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Evaluation of Ground Water Contamination in and Around Raipur Municipal Solid Waste Dumpsite

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Abstract - Leachate is the fluid which is formed when water percolates through waste and becomes contaminants with dissolved soluble organic and inorganic compounds as well as suspended particles. Landfill is one of the major sources of water pollution where as unscientific management in municipal solid waste dumpsite has led to generation of voluminous leachate in urban areas. Purely managed disposal of industrial solid waste containing heavy metal needs remediation before discharging in the recognized as one of the major threads to the surrounding ground water. The aim of this study was to determine the impact of leachate contaminates on ground water quality of Raipur region. Assessment of physico-chemical characteristics and heavy metal concentration of in landfill leachate was conducted to determine the impact of leachate on ground water environment. All the samples will be analyzing for various physico-chemical parameter including the heavy metals according to standards method, this includes pH, TDS, TH major citations such as calcium, magnesium, major ions and heavy metals such as zinc, iron, lead etc. The ground water at the site adjacent to the spill way in the landfill was partially contaminants by the emission of leachate, thus improved understanding of ground water contamination around the landfill is beneficial for ground water environment remediation.

Key Words: leachate, groundwater, waste water

1. INTRODUCTION

Leachate is the liquid that drains or 'leaches' from a landfill. It varies widely in composition regarding the age of the landfill and the type of waste that it contains. It usually contains both dissolved and suspended material. The dump yard is constantly in the news for the burning of garbage despite it being banned. The dump yard also spills into the pallikaranai marshland which is home to a lot of local and migratory birds. The plans to close the dump yard by the corporation have not yet fructified. In fact the term "leachate" is so often applied to landfill leachate, both within the waste management industry and outside, that it is easy to forget that leachate is the term used for any liquid produced by the action of "leaching". Leaching occurs when water percolates through any permeable material. Leachate refers to the liquid that is generated when water interacts with or percolates through a solid material or waste. It commonly occurs in landfills, where rainwater or other forms of precipitation come into contact with the waste deposited in the landfill. As the water seeps through the waste, it picks up various dissolved and suspended contaminants, such as organic matter, heavy metals, and other pollutants. Leachate can be highly contaminated and pose a significant environmental risk if it reaches water bodies or groundwater sources. It typically has a dark, unpleasant appearance and often carries a foul odor due to the decomposition and breakdown of organic matter within the waste. The composition of leachate varies depending on the type of waste present, the age of the landfill, and other factors.

TYPES OF LEACHATE

Leachate, refers to the liquid that is formed when water comes into contact with waste materials or substances. It is commonly associated with landfills and can contain a mixture of organic and inorganic compounds. The composition of leachate can vary depending on the waste materials present and the stage of decomposition. Here are some common types of leachate:-

I. Landfill Leachate:

This is the most common type of leachate and is formed when precipitation or water percolates through a landfill site, picking up dissolved and suspended substances from the waste. It can contain a range of contaminants such as organic matter, heavy metals, pathogens, and various chemical compounds.

II. Compost Leachate:

Compost leachate is produced during the decomposition of organic waste in composting facilities. It consists of water that has passed through the composting material, carrying dissolved organic compounds, nutrients, and microorganisms. Compost leachate is often collected and used as a nutrient-rich liquid fertilizer.

III. Mine Leachate:

Mine leachate, also known as acid mine drainage (AMD), is generated when water interacts with sulfide minerals present in mining operations. The leachate is usually acidic and can contain high concentrations of heavy metals, such as iron, copper, and zinc, which can have detrimental effects on aquatic ecosystems. Mine leachate refers to the contaminated liquid that is generated as a result of mining activities, particularly in open-pit or underground mines.

COMPOSITION OF LEACHATE

The composition of leachate can vary depending on the type of waste it originates from, the age of the waste, and other factors. However, leachate typically contains a combination of the following components:

i. **Organic Matter:** Leachate often contains various organic compounds derived from decomposing waste materials.

