.42
6	SO4 (mg/l)	460	200	230	0.0013	0.3
7	Nitrate (mg/l)	38	45	84.5	0.006	0.507
8	Zinc (mg/l)	0.91	5	18.2	0.054	0.98
9	Iron (mg/l)	0.28	0.3	93.3	0.9	83.97
					Total = 0.999	Total = 89.78
						WQI = 90.63

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 90.63Very Poor Water Quality

Table: 19 Calculation for Water Quality Index Southern side of Bhalswa landfill site less than 1.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.90	8.5	92.9	0.032	2.97
2	TDS (mg/l)	1960	500	392	0.00054	0.211
3	Hardness(mg/l)	445	300	148	0.0009	0.133
4	Chlorine (mg/l)	640	250	256	0.0011	0.281
5	Calcium (mg/l)	88	75	117	0.0036	0.42
6	SO4 (mg/l)	460	200	230	0.0013	0.3
7	Nitrate (mg/l)	38	45	84.5	0.006	0.507
8	Zinc (mg/l)	0.91	5	18.2	0.054	0.98
9	Iron (mg/l)	0.28	0.3	93.3	0.9	83.97
					Total = 0.999	Total = 89.8
						WQI = 90.70

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 90.70 Very Poor Water Quality

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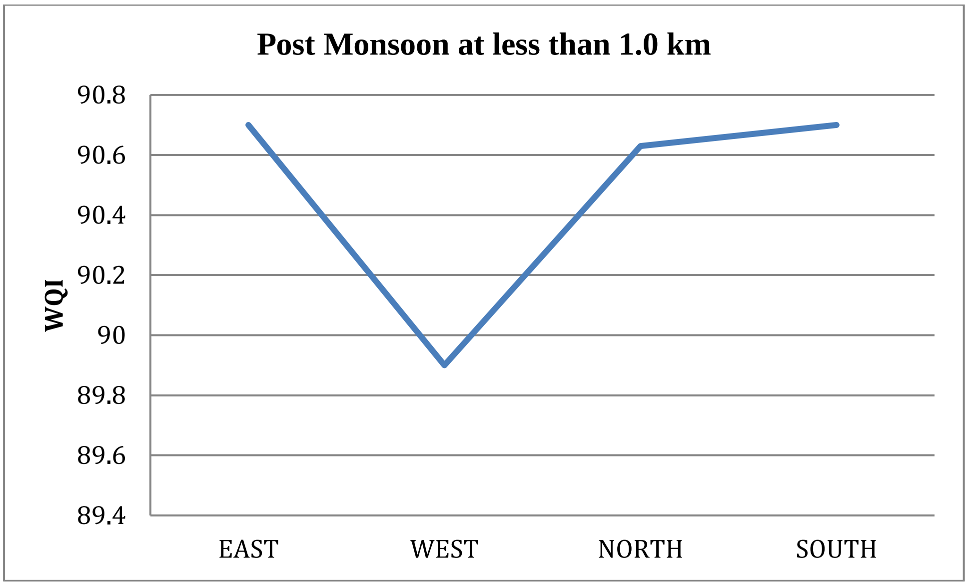

Figure:10 Graphical representation of WQI

Table: 20 Calculation for Water Quality Index Eastern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.54	8.5	88.70	0.032	2.83
2	TDS (mg/l)	3680	500	736	0.00054	0.38
3	Hardness(mg/l)	1200	300	400	0.0009	0.36
4	Chlorine (mg/l)	2715	250	1086	0.0011	1.2
5	Calcium (mg/l)	92	75	122.7	0.0036	0.44
6	SO4 (mg/l)	915	200	497.5	0.0013	0.59
7	Nitrate (mg/l)	38	45	84.5	0.006	0.507
8	Zinc (mg/l)	1.5	5	30	0.054	1.62
9	Iron (mg/l)	0.95	0.3	316.7	0.9	284.4
					Total = 0.999	Total = 292.4
						WQI = 295.35

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 295.35 Not fit for drinking

Table: 21 Calculation for Water Quality Index Western side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.55	8.5	88.8	0.032	2.84
2	TDS (mg/l)	3680	500	736	0.00054	0.38
3	Hardness(mg/l)	1210	300	403.33	0.0009	0.36
4	Chlorine (mg/l)	2720	250	1088	0.0011	1.2
5	Calcium (mg/l)	91	75	121.33	0.0036	0.43
6	SO4 (mg/l)	917	200	458.5	0.0013	0.59
7	Nitrate (mg/l)	42	45	93.3	0.006	0.55
8	Zinc (mg/l)	1.3	5	26	0.054	1.4
9	Iron (mg/l)	0.98	0.3	326.7	0.9	294.03
					Total = 0.999	Total = 301.78
						WQI = 304.83

