"IDENTIFICATION OF LEACHATE POLLUTION INDEX OF UNLINED MUNICIPAL SOLID WASTE"

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

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Under the supervision of

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"IDENTIFICATION OF LEACHATE POLLUTION INDEX OF UNLINED MUNICIPAL SOLID WASTE"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Abhishek (141662) Samarth Vir (141686)**
Aditya Sharma (141698) during a period from July 2017 to May 2018 under the supervision of **Mr Anirban Dhulia** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

Solid waste is of major concern in developing countries, as dumping of such waste in uncontrolled landfills can cause adverse effects on the environment and human health. Health hazards and environmental degradation are well known facts of uncontrolled and unlined landfills. Groundwater contaminated due to leachate produced from these landfills can cause danger to human health. A technique is developed using an index known as Leachate Pollution Index to quantify the landfill leachate pollution. It is a quantitative tool by which data of landfill can be reported uniformly. The LPI is an increasing scale index and has been formulated by Delphi technique. In the report, concept of LPI is described and LPI for 3 sites (Kangra, Nurpur, Pathankot) is calculated based on data collected from field. The LPI for this landfill has been compared with the LPI estimated for treated leachate as per the Indian Standards. Based on the results, it is concluded that a single number index value which reflect the composite influence of significant pollutant variables on leachate pollution is possible and it can provide a meaningful, uniform method of assessing the leachate contamination potential of landfill site at a particular time. In this report the LPI value of the Kangra, Nurpur and Pathankot landfill. We came to know that values are high and proper treatment will be necessary before the discharge of the leachate.

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INTRODUCTION

1.1 General

Pollution is caused due to addition of products in the natural environment. These products are harmful to nature and its difficult to dispose them if they come in contact with our environment. These products are mostly available in the form of solid waste. The solid waste is mostly dumped openly and this type of dumps are called open dumps. These sites are located where there is large amount of land available far away from any living place. These dumps have no safety features, so its of greater concern for human health and environment. They causes environmental degradation and have a bad aesthetic appearance and no precautions is taken to lower the effects of the waste in the environment. Air, water, land pollution is caused by the open dumps which leads to adverse effect on human health and natural environment. The Municipal solid waste (MSW) disposal is of greater concern for the developing countries like India. Increase in population rate, poverty among people and urbanization have increased the MSW. Governments should be funded well to provide good management of MSW. [1] These landfill sites produces leachate which is highly contaminated . The wastewater thus generated is difficult to deal with . Leachate consists of higher concentration of heavy metals, organic matter, inorganic salts, ammonia nitrogen, and chlorinated organic [2]. The Leachate produced in these dumping sites is highly variable and mostly depends upon composition of waste, amount of precipitation, hydrology of site, type of waste and amount of leachate interacting the environment [3]. Leachate is one of the important factor leading to environmental pollution, so there should be well designed systems to treat leachate . Well planned management terms of MSW landfills should be there. Leachate generated from landfills without liners can contaminates ground water and surface water, so it is necessary to treat leachate to avoid further contamination . There is a strong need to avoid contamination of soil, underground water from leachate produced from MSW. Thus there is a need of system which provides facilites to control the Leachate generated and to provide some immediate remediation work. There is a need of tool to analize the contamination potential of leachate so an index is designed to compare the pollution potential of landfill in a certain area and at a particular time[4]. Waste water index; air pollution index are the environmental indices which are developed and a currently in use. A technique was developed by Kumar and Alappat to quantify the contamination potential of leachate generated from landfills, on comparitive scale in form of LPI [5]. LPI is an increasing scale index, the higher value more poorer is the environmental conditions. It is helpful in ranking of landfills . There are 18 pollutants of leachate and their significance is shown. For calculation of LPI concentration of these pollutants should be known to us. The LPI calculated involves some error and bias.

1.2 Problems Definition

Landfill sites have a great effect on environment and human health. These sites are of greater concern globally some issues of these sites are discussed below:

Fig.1.1: Leachate Coming out from Leachate collection system

Leachate is result of waste present in dumping sites. It is a liquid formed due to breakdown of waste. when water seeps through the waste, it gets contaminated and gets toxic. Major contribution of leachate is rain falling on these dumping sites. ground water entering the landfill contributes to leachate as well. This ground water seeps in decomposed waste due to which there is a chemical reaction which produces some toxic leachate. some of chemicals produced are : Methane , Carbon di oxide, Alcohol, Aldehydes and Organic acid.

