RATING OF HAZARDOUS WASTE DUMPS IN HIMACHAL PRADESH AND PUNJAB

A Thesis

submitted for the partial fulfillment of the requirements for the award of the degree of

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ENVIRONMENTAL ENGINEERING

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by

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CERTIFICATE

This is to certify that the present work is being presented in the thesis titled **"Rating of Hazardous Waste Dumps in Himachal Pradesh and Punjab"** for partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "**ENVIRONMENTAL ENGINEERING"** and submitted to the Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Shivani Parmar (Enrolment No. 162752)** during a period from July 2017 to May 2018 under the supervision of Mr. Anirban Dhulia, Assistant Professor, Department of Civil Engineering and Dr. Ashok Kumar Gupta, Professor and Head of Department, Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

In India, about 90% of the hazardous waste is disposed in open dumps which are neighboring to large cities, releasing harmful contaminants. A huge number of un-engineered landfills exist in developing countries those are possibly unsafe to the environment and also release toxic materials to the groundwater in leachate form. The toxic materials form the dumpsites percolate through subsurface and may have great potential to contaminate groundwater, therefore these dump sites need to be prioritized. In this prospect, different hazard rating systems can be used as applicable to evaluate and prioritize those potentially hazardous dumpsites to take appropriate remedial measures. Three ratings systems are used to assess the groundwater contamination by – different ranking system (DRASTIC and mGW-HARAS, SIMRAS). In the present study two hazardous waste dump Sites from Himachal Pradesh and Punjab was considered as these two states has increased generation of hazardous waste with poor management facility. When used for ranking system for hazardous waste landfills in Himachal Pradesh and Punjab, SIMRAS system responds relatively well and observed to be the most sensitive and convenient system than other rating systems like DRASTIC, mGW-HARAS system. The rating scores observed from DRASTIC, mGW-HARAS and SIMRAS were showing different variations especially for DRASTIC. The performance of three systems in sensitivity analysis for the above Sites were also analyzed. It was observed that mGW-HARAS and SIMRAS respond better to change in site condition than DRASTIC, which shows zero sensitivity. In SIMRAS soil permeability, is the most important parameter to affecting the groundwater contamination potential of hazardous waste sites in Himachal and Punjab. The rating system proposed in the study and based on source- pathway- receptor approach. The study of these three systems employs only the major sites parameters that are derived and based on a review and case studies, literature. The best and worst values of the parameters are based on literature, design standards and field values. In this paper the concept of the leachate pollution index, a tool for quantifying the leachate pollution potential of landfill Sites. It has been described and demonstrated by comparing the leachate contamination potential of two Sites. It has been found that the leachate generated from the Site-1 can have more contamination potential in comparison to the Site-2 because of the stabilization of the landfills waste. LPI is an increasing scale index and has been formulated based on the Delphi technique.

Keywords: Hazardous waste dumps; Groundwater contamination; Hazard rating system; Hazard score.

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CHAPTER 1: INTRODUCTION

1.1General

The Environmental Protection Act (1986) was enacted by the Government of India for the protection and improvement of the environment and for efficient handling of hazardous or toxic materials entering in the environment. The implementation of India's Hazardous Wastes Rules are regulated by various state governments and union territories under the observation of the Ministry of Environment and Forests (MoEF). In India the average generation of hazardous waste per annum is approximately 9.3 million MT of which the recyclable portion is about 1.35 million MT, whereas incinerable waste quantity is 0.11 million MT and finally waste considered for dumping is approximately 0.49 million MT. And to handle this much of waste only two engineered dumping sites (both in Gujrat) and 88 incinerators are available throughout India. According to a report, the generation of waste was approximately 304.3 TPD in 2011 in Himachal Pradesh (CPCB, 2012), where the waste generation rate in Himachal Pradesh per person is about 0.413 kg/day. It was also seen that 60% of the waste that was generated finally goes for landfill disposal. Unscientific and uncontrolled disposal of waste finally leads to the creation of anaerobic condition at the landfill area emitting greenhouse and other harmful gases. According to the Department of Science and Technology, Himachal Pradesh, about 6.129 tons of greenhouse gas equivalent CO_2 is released from waste sectors (Department of Science and Technology, GoHP, 2012). A total 42147 MT of hazardous waste was generated in the state out of which 84.27% is dumped to landfill, 5.33% is incinerable portion of waste and the recyclable part is about 10.39% (CPCB, 2009).

According to the annual report of CPCB, approximately 1266 tons per day (TPD) of MSW was generated in Punjab in 1999-2000 which finally goes to about 2793 TPD in 2011 (CPCB, 2012) of which almost 90% of the waste is disposed in un- engineered landfills. Also according to Hazardous Waste Inventory Report of CPCB (2009), per annum about 180,000 tons of hazardous waste of which 13601 tons of landfill able waste, 14831 tons of incinerable waste and 89481 tons of recyclable waste were generated in the state.

Uncontrolled land disposal of hazardous waste can lead to a number of environment hazards, of which including groundwater waste contamination, surface water contamination and air contamination. Moreover several unprotected dumps site have been informed, where leachate generated in the dump site had polluted the groundwater [1] with a high concentration toxic substances. Leachate generated in dump sites not only contaminate the ground water but also pollute the subsurface soil when percolates through the subsurface soil. In India, most of the hazardous waste landfills do not follow engineered measures for the prevention of soil and groundwater contamination and are also uncontrolled. A current study on hazardous waste dumps site in Himachal Pradesh and Punjab indicates that 40% of the landfill sites having sand or silt, clay in their vadose zone and having potential hazard to the groundwater sources, where ground water level is very much close. The depth of groundwater of both sites has been in range of 0-45m. The present study attempts to develop a rating system to assess these kind of potential hazard for contamination from such waste dumping sites of Himachal Pradesh and Punjab. Several kinds of methodologies have been adopted to evaluate possible hazard potential from hazard dump waste sites. Three hazard rating systems are used for the evaluation of groundwater contamination - (DRASTIC, mGW-HARAS) and one newly suggested system (SIMRAS). Out of these three rating system only one (DRASTIC), directly assesses the groundwater contamination. A recently established groundwater hazard rating system is mGW-HARAS that may be used to evaluate and assess the potential for groundwater contamination. The rating scores were recorded and assessed for different rating systems and these were normalized to 0-1000 scale. In DRASTIC score are in clustered range of 150-800. mGW-HARAS shows efficient and better results in wider range of 60-1000 unlike DRASTIC. The algorithm used in mGW-HARAS is additive –multiplicative scoring and use complex algorithm in comparison to DRASTIC. A simplified system SIMRAS, designed on the basis of integrating a set of indicators i.e. aquifer zone, vadose zone indicator, indicator for source rating [1] using a multiplicative systems. Landfill hazard rating system helps in ranking of landfills or open dumps. On the other hand, hazard assessment method is modest and faster for application purpose, these system assess one site compared to other. The site parameters describing different environmental settings of a landfill and are combined with hazard score to decide the final rank for landfill sites. SIMRAS system, because of minimalism in calculation, can be considered as an efficient method for ranking waste dumping sites. Sensitivity analysis have been done to assess, evaluate and compare the efficiency and effectiveness for the newly proposed system and old systems.

Existing available rating systems for dumping sites used in to access different environmental threats of waste site which is represented in Table 1. Among these hazard rating systems most of them are grounded on source- pathway- receptor method. The ratings systems are be unlike with respect to the hazard pathways reflected, parameters, number of different parameters which were used to assess the data of dumping sites in Himachal Pradesh and Punjab. Conventional systems analyze potential environmental hazard of waste sites by various routes, e.g. groundwater, soil and also surface water.

Table 1 Conventional rating systems and their suitability to hazardous waste disposal sites for groundwater contamination [1]

Suitability of rating system	No. of systems	Systems available
Hazardous waste	12	Hazard Assessment Rating Methodology[20]; Hazard Ranking System-1982 [21]; Defence Priority Model [13]; Hazard Ranking System-1990 [22], Washington Ranking Method [28], National Corrective Action Prioritization System [23], Relative Risk Site Evaluation (Rel-risk) Method [24], Environmental Repair Program Hazard Ranking System [25], Indiana Scoring Model [26], Risk Screening System [27], Risk Assessment Of Small Closed Landfills [29] And National Classification System [30]
Hazardous waste, Municipal Solid waste	03	Hazard Ranking Using Fuzzy CompoSite Programming (HR-FCP) [31], Joseph Et Al.(JENV) (2005) And National Productivity Council (NPC) System [32
Municipal Solid waste to evalute groundwater/ surface contaminations	03	DRASTIC [17], GW-HARAS [15], mGW-HARAS [16]

Growing concern about environmental hazard of Sites and groundwater contamination, subsurface soil are taking appropriate remedial action or some control measures of Himachal and Punjab hazardous waste Sites.

In India hazardous wastes from industries are also disposed with municipal soil waste and there is no separate provisions for disposal of hazardous waste in dumping sites. Landfills leachate, containing several harmful and toxic substances and chemicals had high potential to contaminate the surrounding soil and polluted the environment as well as human, which definitely needs some proper remedial actions to avoid the potential threats of groundwater and surface water contamination. In the present study, to prioritize remedial actions systems are used and analyzed, in which landfills require instant attention for the remedial actions. For the assessment leachate contamination potential of these landfills leachate pollution index (LPI) could be a useful tool for the assessment. The application of LPI has been validated for classification of two sites in Himachal Pradesh and Punjab on the basis of the potential contamination hazard of the leachate generated from the sites.

1.2 Need of Study

Present status of this study needs to evaluation of Three rating system, which are used to ranking of the hazardous waste Site. These ranking systems identify the Site hazard and find the harmful effect to the environment and other living organisms. Evaluation of cconventinal system (DRASTIC) and mGW-HARAS and another newly suggested system (SIM-RAS) of hazard dump site. The sensitivity assessment and range of rating score and actual application of SIMRAS was found to be more efficient compare to DRASTIC and mGW- HARAS.

Hazardous solid waste dumps in Himachal Pradesh and Punjab have significant potential threats to the environment as well as human which require immediate attention in order to control and prevent environmental pollution.

