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

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Abstract: **It is worthy of note that, once groundwater becomes contaminated, full restoration of its quality is very difficult and even impossible in some cases. In the course of this research Study, emphasis is given to the review about the previous study on threatening effects of a particular source of groundwater contamination that are represented by solid waste disposal (SWD) site, particularly Kathonda located in Jabalpur city (M.P.) At the SWD sites, precipitation that infiltrates the waste materials mixes with the organic and moisture contents of the waste to leach toxic compounds. The leachate formed contains dissolved organic and inorganic solutes, which potentially percolate through the soil to alter the physicochemical characteristics of the groundwater aquifer. The extent of leachate transport processes varies widely depending on many factors, such as hydrogeology, physiographic and other environmental settings of the affected area.**

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

I - INTRODUCTION

Groundwater is water stored in the soil and rock formations below the earth's surface. It is the primary source of drinking water for many communities and the secondary source for others. Groundwater is used extensively for irrigation. It is also an important source of water for rivers and streams, especially during extended dry periods. Groundwater emerging at the bases of mountains and foothills provides the base flow of streams in the area during the dry season. Activities taking place at the earth's surface are primarily responsible for groundwater pollution. For example, groundwater pollution can occur due to accidental spills and improper disposal of petroleum products and industrial solvents; over-application of fertilizers, pesticides, food wastes, and animal wastes to the land; and the use of septic systems in unsuitable locations. Because groundwater is usually remote and inaccessible, it is difficult or impossible to clean once it becomes polluted. Methods of cleaning groundwater, such as isolating the contaminated area and pumping and treating the contaminated water, are not always successful. Regardless of success, attempts to clean groundwater are always expensive.[1]

If landfills are not properly constructed, liquid from decomposition of materials, or leachate, can leak out of the landfill into an aquifer. Leachate can contain high levels of bacteria, hazardous chemicals, metals, and ammonia. Runoff water from landfills after rains can also carry pollution to groundwater recharge areas &and hence into groundwater.

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

High levels of arsenic above the permissible levels of 50 parts per billion (ppb) are found in the alluvial plains of Ganges covering six districts of West Bengal. Presence of heavy metals in ground water is found in 40 districts from 13 states, viz., Andhra Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, and five blocks of Delhi.

Non-point pollution caused by fertilizers and pesticides used in agriculture, often dispersed over large areas, is a great threat to fresh groundwater ecosystems. Intensive use of chemical fertilizers in farms and indiscriminate disposal of human and animal waste on land result in leaching of the residual nitrate causing high nitrate concentrations in groundwater.

Pollution of groundwater due to industrial effluents and municipal waste in water bodies is one of the major concern in many cities and industrial clusters in India. A 1995 survey under taken by Central Pollution Control Board identified 22 sites in 16 states of India as critical for groundwater pollution, the primary cause being industrial effluents. A recent survey undertaken by Centre for Science and Environment from eight places in Gujarat, Andhra Pradesh and Haryana reported traces of heavy metals such as lead, cadmium, zinc and mercury. Shallow aquifer in Ludhiana city, the only source of its drinking water, is polluted by a stream which receives effluents from 1300 industries. Excessive withdrawal of groundwater from coastal aquifers has led to induced pollution in the form of seawater intrusion in Kachchh and Saurashtra in Gujarat, Chennai in Tamil Nadu and Calicut in Kerala.

II - LITERATURE REVIEW

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.

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According to ***G. Arrieta et al(2015)*** Colombia generates 27,000 tonnes/day of waste, which is deposited into landfills. Approximately 30% of these sites do not comply with the requirements to be considered for controlled landfills. According to the legal framework, these disposal systems of solid waste are compelled to carry out an Environmental Impact Assessment (EIA) process in order to minimize their associated problems. Even though there are tools designed to perform the EIA prior to the landfill construction, this is not the case for the follow-up and control stages ofthe operation phase. The University of Granada (Spain) developed a diagnosis methodology called EVIAVE, which allows for quantifying – through indexes –the environmental impact of landfills according to location and exploitation conditions, which allows for the implementation of environmental management plans. EVIAVE was designed for municipal landfills according to the European Union’s legal framework. However, it has been successfully applied in Chile, Venezuela and Iran with adaptations regarding their legal, socio-economic and ecosystem features. This work shows EVIAVE’s adaptation in Colombia, in order to diagnose active landfills. Modifications include flora and fauna, which allow for obtaining a wider description of the environment and updating the methodology according to the Convention on Biological Diversity. The assessment of environmental descriptors was also reformulated to cover the concept of vulnerability.

