Development of Leachate Pollution Index of Jhiri Dumpsite; Ranchi, Jharkhand

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Abstract

Municipal solid waste generating in a city is emerging as a management issue in India. It continuously degrades air, water, and soil quality in the surrounding area. Population growth and migration along with heavy industrialization in city premises is leading to the increased generation of solid waste on a daily basis. In the present paper, an attempt was made to estimate the leachate pollution index for a dumpsite at Jhiri, Ranchi. The result was compared with few developed dumpsite in Delhi. The application of LPI helps us to identify the strength of various pollutants and functioning of dumpsite which may be useful for taking up appropriate steps and planning for leachate treatment and management practices.

Keywords: Municipal Solid Waste; Landfill; Leachate; Leachate Pollution Index; Jhiri, Ranchi.

Introduction

Wastes collected from household, industries and agrarian waste are usually collected and dumped at dumpsites at various locations, selected by fulfilling various criteria's setup by government authorities. If these dumpsites and landfills are not effectively managed, a huge amount of waste is destined to pile on these places. These wastes generally contains organic, inorganic, recyclable, degradable waste, which could produce foul smells and also imparts harmful effects on population leaving alongside its premises. The open nature of dumpsites would lead to direct interaction with environment. When flowing water comes in these dumpsites, chemicals such as heavy metals and other pollutants got dissolved in these wastes and generate a highly condensed liquid which got accumulated at the base, called as leachate. Depending on the climatic conditions, the leachate flow increases significantly during rainy season and reduces during dry season. Leachate discharge caused by municipal solid waste landfills leads to environmental degradation of soil and water resources especially when the landfills are not scientifically designed.

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Rapid urbanization and population growth are largely responsible for exponentially increasing rate of solid waste in the urban areas. The lack of proper management and recycling is a major problem of Municipal Corporation which is a great concern of human health and environment (Kurakalva et al., 2015). This has been observed thatin most cities, the solid waste is dumped in open dumps without proper lining which affects the environmental media such as air, water and land (Banupriya et al., 2018). Uncontrolled landfilling is predominant in developing countries like India. Leachate generated from these landfills contains variety of contaminants, which even at trace levels can cause health problems of unknown dimensions and magnitude (Singh and Mittal, 2009). Handling and management of municipal solid waste (MSW) are major challenges for solid waste management in developing countries. Open dumping is still the most common waste disposal method in India. However, landfilling also causes various environmental, social, and human health impacts. The generation of heavily polluted leachate is a major concern to public health. Knowledge of leachate quality will be useful in planning and providing remedial measures to protect surface and ground water quality in the area (Mishra et al., 2017). Naveen et al. (2014) studied the characteristics of leachate generated from municipal solid waste landfill and its effect on surrounding water bodies near Mavallipura landfill area in Bangalore. Many studied are found on characterisation of leachate and its impact on surrounding environment specially on groundwater quality (Gupta and Rani, 2014; Maiti et al., 2015; Agarwal et al., 2015; Singh et al., 2016; Rajasingh et al., 2017;), leachate treatment methods and efficiency (Hossain et al., 2016; Gandhimathi, 2017; Kumar et al., 2018). Composition of leachate greatly depends on the age of the landfill and also on the process occurring in that age. The landfill cannot fill at a time and therefore contains many cells and section and experiences different pressure condition (Adhikari et al., 2014). Open dumping of municipal solid waste is prone to groundwater contamination because of leachate production.