1.3 Objectives

- Sensitivity analysis of hazardous waste landfill Sites using conventional (DRASTIC, MGW-HARAS, SIMRAS) hazard rating system.
- To investigate the advantages of SIM-RAS over existing hazard rating model.
- Prioritization of Hazardous solid waste landfill Sites for implementing remediation technique and control measure using suitable rating model in Himachal Pradesh and Punjab.

1.4 Scope of Project

The scope of the present study incorporates hazardous waste dump sites in Himachal Pradesh and Punjab having population is more than a seventy crores. The present study reflects the groundwater contamination potential as it causes an interminable effects on the groundwater table and environment. To determine the groundwater contamination potential for hazardous waste dumps in two states. Identify the Problem and analysis of both Sites and using some Remedial Strategies to improve the environmental effects by groundwater contamination.

CHAPTER 2: LITERATURE REVIEW

2.1General

The summary of previous research work done in this current topic is summarized in the current chapter.

Manoj Datta, Amit Kumar. (2017). ***[1]*****:** The objective of research paper is to evaluate the potential of ground water contamination. In this paper only the groundwater contamination and its effect on the groundwater. The study investigates the usefulness of the existing system of the various disposal sites in Indian cities which is populated more than a million. These existing system and newly proposed system are applied to the waste dumps in India. Through the analysis of numerous models and approach ranges for the determination of simulations of the water balance and stochastic failure through the various hazard rating system that are based on structured values and approaches. In this study, the DRASTIC system which is one of the various hazard rating system determine the subsurface contamination potential across the Various dumping sites in various cities of India. Seeing the complex city of the DRASTIC system an simplified system SIMRAS another hazard ranking method which is derived through GW-HARAS and mGW-HARAS hazard rating system is suggested in this paper for the evaluation of potential of contamination of groundwater at MSW dump sites. SIMRAS and mGW-HARAS have higher sensitivity towards the parameters such as water index annual rain and permeability of the soil whereas in comparison DRASTIC systems have zero sensitivity towards above mentioned parameters.

1. DRASTIC Index $= \sum_{i=1}^{i=7} W_i R_i$ Eqn 1.1

W_i weight of parameter i, rating of parameter i

2. GW- HARAS:

$HR = H_s \times H_p \times H_R$

H_s = source of hazardous rating

H_P = pathway of hazardous rating

H_R = receptor of hazardous rating

3. mGW-HARAS relationship is: HR = $H_s \times H_p \times H_R$ with addition of different parameters. This is a modified system of GW –HARAS.

H_s = source of hazardous rating

H_p = pathway of hazardous rating

H_R = receptor of hazardous rating

Khalid Mahmood, Syeda Adila Batool, Muhammad Nawaz Chaudhary, Zia Ul-Haq (2017) *[2]*: The objective of this paper is to assess the criteria of various existing disposal sites. For analysis of these criteria geographic information has been used. In this study to implementation and prioritization of these existing non- engineered MSW disposal sites use mathematical scheme.

V. Arunbabu, K.S. Indu and E.V. Ramasamy (2017) *[3]*: The objective of this paper is to analyzed the various stress parameters and its relationship with calculated LPI value. In this study Brahmaouram MSW treatment facility case study is preferred where it was found that due to the liquid waste India is highly polluted within the leachate index value is high because of high biochemical oxygen demand and chemical oxygen demand ratio indicates the biological treatment of leachate potential. It is revealed through phytotoxicity test that with low concentrations leachate promoted plant growth and effected the growth at higher concentrations, since leachate concentrations is directly related to the growth therefore metabolic process in growth plants are directly related to the LPI value. Hence LPI value can be considered as most suitable indicator for leachate toxicity in phytoremediation of leachate.

Amit Kumar, Manoj Datta, Arvind K. Nema and R. K. Singh (2017) *[4]*: The objective of this research paper is the investigation of existing systems of hazard rating for contaminated air and to determine suitability of such rating systems. In this paper it emphasis on suitability of existing systems of hazard rating for the determination of potential of air contamination of MSW sites. The RASCL modifications consist of modification of indicators such as waste quantity, rainfall and fresh water quantity. These improvements in system will exhibit lower clustering of scores higher sensitivity and wide range of scores as compared with existing systems of ratings for different waste sites of cities in India.

Gurtej Sing, Yogender Pal, Puneet Juneja Arashdeep Singh, Dr. Rudra Rameshwar (2016) *[5]*: The objective of this paper is to make certain the community a safe and healthy environment disposal a hazardous waste in proper manner. The municipal solid waste plan formulated by the government of Punjab is highly ambitious, but the work carried out is very less and plants under public private partnership will also harness the power scenario of the Punjab that products of processing plant such as refused derived fuel (RDF), Vermicomposting and recycling of the paper products will ensure the sustainable growth of the population. .

Amit Kumar, Manoj Datta, Arvind K. Nema, R.K. Singh (2016) ***[6]*****:** The objective of this paper different waste site use criteria to prioritize these sites for remediation measure. In this study existing system are used for ranking of the waste disposal sites, whereas on the basis of relative rating improved system is used to assess the contamination of water hazard from leachate of MSW sites. These systems were applied to MSW dumps from Indian landfill cities, whereas it gives a different wide range of the rating scores. On the basis of improved system find out the sensitivity analysis of these system.

Manoj Datta, **Amit Kumar (2015)** ***[7]*****:** objective of this paper Prioritization of the landfills. This is first step in planning for closure and information about the size of the different sites and proximity to the environment of significance. In this paper demonstrates how hazard rating system method can be used for assessing the relative potential of MSW dump sites for contamination of groundwater and surface water. It is based on the rating scores, each score identify the suitability of geo- environmental measures for closure of MSW dumps which have different impact on the environment due to varying site conditions with different landfill sites.

Chitra Kumar, Rishav Kumar, Shalini Jaiswal (2015) ***[8]*****:** under this study find out the impact of solid waste at various landfills sites. The inappropriate disposal of waste responsible for depletion of water, air land and also risks to human health and environment.

Amit Kumar, Manoj Kumar, Arvind k.Nema, R.K. Singh (2015) ***[9]*****:** The objective of this research paper is to develop contamination hazard from disposal site that assess on relative rating system. Several kinds of method are applied for evaluation of potential hazard of disposal sites of India. DRASTIC, ERP-HRS, HR-FCP, RSS, RASCL rating systems used to determine hazard of disposal sites and each relative systems. The basis of these systems is Source-Pathway-Receptor relationship and such above systems were selected for detailed analysis for the study. Under this study some existing systems are selected for the detailed analysis. The aim of these systems is to evaluate the potential hazard from these waste sites. All the systems represent the methodologies used in hazard rating systems. Some systems assess potential hazard for groundwater water routes and are widely used in region of their geographical origin. Complex and simple parameters along with scoring algorithm are used for each system. Existing system based on surface water contamination and on the basis of these systems produced clustered scores through ranking of sites and also clear distinction is not possible between different waste sites.

Lathamani.R, M.R. Janardhana, B. Mahalingam and S. Suresha (2015) ***[10]*****:** under this study integrating the DRASTIC model to determine the aquifer vulnerability contamination potential whereas it use the highly reliable method DRASTIC and GIS system. In this study DRASTIC index considered the value is < 70 which is more than to 100. Due to high net recharge, area, slopes ranges, it shows the very high vulnerability index. The results of this DRASTIC model, GIS system and analysis of groundwater potential are very effective to assess the groundwater contamination and environmental risk hazard.

Akhtar Malik Muhammad, Tang Zhonghua, Ammar Salman Dawood and Bailey Earl (2015) ***[11]*****:** under this paper groundwater resource management is use the maps for making information of the groundwater, whereas it identify the contaminants of sources, factors by degradation and properties to maintain the groundwater quality. In this paper it identifies the level of vulnerability at Lahore city on the basis of DRASTIC model and GIS. Seven parameters were used in DRASTIC system whereas groundwater vulnerability map is used for the assessment of groundwater resources risk and other planning for future activities. This map was helpful to the management of groundwater resources.

Izhar Ahmed, Dr. TVD. Prasad Rao, **Mushtaq Hussain (2014)** ***[12]***: the objective of this paper conducted of work, estimation, design of foundation and future development plan to understand the behavior of chemicals which is expose to the dumping waste sites whereas in this waste sites Heavy metals and toxicity of leachate escape from these waste dumps. Hence non- biodegradable waste and heavy metals can be removed by mining and chemical process.

Hossein Jafari Mansooriana, Ahmad Reza Yaribc, Ahmad Rajabizadehd, Shidvash Dowlatshahie, Narges Khanjanif, Behnam Hatamig (2013) ***[13]*****:** Under this case study the objective is evaluation of disposal hazardous waste by collection, transportation, recycling waste in the Khazra Industrial Park of Kerman, Iran whereas on the basis of results Khazra Industrial Park needs unified system and transportation with basic facilities for collecting the sorted waste. Some regulations and guidelines for waste management initiatives can be suggested as follows: some steps are applying and obeying the regulations for united and proper management of hazardous and industrial waste at the Khazra.

Raj Kumar Singh, Manoj Datta, Arvind Kumar, Iñaki Vadillo Pérez (2012) ***[14]***: In this paper the objective is to evaluate the hazard rating system of disposal sites on the basis of relative scale of one or more hazard rating modes. In this paper the HARAS system is basis on the relationship of Source-pathway-receptor for evaluation of potential of groundwater contamination of disposal sites and it lie between 0-1000 scale ranges. Some parameters considered on the basis of expert opinions. The groundwater contaminations are ratings are high in India because some landfills were larger in size and area and having no covers and leachate contamination systems.

Islam M. Rafizul, Muhammed Alamgir and S.M. Shahed Sharif (2012) ***[15]*****:** The objective of this paper is calculating the LPI value with various possible aggregation functions for pilot scale disposal sites. On the basis of results it concludes that calculation of LPI value by weighted parameters and best possible liner aggregation of function is required. In this case LPI calculation for leachate pollution is a least sensitive

Manoj Datta (2012) ***[16]:*** The objective of this paper is design, construction and costing of disposal sites and closure of tailings, increment in height of embankments of ash ponds through determination of hazard ratings of MSW waste disposal sites. Use of low- permeability hydraulic barrier systems for containment of waste and high-permeability drainage systems for collection of emissions/ contaminants, two important aspects of environmental control at waste disposal sites which have been highlighted. In this paper permeability of soil on design of waste disposal facilities has been demonstrated.