These can include carbohydrates, proteins, fats, oils, cellulose, lignin, and other organic substances.

ii. **Inorganic Compounds:** Leachate can contain a range of inorganic compounds, including salts, minerals, and trace elements. These may include sulfates, chlorides, nitrates, phosphates, carbonates, and metals such as iron, aluminum, manganese, and zinc.

iii. **Heavy Metals:** Leachate from certain waste sources, such as landfills or industrial sites, may contain elevated levels of heavy metals. These can include lead, cadmium, mercury, chromium, arsenic, and others. Heavy metals pose risks to human health and can have harmful effects on ecosystems.

iv. **Pathogens:** Leachate can harbor various pathogens, including bacteria, viruses, and parasites. These microorganisms may originate from sewage waste, animal waste, or other sources and can pose a risk to human health and the environment if not properly treated.

v. **Nutrients:** Leachate often contains nutrients such as nitrogen (in the form of ammonia, nitrites, and nitrates) and phosphorus. These nutrients can promote eutrophication when leachate enters water bodies, leading to excessive algae growth and oxygen depletion.

vi. **Volatile Organic Compounds (VOCs):** Leachate can contain volatile organic compounds, such as benzene, toluene, ethylbenzene, and xylene (BTEX), as well as various organic solvents. These compounds can contribute to the odor of leachate and pose risks to human health and the environment.

vii. **pH:** The pH of leachate can vary depending on the waste composition. Landfill leachate, for example, is often acidic due to the generation of organic acids during waste decomposition. Other sources of leachate, such as mine leachate, can be highly alkaline due to the presence of minerals and chemicals.

GROUNDWATER CONTAMINATION

The groundwater framework is most in danger in regions that have a shallow water table and high precipitation. Traditionally, several sites were designed with the "dilute and disperse" principle in mind, allowing leachate to drain into the groundwater systems nearby. While the vast majority of the examination into leachate crest focuses on these more seasoned destinations and individuals in touchy regions, control locales likewise show confirmation of leachate defilement of the groundwater with leachate crest. Groundwater contamination due to leachate is a significant concern and a potential environmental consequence of improper waste management practices, particularly in landfills or sites where leachate is generated. Leachate, which is the liquid produced when water interacts with waste materials, can contain various pollutants and contaminants. When leachate is not effectively managed or if it escapes containment systems, it can infiltrate the ground and contaminate the underlying groundwater. Groundwater is an essential source of drinking water for many communities, and its contamination poses a serious risk to human health and the environment. The contaminants present in leachate can include organic compounds, heavy metals, chemicals, pathogens, and nutrients. These substances can persist in the groundwater for long periods, potentially spreading over a wide area and affecting surrounding wells, surface water bodies, and ecosystems.

STUDY AREA

With around 18,17,000 people, Raipur is one of the most inhabited cities. The issue of managing solid waste in Raipur has been growing quickly as a result of urbanisation, population growth, changes in lifestyle, and changes in consumption patterns. Municipal Solid Waste While business establishments and educational institutions have increased in the southern part, industries have expanded more quickly in the northern part. The pattern of land usage is drastically altered as a result. (MSW) for the city of Raipur is being disposed of in the Sakri landfill site, one of the largest.

The Chhattisgarh high court will be asked for an extension of time so that Raipur Municipal Corporation (RMC) can move the waste dumping and processing work to the recently assigned trench land in Sakri. According to an RMC official, the incomplete construction at the Sakri landfill site was to blame for the delay in moving the rubbish disposal zone. The Sarona Trench Ground rubbish is currently being collected and dumped by the Ramki Group, a solid waste management organisation.

WASTE GENERATION

The current MSW generation from the city is about 650-700 t/day. The quantity of waste that is currently dumped in the total area used for dumping is around 67 acres. Approximately the depth of ground water table is 2 meters below the ground level at the dumpsite. Within the boundaries of Raipur city's municipal jurisdiction, a research is conducted addressing every area of the management of municipal solid waste. The many garbage types produced by cities are also investigated. This study is being done to better understand how the waste that is produced in the eight zones of the city of Raipur is managed. The system for collecting, transporting, and disposing of municipal waste is thoroughly studied.
Waste transportation is carried out via door-to-door collection and vans equipped with waste sorting capabilities. With the aid of a GPS device, the vehicle utilised for collecting and transportation is tracked. The amount of waste collected from different trash cans and door-to-door pickup is analysed. Method using a fully automated equipment that is installed at the final disposal site, which is situated at Sakari on the outskirts of the city. It has been suggested installing a waste-to-energy facility at the disposal site so that waste can be converted into energy. Waste water collected from wet waste can also be used for a variety of purposes, such as watering the garden at the disposal facility.

