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# Contamination of Ground Water Due To Landfill Leachate

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**ABSTRACT**

The present site under investigation at Ajitsingh Nagar in Vijayawada of Andhra Pradesh is initially a low lying area and used for disposing the urban solid waste for the last few years, through open dumping with out taking any measures to protect the Ground water against pollution. The present study has been taken up to measure the degree of pollution of ground water due to leachate produced in the landfill site. Bore holes were made at eight random locations to measure the depth and characteristics of solid waste. Four sampling wells were made for the collection of ground water samples and they were analyzed for various parameters. All parameters were measured based on Standard methods. It is found that the ground water is contaminated due leachates of Landfill to the large extent and is not suitable for Drinking, Domestic and Irrigation purposes.

**Key Words:** Landfill, Leachate, Soil profile, Sampling wells

## 1. INTRODUCTION

A common problem of the storage of wastes in landfills, is the potential contamination of soil, groundwater and surface waters that may occur as leachate. This is usually produced by water or liquid wastes moving into, through and out of the landfill and migrates into adjacent areas.

The quantity of leachate produced is affected to some extent by decomposition reactions and initial moisture content; however it is largely governed by the amount of external water entering the landfill, the climate and geomorphology of the area.

The chemical quality of leachate varies as a function of a number of factors. It includes the original nature of the buried waste materials and the various chemical and biochemical reactions that may occur as well as the conditions prevailing throughout the waste materials decomposition.

The present site under investigation at Ajitsingh Nagar in Vijayawada is initially a low lying area and used for disposing the urban solid waste for the last few years, through open dumping with out taking any measures to protect the environment against pollution.

The present study was undertaken to determine the likely concentrations of principal contaminants in the groundwater over a period of time due to the discharge of such contaminants from landfill leachates to the underlying groundwater.

## 2. SITE DISCRIPTION

The Proposed landfill site is located at Ajitsingh Nagar, on North side of Vijayawada city, Krishna District, Andhra Pradesh.

Vijayawada is the biggest city in the Krishna District and the third largest city in the state of Andhra Pradesh, after Hyderabad and Visakhapatnam with an area of 61.88 sq km. Vijayawada is located at 16.52° North Latitude 80.62° East Longitude. It is situated on the banks of the Krishna River as shown in Location Map (Fig.2.1). The City has a population of 10,48,240 (2011 Census). The City is also known as Bezawada. It is located at about 275 Km from Hyderabad. It is well connected to other regions via road, air and rail, and is one of the biggest railway junction in India. It is hub of various businesses including retail and wholesale markets. Famous Kanaka Durga Temple is situated on the banks of River Krishna.

The climate is tropical, specifically a tropical wet and dry climate, with hot summers and moderate winters. The peak temperature reaches 47 °C (117 °F) in May - June, while the winter temperature is 20-27 C. The average humidity is 78% and the average annual rainfall is 103 cm.

The proposed site is surrounded by roads on North, East and West sides. It is a filled up area with urban solid waste as shown in Fig. 2.2. The terrain of the disposal site is flat and covered with wild vegetation consisting of low plants and grass. Adjacent to this site, Sriram energy system plant and

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burial ground are situated. And Residential buildings are also located nearby.