Vandana Mathur (2012) ***[17]*****:** The objective of this paper to understand the waste management system and population pressure on waste generation and amount of waste generated. To establish the scope of hiring waste collection services. Data was collected by primary as well as secondary method and was collected through questionnaire and discussions with the people from different cities. In this paper used a 'non comparative technique'. The rating scales used was nominal scale. Various landfills reducing the amount of garbage and should be regulated by checking the waste which has been strictly passed through segregation and treatment process.

You-Hailin, Xu-Ligang, Ye- Chang, Xu- Jiaxing (2011) ***[18]*****:** Objective of this paper is determining the hydro geological conditions whereas each unit and data of existing area is identify. In this study the rate and weight of each hydro geological unit and actual data of existing area is used to determine the vulnerability index.

DRASTIC vulnerability index VI $= D_rD_w + R_rR_w + A_rA_w + S_rS_w + T_rT_w + I_rI_w + C_rC_w$.

In this formula, the subscript w is weight, r is rate.

Raj Kumar Singh & Manoj Datta & Arvind Kumar Nema (2010) ***[19]*****:** The objective of this paper is to prioritization of municipal solid waste dumps for adopting control and remedial measures. In this study time- dependent system partially based on structure value and approaches has been used for evaluating the groundwater contamination hazard rating of MSW dumps. The proposed system has been applied with equal importance to past and future groundwater contamination form an MSW dumpsite. The proposed system produces significantly varying scores for different scenarios. This shows that the proposed system is adequately sensitive to each group of source, pathway, and receptor parameters.

R. Rajput, G. Prasad and A.K Chopra (2009) ***[20]*****:** The objective of this paper is various site conditions, issue and problem of urban waste management system in the industrialized and developing world generates a large number of wastes. System needs adequate facilities, competent government institutions and bureaucracies to manage their waste. In this paper the final destination of solid waste in India is disposal. Most urban solid waste in Indian cities and town is land filled and dumped. A wide range of disposal options in many developing countries is available like non- engineered disposal, sanitary land filling, composting, incineration, Vermicomposting, reuse and recycling of waste.

Bharat Jhamnani and SK Singh (2009) ***[21]*****:** Under this study is to find out the level of concentrations of potential contaminants over the passage of time in groundwater through recharge from landfills leachate to the groundwater. In this case study dumping sites in Delhi wastes generated, at three locations Bhalaswa dump site, Ghazipur dump site and Okhla dumps without any safety and proper care for the protection of surrounding environment. Bhalaswa dump site in Delhi is expected to become cause of serious groundwater pollution and human health. Leachate generation of these landfills having high concentration of chlorides and COD. Hence, groundwater supply requires Urgent attention from this region.

Raj Kumar Singh, Manoj Datta, Arvind Kumar Nema (2009) ***[22]*** **:** The objective of this paper, the performance of existing systems for groundwater contamination hazard rating is assessed and a new system that overcomes with various shortcomings of the existing system. The proposed and existing system to set of landfills with different site conditions and types of waste shows that in comparison to the existing systems. In this paper proposed system shows better response both to change in site conditions and in type of waste. New proposed system with the various shortcomings of the existing systems therefore, it form a better basis for prioritizing landfills for control and remedial measure.

Manoj Datta (2008) ***[23]*****:** under this study is finding out the textured of geo-membrane at small heights and reinforcement of this membrane is high, whereas it helps to improve the stability of slope. In this paper a case study cover and liner configurations is used for old waste dumps whereas some of the waste dumps are more stable and have no harmful impact on the environment.

Atiqur Rahman (2008) ***[24]:*** The objective of this paper is identifying the sensitivity of the various resources to its environment, and as a practical visualization tool for decision-making. In this study the DRASTIC standard system is used for evaluating the Groundwater pollution potential. In this study a GIS model to determine the groundwater contamination potential of any area. This was accomplished using the DRASTIC model. DRASTIC system is used for a wide range of applications and prioritization of area for monitoring purposes. It will be very helpful to the future development and policy makers while selection of areas for waste disposal.

Atul Sharma, Srikanth Meesa, Somali Pant, Babu J. Alappat and Dinesh Kumar (2008) ***[25]*****:** The objective of this paper is formulation of an index termed the landfill pollution potential index. This landfill pollution potential index can be used for landfill diagnosis and prioritize remediation investment of the landfill sites. It depends upon the locality, geographic and climatic conditions. The evaluated Landfill pollution potential index is based on the concentration of various parameters that constitute the six environmental elements: sub-surface water, surface water, ambient air quality, aesthetics, noise level and flora and fauna and it varies significantly with different phases of the landfill.

Vikash Talyan, R.P. Dahiya, T.R. Sreekrishnan (2007) ***[26]*****:** The objective of this paper, evaluation of the MSW site management system of Delhi. In this study the waste quantity generated of MSW in Delhi represents that present status and existing infrastructure are inadequate with control measures due to which initiatives taken by policy makers under delivered the results until and unless proper implementation is followed. Hence any variation in present scenario is impossible without the partnership of government, private sector.

Raj Kumar Singh, Manoj Datta and Arvind Kumar Nema (2007) ***[27]*****:** The objective of this paper is evaluating groundwater contamination potential of different MSW landfill sites on the basis of relative hazard rating system. This system tool can be used for prioritize the MSW sites for control measures. In this study discussed about four landfills and the results are compared with existing models. The hazardous rating scores of various disposal sites by the present model vary from lower to higher score, whereas other system vary in narrow range though all pores sides are different.

Suman Mor1, Khaiwal Ravindra, R. P. Dahiya1, A. Chandra (2006*) [28]*:** The objective of this paper is to reduce further groundwater contamination via leachate percolation, the present study demand for the proper management of waste. The groundwater quality improves with the increase in depth and distance of the well from the pollution source. The concentrations of few contaminants do not exceed drinking water standard even then the ground water quality represent a significant threat to public health, recommends some remedial measures to stop further groundwater contamination.

Dinesh Kumar, Babu J. Alappat (2005) ***[29]*****:** under this paper is to calculate and determine groundwater contamination on the basis of LPI value of two hazard ranking disposal sites with significance weights and concentrations of ions produced by leachate. LPI provides the meaningful evaluation of potential leachate contamination at different MSW disposal sites. In this paper important information tools are require to find the environmental threat by leachate pollution of different waste disposal sites. Leachate produced from this MSW sites should be treated as post- closure measure and it required until leachate generation is stabilized.

R.A.N. Al-Adamat, I.D.L. Foster, S.M.J. Baban (2003) ***[30]*****:** The objective of this research paper is to implementation DRASTIC method with GIS system. In this study certain factors were added to DRASTIC vulnerability index to produce risk index. Under this study investigate the vulnerability and risk of groundwater potential of DRASTIC model which include the six parameters to find the vulnerability of groundwater potential with GIS system. Due to unavailability of the data hydraulic conductivity of the aquifer was excluded whereas in DRASTIC index data can be computed for many parts of the world and must be emphasized that no attempt towards low directions and groundwater fluxes are made within aquifer.

Inamul Haq and S. P. Chakrabarti (1997) ***[31]:*** The objective of this paper is deals with identification of hazardous waste generating units, quantification and classification of hazardous wastes generated. The hazardous wastes are often mixed with other wastes and it would be segregated from non- hazardous wastes to reduce their volume for effective treatment and disposal. Most of the industries dispose off their wastes outside the plant which is premises in low- lying area, and recovery and recycling are not much practiced.

Efralm Halfon (1989) ***[32]*****:** The objective of this paper what is the criteria used for ranking. The contradictions in ranking of MSW disposal sites is identified by the probability of harm done by chemicals present in the environment. Further it identifies which criteria are best suitable and critical for ranking purposes.

Steven J. Haness and John J. Warwick (1991) ***[33]*** **:** under this paper developed the hazard ranking system and these systems identifying the most dangerous hazardous waste facilities and it will be more straightforward and suitable for application against a large number of sites with a variety of conditions. HRS is a useful application for the analysis. They provide methods to guide the data acquisition process, and it demonstrate that the availability of sufficient support information on the factor hazardous waste quantity. According to this system it defines an effective measure of the relative importance of factor by generally quantifying the sensitivity of final scores to increases in specific factor values. An additive design which is allows controlled and predictable modification, and it can consistently emphasize those factors that are considered important.

By Jy S. Wu1 and Helena kilger (1984) ***[34]:*** The objective of this paper is to uncontrolled hazard landfill sites ranking of the system is use to evaluate the relative potential of sites whereas due to the uncontrolled damages of landfill it causes safety problems and environmental damages. For evaluation of potential hazard of uncontrolled landfill sites HRS system provide an expedient and consistent procedure for landfill information and its facilities. In this study the criteria was used to estimate the potential hazard of landfill site in adequate. Hence more than 3 miles upstream distance of the water HRS system allows the zero score range.

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CHAPTER 3: METHODOLOGY OF THE SYSTEM

In this present study we will investigate the groundwater contamination of landfill Sites of Himachal Pradesh and Punjab. Groundwater pollution is a long term phenomenon where the contaminants are not removed periodically from the ecosystem. The DRASTIC, mGW-HARAS, SIMRAS model has been adopted.

3.1 DRASTIC System

In DRASTIC model, there are seven parameters which influent and control the groundwater flow and contamination. To apply the DRASTIC model seven parameter are necessary, such as depth to water level, net recharge, aquifer media, soil media, topography, impact of vadose zone and hydraulic conductivity. Each hydro- geological parameter is assigned a weighting, from one to ten (Table 2) the DRASTIC index was computed by summing up the weighted values of each area.