Pooja Solanki et al (2014) examined the level of groundwater contamination near a municipal landfill site in Delhi. Water quality parameters (physico-chemical and heavy metals) of groundwater samples were analyzed. The results of analysis of the following specific water quality parameters were within the WHO permissible limits. The mean concentration of $SO_4$2- varied from 45.7±1.2 – 142.5±1 mg/L, Cl- varied from 71.35±0.95 –237.8±1.36 mg/L. The mean concentration for heavy metals ranged from 0.07±0.01 –0.018±0.06 mg/L for Fe, 0.09±0.22 – 0.14±0.067 mg/L for Zn, 0.013±0.02 – 0.037±0.01mg/L for Cu, 0.11±0.01 – 0.64±0.12 mg/L for Cr. The current results show in significant impact of the landfill operations on the groundwater resource.

In Romania’s industrialized areas there are a large number of people, and therefore the amount of generated waste becomes important. Moreover, waste management activities have a high share in local and national administration. Prahova County had the highest national average density of 62.83 inhabitants/km^2. With two major cities, Ploiesti and Campina, the composition of the urban and rural waste stored in landfill does not always respect the existing norms at national and local level. ***Casen Panaitescu and Rodica Bucuroiu (2014)*** elaborated in order to find the alternatives and practices necessary to be implemented to reduce the land filled municipal waste and to increase the degree of recycling. This is based on the analysis of municipal waste composition in the two areas. Based on this analysis, we proposed the construction of a sorting station to reduce the amount of recyclable waste land filled and to minimize environmental impacts.

RajkumarNagarajan 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^{2-}, and $NH4^+$ 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.

Christopher O et al (2010) carried out Physical, chemical and bacteriological analyses of water samples from three boreholes located near a landfill at Akure, Nigeria was carried out to ascertain the magnitude of dumpsite pollution on groundwater quality. Borehole locations were at radial distances of 50m, 80m, and 100m respectively away from the landfill. The parameters determined included; turbidity, temperature, pH, Dissolved oxygen (DO), total dissolved solids (TDS), Total Hardness, Total Iron, Nitrate, Nitrite, Chloride, Calcium and heavy metals such as Copper, Zinc and Lead using convectional equipment and standard laboratory procedures.

Most of these parameters indicated traceable pollution but were below the World Health Organization (WHO) and the Nigerian Standard for Drinking water quality (NSDWQ) limits for consumption. The pH ranged from 5.7 to 6.8 indicating toxic pollution, turbidity values were

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between 1.6 and 6.6 NTU and temperature ranged from 26.5 to27.50C. Concentrations of iron, nitrate, nitrite and calcium ranged from 0.9 to 1.4 mg L^{-1}, 30 to 61 mg L^{-1}, 0.7 to 0.9 mg $L^{-1}$and 17 to 122 mg L^{-1} respectively. For heavy metals, zinc ranged between 0.3 and 2.3 mg L^{-1} and lead ranged from 1.1 to1.2 mg L^{-1}.

The landfill was not directly responsible for the presence of Chromium in one of the wells but could be traced to an abattoir near the well. Bacteriological examinations revealed severe pollution in all the wells. Statistical analyses indicated significant differences among all the parameters tested for in the samples at 95% level. The results showed that all but one of the boreholes was strongly polluted but require urgently certain levels of treatment before use. Public enlightenment on waste sorting, adoption of clean technology, using climate change mitigation strategies and the use of sanitary landfill to prevent further contamination of ground water flow are recommended.

E.O. Longe and M.R. Balogun (2010) examined the level of groundwater contamination near a municipal landfill site in Alimosho Local Government Area of Lagos State, Nigeria. Water quality parameters (physicochemical and heavy metals) of leachate and groundwater samples were analyzed. The mean concentrations of all measured parameters except NO3G, PO4 + and Cr G conform to the stipulated World Health Organization potable water standards and the Nigerian Standard for Drinking Water Quality. Mean concentration values for TDS, DO, NH4 +, SO4 +, PO4 +, NO3G and ClG are 9.17 mg LG $^{-1}$, 3.19 mg LG^{-1}, 0.22 mg LG^{-1}, 1.60 mg LG^{-1}, 10.73 mg LG $^{-1}$, 38.5 mg LG^{-1} and 7.80 mg LG^{-1} respectively. The mean concentration values for Fe, Mn, Zn and Cr- in groundwater samples are 0.07mg LG^{-1}, 0.08mg LG^{-1}, 0.08mg LG^{-1} and 0.44mg LG $^{-1}$ respectively. The current results show insignificant impact of the landfill operations on the groundwater resource.