1.3 Treating Leachate

It can be done in different ways, these includes :-

1. Biological Treatment: It is first step in treatment of landfill leachate. Different types of filters are used to remove nitrogen and other biological compound from waste water. Activated sludge is most commonly used biological treatment. It is a suspended growth process which uses aerobic micro organism for degradation of organic contaminants in leachate. In this process, leachate is aerated in an open tank with mechanical aerators or diffusers.

2. Chemical-Physical Process: It includes wet oxidation process such as ozonisation . In case of organic pollutant, leachate cannot be degraded biologicaly or using a wet oxidation process so activated carbon adsorption is used. The contaminants are bounded tocarbon through adsorption and incineration is used to destroy them. Techniques like precipitation/flocculation , ion exchange can also be used .

CHAPTER 2

2.1 General

Man made depressions in the ground or the mounds above the ground where large amount of waste is gathered are called Landfills. These are the disposal sites which can be lined or unlined. To prevent leakage of landfills it is provided with a lined design. Leakage mostly happens through the base of the Landfill or the landfill just overflows which have harmful effect on the environment[6]. The waste in the landfill site is mainly due to households, business, industrial waste. It contributes about two third from these areas.

Fig.2.1: JCB clearing the MSW on the Landfill Site

2.2 Landfills

It's an engineered pit, where the solid waste from different locations is brought, dumped and compacted. These landfills are lined from the bottom for prevention of any ground water pollution. Landfills designed by engineers have a lined bottom, a collection system for leachate and its treatment[6].

2.3 Environmental Impacts of Land filling

(a) Air Pollution : Landfill waste mainly consists of organic matter from households, business and industry[7]. Its about two-third of all waste in the landfills. When the material decomposes in the landfills,gases like methane are released, its a greenhouse gas, it is 20 times more effective than carbon dioxide trapped in atmosphere[8]. so methane emission from landfillnsites is one of the majour contributor to green house gases. to reduce this effect methane is used to produce electricity , it gives carbon dioxide as a byproduct which have very less effect than methane. All these leads to unpleasent smell which surrounds the area near dumping site.

(b) Impact on biodiversity: Development of landfill site have an adverse effect on the species living there, it requires to clear a large portion of area so animals living there are in danger. Loss of some mammals and birds likes crows, sparrows can be seen when the land is cleared. There will be a change in the vegetation in the area, thus changing the ecosystem.

(c) Ground water pollution: During rain the water comes in contact with the degraded waste and the organic and inorganic constituents get dissolved with it, which leads to the formation of highly toxic leachate. This toxic leachate gets collected at the bottom of the landfill, which contains metals, ammonia, and other toxic organic compounds and pathogens. If the leakage of leachate happens it may result in contamination of ground water sources. This leachate have a highly biological oxygen demand, so on mixing with ground water or rivers it can danger the aquatic life.

(d) Effect on Soil Fertility: The decomposed organic material and mixtures of poisonous substances impacts the soil quality of surrounding area near the landfills. It effect the biodiversity as vegetation may cease to grow

(e) Visual and Health Impact: Landfills ruins the natural and landscape, due to increase in vermin there is spread in disease which is a major issue. Health effects such as cancer, respiratory illness, birth defects are also due to landfill sites.

2.4 Leachate Formation

When the waste in the landfill site degrades and rain seeps through it the resulting product formed is leachate. It's a black coloured liquid containing organic and inorganic chemicals, heavy metals as well as the pathogens. It's not good for human health if the leachate comes in contact with the ground water. Percolation of water through waste enhances the process of decomposition by bacteria and fungi. Due to release of by products of decomposition and increased oxygen demand creates an anoxic environment. Sudden rise in temperature and fall in pH results in dissolving of many metal ions in developing leachate. Due to decomposition there is a release of water which adds up in leachate volume. Leachate reacts with material that are not prone to decomposition such as, fly ash and gypsum based materials which change the chemical composition. Due to this there is generation of hydrogen sulphide, which may be released in leachate and in formation of landfill gas.