The DRASTIC index was calculated by applying linear combination of all variable with the help of equation [3.1.1]

$$DI = \sum_{i=1}^{7} R_i W_i \qquad (3.1.1)$$

$$DI = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw$$

Where D, R, A, S, T, T, I and C are parameters and r and w are the corresponding rating and weights. Index range of DRASTIC is 23-226 (a higher score indicates greater susceptibility to possible hazard).

Table 2 Weights given to each DRASTIC Parameter [11].

Parameters	DRASTIC Weight
D- Depth to groundwater water: Deep water tables consider safer from pollutants then shallow water tables.	5
R- Annual Recharge: high recharge rate indicates more contamination infiltrate towards groundwater water.	4
A- Aquifer media: the aquifer media determines chances resistance against contaminant transport.	3

S- soil media: the soil media exposes pollutants moving time from surface to water table	2
T- Topography: a high slope results in rapid runoff, which indicates less chance to infiltrate contamination into ground.	1
I- impact of the vadose zone: the vadose zone thickness and matrix are affect contamination intensity and transport timing	5
C-Hydraulic conductivity: the hydraulic conductivity of the aquifer indicates the quantity of water percolating through the aquifer	3

3.2 mGW- HARAS System:

mGW- HARAS is an improved and modified version and recently developed groundwater hazard rating system which can be used for rating of contamination potential by eliminating the receptor component. mGW- HARAS is a multiplicative algorithm (Table 3) mGW-HARAS is based on source – pathway – receptor relationship and evaluates the groundwater contamination of hazard rating of landfill Site on a relative scale of 0-1000. The relationships of source-pathway-receptor of mGW-HARAS parameter have been identified based on literature and expert opinions. mGW-HARAS is more sensitive to the changes in soil permeability [1]. As mGW-HARAS is a derivative of GW-HARAS only. GW-HARAS will not be discussed in this study. In these two existing system DRASTIC and mGW-HARAS three parameters which influence the leachate movement i.e. depth to groundwater, vadose zone, soil permeability and groundwater gradient are used by two these two systems. Index Range: **60 – 1000** (a wider range thus more sensitive, a higher score indicates greater susceptibility to possible hazard). mGW-HARAS use complex equations as well as DRASTIC use simple line equations.

Table 3 Evaluation of Groundwater mGW-HARAS rating system: [1]

mGW-HARAS ($HR = H_s \times H_p \times H_R$)
Formulae
$H_s = W_qi \times W_ci \times I_pi$
$W_{qi} = 225 \times (W_q)^{0.1}$
$W_{ci} = 0.6 + 0.4[\frac{25H+5B+C}{500}]$
$I_{pi} = 0.6 + 0.4 \times \frac{Ps \times is}{10}$

$H_p = V_i \times A_q i$
$V_i = X_1 + X_2[[\frac{\log(kv)b - \log(kv)}{\log(kv)b - \log(kv)w}] \times [\frac{lb - lf}{tb - tw}]]$ 10^{-8} 10^{-6} Where $X_2 = 1 - X_1$ $X_1 = 0.2$ for $k \le 10^{-8}$ $= 0.4$ for $10^{-8} < k\ (m/s) \le 10^{-6}$ $= 0.7$ for $k(m/s) > 10^{-6}$
$A_{qi} = 0.8 + 0.2 \times [\ z^{0.5}{}_{gg} - {}^{0.5}{}_{ggb} / z^{0.5}{}_{ggw} - z^{0.5}{}_{ggb}]$
$H_R = \max(GU_{ij})$

HR hazard rating, H_s source rating, H_p pathway hazard rating, H_R receptor hazard rating W_{qi} waste quantity indicator, W_{ci} waste composition indicator, I_{pi} infiltrating precipitation indicator, W_q waste quantity (tons), H Hazard fraction(%), B biodegradable fraction(%), C construction and demolition fraction (%), P_s precipitation factor, is infiltration score, V_i vadose zone indicator, k_v vadose zone permeability, L is vadose zone thickness, A_{qi} aquifer zone indicator, W_{ab}, W_{ap} and W_{gg} relative important weights and Z_{at}, Z_{ap} Z_{gg} and Z_{dw} are the parameters value of aquifer thickness, permeability, groundwater gradient, and distance to nearest groundwater well, subscripts b, w is best and worst value GU_{ij} groundwater user category

3.3 SIMRAS System

mGW-HARAS rating system has been converted into a simplified system SIMRAS system so as to increase the ease of application without reducing its sensitivity [1]. SIMRAS system generally is based on the same relationship of mGW-HARAS, Source-pathway-receptor concept. In SIMRAS source refers to the dumpSite of Himachal Pradesh and Punjab and is characterized by a number of parameters dealing with leachate quality and quantity. Pathway described by various leachate characteristics that govern the leachate transport. Receptor are identifying by environment and the community affected by the contamination i.e. livestock, crops, local flora and fauna, adjacent soil and groundwater.

$HR = H_s \times H_p \times H_R$ ...Eqn. 3.4.1

Hazard rating system can be converted in to Contamination potential rating system by eliminating receptor component, value of H_R is taken one.

$CPR = P_s \times P_p \times P_R$ ...Eqn. 3.4.2

P_s = source potential

P_p = pathway potential

P_R = receptor potential (taken as unity) [1]

Source potential rating eqn. is given as:

$Ps = I_{wq} \times I_{wc} \times I_p$ ...Eqn. 3.4.2.1

I_{wq} = waste quantity indicator, I_{wc} = waste composition indicator, I_p = infiltrating precipitation indicator.

$PR = I_v \times I_{aq}$ . ...Eqn. 3.4.2.2

I_v = vadose zone indicator, I_{aq} = aquifer indicator

SIMRAS system basically consists of integrating set of indicators i.e. indicator for source rating which is depends on quantity of hazardous waste from the dump Site, indicator of vadose zone depends on the depth of the groundwater and soil type of the Sites, Aquifer zone indicator depends on groundwater gradient.

Table 4 The parameters of three systems which is collected from the waste Site of Himachal and Punjab

Parameter	DRASTIC	mGW- HARAS	SIMRAS
Area (ha)		√	√
Waste thickness/height (m)		√	√
Waste composition (%)		√	√
Rainfall/recharge (mm)	√	√	
Depth to groundwater (m)	√	√	
Soil permeability (m/s)	√	√	
Groundwater gradient (%)	√	√	√
Slope of the top surface	√	√	
Aquifer permeability (m/s)	√		√
Aquifer thickness (m)			√

Vadose zone permeability (m/s)			√
Vadose zone thickness (m)			√

3.4 Sensitivity Analysis

To identify the reasons for a less than satisfactory response of different hazardous rating system to hazard waste landfills, a sensitivity analysis was performed. For the sensitivity analysis, three system and seven parameters were selected. Whereas the three selected systems were the three representative systems, the seven parameters selected include landfill area, landfill height, annual rainfall, biodegradable fraction, soil permeability and depth to groundwater (m), Groundwater gradient.

To study the impact of the selected parameters on hazard score a base case was considered (Table 4.4). Each of these parameters was varied by ±50 % so as to cover its likely range of variation. The resulting impact on the groundwater contamination hazard score produced by DRASTIC, mGW-HARAS, SIMRAS was measured in terms of percentage change (increase or decrease) in the base case hazard score. The results of the sensitivity analysis are summarized in Table 4.3.

Table 4.4 shows that among the three systems, DRASTIC shows nil sensitivity. mGW-HARAS, SIMRAS exhibit sensitivity to all of these parameters (Table 4.4). The sensitivity of SIMRAS is to soil permeability, the most important parameters affecting the groundwater contamination.

3.5 Advantages of SIMRAS over Existing mGW-HARAS

- mGW-HARAS uses Additive Multiplicative Algorithm, SIMRAS employs Multiplicative Algorithm i.e. more simple algorithm than mGW-HARAS.
- SIMRAS has low to medium sensitivity whereas DRASTIC shows nil sensitivity
- The sensitivity of SIMRAS to soil permeability, the most important parameter affecting the subsurface contamination potential of a waste Site is very high (120%) whereas for DRASTIC it was low (50%) [1].

3.6 Methodology for System Development

- The methodology for input data based on literature review and expert opinions. The Delphi technique was used to drive the relative importance weights of the group parameters.
- This system consists of source, pathway and receptor.
- The source is assumed to be mainly dependent on parameters affecting leachate generation such as the waste area, waste composition and annual rainfall.

3.6.1 Delphi Method to Determine

- The most important injury hazard in each area.
- The most important injury prevention behaviors.
- Behaviors to reduce injury risks.

3.7 Ranking of Landfill Sites Using LPI

For Table 4.5 Himachal Pradesh and Punjab dump Site index with a population close to 70lakh. Site-1 generates huge quantities of waste every day. An average daily total of 50,000 MT of hazardous waste (which includes the domestic, industrial, and commercial) was delivered for disposal at incineration. The land filling of millions of tons of waste every year has the potential to cause major impacts on the environment. The greatest and the most sustained risk arise from the generation of landfill leachate.

In this study, the two landfill Sites in Himachal, Punjab have been considered for evaluating the leachate contamination potential based on the composition of leachate produced in these landfills.

- Himachal Pradesh Site-1 (Shivalik solid waste management limited, Majra) active since 2006 and receiving of domestic and industrial waste.
- Punjab is also active Site since2004 and receiving commercial, domestic and industrial waste.

3.7.1 Calculation of LPI

LPI was calculated according to the procedure given by [3]. 10 parameters used for the calculation the LPI.

$$LPI = \frac{\sum_{i=1}^{m} wiPi}{\sum_{i=1}^{m} wi} \qquad \text{Eqn. 3.7.1.1}$$

LPI = Leachate pollution index,

wi= weight of the ith pollutant variable

pi= sub index score of the ith leachate pollutant variable

m = number of leachate pollutant variables used in calculating.