The existing soil stratigraphy at the landfill site consisting of clay and salty clay is deduced to have significantly influenced natural attenuation of leachate into the groundwater resource. It is however observed that in the absence of a properly designed leachate collection system, uncontrolled accumulation of leachates at the base of the landfill pose potential contamination risk to groundwater resource in the very near future. The research recommends an upgrade of the solos landfill to a standard that would guarantee adequate protection of both the surface and the groundwater resources in the locality

Peter Kjeldsen et al (2010) carried out a review on Present and Long-Term Composition of MSWL and fill Leachate. The major potential environmental impacts related to landfill leachate are pollution of groundwater and surface waters. Landfill leachate contains pollutants that can be categorized into four groups (dissolved organic matter, inorganic macro components, heavy metals, and xeno biotic organic compounds). Existing data show high leachate concentrations of all components in the early acid phase due to strong decomposition and leaching.

In the long methanogen phase a more stable leachate, with lower concentrations and a low BOD/COD-ratio, is observed. Generally, very low concentrations of heavy metals are observed. In contrast, the concentration of ammonia does not decrease, and often constitutes a major long-term pollutant in leachate. A broad range of xenobiotic organic compounds is observed in landfill leachate. The long-term behaviour of landfills with respect to changes in oxidation-reduction status is discussed based on theory and model simulations.

According to ***Bharat Jhamnani and SK Singh (2009)—***Sampling and analysis of leachate from Bhalaswa landfill and groundwater samples from nearby locations, clearly indicated the likely contamination of groundwater due to landfill leachate. They carried out the simulation and analysis for the migration of Chloride from landfill shows that the simulation results are in consonance with the observed concentration of Chloride in the vicinity of landfill facility. The solid waste disposal system presently being practiced in Delhi consists of mere dumping of wastes generated, at three locations Bhalaswa, Ghazipur, and Okhla without any regard to proper care for the protection of surrounding environment. Bhalaswa landfill site in Delhi, which is being operated as a dump site, is expected to become cause of serious ground water pollution in its vicinity. The leachate from Bhalaswa landfill was found to be having a high concentration of chlorides, as well as DOC & COD. The present study was undertaken to determine the likely concentrations of principle contaminants in the groundwater over a period of time due to the discharge of such contaminants from landfill leachates to the underlying groundwater.

The observed concentration of chlorides in the groundwater within 75m of the radius of landfill facility was found to be in consonance with the simulated concentration of chloride in groundwater considering one dimensional transport model, with finite mass of contaminant source. Governing equation of contaminant transport involving

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advection and diffusion-dispersion was solved in matlab7.0 using finite difference method.

R. Nagendran et al (2006) carried out a brief review on Phytore mediation and rehabilitation of municipal solid waste landfills and dumpsites Environmental problems posed by municipal solid waste (MSW) are well documented. Scientifically designed landfills and/or open dumpsites are used to dispose MSW in many developed and developing countries. Non-availability of land and need to reuse the dump site space, especially in urban areas; call for rehabilitation of these facilities. A variety of options have been tried to achieve the goals of rehabilitation. In the last couple of decades, phytore mediation, collectively referring to all plant-based technologies using green plants tore mediate and rehabilitates municipal solid waste landfills and dumpsites, has emerged as a potential candidate.

Research and development activities relating to different aspects of phytore mediation are keeping the interest of scientists and engineers alive and enriching the literature. Being a subject of multi-disciplinary interest, findings of phytore mediation research has resulted in generation of enormous data and their publication in a variety of journals and books. Collating data from such diverse sources would help understand the dynamics and dimensions of landfill and dumpsite rehabilitation.