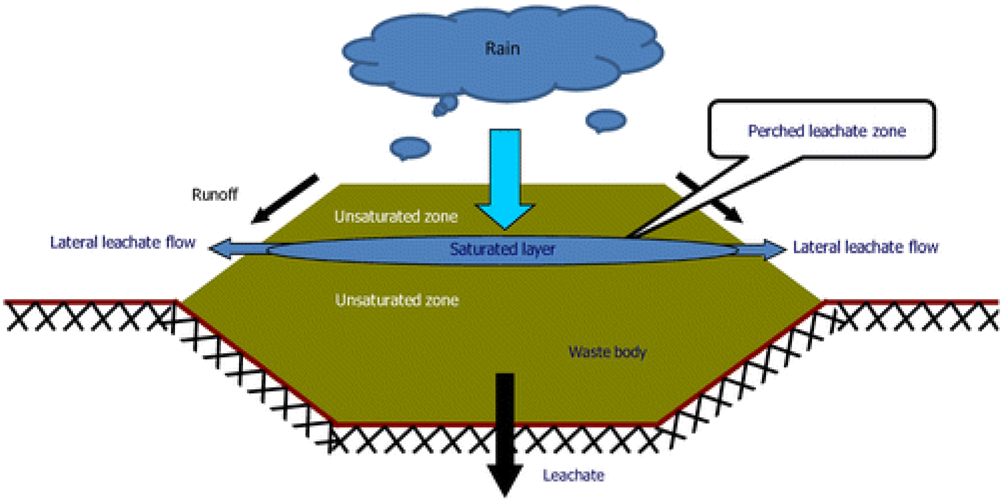

Fig.2.2: Typical cross-section of Engineered Landfill

2.5 Human Health Effects Associated with Leachate.

The ground water is contaminated when water seeps through the disposed waste and percolates to the ground, most times it carries toxic substances from the waste it passes. It could be rain water or water in the waste itself. There are various substances involved in polluting the ground water and making it unsable for consumption. Health effects could be acute short exposure, or long term chronic exposure to leachates from landfills[9].

(a) Chemical/metal Health effects from acute exposure

Lead : Abdominal pain, diarrhoea, vomiting, confusion, drowsiness, seizures

Mercury : Bloody Diarrhoea, Dehydration, renal failure

Cadmium Compounds : Metallic taste, cough, chest pain, nausea, diarrhoea, skin irritation

Nickel : Skin irritation, dermatitis, diarrhoea, gum disease

Toluene : Termors, convulsions, coma

Phenols/Cresols : Burning pain in the mouth and throat, nausea, vomiting, diarrhoea, sweaing, coma, shock

(b) Chemical/Metal Health effects from long term exposure

Lead : Anorexia, abdominal pain, constipation, chronic nephropathy, hypertension

Mercury : Tremors, memory loss, seizures, coma, irritability, acute kidney faliure, decrease in platelets, anaemia that follows gastrointestinal bleed

Phenols and cresols : Renal failure

Cadmium Compounds : Anaemia, kidney damage, possible prostate and lung problems

Benzene : disorders related to blood

2.6 Leachate management

Leachate percolates the waste, if the landfills are unlined or those with no membrane between the waste and the land it can directly come in contact with the ground water. Such that, high concentrations of leachate are often found in nearby flushes and springs. As leachate first appears it can be black in colour, possibly effervescent, and anoxic with dissolved and entrained gases. When leachate becomes oxygenated there is presence of iron salts in suspension and in solution it tends to turn yellow or brown. There is a development of bacterial flora. Landfill operators face a significant challenge in managing the leachate generated from municipal solid waste (MSW) landfills. Due to the changing conditions within the landfill leachate characteristics vary drastically over time. Leachate is often discharged to local publicly owned treatment works (POTWs) because of the complexity and cost of on-site treatment. Additionally, some POTWs have stopped accepting leachate because of nutrient loadings, interference with UV disinfection, or capacity challenges.