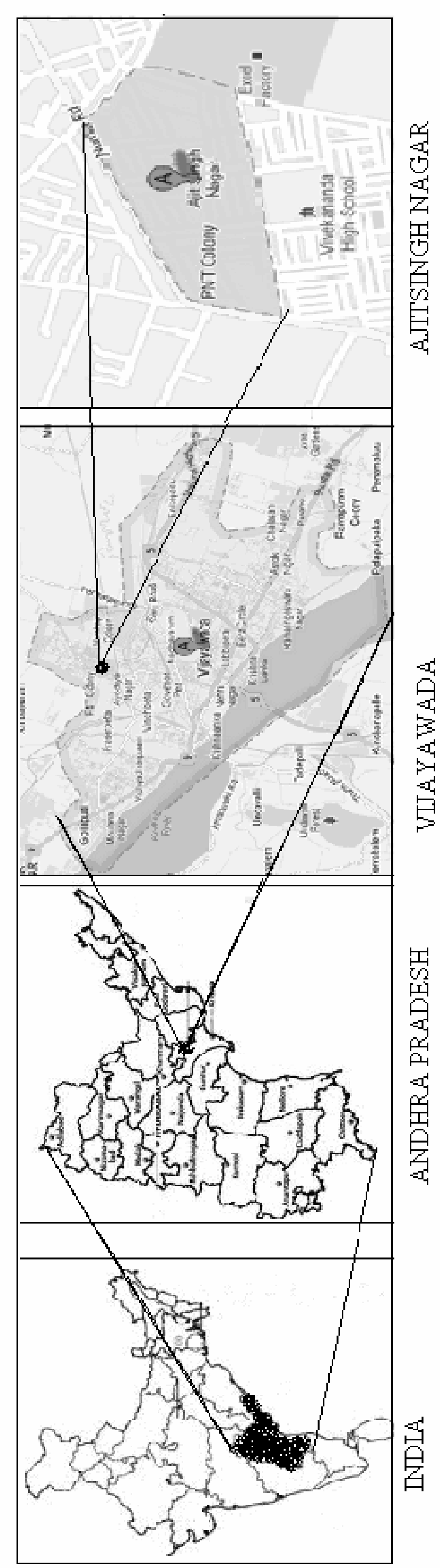


Fig. 2.1 Location Map

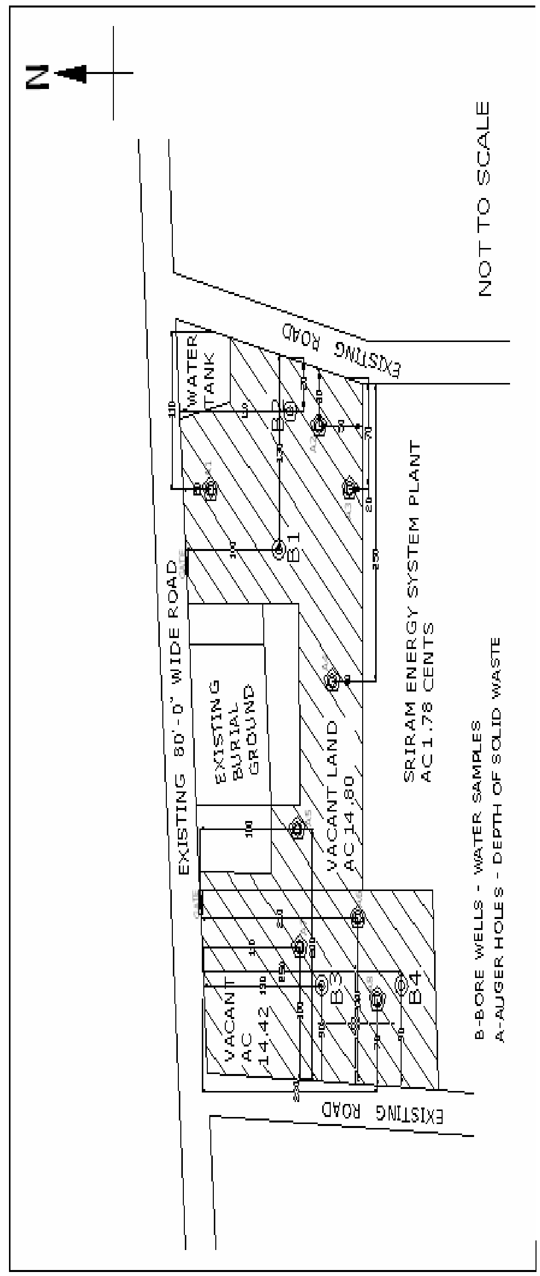


Fig.2.2 Proposed site plan - Showing the Ground Water Sampling Wells and Auger holes

## 3. COMPOSITION AND QUANTITY OF SOLID WASTE

### 3.1. Solid waste and its Composition:

It is observed that the entire area is not filled with solid waste in a systematic and scientific way. The solid waste and soil cover are not uniform in the site. The bottom of the land fill is not lined and there is no provision for the collection of leachate. The bottom layer consists of solid waste to an extent of around 2.00 m. On top of it the soil and the wastes are compacted in alternative layers ranging from 0.2 to 0.4 m of soil and 0.5 to 0.75 m of solid waste respectively up to the surface. The thickness of the soil and the waste layers are not uniform.

By visual observations of the solid waste it is found that it consisted of various constituents like paper, organic matter, Metals, glass, ceramics, plastics, textiles, dirt and wood. The composition of solid waste was determined by sorting of waste into components for weighing to determine the percentage of each component. One waste sample from each auger hole was collected and mean values of the constituents of the solid waste from eight auger holes were presented.

