"Impact of landfill leachate on the groundwater Quality" A Study in Central India

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Abstract: **Sanitary landfill is a process in the solid waste management system. It can be defined as ''a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary.'' This paper presents the results of the analyses of ground water pollution due to the solid waste landfill located at Kathonda landfill, Jabalpur, M.P. To evaluate the environmental impacts associated with solid waste landfilling, groundwater quality near the landfills were analysed. The results of physicochemical analyses of groundwater confirmed that its characteristics were variable with severe contamination. These parameters included conductivity, Total Dissolved Solids, chlorides, pH, Turbidity, Total hardness, Total alkalinity, Dissolved Oxygen. The results suggested the need for continuous monitoring of the groundwater treatment processes.**

Key words: **Solid waste landfill; Leachate; Treatment; Chemical coagulant.**

I - INTRODUCTION

As an indispensable resource for life, water is essential for livelihood as well as the socio-economic development of any community. It is of great concern to note that adequate provision of safe drinking water remains a major challenge to many people worldwide, especially those living in less-developed regions. In spite of the efforts made at various levels around the globe, presently [as at April 2012] there are about 800 million people living without access to adequate and improved water supplies, most of which live in the rural and peri-urban settlements of less-developed countries. The situation is at its worst in Sub-Saharan Africa (SSA), where only around 16% of the population have access to safe and adequate water supply through improved piped systems (WHO/UNICEF, 2012).

Groundwater provides the single largest supply of fresh water on the planet. It is used more extensively now than ever before because of society's increasing demand for fresh water. It is also being used more frequently today because drought conditions and contamination of surface water have reduced the availability of clean, fresh water at the surface. Groundwater is connected to all other water forms in the environment through the hydrologic cycle. These connections make the threat of contamination to the surface water a threat to groundwater quality as well.

Groundwater contamination can come from a number of natural and human-made sources. These can include leaks and spills at factories and commercial facilities, improper hazardous waste disposal, improper use and disposal of pesticides, leachate from landfills, septic systems, saline intrusion, salts and chemicals used to deice roads, liquid waste storage lagoons, fertilizers, animal wastes and leaking underground storage tanks etc.

1.1 Ground Water Pollution and Contamination in India: Extends and Impacts

The crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families cannot be overstated. According to some estimates, it accounts for nearly 80% of the rural domestic water needs, and 50% of the urban water needs in India. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. Also, the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata. But, In India, where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource. Its over-exploitation is causing aquifer contamination in certain instances, while in certain others its unscientific development with insufficient knowledge of groundwater flow dynamic and geo-hydro chemical processes has led to its mineralization. [2]

The incidence of fluoride above permissible levels of 1.5ppm occur in 14 Indian states, namely, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal affecting a total of 69 districts, according to some estimates. Some other estimates find that 65 per cent of India's villages are exposed to fluoride risk.

The main aim of this study ***is "to evaluate the possible impacts of SWD practice on the quality of***

local groundwater sources in Kathonda, Jabalpur, (M.P.) as a means of understanding the interactions between SWM and water supply sources."

II - LITERATURE REVIEW

2.1 Introduction

A review on previous work and research has been carried out on the physic- chemical parameter analysis of ground water quality at different solid waste landfills.

- **Research Paper Related to Ground Water Quality at Different Landfills and Solid Waste Management**

According to ***Magda M. Abd El-Salam et al (2015)*** Alexandria Governorate contracted an international company in the field of municipal solid waste management for the collection, transport and disposal of municipal solid waste. Construction and operation of the sanitary landfill sites were also included in the contract for the safe final disposal of solid waste. To evaluate the environmental impacts associated with solid waste landfilling, leachate and groundwater quality near the landfills were analyzed. The results of physicochemical analyses of leachate confirmed that its characteristics were highly variable with severe contamination of organics, salts and heavy metals . The BOD_5/COD ratio (0.69) indicated that the leachate was biodegradable and un-stabilized.

It was also found that groundwater in the vicinity of the landfills did not have severe contamination, although certain parameters exceeded the WHO and EPA limits. These parameters included conductivity, total dissolved solids, chlorides, sulfates, Mn and Fe. The results suggested the need for adjusting factors enhancing anaerobic biodegradation that lead to leachate stabilization in addition to continuous monitoring of the groundwater and leachate treatment processes.