2.3Research 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 Omtinallah 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 fecal coliform concentrations and decreasing concentration of dissolved oxygen in the groundwater. 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 of Municipal 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/L to 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)

The earlier SWM system for Jabalpur did not have an engineered landfill site for disposal of waste. The waste collected from secondary collection points was dumped in an unorganized manner at Ranital dumpsite in Jabalpur city area. At present, the solid waste of the city is dumped in Kathonda landfill site towards North West direction of Jabalpur city with a spread of over 24.60 hectare. [10]

The project falls under Item 7 (i) (Common Municipal Solid Waste Management Facilities) as per Environmental Impact Assessment Notification dated September 14, 2006.

3.2 Location

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

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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.

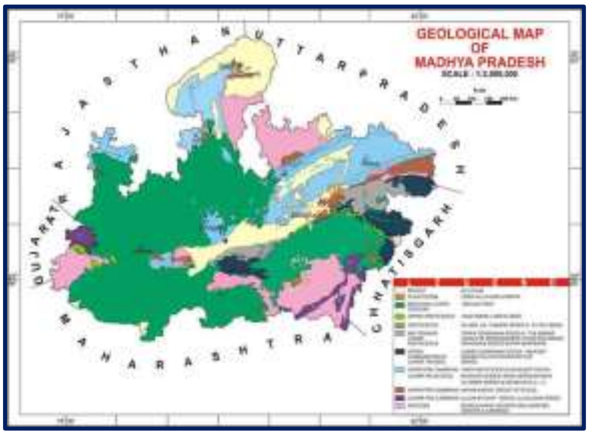

Figure 3.2Geological Map of M.P.

3.5 Ground Water Scenario

3.5.1 Hydrogeology

District Jabalpur is a home of geology since formations ranging from lower Proterozoic to recent age are exposed in the area different types of aquifers are formed by these rocks in the area main 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 second aryporosity 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 aquifers made up of relatively loose & friable shale & sand stone. Ground water in general occurs under unconfined; Semi confined & confined conditions.

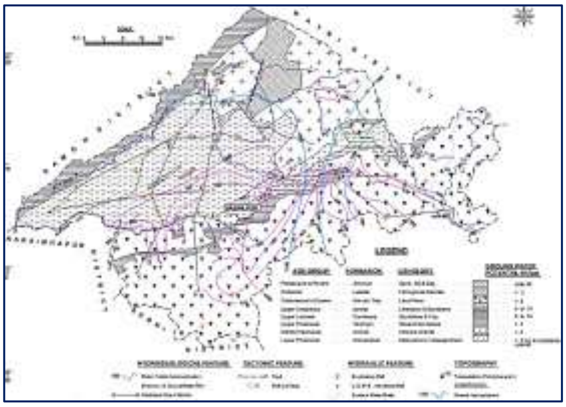

Figure 3.3 Hydrogeology, District Jabalpur

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.

Landfilling is performed by trench method. Daily, the delivered solid waste is weighed at the landfill site, dumped into the cell, compacted and covered with soil layer to minimize fire risk, reduce land fill doors, and reduce windblown garbage. Covering the waste with soil consumes a significant volume of cell capacity. Also, these soil layers decrease the velocity of leachate movement within the cell and hence may cause localized leachate trapping within the cell. Therefore, soil covering layer is removed, leaving a small depth of sand on top of the existing waste. The new waste is then placed above this layer of soil. The waste covering and de-covering activities take place every day till the cell is totally filled [8, 10].

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The landfill cells is lined with 2 polyethylene layers and compacted clay layer to prevent or to minimize the leachate percolation to the groundwater through decreasing the permeability coefficient to 1×10^{-7} cm/s ideally. Gases resulted from solid wastes biodegradation are burned and the produced heat is used for drying the lagoons leachate [8, 10]. The methane produced due to waste anaerobic decomposition from landfill is collected and combusted through flares reducing the greenhouse gas emissions into the atmosphere. The landfill site is equipped with an extensive land-fill gas capture system, a biogas pumping station, and enclosed high efficiency flares [11].

IV- SUMMARY

A thorough literature review has been done on the effects of solid waste landfills throughout the world. Landfills have been identified as one of the major threats to groundwater resources not only in India but throughout the world. The solid waste placed in landfills or open dumps are subjected to either groundwater underflow or infiltration from precipitation or any other possibility of infiltration of water. Further Review focuses on ground water quality impacts in the Jabalpur region due to solid waste management plant. It is very clear from the present review that frequent ground water quality monitoring at vicinity of solid waste dump area is required.

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