

Water Quality Index of Groundwater Using National Sanitation Foundation-Water Quality Index (NSF-WQI) Method in the vicinity of Landfill site in Ludhiana City, Punjab, India

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ABSTRACT:Water is the most important amongst the most vital assets accessible on the planet earth. Water is exchanged from the surface of earth into the pore of soil, then to the rocks until it achieves its natural repository underneath the earth called as an 'Aquifer'. These aquifers are accessible all through the outside layer of earth yet with a differing depth. For human use of portable water, groundwater is the largest and most readily available source of water. Groundwater is also used for various other purposes aside drinking, which are irrigation, washing, bathing etc. The WHO expresses that significant water borne ailments or diseases around 80 % are created by the contamination of ground water. Leachate is a liquid produced from landfill sites and has a high potential of contaminating or polluting the water sources both nearby surface water and ground water. This study provides the result on one of such studies carried out in the surrounding areas of Jamalpur landfill site, Ludhiana, Punjab, India. Ludhiana is closed in North latitude $30^{\circ} 33'$ and $31^{\circ} 01'$ and East longitude $75^{\circ} 25'$ and $76^{\circ} 27'$. The tests conducted were chemical and biological which were conducted on the groundwater from the vicinity of the landfill site. Various tests were performed on the samples collected from the sources near the landfill site. The various tests performed are turbidity, electrical conductivity, pH, TDS, TSS, TS, sulfates, chlorides, acidity, alkalinity, DO, BOD, COD, and hardness. By the conduction of this study, it has been observed that the ground water quality in the surrounding of unlined open landfill site of Jamalpur has greatly been deteriorated. The turbidity was found to be high in the samples of ground water. Even on the other parameters like hardness, chlorides, sulfates, TDS, TSS, TS, alkalinity and acidity was found to be higher than the usual concentrations found in Punjab state. The water quality of the area was judged on the water quality index based on the WQI by National Sanitation Foundation (NSF). The water quality index of ground water was found to be 52.69 by NSF methodology.

KEYWORDS: Groundwater, Leachate, Landfill site, Unlined landfill site, Groundwater quality, water quality index (WQI), National Sanitation Foundation (NSF).

I. INTRODUCTION

Water is the most important amongst the most vital assets accessible on the planet earth. As far back as from early times of man, the significance of water can't be disregarded as all the early human advancements were shaped close to the banks of rivers. Planet earth comprises of 71 % of water, but 96% of this water is concealed in seas and oceans which is saline and can't be utilized by humans. The rest of the 4% can be utilized by humankind yet out of this again

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70% is frozen in the icy masses or Polar ice tops of Antarctica. Staying 28% is accessible underneath the ground as underground water, and 1% is accessible as new water in the types of Rivers, Lakes, and Streams and so on. [1] Through these insights one can gauge the significance of water on planet earth. One such device of checking the water quality is WQI – Water Quality Index. This strategy is to record the different physio-chemical parameters of water tests viz. Color, Taste, Temperature, pH, Electrical conductivity, Alkalinity, BOD, COD, Hardness, amounts of heavy metals, fluorides, chlorides and so on and after that a comparison is made with the parameters set up by the WHO and Indian Standards. [2]

Management of solids has turned out to be one of the preeminent environment issues everywhere throughout the world. In India there has been a huge increment in the city solid waste production amid the previous years. This increment in waste generation is because of quick increase in populace, industrialization and quick development in the nation. [3] The number of inhabitants in India according to 2011 registration was 1.21 billion, of which 277.3 million individuals lived in 5161 urban regions. Annual generation of strong waste in India has been assessed to 47.2 million tons for every year (TPY) out of which only 30% is treated or processed. The issue of waste administration is critical not just in light of the fact that the amount of waste generation but additionally because of the land space required by the treatment bodies for treatment. In India the major five metropolitan urban cities alone together contribute an aggregate of 21275 tons of waste in a day. The amount of municipal solid waste that is produced relies on the extent of the urban population and the per capita salary. The increment in the amount of solid waste because of urban development is self-evident. [4][5]

India, the world's second most populated nation with population surpassing 1.2 billion and one of the speediest urbanizing nations, is a place where there are physical, climatic, geographic, biological, social and phonetic assorted qualities. By the end of 2020, India will attain a status of industrialized nation as forecasted by the growth. India as of now is confronting a municipal solid waste problem, for which all sections of the general public are responsible. [6]

For human use of portable water, groundwater is the largest and most readily available source of water. Groundwater is also used for various other purposes aside drinking, which are irrigation, washing, bathing etc. Increment in human populace is effectsly affecting the normal assets including water. In a decade only, the population in India has expanded by 30 million, so is the request of consumable water. There are numerous other human-made causes like fast Industrialization, Excessive utilization of concoction manures, mining process which additionally increase the pollution of ground water. All life relies on the nature of water which exists in lakes, waterways, streams and groundwater. [7]