The greatest challenge, as far as landfill designing is concerned, is building a drainage system capable of diminishing the most severe negative effect, i.e., groundwater pollution. Based on waste collection system configuration – drainage conditions for existing landfills, drainage of homogeneity, etc. – ***Casen Panaitescu (2015)*** managed to determine the hydraulic conductivity of the drainage layer and the maximum depth of saturation. Drainage system effectiveness is highly dependent on efficient analyses of the leachate collection systems. One of the most important factors of the present study is represented by the maximum saturated depth of infiltration with a net value of 98 cm/year.

The hydraulic conductivity determined for this value of net infiltration reveals that, in some cases, the vertical drain leachate drainage is prevalent. The study covered a span of two years. In order to identify groundwater pollution levels in Muntenia region five sampling points were established; their focus was to analyse COD,BOD, pH and TSS values. Study results revealed a lower degree of pollution in the case of industrial waste landfills as compared to domestic waste ones.

Rajkumar Nagarajan et al (2014)were collected Leachate and groundwater samples from Vendipalayam, Semur and Vairapalayam landfill sites in Erode city, Tamil Nadu, India, to study the possible impact of leachate percolation on groundwater quality. Concentrations of various physicochemical parameters including heavy metals (Cd, Cr, Cu, Fe, Ni, Pb, Fe and Zn) were determined in leachate samples and are reported.

The concentrations of Cl^- , NO_3^- , SO_4, NH_4^+ were found to be in considerable levels in the groundwater samples particularly near to the landfill sites, likely indicating that groundwater quality is being significantly affected by leachate percolation. Further they were proved to be the tracers for groundwater contamination near Semur and Vendipalayam dump yards. The presence of contaminants in groundwater particularly near the landfill sites warns its quality and thus renders the associated aquifer unreliable for domestic water supply and other uses. Although some remedial measures are suggested to reduce further groundwater contamination via leachate percolation, the present study demands for the proper management of waste in Erode city.

- **Research Paper Related to Ground Water Quality in Jabalpur**

Ratna Kumar Srivastava and Deepti Pandey (2012)undertaken to characterize nature (parameters) of groundwater in Jabalpur city, by taking water samples from six different stations locating near to the Omti- nallah area. Evaluation of physicochemical and microbiological parameters of water samples was carried out during March – April 2011. To assess the quality of groundwater, each parameter was compared with the standard desirable limit of that parameter in drinking water as prescribed by BIS 10500-91. The comparison of different parameters spatially showed an increasing pattern of alkalinity, total dissolved solids, total hardness, calcium, fluoride and fecalcoli form concentrations and decreasing concentration of dissolved oxygen in the ground water. It is necessary to apply strong preventions immediately to save ground water from deterioration in the area around Omti nallah in Jabalpur city.

According to ***Pushpendra Singh Bundela et al(2012)*** the usual and the most neglected cause of water pollution are uncontrolled dumping ofMunicipal Solid Waste. Infiltration of water by rainfall, water already present in the waste, or water generated by biodegradation, cause the leachate to leave the dumping ground laterally or vertically and find its way into the groundwater thereby causing contamination. Ten groundwater samples collected during the rainy season 2011 from the study region and the samples were analyzed for various physical and chemical properties. During the study it was found that Total Dissolved Solids varies from 546 mg/Lto 907 mg/L and compared with permissible limits. Therefore, the best accepted option is to avoid the possibility of polluting the groundwater resources.

III - STUDY AREA

3.1 General

The Jabalpur City population as per the census data 2011 showing is 1081677. It is spread over an area of 122 sq. km. The entire city is currently divided into 60 election wards and 8 Zones. The Jabalpur Municipal Corporation is responsible for collection, transportation, treatment and disposal of Municipal Solid Waste generated under MSW rule 2000. Hence, JMC had initiated development of Municipal Solid Waste (MSW) processing complex & sanitary landfill site at Kathonda, with an objective of waste reduction and ultimately effective management system. (Census 2011)

3.2 Location

Jabalpur is located at 23º10'N 79º56'E. The central point point of India is in Jabalpur district. It has an average elevation of 411 metres (1348 feet)

Figure 3.1 Map of Kathonda landfill

3.3 Geology

Jabalpur district can broadly be divided in to three physiographic units.