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 304.83 Not fit for drinking

Table: 22 Calculation for Water Quality Index Nortern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.93	8.5	93.3	0.032	2.99
2	TDS (mg/l)	1960	500	392	0.00054	0.211
3	Hardness(mg/l)	1210	300	403.33	0.0009	0.36
4	Chlorine (mg/l)	2720	250	1088	0.0011	1.2
5	Calcium (mg/l)	91	75	121.33	0.0036	0.43
6	SO4 (mg/l)	915	200	497.5	0.0013	0.59
7	Nitrate (mg/l)	44	45	97.8	0.006	0.58
8	Zinc (mg/l)	1.5	5	30	0.054	1.62
9	Iron (mg/l)	0.90	0.3	300	0.9	270
					Total = 0.999	Total= 277.99
						WQI = 280.72

$$K = \frac{1}{\frac{1}{8.5} + \frac{1}{500} + \frac{1}{300} + \frac{1}{250} + \frac{1}{75} + \frac{1}{200} + \frac{1}{45} + \frac{1}{5} + \frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 280.72 Not fit for drinking

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Table: 23 Calculation for Water Quality Index Southern side of Bhalswa landfill site less than 2.0 Km

S.No	Parameter	Observed Value (V_n)	Standard Value (S_n)	Quality Rating $Q_n = \frac{V_n}{S_n} \times 100$	Unit Weight $W_n = \frac{K}{S_n}$	Water Quality Index $WQI = Q_n \times W_n$
1	pH	7.5	8.5	88.23	0.032	2.82
2	TDS (mg/l)	3690	500	738	0.00054	0.40
3	Hardness(mg/l)	1215	300	405	0.0009	0.36
4	Chlorine (mg/l)	2720	250	1088	0.0011	1.2
5	Calcium (mg/l)	91	75	121.33	0.0036	0.43
6	SO4 (mg/l)	915	200	457.5	0.0013	0.59
7	Nitrate (mg/l)	42	45	93.3	0.006	0.55
8	Zinc (mg/l)	1.3	5	26	0.054	1.4
9	Iron (mg/l)	0.95	0.3	316.7	0.9	284.4
					Total = 0.999	Total = 292.15
						WQI = 295.02

$$K = \frac{1}{\frac{1}{8.5}+\frac{1}{500}+\frac{1}{300}+\frac{1}{250}+\frac{1}{75}+\frac{1}{200}+\frac{1}{45}+\frac{1}{5}+\frac{1}{0.3}} = \frac{1}{3.68}$$

