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# Impact of Landfills on Soil and Ground Water: A Case Study

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**Abstract**

*Growing population demands for more and more land as well as other resources to fulfil their basic needs and daily requirements. As the population grows the consumption of resources increases that leads to generation of more waste materials. This waste can be solid or liquid that need proper disposal or it can lead to hazardous condition in a region. Municipalities around the world use either burning of the waste material or they put the waste into landfills (also known as dumping grounds). Landfill is most popular method of solid waste disposal in the developing countries like India. But due to lack of technology and proper funding these landfills are the source of pollution to soil and water. Toxic materials coming in contact with the surface and subsurface soil as well as the water resources lead to degradation of these valuable resources. In the light of above discussion the present study intends to examine the quality of soil and water resources in and around the dumping location of SahibzadaAjit Singh Nagar. The study will analyse the chemical, physical and biological characteristics of the soils and ground water sources within the landfill location and at the specific distance. Study is based on the primary data collected from the field and analysed in the national level testing laboratories. Results obtained are then compared with the world health organisation and Indian Standards of Drinking Water Quality.*

***Keywords***: *Ground Water, Pollution, Landfill.*

## Introduction

India, being a developing country is highly dependent on ground water for various purposes and one of the largest users of ground water across the world (The World Bank, 2012). Ground water is accepted as reliable source of water and the constant rise in reliance on water resource results in unmethodical extraction in various areas of the country while neglecting adverse effects. From house hold use to agriculture or industrial use groundwater is the most prominent resource of water. It was observed that the value of annual rest storable (replenish able) ground water resource of India is four hundred thirty three cubic meters (bcm), and three hundred ninety nine bmc is considered as available for various purposes (Jha&Sinha).

Because of the human influences, ground water is highly vulnerable to contamination which results in pollution. The advancement in industrialization and urbanization without considering its environmental consequences are some of the major factors for groundwater pollution (Longe&Balogun, 2010). Studies have shown that one of the prime causes for water pollution is leachate discharge from water sites or landfills (Ikem, Osibanjo, Sridhar &Sobande, 2002). In developing as well as developed countries land filling is considered as the most simple, cheap and cost effective method for disposing waste (Barrett &Lawlor, 1995) which is also considered as one of the major threats to ground water resources (Fatta, Papadopolus&Loizidou, 1999; USEPA, 1984).

Landfill leachate is highly concentrated with dissolved organic and inorganic components viz. ammonium, calcium, magnesium, sodium, potassium, iron, sulfates, chlorides and various heavy metals like cadmium, chromium, copper, lead, zink, nickel and xenobiotic organic substances (lee & jones-Lee, 1993; Christnensen, et.al, 2001). Leachate concentrates at the bottom of landfills and penetrates into the soil and cause pollution (Mor, et.al, 2006).

Keeping in view the above facts it becomes important to study the hazardous effects of various organic and inorganic components dissolved in ground water due to landfills and thus the adverse effects of contaminated water on human beings are discussed below:

### *Ammonium*

The level of ammonium in groundwater is usually below 0.2 mg per liter to 3 mg per liter (Dieter &Möller, 1991) and the surface water level may contain up to 12 mg per liter (WHO, 1986). The presence of higher concentration of ammonia than geogenic levels is one of the crucial indicators of faecal pollution (International Organization for Standardization, 1984, 1986). Ammonium reacts with chlorine and it becomes highly difficult to disinfect water (Wendlandt, 1988).

### *Calcium*

The high concentration of calcium in water makes it hard. If the concentration is higher, the calcium reacts with iron, zinc, magnesium and phosphorous in the intestine and consequently deduce the absorption of these elements (Sengupta, 2013). Studies also indicated the positive correlation between that water with higher concentration of calcium, and gastric cancer (Yang, Cheng, Tsai & Hsieh, 1998).

***Magnesium***

According to the WHO Guidelines for Drinking-water Quality (2011) the excessive intake of magnesium may cause hypermagnesaemia which leads to diarrohea in human beings. The water with high concentration of magnesium show laxative effect and also interferes with gastrointestinal functions.