Rafizul et al. (2012) discussed a technique to quantify the leachate pollution potential of solid waste landfills on a comparative scale using an index known as the leachate pollution index (LPI). The LPI is a quantitative tool by which the leachate pollution data of the landfill sites can be reported uniformly. It is an increasing scale index and has been formulated based on Delphi technique. The formulation process involved selecting variables, deriving weights for the selected pollutant variables, formulating their sub-indices curves and finally representing the pollutant variables to arrive at LPI. The aggregation function is one of the most important steps in calculating any environmental index. If aggregation function is ambiguous, the result will raise an unnecessary alarm, indicating a comparatively less polluted environmental situation as mere contaminated. Similarly, if the aggregation function is eclipsed a false sense of security may be created, indicating a highly polluted environmental situation as less polluted. The Physico-chemical characterization has been documented and based on these, LPI was estimated for three landfill sites in Delhi, i.e. Gazipur, Okhla and Bhalswa (Naveen and Malik, 2017).Ranchi, the capital of Jharkhand, is one of the growing city of India. In an estimate, it is found that near about 700 ton every day waste is dumped at Jhiri, a place located once at the outskirts of Ranchi, but now within the city. In this paper, an attempt has been made todetermine the dumpsite pollution strength using Leachate Pollution Index and compare with well-developed dumpsite in India.

Materials and Methods

Study Area

Ranchi is the capital of Jharkhand state, with 1.5 million population (23°22′ N and 85°20′ E) (Fig. 1). The average elevation of the city is 651 m from the mean sea level and receives an annual rainfall of 1430 mm. The total area covered by Ranchi municipality is 175 km^2. Mixed solid wastes generated in many parts of the city are collected and disposed without any processing or treatment in a dumping site at Jhiri village, 18 km away from the city. Dumping site is spread over an area of 22 acres and operational for the last 15 years. Approximately 700 t of MSW is currently being dumped every day.

Leachate pollution index

Leachate pollution index (LPI) is an index is an index for quantifying the contamination potential of municipal landfills (Kumar and Alappat, 2003). It is a quantitative tool by which the leachate pollution data of landfill sites can be reported uniformly. LPI is an increasing scale index and has been formulated based on the Delphi technique (Kumar and Alappat, 2003). It provides a convenient means of summarizing complex leachate pollution data and facilitates its communication to the general public, field professionals and policy makers. However, it is observed that the LPI, like any other environmental index, fails to effectively communicate the details

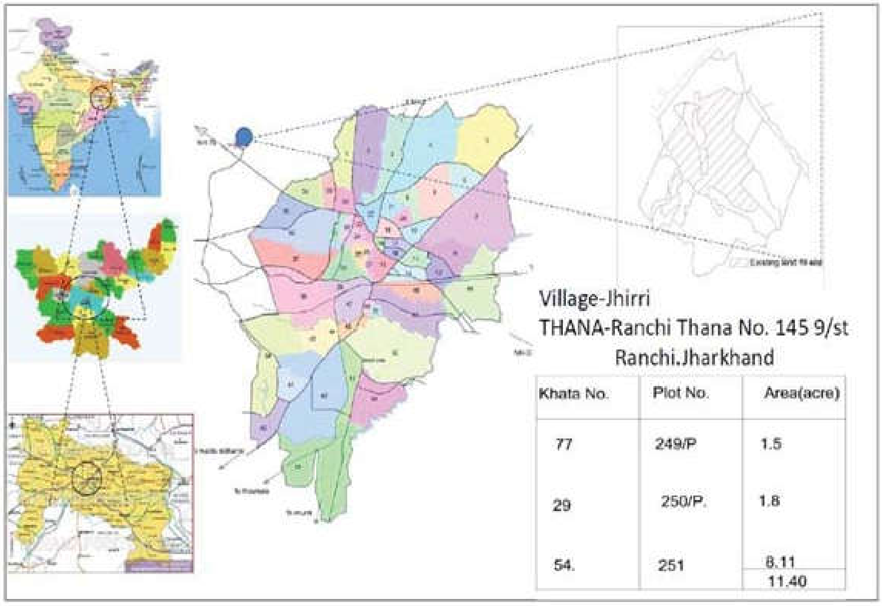


Fig. 1: Location of Jhiri Dumpsite, Ranchi

about the strength of variable pollutant /pollutants group present. In an effort to make the LPI more informative and useful, it is proposed to divide the LPI into three sub-indices. The aggregation of these three LPIs will result in the overall LPI.