1. The Vindhyan Tract
2. The South eastern plateaus of the Satpura
3. The Bhitright Range & the associated hill area.

3.4 Soils

Jabalpur district is covered by three types of soils –

1. The loam to sandy loam confined to the river courses of the Narmada & Hiran falling in Shahpura & Patan blocks.
2. Medium black soil covering Kundam, Bargi, eastern parts of Shahpura, Panagar & Sihora blocks.
3. Deep block soil covering Shahpura, Patan & Sihora blocks. In the Narmada valley, the block soil is composed mainly of clay & silt washed down by rivers.

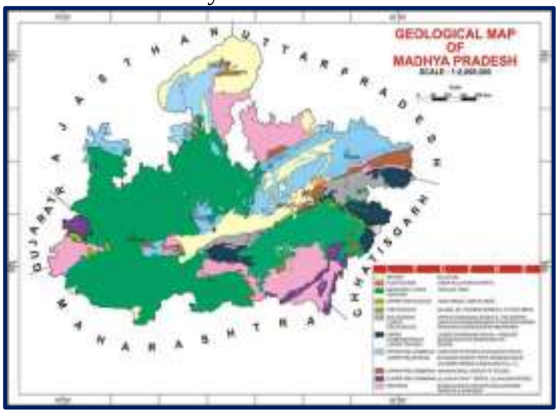


Figure 3.2Geological Map of M.P

3.5 Ground Water Scenario

3.5.1 Hydrogeology

District Jabalpur is a home of geology since formations ranging from lower proterozoic torecent age are exposed in the area different types of aquifers are formed by these rocks in the areama in geological units of the area are Archaens, Gondwana, Lameta, Deccan Trap and Narmada alluvium. Occurrence & movement of ground water in hard rocks is mainly controlled by secondary porosity through Joints & fractures. Primary porosity in Gondwana sand stone & vesicular basalts in Deccan Traps play are important role in ground water movement. Lameta are also forming potential aquaifers made up of relatively loose & friable shale & sand stone. Ground water in general occurs under unconfined; Semi confined & confined conditions.

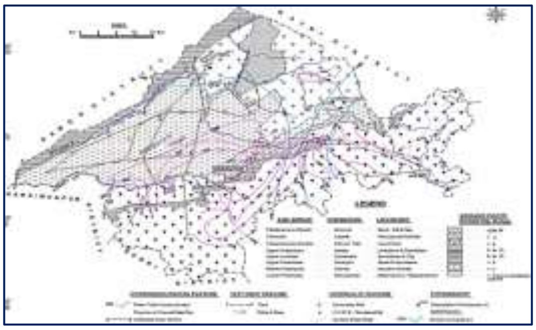


Figure 3.3 Hydrogeology, District Jabalpur

3.6 Solid Waste Generation in Jabalpur District

In 2015, Municipal solid waste generation in Jabalpur district is about 398TPD. Landfilling of municipal solid waste (MSW) is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world. In Jabalpur, Kathonda is used as a landfill for solid waste having landfill area of approximate 70 hectare. According to Census 2011 the Per Capita Waste Generation (kg/day) is about 0.262 kg/day.

Municipal waste, mainly derived from households sector, also includes some institutional, commercial and industrial sources which represent around 398 tons/day. All the generated solid wastes (398 tons) are collected daily and transported to Kathonda plant. Biodegradable organic waste that of the daily MSW generation is transferred to compost plant.

IV - MATERIALS & METHODS

4.1 General

The study objectives and problem identified are presented in section I. In Section II of literature part, various tasks that have been proposed to be carried out during the present investigation are presented. The tasks can basically be divided in to the following categories

1. Collection of water samples and physico-chemical analysis
2. Analysis according to the Standard Methods for the Examination of Sample Water
3. Determination of Water Quality Index (WQI) with reference to BIS standards.

4.2 Sample Collection

Water samples were collected in the morning hours between 7 am and 9 am. The total water collection in the year of 2016 is divided in to two seasons, one is pre monsoon and another one is during the monsoon (July). Sampling in the month of June (pre monsoon) was chosen since it was offset to summer season where most of the aquifers are under saturated condition with high concentrations.

The summer season was also selected to avoid dilution if any due to rainy season. Water was collected in sterilized glass bottles labeled with sample code and transported to the laboratory in an ice box. The changes that occur in the bacterial content of the water on storage were reduced to a minimum by ensuring that the samples were not exposed to light. They were maintained under low temperature preferably between 4° to 10°C, but not frozen.

After sampling, analysis was done immediately in Jabalpur Engineering College Jabalpur and Lalpur Filtration Plant Jabalpur. The samples were processed and analyzed scrupulously by standard methods.