AQUIFER SYSTEM

The research region was where the hard solidified formations were mostly found. As the lithology varies within close proximity, the aquifer in these formations is typically heterogeneous in nature. In the studied area, three distinct types of geomorphic units were discovered. Along the eastern side is the coastal plain, which has sand, clay, and silt depositions in a highly permeable zone with potential for groundwater. An aquifer system refers to a geological formation or a network of interconnected layers of rock, sediment, or soil that contains and transmits groundwater. It consists of a saturated zone, also known as the groundwater zone, where the interconnected pore spaces or fractures are filled with water. Aquifer systems are essential for the storage and movement of groundwater, which serves as a vital water resource for human consumption, agriculture, and ecological sustenance. They play a crucial role in maintaining the water balance within an area and contribute to the overall hydrological cycle.

2. PROBLEM IDENTIFICATION

The majority of domestic waste is disposed of or dumped in landfills without being separated or treated. Leachate from solid waste poses a risk of contaminating aquifers that are susceptible. The correct management of solid waste and landfill design are key components in preventing leachate contamination of groundwater.

Climate (rainfall), terrain (run on/run-off), landfill cover, vegetation, and kind of trash are all factors that have an impact on leachate formation. The process is influenced by a number of variables, including water properties, leachate/soil interaction, groundwater aquifer system, and soil chemistry and mineralogy. When leachate is not properly managed, it can lead to several problems in the surrounding areas. Here are some common issues associated with leachate:

- **Groundwater Contamination:** As mentioned earlier, leachate can infiltrate the ground and contaminate the underlying groundwater. This poses a significant risk as groundwater is often a vital source of drinking water. Contaminated groundwater can lead to health concerns for nearby communities and ecosystems.
- **Surface Water Pollution:** Leachate can flow into nearby surface water bodies such as rivers, lakes, or streams, causing pollution. This can harm aquatic life, disrupt ecosystems, and make the water unsuitable for various uses, including drinking, recreation, and irrigation.

3. LEACHATE COLLECTION SYSTEM

A liquid called leachate has passed through the landfill. Precipitation makes up the majority of it, with a minor amount of the waste's natural breakdown accounting for the remainder. Leachate is gathered by the leachate collecting system so that it can be taken out of the landfill and appropriately treated or disposed of. A leachate collection system is a crucial component of landfill infrastructure designed to manage and control the leachate generated within the landfill. Leachate is the liquid that forms when water percolates through the waste deposited in a landfill, picking up various contaminants and pollutants along the way. It is important to collect and properly handle leachate to prevent it from contaminating surrounding soil, groundwater, and surface water bodies. The primary purpose of a leachate collection system is to capture, collect, and transport the leachate for appropriate treatment and disposal. Here's a general overview of how a typical leachate collection system functions:

i. **Collection Wells:** Strategically placed collection wells or sumps are installed throughout the landfill. These wells consist of perforated pipes or risers that extend into the waste mass or leachate accumulation areas. They are designed to efficiently collect the leachate as it drains or accumulates.

ii. **Geo-synthetic Liners:** The landfill is lined with specialized geo-synthetic liners, including a composite liner system or a geo-membrane liner. These liners help to prevent the leachate from infiltrating the underlying soil and groundwater, directing it towards the collection system instead.

iii. **Leachate Collection Pipes:** Perforated collection pipes are laid within the landfill on top of the liners. These pipes connect the collection wells, forming a network throughout the landfill. They are designed to allow the leachate to flow into the pipes while preventing waste materials from entering.

iv. **Header Pipes and Manifolds:** The leachate collection pipes are connected to larger header pipes, which collect and consolidate the leachate from multiple wells or sections of the landfill. These header pipes lead to a manifold, a central collection point for the leachate.

v. **Leachate Pumping Stations:** At the manifold or central collection point, pumping stations are installed to lift the leachate from the collection system and transport it to a treatment facility. The pumps ensure that the leachate is moved efficiently and at the required flow rate.