***Sodium***

Sodium is essential for human beings. Its normal daily intake ranges from 120-400 mg in infants and young children to 500 mg in adults (National Research Council, 1989). In human beings the kidneys excretes the sodium from the body but the overdose may cause death of the individual (WHO, 1979). The acute effects of sodium intake can be nausea, vomiting, convulsions, muscular twitching and rigidity, cerebral and pulmonary oedema (Department of National Health and Welfare, Canada, 1992; National Academy of Sciences, 1977) whereas the excessive intake may cause chronic congestive heart failure (WHO, 1979).

***Potassium***

According to the WHO guidelines for drinking water quality report (2009), the excessive ingestion of potassium may cause potassium intoxication and may cause chest tightness, nausea and vomiting, diarrhoea, hyperkalaemia, shortness of breath and heart failure.

***Iron***

Iron is one of the crucial elements for growth and development of human. Its daily requirement ranges between 10 to 50 mg per day depending upon age, sex and physiological characteristics (WHO, 1998). But if the level of iron increases in body it adversely affects the health of the individual. One of the serious health hazards is known as "iron overload." The term refers to the condition when excess iron accumulates in the body. Studies have shown that iron overload increases the risk of various liver diseases (cirrhosis, cancer), heart failure, diabetes mellitus, osteoarthritis, osteoporosis, metabolic syndrome, hypothyroidism, hypogonadism, even premature death in some cases (IDI, 2018).

***Sulfate***

Sulphate is present in almost all natural water resources including groundwater. The high concentration of sulfate in water may cause laxative effects while combined with calcium and magnesium. According to WHO guidelines on drinking water quality (2004) "the maximum of 250 mg/l of sulfate in water intended for human consumption".

***Nitrogen***

Nitrogen penetrates into groundwater through the soil and contaminates it. Nitrates formed because of fertilizers, decaying plants, manure and other organic residues (Gao, Yu,Luo& Zhou, 2012).Excessive nitrate level in water cause health problems like conversion of hemoglobin to methemoglobin which is responsible for depleting oxygen level in blood (WHO, 2008). It also results in thyroid gland enlargement, vulnerability towards cancer, birth defects, hypertension, stomach cancer etc. (Payne & Jones, 1993).

***Lead***

Lead dissolves in ground water when it percolates into ground through landfills. And when lead dissolved water is consumed, the brain cells absorb it. Consequently the frontal lobe (the area responsible for higher order cognitive processes (critical thinking, learning, problem solving, attention), hippocampus (responsible for memory consolidation) gets strongly affected (Ossola, 2016).

***Zinc***

Zinc is the other metal which is important for optimum functioning of human body, but its excessive consumption may leads to health hazards like nausea, vomiting, and diarrhea, sometimes accompanied by bleeding and abdominal cramps, pulmonary distress, fever, chills, and gastroenteritis (Elinder, 1986).

***Copper***

In healthy adult individuals, the liver contains 8-10% of body's total copper amount, approximately 50% found in muscles and bones; however in infants liver contains 50-60% of body's copper (Luza&Speisky, 1996). The copper is essential for proper functioning of the body. Intake of excessively large doses of Copper may leads to severe mucosal irritation and corrosion, capillary damage, hepatic and renal damage and central nervous system irritation even depression (Vaishaly, 2015). Copper toxicity also causes blue green diarrhea stool, acute haemolysis and kidney functioning abnormalities (Krishnamurti&Viswanathan, 1991).

***Chromium***

The average intake of chromium ranges between 100 to 300 mg per day. The excessive consumption of chromium may cause toxicity which leads to liver necrosis, membrane ulcer and dermatitis by skin contacts (Krishnamurti&Viswanathan, 1991).

***Turbidity***

Turbidity can be defined as the cloudiness or muddiness of a liquid which is caused due to suspended particles that are usually invisible to the naked human eye.

***PouvoirHydrogne (pH) value***

The 'Power Hydrogen' (pH) value of an aqueous refers to its acid of basic property on a numeric scale where the pH value greater than 7 is considered to be acidic and less than 7 is considered to be basic.

***Dissolved oxygen (DO)***

Dissolved oxygen refers to the level of free and non-compound oxygen level present in water. It is one of the important parameters to measure quality of water as it influences the organisms living in water bodies.