Groundwater samples were collected from three monitoring wells (Approximate 100 m distance from the landfill), one at each site, which are drilled around the landfills sites in order to monitor the closer aquifer extent of contamination.

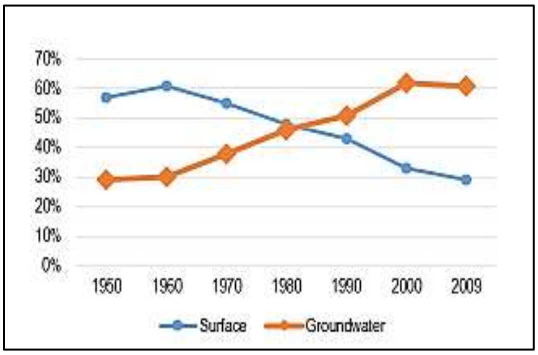


Figure 4.1 Increase in ground water utilization for irrigation and drinking water (Sources: Agricultural Statistics at Glance 2014, Ministry ofAgriculture; PRS.)

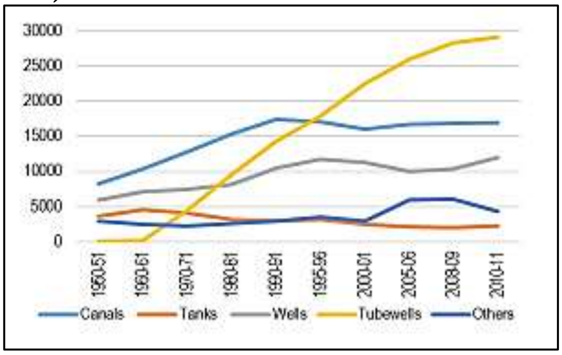
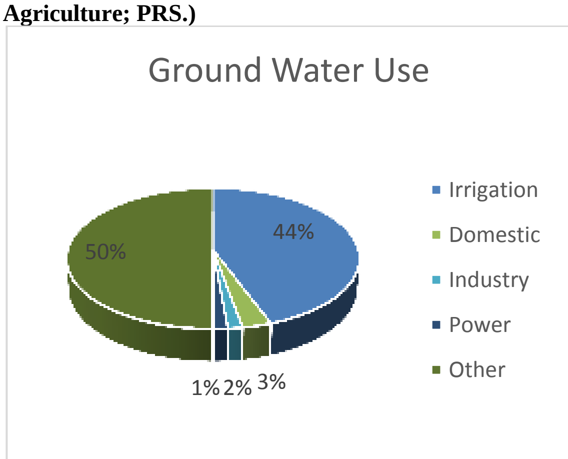


Figure 4.2 Tube wells increasingly being the main source of drinking and irrigation (Source: Agricultural Statistics at Glance 2014, Ministry of Agriculture; PRS.)



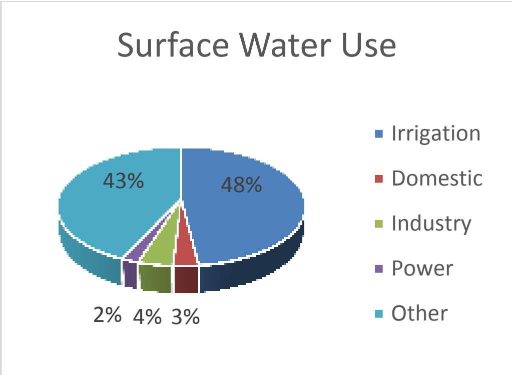


Figure 4.3 Percentage uses of Ground and Surface Water

4.3 Assessment of Water Quality Parameters

Some physiochemical and microbial parameters were tested to find the quality of the ground water samples collected.

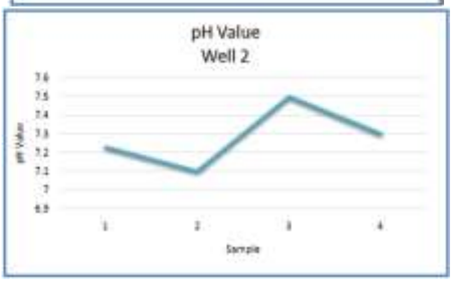
Table 4.1 Experimental Parameters and Methodology

S. No.	Parameters	Unit	Methodology
1	pH	——	Digital Electrode pH Meter
2	Alkalinity	Mg/l as $CaCO_3$	Titrimetry with H_2SO_4
3	Total Hardness	Mg/l as $CaCO_3$	Titrimetry with EDTA
4	Chloride	Mg/l	Argentometric Method
5	Dissolved Oxygen	Mg/l	Winkler's Method
6	BOD	Mg/l	BOD_5 Method (Winkler's Method)
7	EC	µS/cm	Hach Method
8	TDS	ppm	Hach Method

V - RESULTS & DISCUSSION

The following observation has been obtained during the Analysis.