2.7 Development and Formulation of Leachate Pollution Index (LPI)

To develop a system to compare the leachate contamination potential of various landfill sites in a given geographical area, 80 panelists, which included academicians in environmental engineering, consulting engineers, environmental regulatory authority scientists, and members of the International Solid Waste Association (ISWA) from all over the world, were surveyed. The survey was conducted using multiple questionnaires to develop a LPI[10]. The index is a simple mathematical method of calculating a single value from multiple biological and chemical test results of the landfill leachate. The single value LPI is like a grade that tells the overall leachate contamination potential of a particular landfill, based on number of leachate pollution parameters at a given time. It is an increasing scale index, when the index value is high it indicates a poorer environmental condition[10]. The 18 leachate pollution parameters selected for inclusion in the LPI, based on the survey of the panelists, were chromium, chemical oxygen demand (COD), mercury, 5 day biochemical oxygen demand (BOD), arsenic, lead, cyanide, phenolic compounds, zinc, Total Kjeldahl Nitrogen, pH, nickel, total Coliform bacteria, ammonical nitrogen, total dissolved solids (TDS), copper, chlorides and total iron . The weights for these parameters were calculated based on the significance levels for these parameters on a scale of 1 to 5 and are shown in Table 1. A selected group of panelists were asked to draw curves for the pollutant variables in the LPI with respect to leachate pollution ranging from 5 (best) to 100 (worst). Levels of leachate pollution from 0 to 100 were indicated on ordinate in each graph, while various levels of concentration of the particular variable, up to the maximum limits reported in literature, were indicated on the abscissa. The curves drawn were averaged to obtain “average sub index” curves for each of the parameters.

Table 2.1. Weights of Pollutant Variables Included in Leachate Pollution Index[11]

No.	Pollutant	Pollutant weight
1	Chromium	0.064
2	Lead	0.063
3	COD	0.062
4	Mercury	0.062
5	BOD	0.061
6	Arsenic	0.061
7	Cyanide	0.058
8	Phenolic compound	0.057
9	Zinc	0.056
10	pH	0.055
11	TKN	0.053
12	Nickel	0.052
13	Total Coliform bacteria	0.052
14	Ammonia nitrogen	0.051
15	TDS	0.050
16	Copper	0.050
17	Chlorides	0.049
18	Total Iron	0.045
	Total	1

2.8 Variable Selection

Eighteen leachate pollutant variables were selected to be included in LPI. They are pH, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Iron, Total Kjeldahl Nitrogen (TKN), Nickel, Copper, Ammonia Nitrogen, Zinc, Lead, Chromium, Mercury, Arsenic, Phenolic Compounds, Chlorides, Cyanide and Total Coliform Bacteria[8].

2.9 Variable Weights

Each individual pollutant has its significance level which is used to calculate its weight. Hence the weights for these eighteen parameters were calculated. The importance of every pollutant variable is indicated by the weight factorto the overall leachate pollution. For example, the weight factor for chromium is 0.064, and so it is most important variable than the other pollutant variables, while total iron with a weight factor of 0.045 is least important variable on comparing to other pollutant variables included in LPI. The weights for other pollutant variables are TDS: 0.050; BOD5: 0.061; COD: 0.062; TKN: 0.053; Ammonia Nitrogen:0.051; Copper: 0.050; Nickel: 0.052; Zinc: 0.056; Lead: 0.063; Mercury: 0.062; Arsenic:0.061; Phenolic Compounds: 0.057; Chlorides: 0.049; Cyanides: 0.058 and Total Coliform Bacteria: 0.052. The sum of the weights of all the eighteen parameters is one(unity)[12].

2.10 Variable Curves

The averaged sub index curves for each parameter were drawn to establish a relation between the leachate pollution and concentration or strength of the given parameter. The averaged sub index curves are those curves that represent the relation between leachate pollution and the concentration or strength of the parameter. The averaged subindex curves are shown in given figures below.