***Water Holding Capacity (WHC)***

WHC refers to the water holding capacity of a soil. Generally it is observed that the heavier soil can retain more moisture than lighter soil. More moisture the soil can retian more it is valuable for the plans and biotic life. The soils rich in humus and having dominance of clay can retain much more water than the soil that is rich in sand and have low level of organic matter.

***Porosity***

Porosity of the soil can be defined as the capacity of the soil to allow water to percolate into the lower levels. It depends upon granule size and the total composition of the soil. The porosity of the sand is much higher than the clay because of the difference in granule size.

On the basis above information the present case study intends to analyze the quality of ground water around the landfill (Dumping ground) of SahibzadaAjit Singh Nagar, Punjab.

**Material and Methods**

The present study is conducted using the primary field survey. For the purpose of the study the data was collected from the field using random sampling method from within the dumping ground and at a specified distance from the landfill. Samples of soil from the same distances were also collected using the same method. Following section introduces the area selected for the present study along with the data sources and methodology adopted for carrying out the research.

***Study area***

Present research work has been carried out in the outer margins of the SahibzadaAjit Singh Nagar where the solid waste collected from the city is being dumped in the form of landfill. The dumping ground is located in the North West side of the city which is physiologically plian area with general gradient from South East to North West. The location is basically plain area with average slope of less than three degrees. The geographical extended of the areas is from 30$^{o}$ 42' 30" N to 30$^{o}$ 42' 41" N and from 76$^{o}$ 40' 52" E to 76$^{o}$ 41' 50"E. The study area has four distinct seasons starting from May till July is the summer season, from August to November is Monsoon season, from December to February is winter season and from March to May is spring season. The climate of the regions is sub-tropical semi humid type were majority of the rainfall is received during the monsoon season and some occasional showers are received during the winter season. The area is basically located in the foothill zones of Shiwalik hills and is generally fluvial plain. The soil is alluvium with larger share of sand in the soil.The depth of ground water is shallow. The region is heavily populated with average density of more than four thousand people per square kilometres. The location of dumping site is on the margin of the city which makes it more hazardous as majority of the residents loving around the dumping ground use ground water as a source of drinking water in theire daily activities.Map 1 shows the location of dumping ground in the SahibzadaAjit Singh Nagar and Map 2 shows the buffer zones of 50, 100 and 150 meters from where the water samples were collected for the study.

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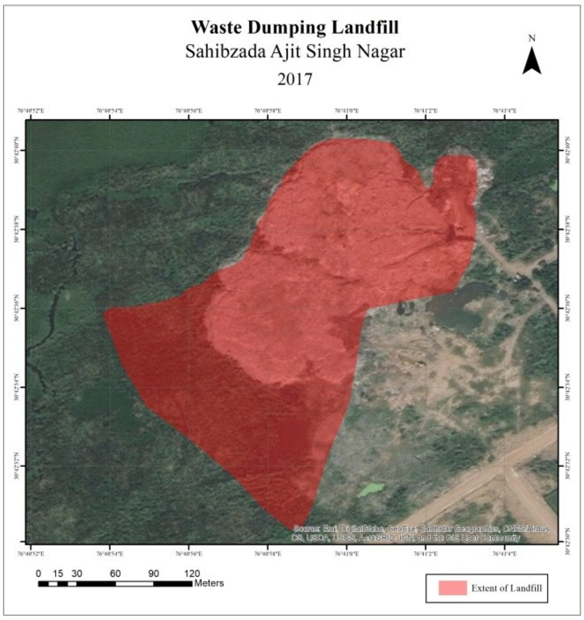
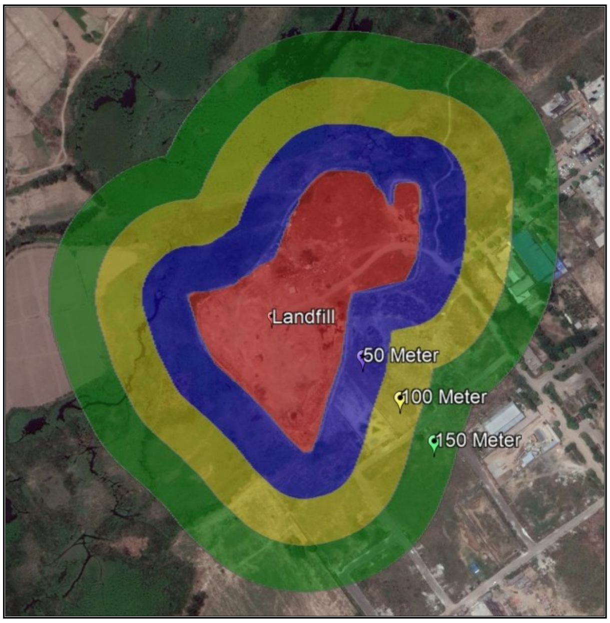