Leachate is a liquid produced from landfill sites and has a high potential of contaminating or polluting the water sources both nearby surface water and ground water. One of the real contamination issues brought about by the MSW landfill especially in non-engineered landfill is the landfill leachate, site which is created as a result of precipitation, surface water running off and intrusion of groundwater permeating through a landfill and get dissolved the organic and inorganic impurities. Leachate is the fluid build-up coming about from the different chemical, physical and natural procedures occurring inside the landfill. Landfill leachate is produced by overabundance water permeating through the waste layers in a landfill. [8][9] A mix of physical, chemical and microbial forms in the waste exchange harmful substances or toxins from the waste material to the passing water. Even after closing of dumping site, the site will be continuously produce contaminated leachate for coming 30-50 years.

II. RELATED WORK

Bhalla et. al., 2014 carried out study on the potential of leachate produced from the landfill site in Ludhiana city. They had counted the potential by leachate potential index (LPI) and shown the various characteristics of leachate on the basis of 18 selected parameters and found that the LPI was under permissible limits after treatment of leachate as per Municipal Solid Waste (Management and Handling) Rules, 2000, Government of India. [13]

Ichwana et. al., 2016 carried out a study on quality of water in Krueng Tamiang. The study was carried out to determine the quality of water by water quality index on the basis of National Sanitation Foundation method (WQI-NSF) of water quality index that is having 9 parameters. [15]

Garima et. al., 2013 carried out a study on quality of water by water quality index National Sanitary Foundation (WQI-NSF). The study was carried out by both of the methods i.e. by taking all of the nine parameters as given by NSF and also by missing parameter. The results are then compared for both of the methods. [16]

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III. MATERIALS AND METHODS

3.1 Study Location

Ludhiana is a district that falls in center area of Punjab. Ludhiana is closed in North latitude $30^{\circ} 33'$ and $31^{\circ} 01'$ and East longitude $75^{\circ} 25'$ and $76^{\circ} 27'$. The Satluj river marks the North border of the district with Jalandhar and Hoshiarpur districts. Ropar and Fatehgarh Sahib districts are at the eastern and south eastern sides. The border on the West is shared with Moga and Ferozpur districts. The total geographical area under the district is 3790 sq.kms. The ordinary yearly precipitation of the locale is 680 mm which is unevenly dispersed over the range in 34 days. The south west rainstorm or the monsoon, sets in from a week ago of June and pulls back in end of September, contributed around 78% of yearly precipitation. July and August are the wettest months. Rest 22% precipitation is gotten amid non-rainstorm period in the wake of western disturbances and thunder storms. The region is possessed by Indo-Gangetic alluvium. The region is plain and main channels are Satluj and its tributaries and BudhaNala. The locale zone is possessed by Indo-Gangetic alluvium of Quaternary age. The subsurface topographical developments of the zone involve sand, residue, dirt and kankar in different extents. In general, the Ground water of the district is fresh with the exception of in and around Ludhiana city where the ground water is contaminated because of modern industrial effluents. The aquifer disposition of the region is uncovered by boring information carried down to 408 m by Central Ground Water Board and state govt. The lithological information of these boreholes demonstrate the presence of many sand beds framing the main aquifers isolated by clay beds at different depths.

The Municipal Corporation areal limits of city is extent over an area of 141sq.km. The population of the city within the Municipal Corporation area is estimated at 34,87,882 in 2011. Only Ludhiana generates 31% of the total municipal solid waste produced in the state of Punjab. The Ludhiana city was having three dumping sites earlier. Now these days only one site is open for dumping in Ludhiana city i.e. Jamalpur dumping site which is the study location of the study carried out. The three dumping sites are Jamalpur, Jainpur and Noorpur belt. The data of these dumping sites is given in table 1.[9][10][11][12][13]

Table 1: Different Landfill sites in Ludhiana

S.No.	Sites	Land Area (acres)	Depth (ft)	Future life (years)	Distance from city centre
1	Jainpur	10	Filled	Nil	10 km
2	Jamalpur	25	8 to 10	25	11 km
3	Noorpur Belt	21	12 to 15	25	14 km

Source: Vision 2021, Ludhiana City Development Plan [12]

Plate 1: Satellite view of Jamalpur Landfill site



Source: Google maps

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3.2 Landfill Site Location

The study location i.e. Jamalpur dumping site is having the latitude of 30.928243 and the longitude of 75.907920. There is no lining of these landfills and also there is no treatment process for the leachate produces that means these are unsecured landfill sites. From these landfill sites the leachate produces find its way easily to the underground water. The rag pickers regularly set a blaze the waste to distinguish the combustible and incombustible waste. There is no provision of proper compaction of waste at the land fill site. Normally the major part of dumping the waste is carried out by A2Z Ltd. waste dumping company in Ludhiana. The satellite view of Jamalpur site is shown in following plate 1.