### 3.2 Depth of Solid Waste

Eight locations at random, are selected for making auger bore holes namely A1 to A8 in the above site and the locations of them are shown in the Fig. 2.2. It found that the depth of solid waste is varying from 3.65 m to 3.96 m and average depth found to be 3.65 m. The photograph (Fig. 3.1) of the auger holes to measure the depth of solid waste is enclosed.

Fig.3.1: Typical bore hole at the site.

## 4. MAKING BORE WELLS AND COLLECTION OF GROUND WATER SAMPLES

The Sub-soil/water investigation was carried out to determine

1. Sequence and extent of each soil & water depth.
2. Nature of each stratum and water.
3. Location of ground water table and collection of water.

The following methods were adopted for sub-soil investigations. Four water bore wells of 150 mm diameter up to a depth of 30.48 m (100 feet) were proposed and drilled within the specified locations as shown in Table 4.1. The location of these bore wells (B1 to B4) is given in Figure 2.2. The boring was done using combination of shell and auger with casing pipe depending upon the type of strata met with in the bore hole location using hand boring machine [Wash Boring]. Bore holes of 150 mm diameter with casing pipe were drilled to facilitate collection of ground water samples. These bore wells were made permanent by inserting a casing pipe up to 30.48 m (100 ft) with perforation at the bottom of the pipe so that there will be yield of water. After pumping continuously for 24 hours water samples were collected for testing.

Table- 4.1: Characteristics of the wells

| **Well No.** | **Location ( m)** | **Depth (m)** |
|---|---|---|
| Well 1 | 39.6 m from east side existing road and 30.5 m from north side existing road | 30.50 |
| Well 2 | 6.1 m from east side existing road and 33.5 m from north side existing road | 30.50 |
| Well 3 | 27.4 m from west side existing road and 39.6 m from north side existing road | 30.50 |
| Well 4 | 27.4 m from west side existing road and 76.2 m from north side existing road | 30.50 |

## 5. SOIL PROFILE

The Sub soil profile of a typical bore well is given in Table 5.1 and shown in Fig 5.1, based on the identification of soil samples. Ground water is at 10.36m (34 feet) below the existing ground level during January 2012.

Table-5.1: Typical Soil Profile of Bore well – B1

| **Depth Below G.L** | **Soil Type** | **Remarks** |
|---|---|---|
| 0.00m – 3.65m | Filled solid waste | --- |
| 3.65m – 6.09m | Brownish plastic silty clay | --- |
| 6.09m - 30.48m | Yellowish brown fine to medium sand (Ground water is at 10.97m below the EGL) | Water sand |

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Volume No.1, Issue No.2, pp : 48-53 01 Dec. 2012

**B1**

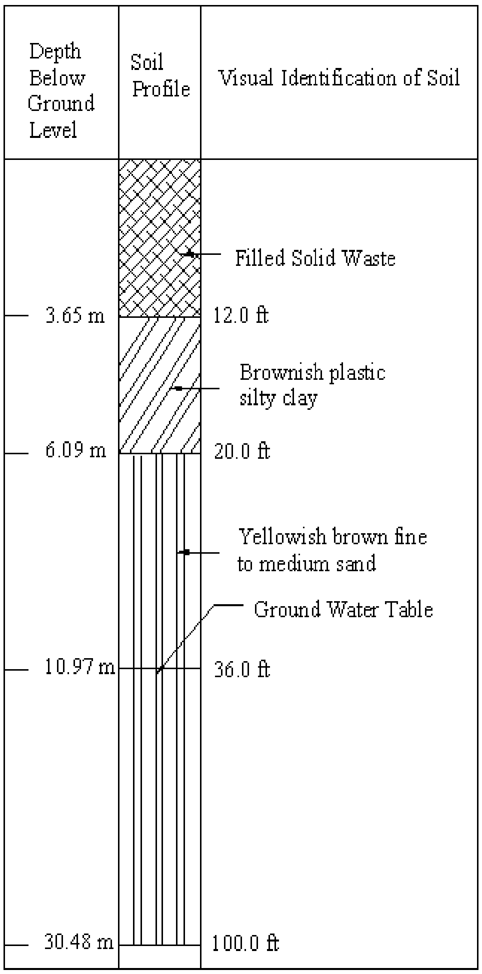


Fig. 5.1 Typical profile of Bore well B1

## 6. ANALYSIS OF GROUND WATER SAMPLES

Ground water samples were collected from bore wells at four locations in the above site (Fig.2.2) for testing. Two water samples were collected from each bore well and tested in the laboratory and the mean values are presented for each bore well in the Table 6.1. The parameters measured were Turbidity, $P^H$ Value, Total Solids Suspended Solids, Dissolved Solids, Fixed Solids, Volatile Solids, Electrical Conductivity (EC), Total Hardness, Permanent Hardness, Alkalinity, Acidity, Bio-Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Phosphates, Sulphates, Ammonia, Nitrates, Nitrites, Chlorides, Fluorides, Iron, Copper, Cadmium, Lead, Zinc and Chromium. All parameters were measured based on Standard methods.