It has been shown that the splitting of LPI into three sub-indices provides a better insight on the strength of various pollutants and can be useful to the experts in deciding various management issues regarding leachate treatment (Kumar and Alappat, 2003). On the graph sheets, level of leachate pollution (sub-index score) from "0 to "100 were indicated on the ordinate of each graph. Sub-index scores of (a) pH, (b) Total dissolved solids, (c) Biological oxygen demand, (d) Chemical oxygen demand, (e) TKN, (f) Ammonia nitrogen, (g) Total iron, (h) Copper, (i) Nickel, (j) Zinc, (k) Lead, (l) Chromium, (m) Mercury, (n) Arsenic, (o) Phenolic compounds and (p) Cholorides are shown in Fig. 2. The short description of LPI is as discussed under

$$\text{LPI} = \sum_{i=1}^{n} W_i P_i \qquad \text{...(1)}$$

Where, W_i and P_i are the weight and sub-index values of the i[th] leachate pollutant variable in the given order and n is the total number of pollutant variables. If the total number of pollutant variables is equal to 18, the total weight of the pollutant is equal to 1 and the LPI can be calculated to its approximate value by using Equ. 1. In case, the number of variables of pollutants is less than 18 then, for the estimating the LPI, Equ.1 is divided by the total value of weights of the pollutant variables and so the LPI under this condition is described as under:

$$\text{LPI} = \sum_{i=1}^{m} W_i P_i / \sum_{i=1}^{m} W_i \qquad \text{...(2)}$$

Where "m" is less than n = 18.

Results and Discussion

The Physico chemical analysis data of Jhiri landfill leachate (Chakraborty and Kumar, 2016) was used to develop the leachate pollution index at Jhiri dumpsite in Ranchi, Jharkhand. The water quality data was matched with the values given in Fig. 2 in order to determine the sub-index scores (P_i). Table 1 shows the sub-index score and corresponding P_iW_i values. For an example, the leachate value for chloride was reported as 9890 mg/L and corresponding value of sub index for chloride was obtained as 93. Similarly, the sub index value for all other twelve elements were determined. Example calculation is illustrated below:

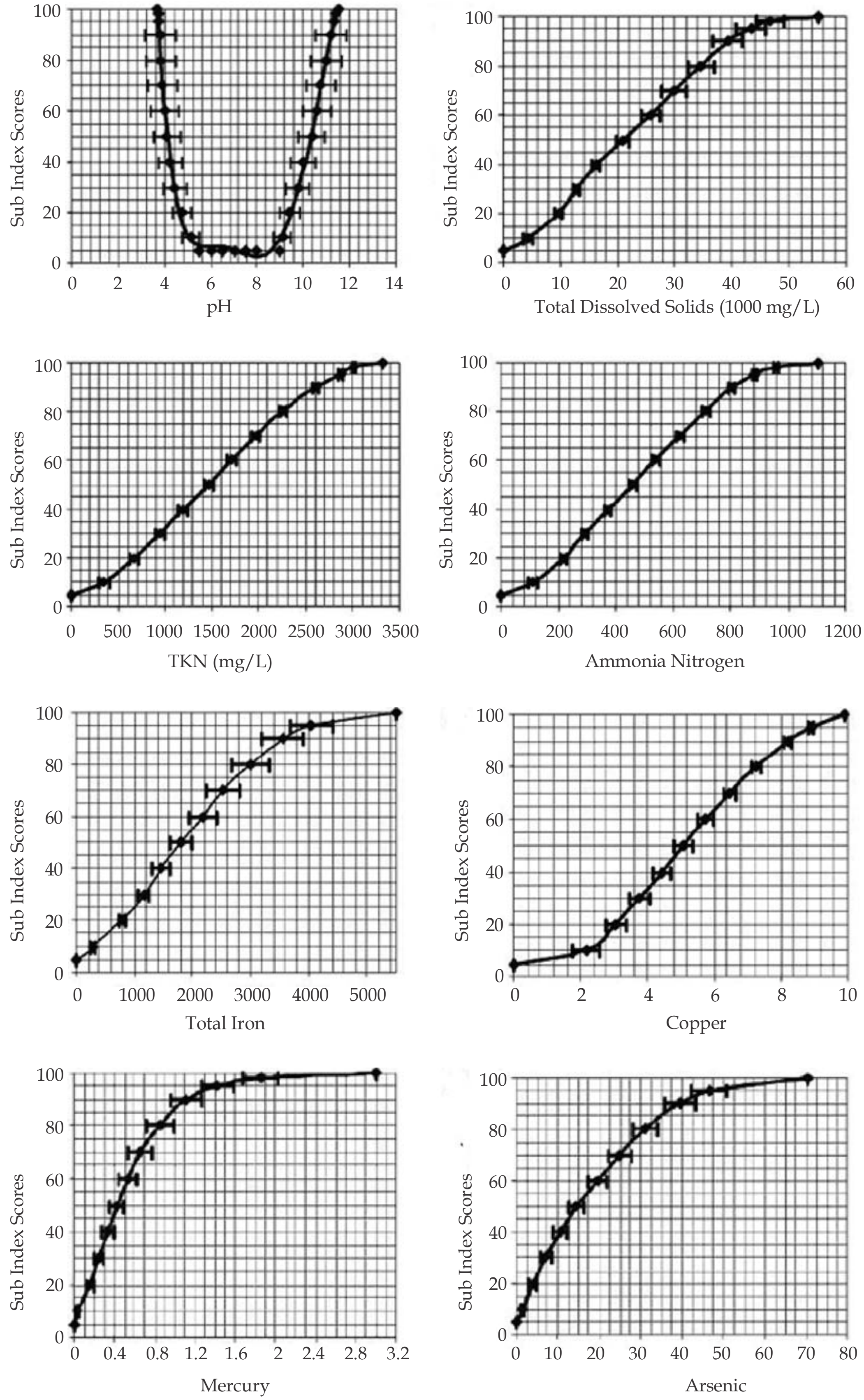
P_iW_i =20.634 and W_i = 0.653

By using Equ. 2,

$$\text{LPI} = \sum_{i=1}^{m} W_i P_i / \sum_{i=1}^{m} W_i$$

i.e. LPI =20.634/0.653 = 31.5988 = 31.60

The contamination potential of leachate is effectively presented through Leachate Pollution Index (LPI). Value of LPI was obtained as 31.60 which is more than 18. The higher value of Leachate Pollution Index indicates that the dumping site leachate has not been stabilized. This


Sub Index Scores
pH
Total Dissolved Solids (1000 mg/L)
TKN (mg/L)
Ammonia Nitrogen
Total Iron
Copper
Mercury
Arsenic