*Map 1 Location of Study Area*




*Map 2 Distance of sampled wells in study area*

***Water analyses***

The present study for collection of water samples utilized the existing boreholes located within the dumping location and at the radius of 50, 100 and 150 meters from the boundary of the dumping ground. The average depth of the boreholes was recorded to be fifty meters.For every borehole total of five water samples were collected using the serialized plastic bottles of 500 ml each. After collecting the samples they were stored at temperature of four degrees and then they were analysed for the physical characteristics, chemical composition and biological parameters of the water. The quantitative analysis was carried out in the Water Testing Lab, located at Phase 2, SahibzadaAjit Singh Nagar, Punjab. The physical characteristicsbeing observed included odour, colour, turbidity and temperature of the samples.

Chemical parameters of the sampled water were analysed included pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Total Hardness (TH), Iron (Fe), Nitrite (NO3), Chloride (Cl), Calcium (Ca) and heavy metals such as Copper (Cu), Zinc (Zn),and Lead (Pb). The pH of the water was measured using the Apera Instruments PH700 Benchtop Lab pH Meter by direct measurement of the samples. Same instrument was also used for recording the temperature of the samples.Lab-line Digital turbidity meter was used to analyse the turbidity of the water in the collected samples. The samples in the testing laboratory were analysed using the standard methods for examination of water provided by the American Public Health Association (2005). All the results obtained from the analysis of thesamples were then compaired with the international standerds provided by the World Health Organization (WHO, 2004) and the Indian Standerds of Drinking Water provided by the Bureau of Indian Standards (BIS, 2012).

***Soil sampling and analysis***

The samples of the soil were collected from the dumping ground (Landfill) of the SahibzadaAjit Singh Nagar. For the purpose of the study soil samples of 100 grams each from the surface and at the depth of 10, 20 and 30 cms from the five different locations located at least ten meters apart from each other. The samples of the soil were collected from the specified depth using soil angular. The samples of sil were firstly air dried and then kept in thepolythene bags for further analysis. The samples of the soil were analysed for pH, organic content (OC) further the levels of nitrogen (N), phosphorus (P), sodium (Na), calcium (Ca), magnesium (Mg), cyanide (Cn), copper (Cu), lead (Pb), silver (Ag) and mercury (Hg) were also examined from the samples. The samples were examined in the National Soil Testing Laboratory located at Sector 22, Chandigarhusing the Bureau of Indian Standard's guidelines in Methods of soil test. The examined results were then compared with the standards of Food and Agriculture Organisation of United Nations.

**Results and Discussions**

***Water analyses***

The physical characteristics of the water collected and analysed is presented in Table-1. The table shows the colour, order, turbidity and temperature of the water at the time of collection. The samples were found to be having pollutants in it. Colour of the water was not clear at all the locations and the water was having mild odour. The turbidity of the water was recorded to be 6.7, 3.6 and 1.8 NTU at the distance of 50, 50-100, and 100-150 meters respectively. Temperature of the water was centred around 27°C with deviation of one degree was found to be outside of the World Health Organisations standard of 4°C which indicated the presence of foreign bodies in the water.

Table-1. Physical characteristics of the sampled borehole water.

| Sample | Colour | Odour | Turbidity (NTU) | Temperature (°C) |
|---|---|---|---|---|
| Within 50 meters | not clear | mild | 6.7 | 27.8 |
| Between 50-100 meters | Semi clear | mild | 3.6 | 27.5 |
| Between 100- 150 meters | not clear | mild | 1.8 | 26.7 |

*Source: Samples collected from Primary Field Survey, 2017*
*NTU – Nephelometric Turbidity Unit*
*°C – Degree Centigrade*