### 6.1 Ground water quality for drinking

Water quality criteria provide basic scientific information about the effects of water pollutants on a specific water use. They also describe water quality requirements for protecting and maintaining an individual use.

Various Physical and Chemical water quality parameters were tested and presented in the Table 6.1.

Table-6.1: Ground water Characteristics for sampling wells B1, B2, B3 and B4

| S. No. | Characteristics | Well B1 | Well B2 | Well B3 | Well B4 |
|---|---|---|---|---|---|
| 1. | Appearance | Clear | Clear | Clear | Clear |
| 2. | Odour | Objection able | Objection able | Objection able | Objection able |
| 3. | Turbidity (NTU) | 2.80 | 2.95 | 2.90 | 3.10 |
| 4. | EC (μ mohs / cm) | 3510 | 3120 | 6883 | 7410 |
| 5. | $P^H$ Value | 6.72 | 6.51 | 6.77 | 6.93 |
| 6. | Dissolved solids (mg/l) | 1640 | 1485 | 3570 | 3620 |
| 7. | Total Hardness as $CaCo_3$ (mg/l) | 578 | 550 | 984 | 1220 |
| 8. | Permanent Hardness (mg/l) | 405 | 365 | 795 | 1010 |
| 9. | Temporary Hardness (mg/l) | 173 | 185 | 189 | 210 |
| 10. | Chlorides as Cl (mg/l) | 688 | 630 | 2115 | 1830 |
| 11. | Sulphates (mg/l) | 187 | 150 | 260 | 201 |
| 12. | Fluorides (mg/l) | 1.12 | 1.10 | 1.35 | 1.40 |
| 13. | Iron as Fe (mg/l) | 0.91 | 0.83 | 1.14 | 0.96 |
| 14. | Nitrates (as $NO_3$) (mg/l) | 13.40 | 12.20 | 10.60 | 7.30 |
| 15. | Nitrites (mg/l) | 0.64 | 0.80 | BDL | BDL |
| 16. | Total Alkalinity (mg/l) | 423 | 348 | 362 | 374 |
| 17. | Total Acidity (mg/l) | 17 | 14 | 10 | 07 |

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Table-6.1: Ground water Characteristics for sampling wells

| S. No. | Characteristics | Well B1 | Well B2 | Well B3 | Well B4 |
|---|---|---|---|---|---|
| 18 | COD (mg/l) | 87 | 80 | 91 | 88 |
| 19 | BOD (mg/l) | 10.4 | 9.2 | 9.2 | 10.4 |
| 20 | Copper (as Cu) (mg/l) | 0.048 | 0.054 | 0.05 | 0.047 |
| 21 | Cadmium (as Cd) (mg/l) | BDL | BDL | BDL | BDL |
| 22 | Phosphates (mg/l) | 1.31 | 1.26 | 1.22 | 1.45 |
| 23 | Total Solids (mg/l) | 1729 | 1590 | 3668 | 3745 |
| 24 | Suspended Solids (mg/l) | 89 | 105 | 98 | 125 |
| 25 | Total Fixed Solids (mg/l) | 1334 | 1265 | 3196 | 3225 |
| 26 | Total Volatile Solids (mg/l) | 395 | 425 | 472 | 520 |
| 27 | Lead (as Pb) (mg/l) | 0.12 | 0.124 | 0.13 | 0.16 |
| 28 | Zinc (as Zn) (mg/l) | 1.67 | 1.74 | 0.41 | 0.38 |
| 29 | Chromium (as $Cr^{+6}$ ) (mg/l) | BDL | BDL | BDL | BDL |
| 30 | Coliform Organisms Number / 100 ml | + ve | + ve | + ve | + ve |

BDL: *Below Detectable Level*

## 7. RESULTS AND DISCUSSIONS

The Urban Solid Waste is heterogeneous in nature and consists of number of different materials which are derived from various types of activities. The major constituents are paper and putrescible organic matter. Other Materials like Metals, Glass, Ceramics, Plastics, Textiles, Wood are generally present in different proportions, and their relative proportions depends on local factors.