4. MATERIALS & PROCEDURES

The purpose of this study was to evaluate the effect of leachate on landfill surface and groundwater quality. Sampling techniques have been to arrive at an appropriate methodology. To watch the spatial and transient varieties in the groundwater science, the groundwater tests were gathered by considering the topographical arrangements and geology of the review range. It's important to note that the selection of a specific leachate treatment method or combination of methods depends on the characteristics of the leachate, site-specific considerations, regulatory requirements, and treatment objectives. Engineering expertise and a thorough understanding of the leachate composition are essential fordesigning an effective treatment system. Additionally, regular monitoring and compliance with applicable regulations are necessary to ensure the ongoing effectiveness of the treatment process.There are several methods commonly used for leachate treatment, depending on the composition of the leachate, the required treatment level, and site-specific conditions. The specifics of the laboratory studies conducted are described in this chapter. The impacts of leachate pollution on the geotechnical and geo-environmental characteristics of natural soils were examined through a variety of laboratory studies. In order to support the analysis of polluted leachate behaviour provided in following chapters, parameters measured in this chapter will be employed.

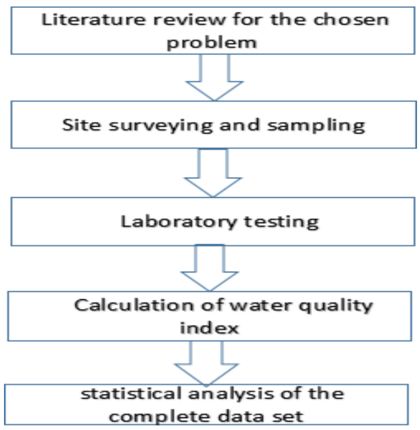

Figure 4.1 Process flow chart

BOD & COD TEST PROCEDURE FOR LEACHATE

The BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) tests are commonly used to assess the organic content and oxygen-consuming capacity of leachate. Here is a general procedure for conducting BOD and COD tests on leachate:

BOD Test Procedure:

- Collect a representative sample of leachate from the landfill or waste disposal site using appropriate sampling techniques.
- Determine the initial dissolved oxygen (DO) concentration in the sample by measuring it with a dissolved oxygen probe or an oxygen titration method. This is the initial DO (DOi) value.
- Prepare BOD bottles by adding a known volume of the leachate sample, usually 300 mL or 500 mL, to multiple bottles. Ensure the bottles are clean and properly labeled.
- Add a seed inoculum to each BOD bottle. The seed can be obtained from an active biological treatment system or obtained commercially. The seed provides the microorganisms necessary for the decomposition of organic matter.
- Incubate the BOD bottles in a dark, temperature-controlled environment at a specified temperature, typically 20°C or 25°C. Maintain the temperature consistently throughout the incubation period.
- After 5 or 7 days of incubation, measure the final dissolved oxygen (DO) concentration in one of the BOD bottles using the same method as step 2. This is the final DO (DOf) value.
- Calculate the BOD value using the formula: BOD = (DOi - DOf) × dilution factor, where the dilution factor accounts for the volume of sample and seed inoculum used.
- Record the BOD value, and if necessary, repeat the test with duplicate or triplicate samples to ensure accuracy and reliability.

HEAVY METAL ANALYSIS FOR LEACHATE

Testing for heavy metals in leachate involves specific procedures to analyze the presence and concentration of various heavy metal contaminants. Here is a general procedure for conducting heavy metal testing in leachate.

i. **Sample Collection:** Collect a representative sample of leachate from the landfill or waste disposal site using appropriate sampling techniques. Ensure proper sample preservation and transportation to the laboratory to maintain the integrity of the heavy metal content.

ii. **Sample Preparation:** Homogenize the leachate sample to ensure a uniform composition. If the leachate contains suspended solids, filter the sample using a suitable filter to remove particulate matter. Adjust the sample pH if required to meet the specific testing requirements.

iii. **Digestion:** Heavy metals in leachate samples are typically present in complex forms. Digestion is performed to break down organic and inorganic compounds and convert heavy metals to a soluble form suitable for analysis. There are various digestion methods available, such as acid digestion, microwave digestion, or fusion digestion. Select an appropriate digestion method based on the heavy metals of interest and the characteristics of the leachate sample.

iv. **Analytical Technique:** Choose the appropriate analytical technique for heavy metal analysis, such as atomic absorption spectroscopy (AAS), inductively coupled plasma optical emission spectrometry (ICP-OES), or inductively coupled plasma mass spectrometry (ICP-MS). These techniques provide accurate and precise measurements of heavy metal concentrations. Follow the specific instrument's operating instructions and calibration procedures.

v. **Calibration:** Prepare calibration standards for each heavy metal of interest. Use certified reference materials or prepare standard solutions of known concentrations to establish a calibration curve. Ensure the calibration curve covers the expected range of heavy metal concentrations in the leachate samples.