5.1 pH Value



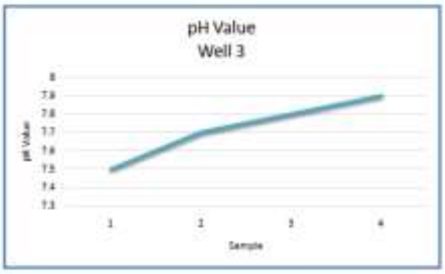


Figure 5.1 The pH value distribution for Well 1,2 and Well 3 respectively

In general, a water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. Alkalinity is a measure of the capacity of the water to resists a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is desirable to determine the corrosivity of the water.

It is observed from the above results that the pH value is more than 7. The water is of basic nature. The pH value of water is under considerable limit but near about the upper limit.

5.2Turbidity

In this study, turbidity values were found to be reasonably high and varied in most of the groundwater samples, as presented in Figures 5.2. Samples collected in May were found to have less turbidity values ranging from 3.2 Nephelo metric Turbidity Units (NTU) to 7.4 NTU, whereas those collected in June-July showed values that varied between 16 NTU and 28 NTU. This variation is due to the fact that rainy season improves the suspended solids.

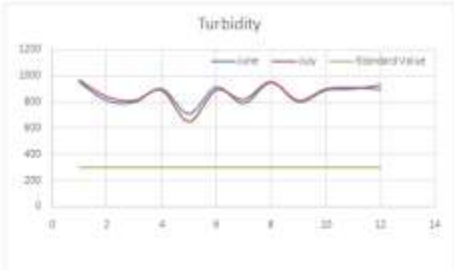


Figure 5.2 The Turbidity distribution.

5.3 Electrical Conductivity

All of the samples collected in May-June had EC values that varied from 854µS/cm to 945µS/cm, while those collected in June-July had values that varied from 854.5 µS/cm to 967µS/cm. According to WHO standards EC value should not exceeded 300 µS/cm.(as per WHO standard)

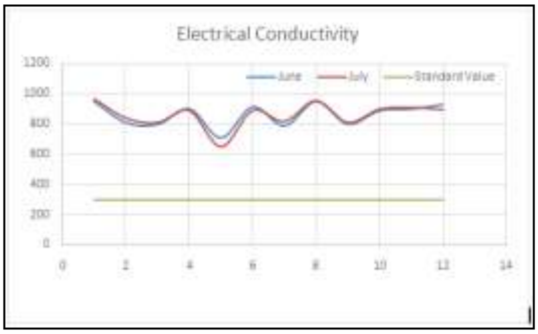


Figure 5.3 Electrical Conductivity distribution

5.4 Total Dissolved Solids

During the study TDS is found between ranged 647 mg/l to 977 mg/l. The TDS concentration was found to be above the permissible limit (Desirable 500 mg/l as per EPA) may be due to the leaching of various pollutants into the ground water which can decrease the potability and may cause gastrointestinal irritation in human and may also have laxative effect particularly upon transits.

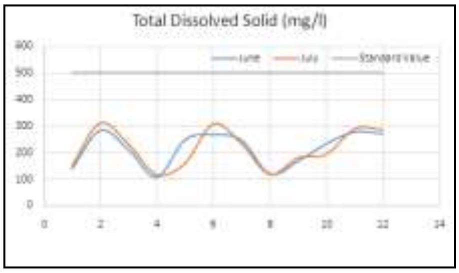


Figure 5.4 Total Dissolved Solids distribution.

5.5 Chloride

Samples collected in May- June had chloride concentrations that ranged between 109 mg/l and 285 mg/l, whereas those collected in June-July had concentrations that varied from 119 mg/l to 311 mg/l. Chlorides are not usually harmful to people; however, the sodium part of table salt has been linked to heart and kidney disease. Sodium chloride may impart a salty taste at 250 mg/l; however, calcium or magnesium chloride is not usually detected by taste until levels of 1000 mg/l are reached. Public drinking water standards require chloride levels not to exceed 250 mg/l.