Table number 2 shows the chemical composition of the water collected from the boreholes at three different locations located 50, 100 and 150 meters from the landfill.The pH value of the water sources were found to be slightly acidic which indicates that there is presence of metals in the water. Metals from the improper disposal of batteries, cells, disinfectants, various types of cleaning agents, etc. and other electric components of the waste is the major source of this as the metals reacting with the air and soil and seeping into the ground water contaminates the ground water. According to the World Health Organisation (2004) the value of neutral water is 7.0 which is tolerated up to the level of 9.2 provided that the microbiological examination shows no damage and deterioration of bacteriological quality of water. In the present case the indicators (Table 4) show damage to the bacterial life which desires urgent attention of the planners and policy makers. Chloride value above 250mg/l can be detectable in the form of change in the taste of water but the values above 200mg/l don't have any adverse effects on human health. The higher values of chlorine can be an indicator of Calcium and Magnesium deposits. In the present case the levels of chlorine are below the international and national standards but the water still needs treatment before drinking purposes. Dissolved Oxygen in the water with the value of 0.91 at the first location nearest to the land fill shows that there is presence of pollutants in the water which use up the dissolved oxygen. At location 2 and 3 the level of DO i.e. 1.89 and 2.39 respectively, is still better but it also shows low levels from which it can be inferred that there is indirect impact of landfill on the nearby water sources also. Although the levels of total dissolved solids in the water are below the WHO standards but the water still shows the impact of pollution with the values of 341, 220 and 198 at location 1, 2 and 3 respectively which means treatment of water is required before drinking purposes. The levels of nitrates in the samples shows appreciable amount of pollution at location 1 and the amount of nitrates decreases as we move away from the landfill. This shows the direct impact of pollutants at the landfill location on the ground water resources.

Table 2. Chemical constituents in the boreholes and their comparison with the WHO Standard (in mg/l)

| Sample | Distance (m) | pH | DO | TDS | TH | Ca | NO3 | NO2 | Cl– |
|---|---|---|---|---|---|---|---|---|---|
| **ISDWQ** | - | 6.5–8.5 | NS | 500 | 200 | 75 | 50 | 3 | 250 |
| **WHO** | - | 6.5–8.5 | NS | 500 | 200 | 75 | 50 | 3 | 250 |
| **Location 1** | 50 | 5.69 | 0.91 | 341 | 141 | 84 | 62 | 0.89 | 125 |
| **Location 2** | 100 | 6.21 | 1.89 | 220 | 139 | 70 | 43 | 0.85 | 25 |
| **Location 3** | 150 | 6.81 | 2.39 | 198 | 135 | 68 | 31 | 0.75 | 19 |

*Source: Samples collected from Primary Field Survey, 2017*

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*PH- PouvoirHydrogne; DO – Dissolved Oxygen;TDS – Total Dissolved Solids; TH – Total Hardnes; Ca – Calcium; NO3 – Nitrate; NO2 – Nitrogen dioxide; Cl – Cloride*

Table 3 shows the levels of iron, lead, zinc, copper, manganese and chromium in the water from the sampled locations. The quantity of iron in the water was found to be below both World Health Organisation and Indian Standards of water but still the water need to be processed before using it as a drinking source. The standards of World Health Organisation (2004) recommend 0.1mg/l of manganese as a tolerable level while above the level of 0.5mg/l the portability of water is impaired. The high levels of iron, lead and zinc are a clear manifestation of toxicwaste material dumped at the landfill which penetrate in the soil and contaminate the ground water.

Table 3. Heavy metal contents in the boreholes and their comparison with the WHO Standard (in mg/l)

| Sample | Distance (m) | Fe | Pb | Zn | Cu | Mn | Cr3– |
|---|---|---|---|---|---|---|---|
| **ISDWQ** | - | 0.5–5.0 | 0.01 | 3.0 | 1.0 | 0.2 | 0.05 |
| **WHO** | - | 0.5–5.0 | 0.01 | 3.0 | 1.0 | 0.1 | 0.05 |
| **Location 1** | 50 | 1.21 | 1.22 | 5.5 | ND | ND | ND |
| **Location 2** | 100 | 1.10 | 1.12 | 3.4 | ND | ND | ND |
| **Location 3** | 150 | 0.92 | ND | ND | ND | ND | 0.26 |