3.8 Study Area (Site-1)

The thesis study proceeds only after data are collected from dump Sites. These data collection Sites were situated in different state, area and location. The study area lies in the Himachal Pradesh and Punjab. Himachal Pradesh located between 30º 22' and 33º 12'N and Between 75º 47' and 79º 04 E having altitude ranging from 350 to 7000 meter above mean sea level, Solan become a district of Himachal Pradesh. The study area comprises of surrounding area of project Site Shivalik solid waste management limited in village Majra, of Nalagarh in District Solan has offshoot an UPL group of companies in Mumbai.UPL is one of the leading player in the field of environment services in the country. Project Site at village Majra is situated about 10km from Nalagarh-Bharatgarh road. The study investigated the hazardous rating of Site (Shivalik solid waste management) using three methods DRASTIC, mGW-HARAS, SIMRAS. Approximately 50,000 MT of hazardous waste is generated per annum from different sources, with up to 5% of hazard waste and 20% of biodegradable waste. Shivalik solid waste management has different project components to Comprises of secured landfill. Pretreatment process and stabilization unit are available in the Site and Double liner system Leachate collection system E- waste storage facility(facility is sufficient to last more than 20 years).

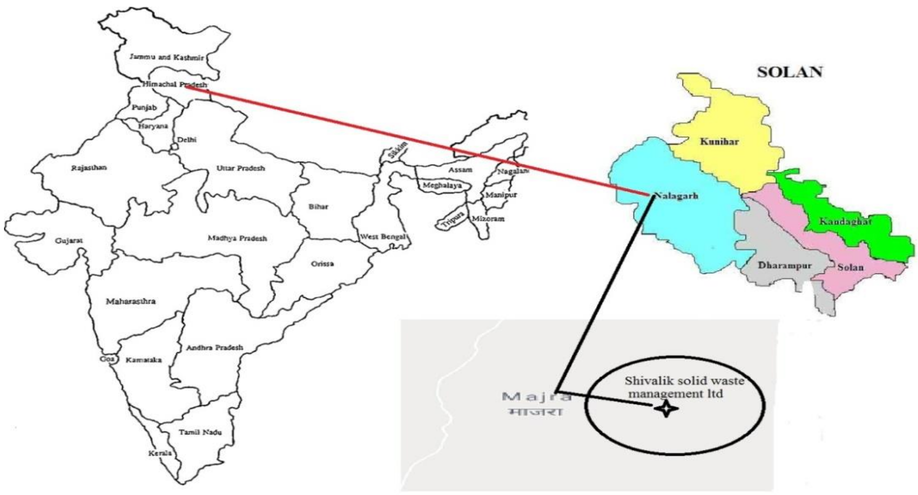

Figure 1 Map showing the city from where the data for Hazardous Solid Waste Site were included in the study (Source-https://www.google.co.in/maps/@31.0738429,76.6247407,14z)

3.9 Study Area (Site-2)

Punjab located between 30.79^{0}N and 75.84^{0}E having altitude ranging from 180 to 500 meters above mean sea level. Punjab is a state in northern India. The project site is situated near Nimbua, a village, 10 Km from Dera Bassi. Currently hazardous waste from 1889 industries have been managed in the plant. Since inception a total of 113763 tons of waste has been treated and disposed of in the landfill. Mission is to contribute towards a healthy and safe environment by dumping all of the hazardous industrial waste produced by those industrial units in Punjab and to confirm the minimization of environmental impact. Nimbua Greenfield (Punjab) Limited (NGPL) has been endorsed by a group of nine companies on the initiative of Govt. of Punjab to implement the project for establishment of a general facility for storage, treatment and effective disposal of hazardous waste. All industrial units those are producing hazardous waste after being duly authorized by PPCB have to dispose of the hazardous waste at the TSDF. NGPL has successfully disposed of 113763 MT of hazardous waste per annum. Nimbua Greenfield (Punjab) Limited (NGPL) operates as an integrated end to end hazardous industrial waste treatment and disposal facility. It engages in testing, collection, stabilization and disposal of hazardous industrial waste generated in the State of Punjab.

Figure 2 Map showing the city from where the data for Hazardous Solid Waste Sites were included in the study

Source- https://www.google.co.in/maps/@30.6101123,76.8903818,13z

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Rating Method

In this study, hazardous rating method DRASTIC, mGW-HARAS and SIMRAS was used to determine the score of groundwater potential for contamination from these three systems are summarized in Figures 3, 4. The study data were collected from the two dump Sites form Himachal Pradesh and Punjab.

4.2 Results and Discussion

4.2.1 Shivalik Solid Waste Management Limited, Majra (Site-1)

Project Site-1 situated about 10km from Nalagarh-Bharatgarh road. Data were collected of three systems shown in Table 5.

Table 5 Site parameters of the hazardous waste Sites, Shivalik solid waste limited used for different rating system.

Parameter	DRASTIC	mGW-HARAS	SIMRAS
Area (ha)		12	12
Thickness of waste (m)		15	15
Composition of waste (1.Biodegradable waste 2. C & D waste)		20+0=20	20
Rainfall/ recharge (mm)	1140	1140	1140
Depth To Groundwater (m)	40	40	
Soil Permeability (cm/sec)	$1x10^{-7}$	$1x10^{-7}$	
Groundwater Gradient (%)	1.5	1.5	
Slope of the Top Surface or topography (%)	1	1	
Aquifer Permeability (cm/sec)	$2x10^{-2}$		$2x10^{-2}$
Aquifer Thickness (m)	20		20

4.3 Analysis and Modelling of DRASTIC, mGW-HARAS, SIMRAS

Data collection from Site-1(Shivalik solid waste management limited, Majra) analysis and modeling has been done. The results have been presented in Fig 3.

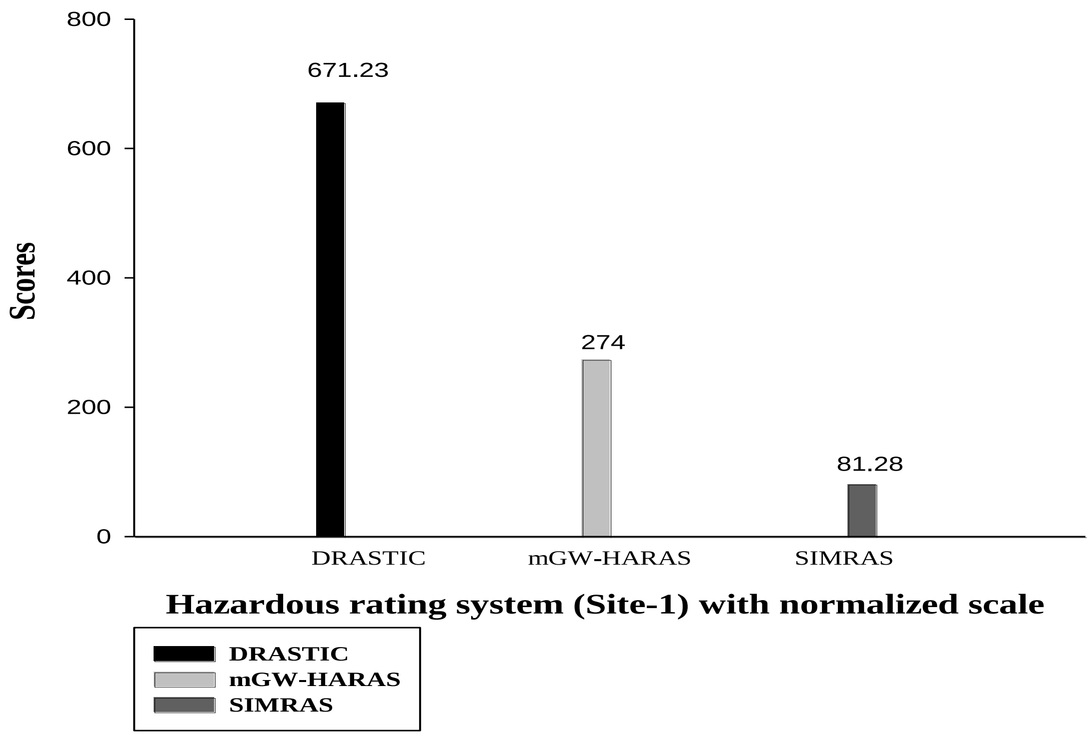

Figure 3 Rating of Shivalik Solid Waste Limited, Majra, Himachal Pradesh using different ranking methods.

4.4 Nimbua Greenfield Limited, Dera Bassi (Site-2) in Punjab

This project Site is located near the village Nimbua, is about 10 km from Dera Bassi. Data is collected from this Site with different parameters shown in Table 6.

Table 6 Site parameters of the hazardous waste Site-2 used for different rating system

Parameter	DRASTIC	mGW-HARAS	SIMRAS
Area (ha)		8	8
Thickness of Waste (m)		15	15
Composition of Waste 1. Biodegradable waste 2. C & D waste		(43+0)= 43	43
Rainfall/ recharge (mm)	1061	1061	1061
Depth To Groundwater Water (m)	11	11	-
Soil Permeability (cm/sec)	$1x10^{-6}$	$1x10^{-6}$	

Groundwater Gradient (%)	1	1	
Slope of the Top Surface or topography (%)	3.0	3.0	
Aquifer Permeability (cm/sec)	$9x10^{-6}$	-	$9x10^{-6}$
Aquifer Thickness (m)	20	-	20

4.5 Analysis and Modelling of DRASTIC, mGW-HARAS, SIMRAS

Data collection From Site-2 modeling and analysis has been done with three rating system. The results have been presented in Fig 4.