3.3 Study of water quality parameters

To study the different water quality parameters of ground water, three samples each from five different ground water sources were taken.

Safeguarding of test sample is not practical as natural processes will continue after specimen has been taken, changes may happen amid taking care of the sample. So, the testing is to be done inside two hours of collection, cool storage is not needed. On the other chance that examination is not to be begun inside two hours of specimen collection, the specimen should be stored at 4°C. It is also to be taken care that the sample should not freeze. For best results the examination of the samples collected should be started within 6 hours.

ISO 5667-5 gives direction on the choice of testing areas and the accumulation of tests when observing drinking water from treatment plants and from channelled distribution works.

The following tests were carried out on water to determine the water quality parameters; Turbidity, Electrical conductivity, pH, Total Dissolved solids, Total Solids, Total Suspended solids, Sulphates, Chlorides, Acidity, Alkalinity, B.O.D, C.O.D, Hardness and Dissolved oxygen. The tests were carried out according to specifications given by IS 10500:2012.

3.4 Water Sampling

The samples were collected from 5 different locations. The details of the sample locations is given in table 2.

Table 2: Different Sampling sites in Ludhiana

S.No.	Distance from Landfill Site (m)	Sample Collection Location
1	200	Hand pump in Jain Colony
2	550	Hand pump in Raju Colony
3	650	Hand pump in Guru Ram Dass Colony
4	900	Motor pump in Bholla Colony
5	1300	Hand pump near Fish market on Tajpur Road

There are numerous indices for determining water quality that may be used for calculating total index such as, NSFQWI (National Sanitation Foundation Water Quality Index), SHI (Stream Health Index), OWQI (Oregon Water quality index) and sustainable information network. Out of these NSF method is used in the study to determine the water quality index of ground water.

3.5 Water Quality Index (NSF method)

The sub-file of various water quality factors (surface water and ground water) were controlled by NSF (National Sanitation Foundation) strategy. A standard water quality record technique was created by paying extraordinary meticulousness in selecting parameters, building up a basic scale and doling out weights. The endeavor was bolstered by the National Sanitation Foundation (NSF) and subsequently as NSFQWI so as to compute WQI of different water bodies fundamentally contaminated. The proposed strategy for looking at the water nature of different water sources is

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based upon water quality parameters, for example, pH, turbidity, total dissolved solids, biochemical oxygen demand (BOD). [15]

The water quality information was recorded and exchanged to a weighting bend diagram, where a numerical estimation of Q_i is acquired. The numerical expression for NSF WQI is given by:

$$WQI = \sum_{i=1}^n Q_i W_i$$

Q_i = sub-index for i^{th} water quality parameter;

W_i = weight associated with i^{th} water quality parameter;

n = number of water quality parameters.

The weight factor for the nine parameters decided by NSF is given in the following table 3.

Table 3: Water Quality Parameters and their weightage factor as indicated by NSF

Parameter	Weight Factor
D.O	0.17
FEACEL COLIFORM	0.16
pH	0.11
BOD	0.11
NITRATE	0.10
PHOSPHATE	0.10
TEMPERATURE	0.10
TURBIDITY	0.08
TDS	0.07

The water quality index is rated from 0 – 100 and is giving the quality of water in the table 4.

Table 4: Water Quality Index and Quality of water as indicated by NSF

WQI	Quality of water
91 – 100	Excellent
71 – 90	Good
51 – 70	Medium
26 – 50	Bad
0 – 25	Very bad

3.6 Water Quality Index considered by study

For skipping of water quality parameters, the weightage of the skipped parameters is divided as per the weightage of the tested parameters taken in consideration of the study to make the total weightage as unity. [17] The new weightage factors are calculated by:

$$W_{in} = \frac{W_i}{\sum_{i=1}^n W_i}$$

W_i = weight associated with i^{th} water quality parameter;

W_{in} = new weight associated with i^{th} water quality parameter;

n = number of parameters taken under consideration.

The new weight factors for the considered water quality parameters are given in the table 5.