*Source: Samples collected from Primary Field Survey, 2017*
**ND – Not detected; Fe – Iron ; Pb - Lead; Zn - Zinc; Cu -Copper ; Mn–Manganese ; Cr3 - Chromium.*

***Bacteriological characteristics***

The bacteriological characteristics of the samples collected from the field at three locations located 50, 100 and 150 meters away from the dumping ground are reported in table 4.Almost all of the samples were reported to be having high levels of bacteriological activity. Coliform Bacteria and Escherichia Coli bacteria are found to be present in the water samples. Only at location 3 located 150 meters away from the landfill is exception,in which the level of Escherichia Coli bacteria was not found. It is a clear indicator of mixing of sewage water in the ground water sources from the nearby location due to improper treatment and management of sewage waste. The present results show that none of the samples were satisfying the guidelines set by the WHO. That means proper treatment and management if required before the water could be called safe for human consumption.

Table 4. Bacteriological constituents in the locations and comparison with World Health Organisation Standard (in 1/100 ml)

| Sample | Bacterial constituent | Water sample result | Variance from WHO |
|---|---|---|---|
| **Location 1** | Total Coliform Bacteria<br>Escherichia Coli | > 1.8<br>> 1.7 | + 0.8<br>+ 0.7 |
| **Location 2** | Total Coliform Bacteria<br>Escherichia Coli | > 1.6<br>> 1.4 | + 0.6<br>+ 0.4 |
| **Location 3** | Total Coliform Bacteria<br>Escherichia Coli | > 1.3<br>> 1.1 | + 0.3<br>+0.1 |

*Source: Samples collected from Primary Field Survey, 2017*

***Soil analyses***

The following table (table 5) shows the physical properties of the soil from the four different locations first located within the landfill site, second locate at the distance of 50 meters, third 100 meters away from the landfill and last located 150 meters from the landfill site. The characteristics of the soil were analysed using the standard procedure defined in the soil testing laboratory. The quantity of sand in the soil decreased as we move away from the dumping ground which shows the reduction in the organic matter in the soil. The moisture content of the refused material decreased as we move outwards from the landfill location. The capacity of the soil to hold water also decreases with the increasing distance from the landfill. The porosity of the soil degraded due to reduction in the share of sand in the soil.

Table 5. Physical properties of soil class (in percentage)

| Locations | MC | WHC | Porosity | Sand | Clay | Silt |
|---|---|---|---|---|---|---|
| **Within Landfill** | 43 | 54 | 49 | 69 | 25 | 6 |
| **Within 50 Mt** | 36 | 48 | 48 | 65 | 29 | 6 |
| **Within 100 Mt** | 36 | 49 | 48 | 61 | 30 | 9 |
| **Within 150 Mt** | 34 | 37 | 43 | 57 | 31 | 12 |

*Source: Samples collected from Primary Field Survey, 2017*
**MC – moisture content, WHC – Water Holding Capacity.*

As shown in the table 6, the range of organic matter was recorded to be from 2.42 to 4.28 with the general trend of decrease with in distance from the dumping location. The high level of organic matter in the dumping location resulted in the high moisture retaining capacity of the soil within and close to the dumping location. Organic carbon also decreased as we move away from the land fill ranging from 2.48 to 1.41.The high levels of organic carbon within and close to the landfill can be the result of burning of solid waste in the dumping ground itself. The quantity of nitrogen, phosphors, potassium also showed the same trend of decrease withthe distance from the landfill location.

As seen in the table 6, the presence of heavy metals such as sodium, calcium, magnesium, copper and lead indicates that the landfill locations are not well managed and there is seepage of toxic matters into the ground. That ultimately results in the contamination of ground water sources.

Table 6. Chemical properties of soil samples at various locations within the landfill site

| Location | pH | OC | OM | N | P | K | Na | Ca | Mg | Cu | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (%) | | | | | (mg/kg) | | | | |
| **Within Landfill** | 7.51 | 2.48 | 4.28 | 0.22 | 33.51 | 1.22 | 1.03 | 11.76 | 6.22 | 101.91 | 54.29 |
| **Within 50 Mt** | 7.41 | 2.48 | 4.25 | 0.22 | 20.14 | 1.03 | 0.98 | 11.72 | 5.54 | 81.25 | 59.71 |
| **Within 100 Mt** | 7.32 | 2.12 | 3.64 | 0.19 | 15.16 | 0.96 | 0.75 | 11.55 | 5.44 | 63.75 | 43.25 |
| **Within 150 Mt** | 6.91 | 1.41 | 2.42 | 0.13 | 11.37 | 0.94 | 0.64 | 10.26 | 4.98 | 31.75 | 24.73 |
| FAO | 7 | - | 3 | 0.15 | 20 | 0.3 | 0.3 | 12 | 1 | 6 | 6 |