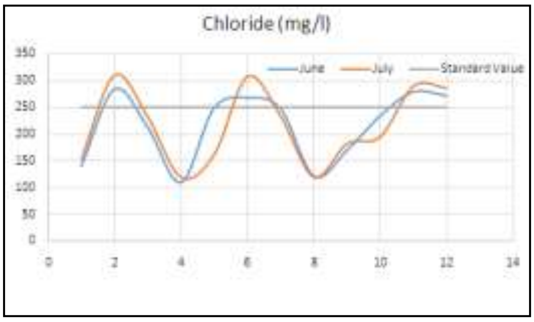


Figure 5.5 Chloride distribution.

5.6 Total Hardness

The total hardness of ground water samples were found in the range of 109 up to 321 mg/l in the month of May-June and about 150-298 mg/l in the June-July month which is further compared with the standard value ranged 300 mg/l. Water hardness is usually due to the multivalent metal ions, which comes from minerals dissolved in the water. However, there is an inverse relationship between water hardness and cardiovascular disease.

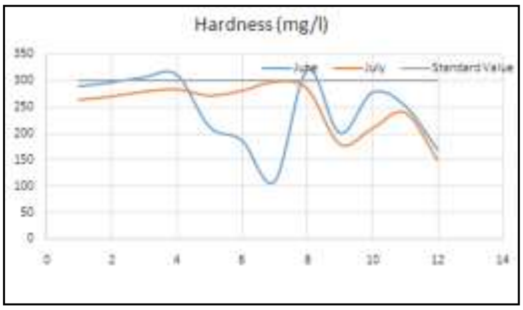


Figure 5.6 Total Hardness distribution.

5.7 Dissolved Oxygen (DO)

DO of ground water samples were found in the range of 3.3 to 6.4 mg/l. due to the capacity of water to hold oxygen

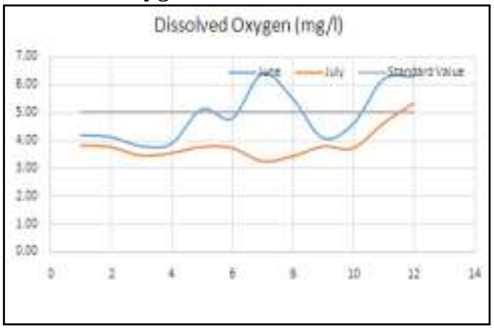


Figure 5.7 Dissolved Oxygen distribution.

5.8 Total Alkalinity

In this investigation, all samples studied were found to have considerably high TA values that varied widely, as presented in Figures 5.8. TA value for Well 1, Well 2 and Well 3are vary from 220-240, 310-360 and 240-260 respectively for month of June and 220-245, 320-345 and 220-256 for the July month. Although there is no health-based guideline value set by the WHO for TA, its high concentration in water could have an indirect positive effect on health due to the reduced solubility of many heavy metals (Seither et al., 2012).

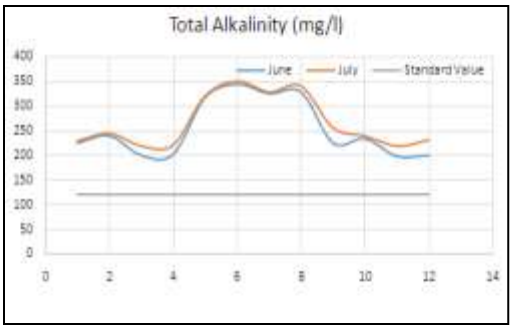


Figure 5.8 Total Alkalinity distribution.

VI - CONCLUSION

The processes of storage, collection, transport, treatment and disposal of wastes all have the potential to pollute the environment and particularly groundwater due to uncontrolled migration of fluids (leachate) derived from the wastes.

For situation assessment, landfills are most readily identified with the pollution of ground water by waste-derived liquids. However, any site where waste is concentrated, processed (e.g. recycled) and stored even for a short period of time, may be a potential point source of groundwater contamination. A critical criterion in estimating potential groundwater pollution from waste disposal is the siting of all of the above mentioned waste treatment and disposal facilities.

Most of the landfills general lyinvolves lining the site with an artificial lining system, but liners leak and degrade with time. Even if the site is well engineered and managed, with an artificial lining system installed, and even if or the waste materials are inert, leachate, which may have the potential to pollute groundwater, will be produced. The study is carried out to analyses the condition of ground water in vicinity of Kathonda Landfill, Jabalpur, M.P.

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