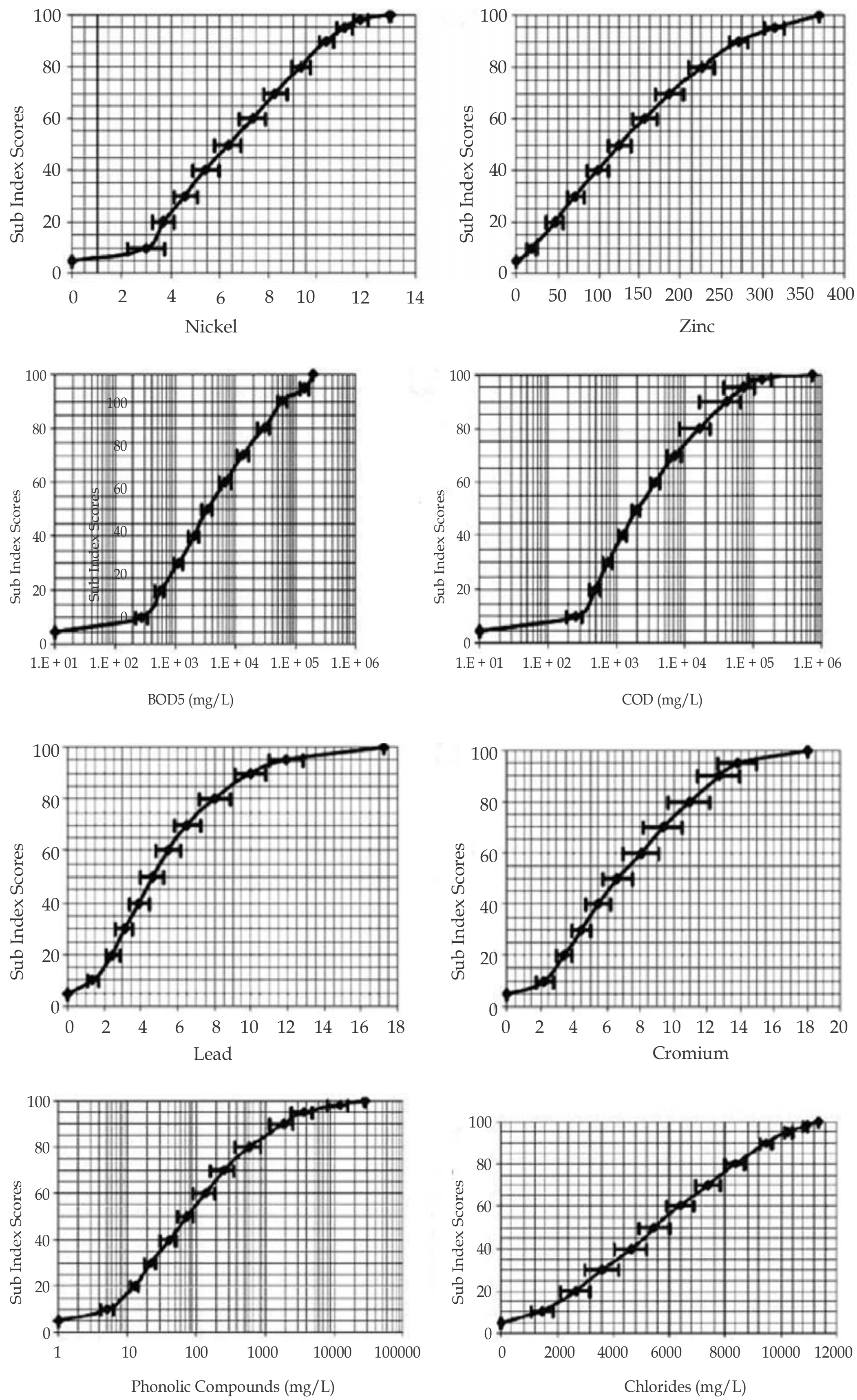


Fig. 2: Sub-index scores of different pollutants (Kumar and Alappat, 2003)