*Source: Samples collected from Primary Field Survey, 2017*
**OC – Organic Content; OM – Organic Matte ;N -Nitrogen ; P -Phosphorus ; K -Potassium ; Na - Sodium; Ca – Calcium; ;Mg -Magnesium ; Cu -Copper ; Pb – Lead.*

## Conclusion

The present investigation was designed to access the pollution of soil and groundwater resources in the landfill area of SahibzadaAjit Singh Nagar. The study revealed that the accumulated garbage in the landfill had been polluting the soil and ground water since long time. The impact of landfill in the pollution of ground water and soil resources can be found highest in the proximity of the landfill location and keeps on decreasing as we move away from it. This shows that degradation of the quality of the ground water depends upon its proximity to the landfill site. It was also found that the factors like type of topography, waste disposal system, underground water system have minimal influence on ground water contamination.Results also showed that the lack of cleanliness and poor hygiene are adversely affecting the health of local residents and the animals. Consequently the soil fertility is also declining under the impact of landfills where toxic material and heavy metals are being dumped.

## References

[1] Ammonia. Geneva, World Health Organization, 1986 (Environmental Health Criteria, No. 54).

[2] APHA (2005): Standard Methods for the Examination of Water and Waste Water. 21st Ed. American Public Health Association, Washington, DC.

[3] Barrett, A. and J. Lawlor, 1995. The Economics of Waste Management in Ireland. Economic and Social Research Institute, Dublin, Pages: 129.

[4] Bureau of Indian Standerds (BIS) (2012) Drinking Water Specificaiton, Second Revision, Publication Division, New Delhi, India.

[5] Bureau of Indian Standerds (BIS) (2014) Indian Standards: Methods for test of Soils, Publication Division, New Delhi, India.

[6] Chilton, J. (1992) Groundwater, In Deborah Chapman Edt. Water Quality Assessments - A Guide

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p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition. Online accessed at http://www.who.int/water_sanitation _health/ resourcesquality/wqachapter9.pdf

[7] Christensen, T.H., P. Kjeldsen, P.L. Bjerg, D.L. Jensen and J.B. Christensen et al., 2001. Biogeochemistry of landfill leachate plumes. Applied Geochem., 16: 659-718.

[8] Department of National Health and Welfare (Canada). Guidelines for Canadian drinking water quality. Supporting documentation. Ottawa, 1992.

[9] Dieter HH, Möller R. Ammonium. In: Aurand K et al., eds. Die Trinkwasserverordnung, Einführung und Erläuterungen. [The drinking-water regulations, introduction and explanations.] Berlin, Erich-Schmidt Verlag, 1991:362-368.

[10] Elinder CG. Zinc. In: Friberg L, Nordberg GF, Vouk VB, eds. Handbook on the toxicology of metals, 2nd ed. Amsterdam, Elsevier Science Publishers, 1986:664-679.

[11] Expert Consultation. Rome, Food and Agriculture Organization of the United Nations, 1988

[12] Fatta, D., A. Papadopoulos and M. Loizidou, 1999. A study on the landfill leachate and its impact on the groundwater quality of the greater area. Environ. Geochem. Health, 21: 175-190.

[13] Gao,Y., Yu, G., Luo, C., & Zhou, P. (2012). Groundwater Nitrogen Pollution and Assessment of Its Health Risks: A Case Study of a Typical Village in Rural-Urban Continuum, China. PLoS One. 2012; 7(4): e33982.

[14] Ikem A., Osibanjo O., Sridhar M.K.C., Sobande A. (2002): Evaluation of groundwater quality characteris¬tics near two waste sites in Ibadan and Lagos, Nigeria. Water, Air, and Soil Pollution, 140: 307–333.