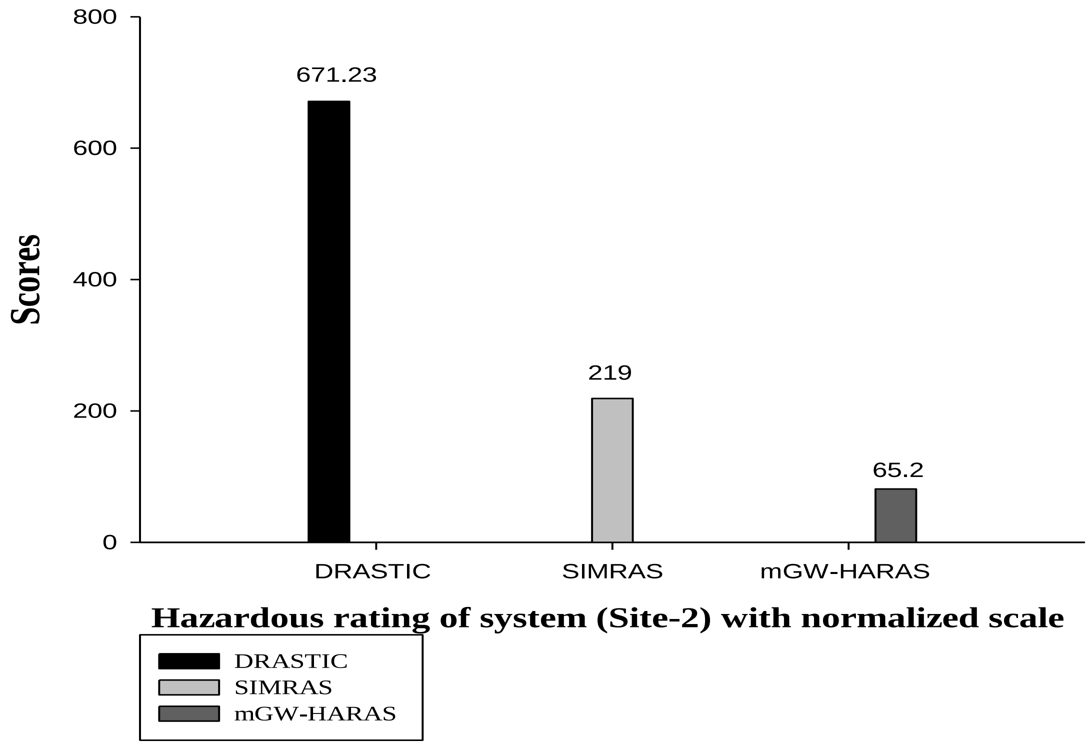

Figure 4 Rating of Nimbua Greenfield limited, Punjab using different ranking system

4.6 Comparison of System between Two Sites (Site-1 and Site-2), Himachal Pradesh and Punjab.

The parameters used by these three system i.e. DRASTIC, mGW-HARAS are presented in Table 5 and Table 6. DRASTIC, which is a simplified method, principally based on additive algorithm (Eqn 3.1.1) and it indicates the groundwater contamination. From Site-1 and Site-2, DRASTIC shows high contamination for both Sites, in (Fig 3 and 4). mGW-HARAS is a modified version and principally based on multiplicative algorithm (Table 3). The comparison of results from the two sites have been presented in (Fig 5). All these systems are used to evaluate the ratings of hazardous waste sites. After obtaining the rating score of Site-1 and Site-2, the rating scores were normalized to 0-1000 scale. DRASTIC score range is 270-800. On the other hand mGW-HARAS and SIMRAS are 60-1000. mGW-HARAS and SIMRAS use Complex equations as compared to DRASTI**C**

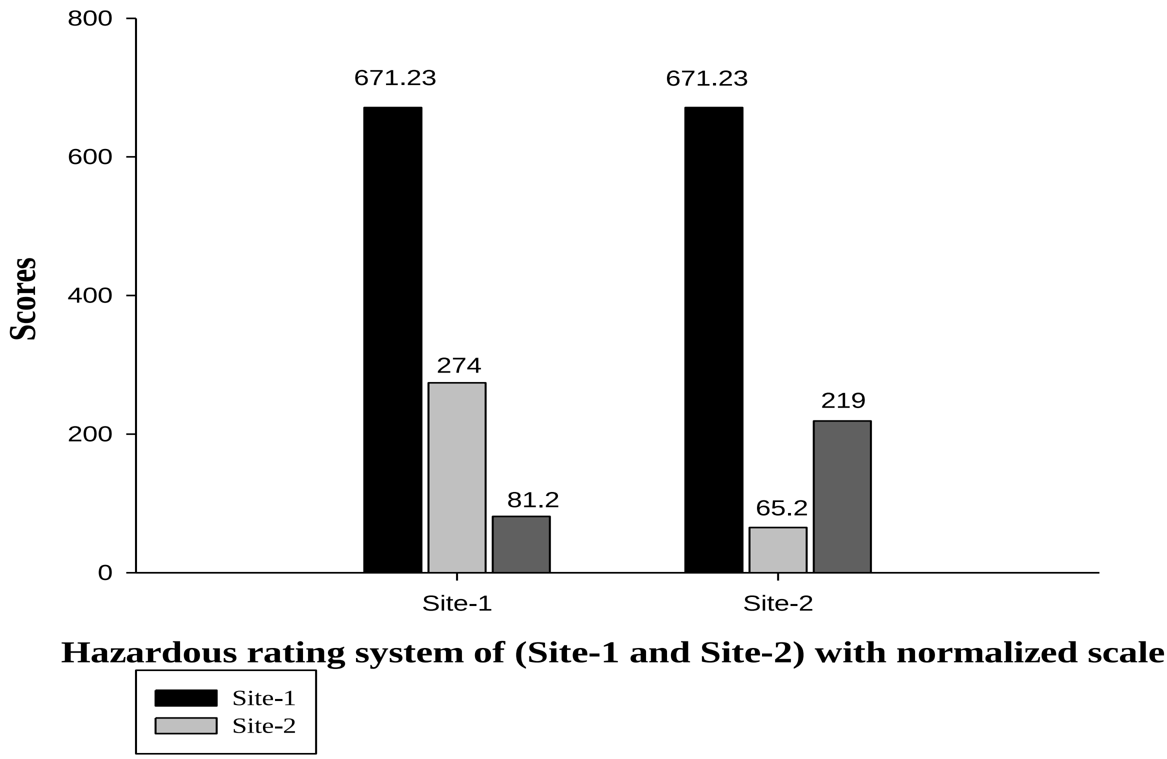

Figure 5 Scores of contamination hazard rating for waste Sites Punjab and Himachal Pradesh with continuously varying characteristics from Different rating systems.

4.7 Scores of the Systems

Table 7 Score of two hazardous waste dumps from three systems.

Rating system	Site -1 value	Site -2 value
	Score range (0-1000)	
DRASTIC	671.23	671.23

mGW-HARAS	274	65.2
SIMRAS	81.28	219.99

The hazard score of the sites and the categories classified by DRASTIC, mGW-HARAS and SIMRAS rating systems of two dump Sites from Himachal Pradesh and Punjab that are presented in (Table 5 and 6). From Shivalik solid waste management plant, in Himachal Pradesh and Nimbua Greenfield limited, Dera Bassi we analyze the data of both Sites with different parameters and Site conditions from DRASTIC, mGW-HARAS and SIMRAS. There are many problems with both hazardous management plant in Himachal and Punjab. As we can see a result of both Sites there is a difference in results of mGW-HARAS and SIMRAS both waste Sites. The values of mGW-HARAS in Site-1 is more due to the waste composition which is include hazardous waste are 5%, biodegradable waste are 20% and Site-2 has hazardous waste is 1% and biodegradable waste is 43% and infiltration score of both Sites are different, thickness of vadose zone, depth to groundwater, area of the waste dumps Sites, location of the region with low to medium rainfall. Site-1 waste dump showing the high ratings from all the three systems from (Fig 5). Both Sites have sandy/silty/ clay soil underneath them with groundwater depth. For these dumps, the rating provided by DRASTIC are in the range of 350-700 (Fig 5). It is the presence of clay, sandy/silty soil underneath these Sites as well as the smaller size of Site-2 that minimize the groundwater contamination potential. Due to the lower sensitivity to soil permeability, DRASTIC shows the higher contamination potential of these both dump Sites.

4.8 Sensitivity Analysis of Site-1 and Site-2

Sensitivity analysis was done to find out the sensitivity of the system with the small changes in values of different parameters which were collected from both Sites. The values for the parameters are varied from -50 to +50%. With the changes in values of the parameters the changes in groundwater contamination potential rating was calculated and summarized in Table 7. It shows that SIMRAS and mGW-HARAS respond efficiently to changes in site environments or site parameters. Due to area, height, waste characteristics and groundwater gradient, DRASTIC indicates zero sensitivity. mGW-HARAS and SIMRAS show significant sensitivity to all of the parameters (Table 8). It has been observed that in SIMRAS system, soil permeability is the most effective parameter which is significantly affecting the potential for groundwater contamination for both the waste sites, i.e. 50% for DRASTIC whereas 120% (±60%) for SIMRAS and mGW-HARAS system.

Table 8 Sensitivity analysis- parameters and results.

Parameters	**Site-1 Shivalik Solid Waste Limited Majra (H.P)**									**Site-2 Nimbua Greenfield (Punjab) Limited**									
	Parameter value	Changed value ± **50%**		DRASTIC % change		mGW-HARAS % change		SIMRAS % change		Parameter Value	Changed Value **±50%**		DRASTIC % change		mGW-HARAS % change		SIMRAS % change	
		-	+	-	+	-	+	-	+		-	+	-	+	-	+	-	+
Area (ha)	**12**	**6.0**	**18**	**0.0**	**0.0**	**5.2**	**3.2**	**4.3**	**0.0**	**8**	**4.0**	**12.0**	**0.0**	**0.0**	**4.7**	**2.1**	**3.8**	**0.0**
Height (m)	**10**	**6.0**	**14**	**0.0**	**0.0**	**7.8**	**3.9**	**6.2**	**0.0**	**10**	**5.0**	**15.0**	**0.0**	**0.0**	**6.7**	**4.1**	**5.3**	**0.0**
Biodegradable fraction (%)	**20**	**14**	**26**	**0.0**	**0.0**	**5.6**	**4.2**	**2.5**	**5.6**	**43**	**21.5**	**64.5**	**0.0**	**0.0**	**7.7**	**7.7**	**3.5**	**8.5**
Annual rainfall (mm)	**1140**	**570**	**1710**	**7.8**	**0.0**	**10.1**	**9.4**	**11.9**	**11.9**	**1061**	**530**	**1591**	**1.9**	**0.0**	**12.7**	**8.4**	**8.8**	**8.8**
Soil permeability	**1×10^{-7}**	**10^{-9}**	**10^{-5}**	**17.6**	**32.4**	**52.9**	**29.7**	**60**	**60**	**1×10^{-6}**	**10^{-8}**	**10^{-4}**	**16.6**	**31.4**	**51.9**	**28.7**	**57**	**57**
Depth to groundwater	**40**	**24**	**56**	**25.8**	**6.2**	**30**	**30**	**25**	**25**	**11**	**5.5**	**16.5**	**5.4**	**1.9**	**12**	**12**	**8.0**	**8.0**
Groundwater gradient (%)	**1.5**	**1.05**	**1.95**	**0.0**	**0.0**	**3.2**	**2.1**	**5.8**	**0.0**	**1**	**0.5**	**1.5**	**0.0**	**0.0**	**4.4**	**2.4**	**6.6**	**0.0**

4.9 Leachate Pollution Index (LPI) for the Shivalik Solid Waste Limited, Majra (Himachal Pradesh) and Nimbua Greenfield Plant Dera Bassi (Punjab).