$$\therefore K = 0.27$$

Result: 295.02 Not fit for drinking

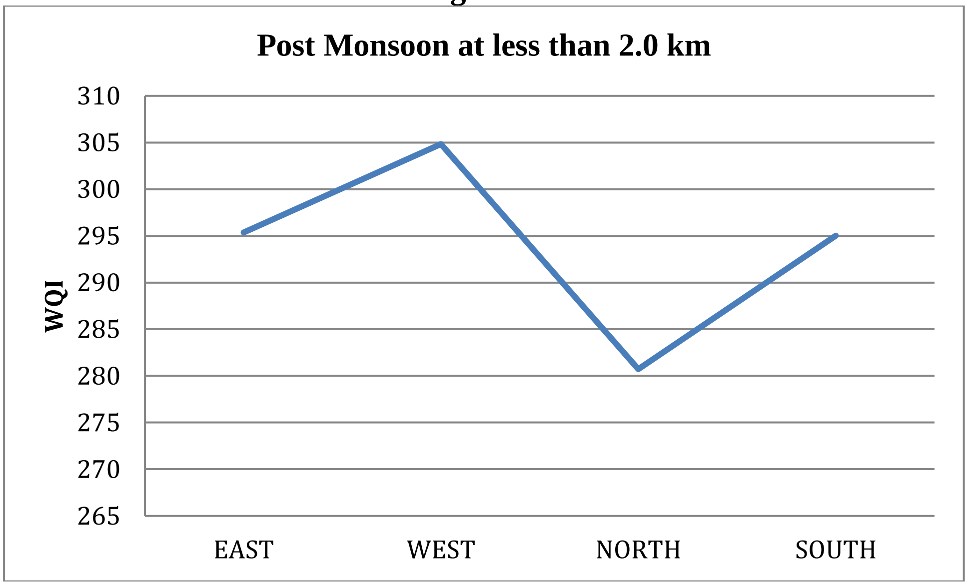

Figure: 11 Graphical representation of WQI

c) Environmental impact of Bhalswa solid waste landfill site

Bhalswa solid waste landfill site has severe impact on environment, particularly on the subsurface soil and water. Besides, it pollutes air due to decomposition of waste, presence of un-burnt hydrocarbons and the debris suddenly catching fire,causingbreathing problems, generation of greenhouses gases, and emissionof methane. Water infilterating through solidwaste landfill sites comes in contact with disposed waste,which extracts chemicals and other constituents forming a highly contaminated liquid i.e.leachate. Leachate penetratsinto groundwater, surface water, and environmental components resulting very high levels of TDS and high ion concentration that causes degradation of environment within and around landfill dumping sites. Problem requires permanent control of leachate as well as gas, and the placement of an impermeable cap. Therefore, government should look forward for alternate sites or processing the waste in a scientific way to adhere to environmental laws.

The Bhalswa solid waste landfill site appears to have received the refuse to its fullest capacity.Therefore, alternate site should be identified, developedand used in accordance with the environmental regulations. The refuse dumped at the landfill siteshould be compactedand left for at least two years afterclosure, and that no large permanent structures should ever be built.

Picture: 3 Refuse burning at Bhalswa landfill site

Effects of Bhalswa solid waste landfill site

1. Most of the parameter are beyond permissible limit due to contamination of groundwaterwithleachate.
2. The precipitated water infillterates into the refuse dumped dissolves chemicals from the waste forming a higly toxic liquid i.e. leachate.
3. Leachate leaks into groundwater which spreads into the adjacent river system by groundwater flow and pollute the surrounding environment.
4. This process does not stop even after the landfill activities have stopped receiving solid waste.
5. Bad smell, breading of insects spreading at large areas
6. Chances of fire eruption in this areas
7. Health issues problems among peoples
8. Un healthy environment due to rack pickers, animals,insects,garbage vehicles
9. Gases can also contribute to climate effects in and around and create smog if left uncontrolled.
10. Chances of damages are high that heap of solid waste can be slides at nearby road
11. Disturb ecology in this areas
12. Delhi have cost in environmental degradation.
13. People near landfill breathe some of the worst air quality in the city.
14. From contamination of the air with harmful gases to water pollution, the outcome is adverse human health effects.
15. Landfill toxic gas releases and water pollution are as well associated with lung and heart diseases respectively.
16. Landfills directly render the soil and land where it is located unusable.
17. Effect of leachates on the soil environment the consequence is harmful effects to human health and also causes hindrance to economic health and development.
18. Heavy metals such as Pb, As, Cd, Cr and Hg leach out from uncontrolled landfill sites and cause a major threat to human health.

19. More Soap Used, life of Clothing decrease, Hair problem Increase.

V. Conclusion

The results indicated poor underground water quality in both seasons (pre monsoon and post monsoon season) due to leachate penetration. Surface water (drain) and groundwater samples close to the dumpsite showed the most pollution impact according to WQI, where for samples with drain are considered as polluted water due to landfill leachate.Samples of groundwater were collected during pre & post monsoon seasons and physico- chemical parameters were analyzed.

The study exhibits that ground water in the surrounding area of Landfill site has been contaminated by percolation of leachate. Most of the results have shown higher concentration of chemical contaminants in ground water samples in pre-monsoon as compared to post monsoon season which may be on account of dilution effect during monsoon season.Almost all parameters are out of range or desirable limit ,The WQI of pH, TDS, Hardness, Chlorine, Calcium, SO_4, Nitrate, Zinc, and Iron are above 75 (limit) that means very poor water quality, Bhalswa landfill site water is not fit for drinking because its WQI is more than 100.

Pre monsoon season results are higher than post monsoon season because in post monsoon season dilution factors are main reason to less effective.Solid landfill leachate sites have an adverse impact on groundwater quality as well as on living being. It contains high levels of organic, inorganic, heavy metal which percolates through the subsoil and continue contaminating the groundwater. The penetration of leachate from landfills can leads to contamination of groundwater, surface water, and environmental components, especially for uncontrolled leachate.

So an environmental engineer will build up landfill site in such a manner that a minimum risk and impact to human health will be avoided and will obey all rules and regulation to construct solid waste landfill sites for present and future generation for benefits and proper treatment of landfill wastes. Suggestion for construction wetland to treat leachate and avoid open dumping waste.

Government of Delhi and central government of India will decide its alternative as soon as possible for the benefits of all human being and clean environment.

VI. References

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