5. APPLIED METHODS

The system consists of the following phases:

1. Writing accumulation and audit, which are no longer necessary for understanding the encounters and findings of earlier scientists in the field. The definition of the speculative underpinnings of the current review was helped by this stage.
2. The strategy of accumulating information is based on field work, where the investigation prompted a few trips to landfill-focused regions to collect the necessary specimens and map the area. A description of the centre and southern landfills' (range) area, geography, groundwater table, and amount and type of garbage saved are only a few examples of the data that have been gathered.
3. Collecting and analysing various groundwater test results from Multiple-level perception wells for the aquifer-to-landfill leachate conveyance.
4. An endless quantity of data and writing has been collected, evaluated, and examined by experts who have started to take the theory into consideration.

COLLECTION METHODS

Leachate was collected from the area surrounding the dump site and the leachate lake. Prior to examination, they were collected in a 5 litre plastic stick and stored at 4°C.

Ten testing locations near to the dumpsite where the examples were gathered were selected in order to concentrate the level of groundwater contamination. One-liter polythene bottles were used to collect the examples. Before the accumulation, all of the jugs were thoroughly washed. approach was used to obtain the groundwater tests with consideration given to how they would relate to land-use plans. These samples were collected in pre-cleaned, 2 liter-capacity polypropylene containers after being flushed with the specimen, sealed shut to prevent disappearance, stored at 4°C, and degraded within two days. Leachate was collected from the area surrounding the dump site and the leachate lake. Prior to examination, they were collected in a 5 litre plastic stick and stored at 4°C.

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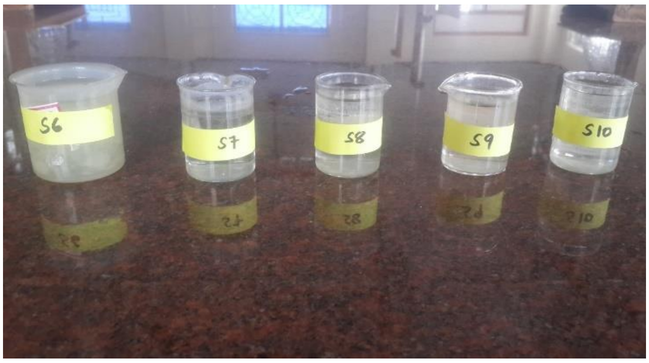
GROUNDWATER CONTAMINATION

The groundwater samples were characterized to ascertain the extent of pollution caused by leachate. The results of physical, chemical and heavy metals analyses of well water samples collected from so many different sources like tube well, open well and from houses which is located nearby dumpsite. The water quality at the wells near the landfill is significantly different at pH 6 to 7 from the recommended groundwater quality indicating that the landfill leachate most likely influenced. The groundwater quality was extremely affected by the migrated leachate from the landfill site. Sample water was collected 1 litre plastic bottle and filled the total volume of container and cap was locked enough so that no air space can be remained inside the bottle.

(a)



(b)

Figure 5.1 (a), (b) Ground water samples collected from near by dumpsite

Water collection from in and around a dumpsite typically involves the implementation of various drainage and collection systems to manage surface water runoff and prevent it from mixing with leachate or spreading contaminants. Here are some common methods for water collection from a dumpsite:

i. **Surface Water Diversion**: The dumpsite is designed with engineered slopes and berms to redirect surface water runoff away from waste area. This helps minimize the contact between water and the waste, reducing the potential for contamination
ii. **Surface Water Collection Ditches**: Ditches or channels are constructed around the dumpsite to capture and direct surface water runoff. These ditches can be lined with impermeable materials to prevent the infiltration of water into the waste and are typically connected to sedimentation ponds or other treatment systems.
iii. **Storm water Ponds or Basins:** Stormwater ponds or basins are constructed to collect and temporarily store surface water runoff. These ponds allow sediments to settle out, reducing the transport of contaminants. The collected water can be treated or discharged to appropriate receiving bodies.