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Table 5: Weight Factor for considered water quality parameters in study

PARAMETER	WEIGHT FACTOR
DISSOLVED OXYGEN	0.32
BOD	0.20
pH	0.20
TURBIDITY	0.15
TDS	0.13

IV. RESULT AND DISCUSSION

4.1 Ground Water Sample Testing Results:

The three samples from each sampling site were tested and the average of the three samples were considered. Hence there is one averaged reading of one site. A total of five sampling sites were considered. Therefore, the readings are given in the Table 6. In addition to these readings the average of the readings is also given in the same table 6.

Table 6: Average Values for the Vicinity of the landfill site

S. No.	Parameter(mg/l)	Jain colony	Raju colony	G.R. Dass colony	Bholla colony	Fish market	Average
1	Turbidity(NTU)	138.33	129.00	72.33	53.67	0.00	78.67
2	EC (μ siemens)	880.67	959.67	846.00	792.00	969.00	889.47
3	pH	7.60	7.44	7.35	7.18	7.29	7.37
4	TDS	1103.00	968.00	511.67	390.33	449.33	684.47
5	TS	1392.67	1221.00	793.00	807.00	752.00	993.13
6	TSS	289.67	253.00	281.33	416.67	302.67	308.67
7	Sulphates	106.67	93.67	89.00	42.33	83.67	83.07
8	Chlorides	67.33	58.33	73.33	73.33	72.33	68.93
9	Acidity	48.00	56.33	72.67	63.67	66.33	61.40
10	Alkalinity	311.00	308.33	341.67	328.67	343.00	326.53
11	BOD	3.03	2.30	2.13	0.33	1.07	1.77
12	COD	7.47	3.67	7.33	0.00	0.00	3.69
13	Hardness	381.67	413.00	371.33	407.00	394.33	393.47
14	DO	2.43	3.47	2.9	4.9	4.33	3.61

4.2 Water Quality Index

The Table 7 depicts the Q-values of different parameters of surface water. The weightage assigned to each of the parameters are based on National Sanitation Foundation method (NSF) of water quality index. The product of Q-value and weight factor is calculated for all the parameters and the addition of their product gives the water quality index. Water quality index is calculated and shown in table 7

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Table 7: WQI of the study area by NSF methodology

S.No	Parameter (mg/l)	Value	Weight Factor(W)	Q-Value(Q)	$W_i \times Q_i$
1	DO (%sat)	43.60	0.32	34.55	11.06
2	BOD	1.77	0.2	83.6	16.72
3	pH	7.37	0.2	92.5	18.5
4	Turbidity (NTU)	78.67	0.15	25.4	3.81
5	TDS	684.47	0.13	20	2.6
TOTAL WQI					52.69

Using this NSF methodology, the WQI is found to be 52.69, that falls in the category of medium water quality.

IV. CONCLUSION

By the conduction of this study, it is concluded that the ground water quality in Jain colony, the turbidity is found to be very high. Electrical conductivity was found high. pH was found good. TDS of the sample was found to be high. Sulphates was found satisfactory. Chlorides was also found in the limits. Alkalinity was also in permissible limits. BOD and COD levels were medium. Hardness of water was found to be satisfactory.

The ground water quality in Raju colony, the turbidity is found to be quite high. Electrical conductivity was found high. pH was found good. TDS of the sample was found to be high. Sulphates was found satisfactory. Chlorides was also found in the limits. Alkalinity was also in permissible limits. BOD and COD levels were medium. Hardness of water was found to be satisfactory.

The ground water quality in Guru Ram Dass colony, the turbidity is found to be high. Electrical conductivity was found high. pH was found good. TDS of the sample was found to be nearly normal. Sulphates was found satisfactory. Chlorides was also found in the limits. Alkalinity was also in permissible limits. BOD and COD levels were medium. Hardness of water was found to be satisfactory.

The ground water quality in Bholla colony, the turbidity is found to be high. Electrical conductivity was found high. pH was found good. TDS of the sample was found to be high. Sulphates was found satisfactory. Chlorides was also found in the limits. Alkalinity was also in permissible limits. BOD and COD levels were almost nil. Hardness of water was found to be satisfactory.

The ground water quality at Fish market at Tajpur road, the turbidity is found to be in permissible limits. Electrical conductivity was found high. pH was found good. TDS of the sample was found to be normal. Sulphates was found satisfactory. Chlorides was also found in the limits. Alkalinity was also in permissible limits. BOD and COD levels were low. Hardness of water was found to be satisfactory.

By the conduction of this study, it is concluded that the ground water quality in the surrounding of unlined open landfill site of Jamalpur has greatly been deteriorated. The turbidity was found to be high in the samples of ground water. Even on the other parameters like hardness, chlorides, sulphates, TDS, TSS, TS, alkalinity and acidity was found to be higher than the usual concentrations found in Punjab state.

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