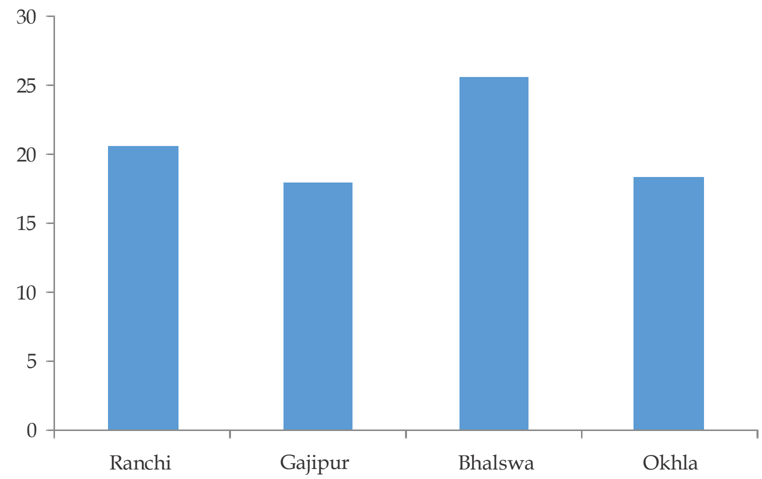


Fig. 3: Comparison of LPI of Ranchi with Gajipur, Bhalswa and Okhla

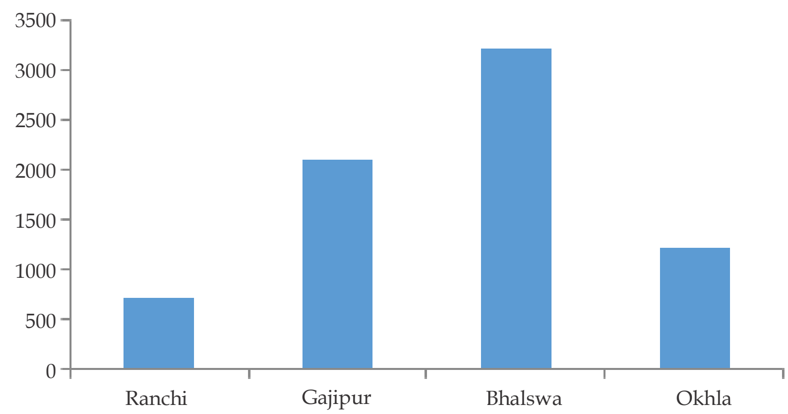


Fig. 4: Waste dumping quantity at different locations in ton per day

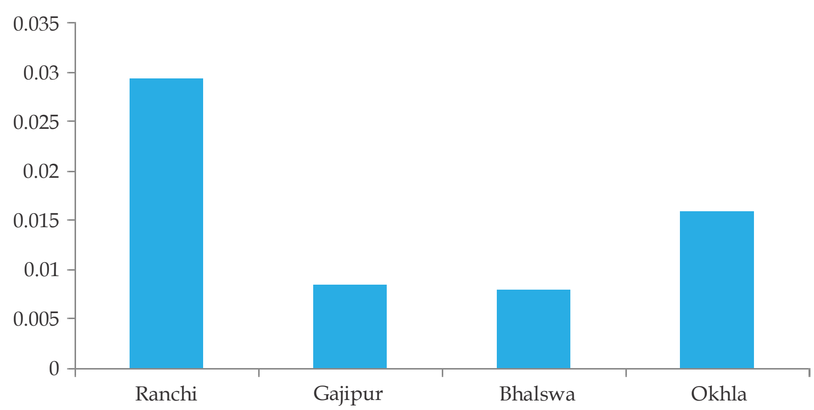


Fig. 5: LPI Contribution per ton of Waste

indicate that the management should be planned appropriately. Further this value was compared to the values obtained for the three major locations of Delhi landfills. LPI on different landfills of Delhi was determined by Malik and Naveen (2017). LPI variation of three land fill of Delhiis compared with the Ranchi dumpsite (Fig. 3). As we compare with the Delhi landfills, as the waste material on per day basis is very large but the lower LPI showing the dumpsite or landfills are less active than Jhiri dumpsite. Daily dumping of waste at Ranchi, Gajipur, Bhalswa and Okhla is shown in Fig. 4. LPI per ton was found maximum in Ranchi (Fig. 5) whereas corresponding LPI for Ranchi was higher.

Conclusion

Along with increase in density and population, the biggest problem is arising to manage the waste material produce by the industries, households, medical, agricultural etc. Dumpsite site of Jhiri, RanchiJharkhand is non-engineered open dump. It has neither any bottom liner nor any leachate collection and treatment system. Therefore, all the leachate generated finds its paths into the surrounding environment. The measured leachate samples would need an appropriate treatment strategy to reduce the pollutants to a satisfactory level prior to discharge into receiving system, which can be done by separating the different waste type to different categories.

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