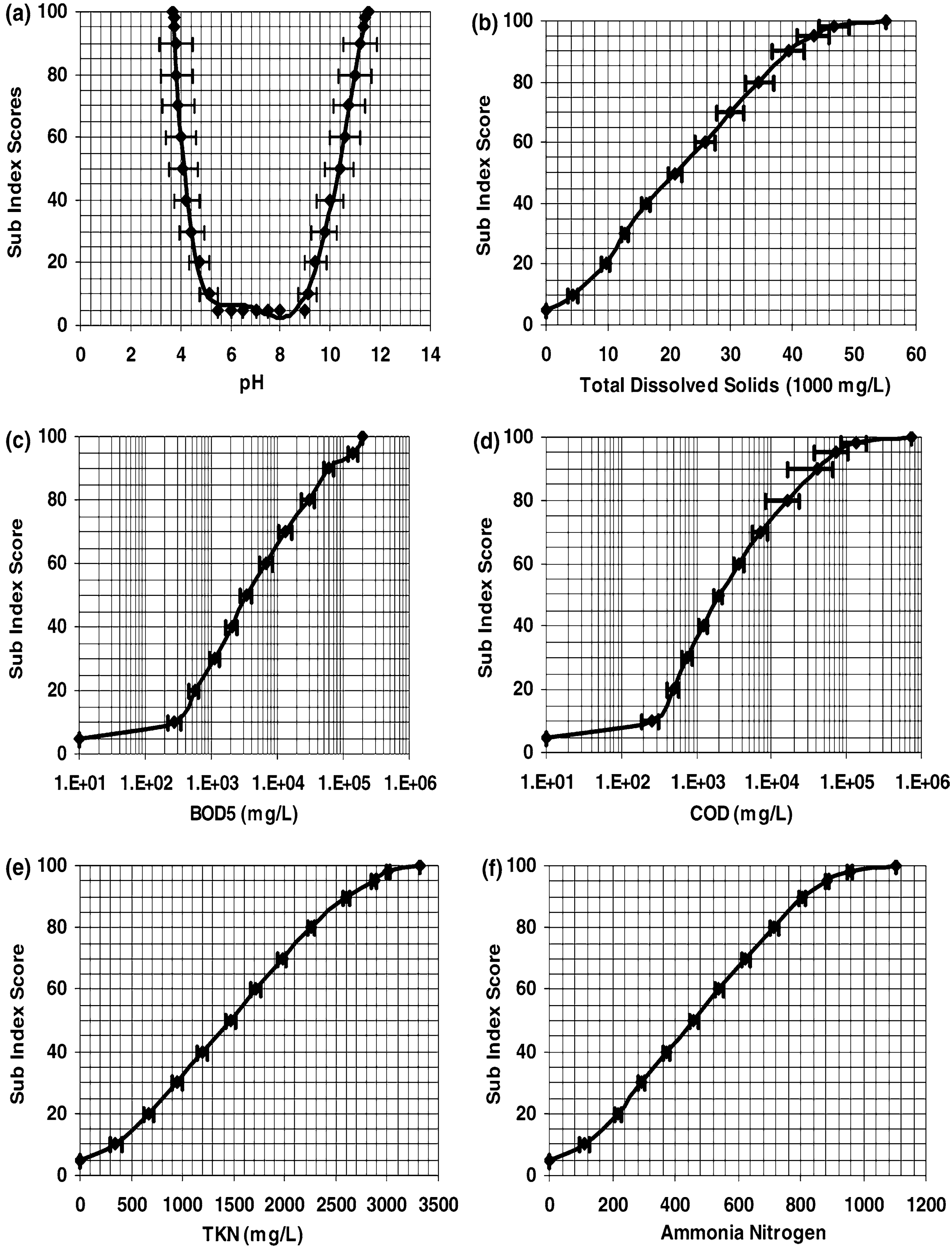
(a)
Sub Index Scores
0 20 40 60 80 100
0 2 4 6 8 10 12 14
pH
(b)
Sub Index Score
0 20 40 60 80 100
0 10 20 30 40 50 60
Total Dissolved Solids (1000 mg/L)
(c)
Sub Index Score
0 20 40 60 80 100
1.E+01 1.E+02 1.E+03 1.E+04 1.E+05 1.E+06
BOD5 (mg/L)
(d)
Sub Index Score
0 20 40 60 80 100
1.E+01 1.E+02 1.E+03 1.E+04 1.E+05 1.E+06
COD (mg/L)
(e)
Sub Index Score
0 20 40 60 80 100
0 500 1000 1500 2000 2500 3000 3500
TKN (mg/L)
(f)
Sub Index Score
0 20 40 60 80 100
0 200 400 600 800 1000 1200
Ammonia Nitrogen