This composition of solid waste (% by weight) consisted of 1.5% Paper, 4% Plastics & Rubber, 0.5% Metals, 2% Glass & Ceramics, 3% Textiles, Wood & Leather, 33% Organic Matter, 54% inert matter and 2% others

The composition of Solid waste is essential in providing the basic data on which the planning of the solid waste management system depends. It includes selection of appropriate equipment and technology and suitable processing, recovery and recycling.

The mean values of the water analysis results obtained from each bore well are shown in Table 6.1. The limits for the various parameters in drinking and construction were taken into account from the Bureau of Indian Standard Specifications.

The $P^H$ Values for all sampling wells were less than neutral (6.51-6.93). The values are close to the lower level of desirable limit (6.5 - 8.5).

The Hardness is very high (550-1220 mg/l) compared to standard limit for drinking, which is 300 mg/l as $CaCO_3$. Hardness of water is objectionable from the view point of water use for laundry and domestic purpose.

BOD and COD values are ranged between 9.2 - 10.4 mg/l and 80 – 91 mg/l respectively. The BOD and COD indicate the organic content in the sewage. From the above BOD values, it is evident that the ground water is polluted by the land fill leachates. Usually no BOD or BOD less than 1.0 mg/l is considered for drinking. In the present study the COD values are very high compared to BOD values. It clearly indicates that the ground water is polluted with more of non biodegradable chemical pollutants. In fact no guide line values are set for both Drinking and Construction in relevant IS codes.

For all wells under investigation the range of dissolved solids is 1485-3620 mg/l. It is well above the desirable limits for drinking water (500mg/l). Higher dissolved solids reduce the Palatability of water and may cause gastrointestinal irritation.

The range of Electrical Conductivity is between 3120-7410 µmohs / cm. The high conductivity values are an indication of its effects on water quality. 500-800 µmohs/cm may be considered for drinking purpose. Higher EC values are due to dissolved matter of inorganic salts, Acid and Bases. It also indicates higher salinity in soil. EC more than prescribed limit ( 2250 µmohs/cm ) indicates unsuitability of this water for vegetation.

High chloride concentrations were observed at all wells (630 - 2115 mg/l) compared to desirable limit for drinking (250 mg/l). Beyond this limit taste, corrosion and palatability are affected. High chloride concentration indicates that ground water is affected by the land fill leachates.

At all wells Alkalinity values (348 - 423 mg/l) were above the standard limit of 200 mg/l. The taste becomes unpleasant beyond this limit.

Sulphate concentrations in three wells were found to be less than 200 mg/l which are within the standard limit (200 mg/l). But in one well it exceeded the standard limit and it is 260 mg/l. It causes gastrointestinal irritation beyond the standard limit when Magnesium or Sodium is present. The tested values in all the wells are well within the limits.

At all wells Iron values (0.83-1.14 mg/l) were above the standard limit of 0.3 mg/l. The taste and appearance are affected beyond this limit. It has adverse effects on domestic use.

The metals Copper and Zinc are characterized as undesirable substances. Copper (0.047 - 0.054 mg/l) was found to be close to the standard limit (0.05mg/l), while Zinc concentrations were found to be below the standard limit (0.38 – 1.74 mg/l ).

Lead, Cadmium and Chromium are characterized as toxic. Lead concentrations were quite high at all wells (0.12 – 0.16 mg/l) and exceeded the standard value (0.05 mg/l). The water becomes toxic beyond this limit. Chromium and Cadmium were not present. No guide line values were set for the above parameters for construction.

## 8. CONCLUSIONS

Ground water is not suitable for drinking and other domestic applications, since almost all of the parameters examined exceeded the permissible limits.
It is not suitable for vegetation, since the Conductivity is high and in addition higher concentrations of chlorides were present.

Finally the present work showed that the landfill leachates constitute a serious problem to the local aquifer. To minimize the impact of such landfills on ground water quality and the environment in general, it is necessary to properly design and construct these facilities to prevent pollution. Regular monitoring is required over a large period, in order to verify the influence of seasonal variations on the contaminant concentrations with time. We must recognize the importance of Groundwater resources as it is becoming the only major available sources of water supply.

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