Table 9 The calculation for LPI values for the two landfill Sites (Himachal Pradesh, Punjab) LPI has been calculated on the basis of the available data

S. No	Leachate characteristic	Values		Pollution Rating (Pi)		Weights(Wi)		Overall pollution	
		Site-1	Site-2	Site-1	Site-2	Site-1	Site-2	Site-1	Site-2
1	PH	8.57	9.8	5	5	0.055	0.055	0.27	0.275
2.	COD	6920	2535	92	28	0.062	0.062	5.704	1.736
3.	BOD	22,000	495	78	8	0.061	0.061	4.758	0.488
4.	TDS	7814	6563	7	5	0.050	0.050	0.35	2.5
5.	TKN	13,000	960	100	30	0.053	0.053	5.300	1.59
6.	Ammonia nitrogen	13,000	760	100	85	0.051	0.051	5.100	4.335
7.	Copper	0.1	0.08	5	5	0.050	0.050	0.250	0.25
8.	Nickel	0.1	0.06	6	5	0.052	0.052	0.312	0.26
9.	Zinc	0.3	0.29	6	6	0.056	0.056	0.336	0.336
10.	Chromium	4.3	0.35	38	6	0.064	0.064	2.432	0.384
	Total					0.554	0.554	24.817	11.92
	Landfill							H.P	PNB
	LPI values							44.79	21.52

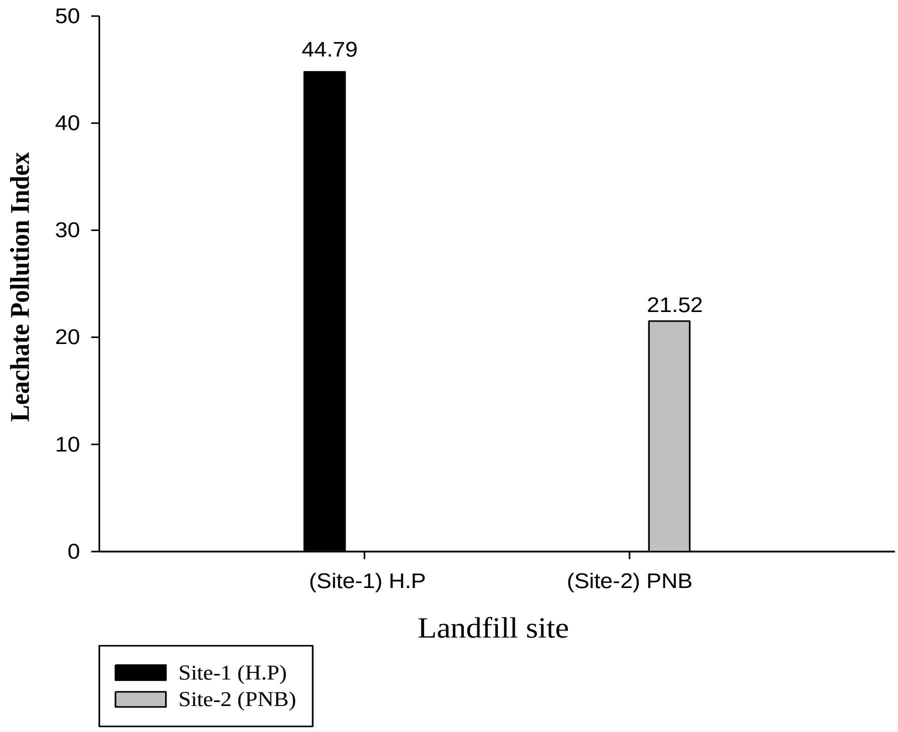

Figure 6 Comparison of the leachate contamination potential of the two landfill Sites under study

The assessment of leachate pollution index values of the two active landfill sites has been presented in (Fig 6). It can be seen that the LPI value for the Site-1 (H.P) is higher than the LPI value of Punjab. The high LPI value (44.79) of Site -1 (H.P) landfill also shows that the waste disposed in Site -1 landfill has not become stable. The High strength of ammonia nitrogen, TKN is also recounted in the leachate composition. The high value LPI signifies that leachate produced from the Site-1 landfill should be properly treated and the site should be continuously monitored. The uncommon high values of ammonia nitrogen in Himachal Pradesh landfill shows that methodology adopted for the treatment of leachate should concentrate on the reduction of these pollutants. The most likely leachate treatment option, with high organic content may be aerobic biological treatment process with extended aeration to remove of high concentration of ammonia nitrogen.

The low value of PNB (Site-2) 21.52 indicate that the leachate produced from the landfill is relatively stable and post closure monitoring could be compromised, based on the state regulations. Site -1 (H.P) landfill site, it has comparatively more potential for contamination, and poses threat to the environment. In this context suitable remedial measures and monitoring should be taken for the safeguard of environment. It should be considered that the pollution index value indicates the contamination potential of landfill leachate in a given geographical area on a relative scale. It is a best hazard identification tool as other factors like dose response effect, it depending on the leachate – receiving environment, volume of leachate generated, type of liner provided in case of a lined landfill, depth of water table, type of soil subsurface and population affected also.

4.10 Problem Identification and Analysis

- From Shivalik solid waste management plant, in Himachal Pradesh we analyze the data of different parameters from DRASTIC, mGW-HARAS, SIMRAS and rating result of this systems are :

DRASTIC = 155, mGW-HARAS=274, SIMRAS = 81.2

- The similar analysis of Nimbua Greenfield plant in Derabasi, Punjab. The rating result comes out of this Site for three systems are :

DRASTIC = 155, mGW-HARAS=65.2, SIMRAS=219

- There are many problems with both hazardous management plant in Himachal and Punjab. As we can see a results of two Site there is a difference between mGW-HARAS and SIMRAS results of both Sites. The values of mGW-HARAS in Site-1 is more due to the waste composition which is include hazardous waste are 5%, biodegradable waste are 20% and Site-2 has hazardous waste is 1% and biodegradable waste is 43% and infiltration score of both Sites are different, thickness of vadose zone, depth to groundwater .
- Non engineered dumping of both hazardous solid waste Sites, which is very a common exercise in most of the cities, however efforts have been made for the improvement in management, has results in heavy air pollution. This involves uncontrolled emission of harmful odorous gases such as NH_3, hydrogen sulphide, and other volatile gases, and materials dispersed due to wind such as plastics and dust. Mosquitoes, flies, and rodents also causes vast problem for neighboring residents.
- Landfill gas is generated form the anaerobic decomposition or biodegradation of organic material presents in hazardous solid waste. Shivalik solid waste management

plant in Himachal landfill does not have a control as well as recovery system for management of landfill gases.

- Uncontrolled release of methane causes air pollution and fire or explosion. Carbon dioxide and methane are the two greenhouse gases that need be controlled in the UNEP programs.
- Shivalik solid waste management is limited as per their report generating around 50,000 MT of hazardous waste per annum.
- The composition of Shivalik solid waste management is commonly characterized by high hazardous waste and a low biodegradable waste , as compare to Nimbua solid waste plant has low hazardous waste and high biodegradable waste
- In Shivalik solid waste management plant it include only 20% of biodegradable waste and Site -2 has 43%
- Biodegradable waste can be commonly found in municipal waste as green waste, food waste, paper waste, and biodegradable waste and plastics.

4.11 Uses of Biodegradable

- Biodegradable wastes may be used for a resource for heating purpose or composting, bio-fuel and electricity by means of incineration or anaerobic digestion.
- Although incineration can only recover most of the energy from the waste, anaerobic decomposition techniques preserve the present nutrients in biodegradable waste and still recover most of the energy in the form of bioethanol, biogas even in form of electricity.
- As per report it has been found that per annum approximately 113763 MT of hazardous waste has successfully disposed of by NGPL.
- A hazardous waste of Site 2 has more waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics

  (a) May cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible.

  (b) Poses a substantial present or great hazards to the environment when inefficiently treated, deposited, conveyed, or predisposed of, or else managed.

Hazardous waste from Site -1 has 5% and it include the

4.12 Sources

- F-list (non-specific sources of wastes): These lists classify waste generated from any collective manufacturing and industrial processes, such as solvent that have been used for cleaning or degreasing. These type of wastes occur across different industry sectors.
- K-list (source-specific wastes): These lists comprise some waste from particular industries, like pesticide manufacturing or petroleum refining other waste like industrial chemicals, pesticides, and pharmaceuticals.

4.13 Infiltration

- Infiltration rate of both Site are different due to soil characteristics including ease of entry, storage capacity, and transmission rate through the soil. The soil texture and structure, vegetation types and cover, water content of the soil, soil temperature, and rainfall intensity all play a role in controlling infiltration rate and capacity.
- Coarse-grained sandy soil has large voids between individual sand particles which in turn allows quick infiltration of water.
- Landfill capping is a containment technology which provides the barrier between the contaminated media and the surface; the cap restricts surface water infiltration into the contaminated subsurface to reduce the potential of contaminants to leach from the Site.

4.14 Vadose Zone

- Vadose zone thickness of Site-1 has less as compare to Site-2 due to natural circumstances, the elevation of the boundary between the unsaturated and saturated zones the water table varies as a function of recharge, discharge, and evapo transpiration.