[15] International Organization for Standardization. Water quality—determination of ammonium. Geneva, 1984, 1986 (ISO5664:1984; ISO6778:1984; ISO7150-1:1984; ISO7150-2:1986).

[16] Iron Disorder Institute. (2018). Iron overdose. Retrieved from: http://www.irondisorders.org/iron-overload.

[17] Krishnamurti, C.R. and PushpaViswanathan: Copper in the Indian environment and its human health implications. In: Toxic metals in Indian environment. (Eds: C.R. Krishna Murti, and PushpaViswanathan). Tata McGraw. Hill Pub. Camp. Ltd. 1991: pp 188-198.

[18] Lee, G.F. and A. Jones-Lee, 1993. Groundwater quality protection: A suggested approach for water utilities. Report to the CA/NV AWWA Section Source Water Quality Committee, August 1993, pp: 8.

[19] LongeE.O., BalogunM.R. (2010): Groundwater qual¬ity assessment near a municipal landfill, Lagos, Nige¬ria. Research Journal of Applied Sciences, Engineering and Technology, 2: 39–44.

[20] Luza SC, Speisky HC (1996) Liver copper storage and transport during development: implications for cytotoxicity. American Journal of Clinical Nutrition, 63:812S–820S.

[21] Mor, S., K. Ravindra, R.P. Dahiya and A. Chandra, 2006. Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environ. Monit. Assess., 118: 435-456.

[22] National Academy of Sciences. Drinking water and health. Washington, DC, National Academy Press, 1977:400-411.

[23] National Research Council. Recommended dietary allowances, 10th ed. Washington, DC, National Academy Press, 1989

[24] Ossola, A. (2016). Lead In Water: What Are The Health Effects And Dangers? Retrieved from: https://www.popsci.com/lead-water-what-are-health-effects-dangers.

[25] Payne MR. Jones JG, editor. Farm waste and nitrate pollution. Agriculture and the environment. 1993. pp. 63–73. Horwood, New York

[26] Requirements of vitamin A, iron, folate and vitamin B12. Report of a Joint FAO/WHO, exper consultation, Rome , Food and Agricultural Orgenisation of United Nations, 1998 (FAO Food and Nutrition Series, No. 23).

[27] Sengupta, P. (2013). Potential Health Impacts of Hard Water. Int J Prev Med. 4(8): 866–875.

[28] Sodium, chlorides and conductivity in drinking water. Copenhagen, WHO Regional Office for Europe, 1979 (EURO Reports and Studies No. 2).

[29] The World Bank. (2012). India Groundwater: a Valuable but Diminishing Resource. Retrieved from: http://www.worldbank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing.

[30] USEPA, 1984. A ground water protection strategy for the environmental protection agency. United States Environmental Protection Agency (USEPA), Office of Ground-Water Protection, Washington, DC., USA., August 1984.

[31] Vaishaly, A.G. (2015). Health effects caused by metal contaminated ground water. International Journal of Advances in Scientific Research, 1(02): 60-64.

[32] Wendlandt E. Ammonium/AmmoniakalsUrsachefürWiederverkeimungen in Trinkwasserleitungen. [Ammonium/ammonia as cause of bacterial regrowth in drinking-water pipes.] Gas- und Wasserfach, Wasser-Abwasser, 1988, 129:567-571.

[33] WHO (2004). Guidelines for drinking water quality. Retrieved from http://www.who.int/water_sanitation_health/dwq/chemicals/sulfate.pdf

[34] WHO guidelines for drinking water quality (2009). Potassium in drinking-water. Retrieved from: http://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/potassium-background.pdf

[35] WHO Guidelines for Drinking-water Quality. (2011). Hardness in Drinking-water. Retrieved from : http://www.who.int/water_sanitation_health/dwq/chemicals/hardness.pdf

[36] WHO. Guidelines for drinking-water quality-Third Edition Incorporating the first and second addenda. 2008. Volume 1. Recommendations. World Health Organization, Geneva website. Available:http://www.who.int/water_sanitation_health/dwq/GDWPRecomdrev1and2.pdf. Accessed 10 Sept 2010

[37] Yang CY, Cheng MF, Tsai SS, Hsieh YL. Calcium, magnesium, and nitrate in drinking water and gastric cancer mortality. Jpn J Cancer Res. 1998;89:124–30.