The groundwater of the studied area is used for drinking and domestic purposes. The chemical characteristics of ground water samples taken in 10 locations were analysed and the results.

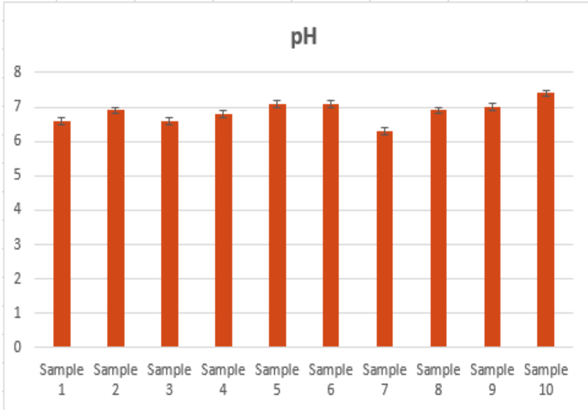


Figure 6.1 pH of 10 groundwater samples

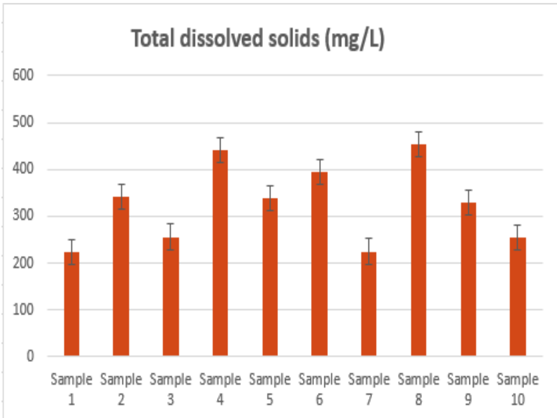


Figure 6.2 Total dissolved solids of 10 groundwater samples

Every sample is below the permitted level. Toxic heavy metals that enter aquatic systems are mostly introduced through industrial discharge, domestic sewage, non-point source runoff, and atmospheric precipitation. Although many metals are necessary for the survival of living things, some of them are extremely hazardous or turn toxic at large concentrations. Since all samples fall within the range of 6.5 to 8.5, water is appropriate for drinking.

The outcomes were contrasted with the IS:10500-2012 drinking water quality criteria. Except for a few places near landfill locations, the groundwater in the area is generally crisp. However, these places are bitter in nature. Surprisingly, access to safe and clean drinking water is essential for human welfare. To treat contaminated water, it is necessary to safeguard water resources and keep them from being contaminated. The several indices of water quality show differences between locations. It proves that there are toxins in ground water and that using it entails some risk. Campers must go far to avoid the landfill because there are several evidence of contamination there. The pH value is a trustworthy indicator of the water's natural acidity or alkalinity. Inconsistent TDS values make water unfit for consumption, although samples of neighbouring water exhibited high TDS values. Water's hardness, flavour, and corrosiveness can all be affected by high TDS levels. The presence of hazardous materials is also indicated by a high level of arsenic symptoms in the water. It is dangerous even in small doses and causes a variety of respiratory illnesses, lung cancer, etc.

6. CONCLUSION

The concentrations of the heavy metals Cr, Cd, Cu, and Iron in the ground water samples are over the permissible upper limit. However, the analysis shows that the leachate test is affecting other subterranean water sources in addition to permeating from the dump site to the groundwater. The current landfill site is polluted by the leachate that has seeped in from the landfill site. The findings demonstrate how seriously polluted the areas close to the dumpsite are. Long-term introduction of excessive amounts of copper and cadmium results in lung growth and kidney damage. If exposed to chromium for a prolonged period of time, it is also thought to cause sickness.

As there is no characteristic or other conceivable explanation behind high grouping of these contaminations, it can be reasoned that leachate has critical effect on groundwater quality in the region close to all the three landfill destinations.

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