4.15 Remedial Strategies

- According to "Himachal and Punjab 21st Century's Agenda," every municipal authority should start their own hazardous solid waste treatment and dumping amenities with the aim of 100% treatments and removal of hazard solid waste. To achieve those goals, some appropriate strategies regarding the proper remedial action are recommended.
- Waste minimization: This is a process of elimination and redesigning of products on changing societal patterns that includes reduction in waste generation from the society

and also eliminates the formation of toxic, harmful and persistent wastes whereas Waste management focuses on processing the waste after it is created, while concentrating on recycling the waste for energy conversion.

- Benefits of Waste minimization can protect the environment and provide good economic and business practices.

4.16 Waste Reduction Alternatives

Four methods are available to reduce the amount of waste that is generated:

1. Source segregation or separation
2. Process modification
3. end-product substitution, and
4. Material recovery and recycling

4.17 Recovery and Recycling

- Recovery of hazardous materials from process effluent followed by recycling.
- Provides an excellent method of reducing the volume of hazardous waste.
- Recovery involves the separation of a substance from a mixture.
- Recycling is the use of such a material recovered from a process effluent**.**

4.18 Environmentally Sound Waste Dumping and Management

Hazardous waste can cause resource as well as environmental problem. Ineffective management and handling of waste indicates the loss of valuable resources and can also cause different environmental problems and may also poses health hazards.

The objective is to use the resources available in waste efficiently and judiciously as well as it is also necessary to minimize the sound effects of uncontrolled dumping that causes emissions of toxic and greenhouse gases, such as CH_4 from landfills, CO_2 from incineration and release of the heavy metals and organic toxins to the environment.

4.19 Delphi Technique Used for Site -1 and Site - 2

- The Delphi technique was considered to determine the comparative importance weights of the cluster parameters.

- Each selected parameter was assigned best and worst values were consigned numerical values that shows the comparative impact of the parameters value on the landfill's hazard rating system to evaluate contamination potential of groundwater.

HARAS evaluate the groundwater contamination hazard rating by the below relationship:

$$H_{R,GW} = (H_S \times H_P \times H_R / SF) \times 1{,}000$$

SF= scaling factor equal to 1 million

Table 10 Parameter of base situation for Delphi technique

S. no.	**Site parameters**	**Parameters value Site - 1**	**Parameters value Site -2**
1	Waste fill area (ha)	12	8
2	Waste fill height/depth (m)	10	12.5
3	Cover system	Soil cover with grading	Soil cover with grading
4	Annual precipitation at Site (mm)	1140	1061
5	Waste composition i. Biodegradable waste (%) ii. Hazardous waste (%)	20 5	43 5
6	Leachate collection, removal and treatment system (yes/no)	Yes	Yes
7	Surface water leachate intercept drain	None	None
8	Facility base slope (%)	1.1	1.0
9	Soil permeability at the base (m/s)	10^{-7}	10^{-6}
10	Intervening ground slope to nearest surface water body	4.5	7
11	Distance to nearest surface water body (m)	800	300

12	Type of surface water body being impacted	River	Lake

- Analyze the data by parameters which is given in above table 9 by Delphi technique.
- The score range of the rating system is 0-1000 for this particular rating system approach.

  Additionally, with the change in site parameters; the source rating, pathway rating and receptor rating for the ranking system constantly changing.

CHAPTER 5: CONCLUSION

The conclusion of the present study are presented in this chapter are given below:

1. The present study first presents the status of Hazardous waste dump in different cities of India. In terms of their size and proximity to groundwater contamination. Although CPCB brings out yearly reports on hazardous waste management in different states and cities.
2. The newly developed / modified rating systems were applied of two waste dumps in Himachal Pradesh and Punjab state.
3. For groundwater contamination rating, SIMRAS was found out to be the best system among the three existing rating system. It has been observed that for all of the parameters used for hazard ranking SIMRAS shows greater sensitivity (Table 8). Soil permeability is found to be the utmost vital parameter that mostly affecting the potential for ground water contamination.
4. It has been found that groundwater contamination potential ca also be evaluated using DRASTIC system. Though it has been also observed that the sensitivity of DRASTIC system is not sufficient for all the parameters considered for the analysis. Further it can be concluded that the sensitivity of DRASTIC is almost zero.
5. The performance of SIMRAS system is very much related to mGW-HARAS system.

5.2 Detailed conclusion

5.2.1 Status of existing hazardous dumps in cities of India. The study first presents the status of hazardous waste dumps of different cities in India of their size and proximity to groundwater. The information was collected by contacting (CPCB) and (PPCB) and two municipal corporations in Himachal and Punjab having a population more than 70lakh. Site visits to the two dump Sites of two states in Himachal Pradesh and Punjab across India were made to collect data. The conclusions drawn from the study are as follows:

The area for dump Site in (12 ha, 8ha) and the waste height is 8m to 15m are respectively.

Both Sites have water table with in 40m to 11m of the depth from the ground surface.

Both Sites are located than 800 to 300m away from a surface water body.

5.2.2 Assessment of the usefulness of existing system for evaluating overall hazard, rating for dump Site.

For groundwater contamination rating three rating system applied, DRASTIC, mGW-HARAS, SIMRAS, performed best with the different range of scores. DRASTIC shows the high contamination of both Sites.

Overall hazard for groundwater contamination of from Site-1(Himachal Pradesh) and Site-2(Punjab) has the maximum contamination potential. Site-1 has the highest score for groundwater contamination rating because of the large quantity of waste at the Site, high permeability of soil (clay loam/ silty sand) at the base and lower depth to the groundwater table at Site-2. Both Sites have the similar Site conditions except that the depth to the groundwater and annual rainfall, waste composition and have no covers and leachate containment system.

5.3 Limitations of the rating system

Like all the rating system, the systems developed in the study have the following limitations.

1. Rating systems assess the hazard of the Site on the relative scale basis but cannot indicate the hazard from a Site.
2. The system depends on Sites parameters and expert judgment and hence outcome depends upon the analysis and modelling of the parameters of these systems.

The rating systems developed in the study are applicable for Site prioritization to plan for remediation of different waste dumps.

5.4 Leachate pollution index

The LPI provides a meaningful method of evaluating the leachate contamination potential of two landfill Sites. It can be a important information tool for the policy makers and leachate pollution threat to environment from the landfill Sites. Both Sites Site-1 and Site-2 is measured for calculating the leachate pollution potential established on the arrangement of leachate that is generated from these sites. The value of leachate pollution index for Himachal Pradesh site shows that the generated leachate from the dumping site is harmful and must be cured and regular monitoring is must for the sites unless or until the leachate that is produced in the landfill is either treated with proper measures or become stable and that do not poses additional hazard to the environment.

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APPENDIX 1: PHOTOGRAPHS

Figure 7 Site Location of Nimbua Green Field Solid waste Management Plant

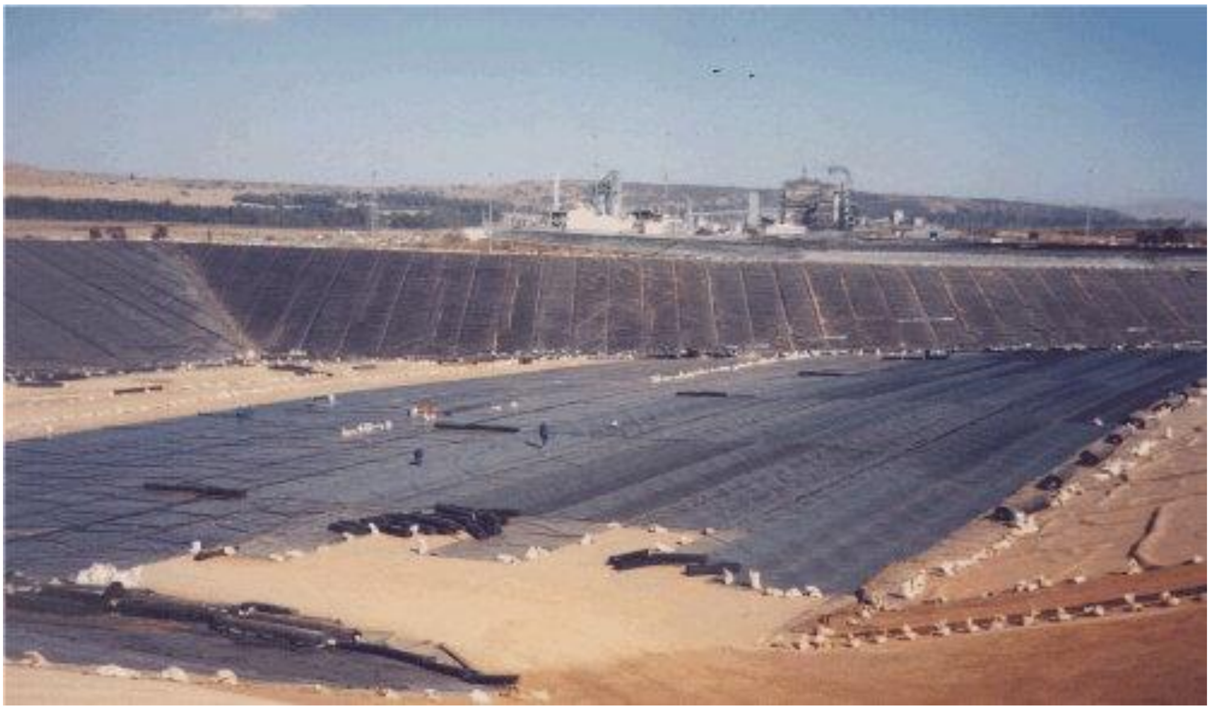

Figure 8 Nimbua Green Field Dump Site

Figure 9 Image Showing Nimbua Green Field Dump Site

Figure 10 Site map of Shivalik Solid Waste Management Plant

Figure 11 Disposal location of Shivalik Solid Waste Management Plant

Figure 12 Waste segregation at Shivalik Solid Waste Management Plant

Figure 13 Dumping area of Shivalik Solid Waste Management Plant

Figure 14 Location of Shivalik Solid Waste Management Plant