Fig.2.3: The averaged sub index curves for the leachate pollutant variables [13]
(a) pH (b) total dissolved solids (c) biological oxygen demand (5 day) (d) chemical oxygen demand (e) total Kjeldahl nitrogen (f) ammonia nitrogen

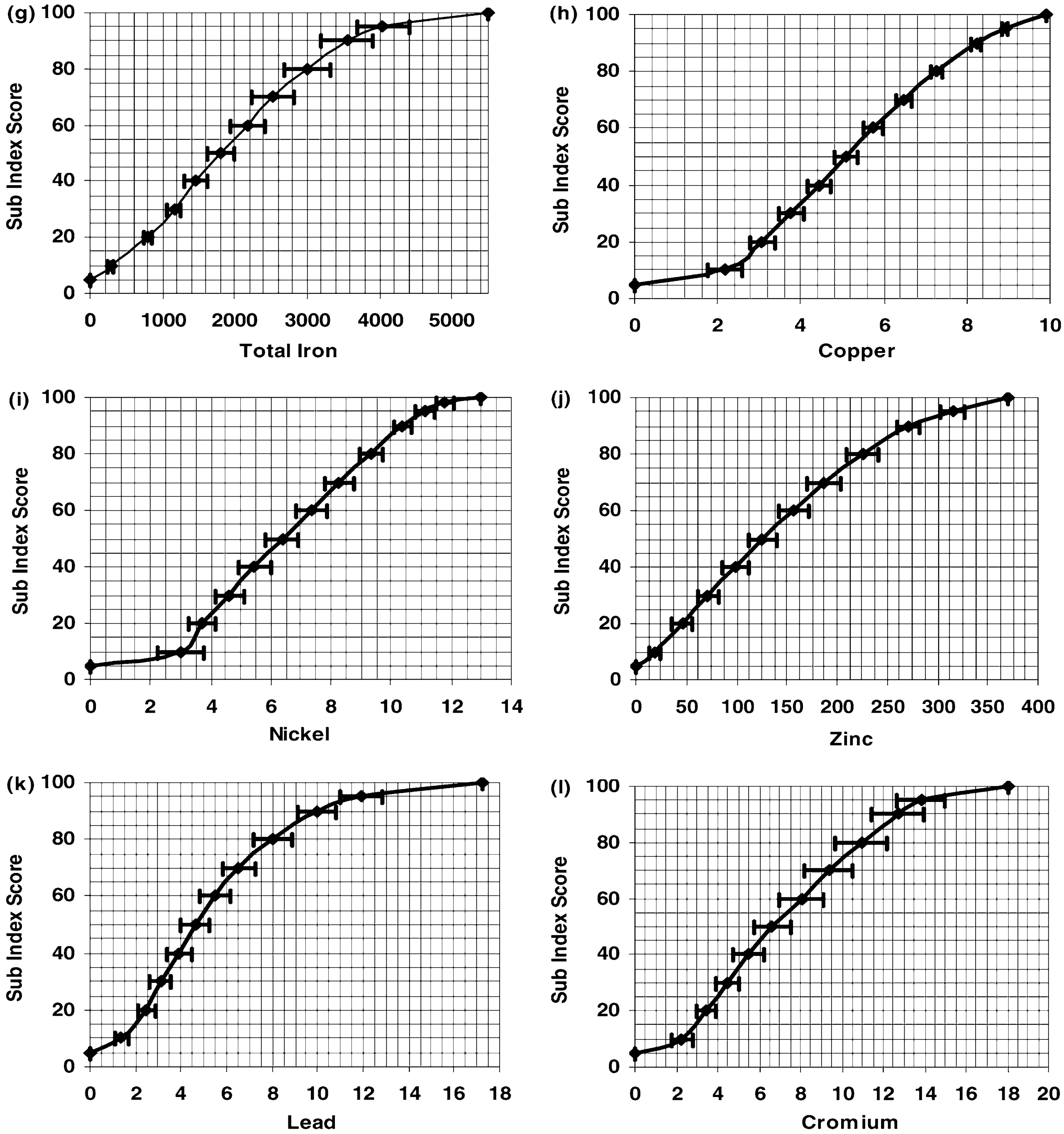

Fig.2.4: The averaged sub index curves for the leachate pollutant variables [13]
(g) total iron (h) copper (i) nickel (j) zinc (k) lead (l) chromium

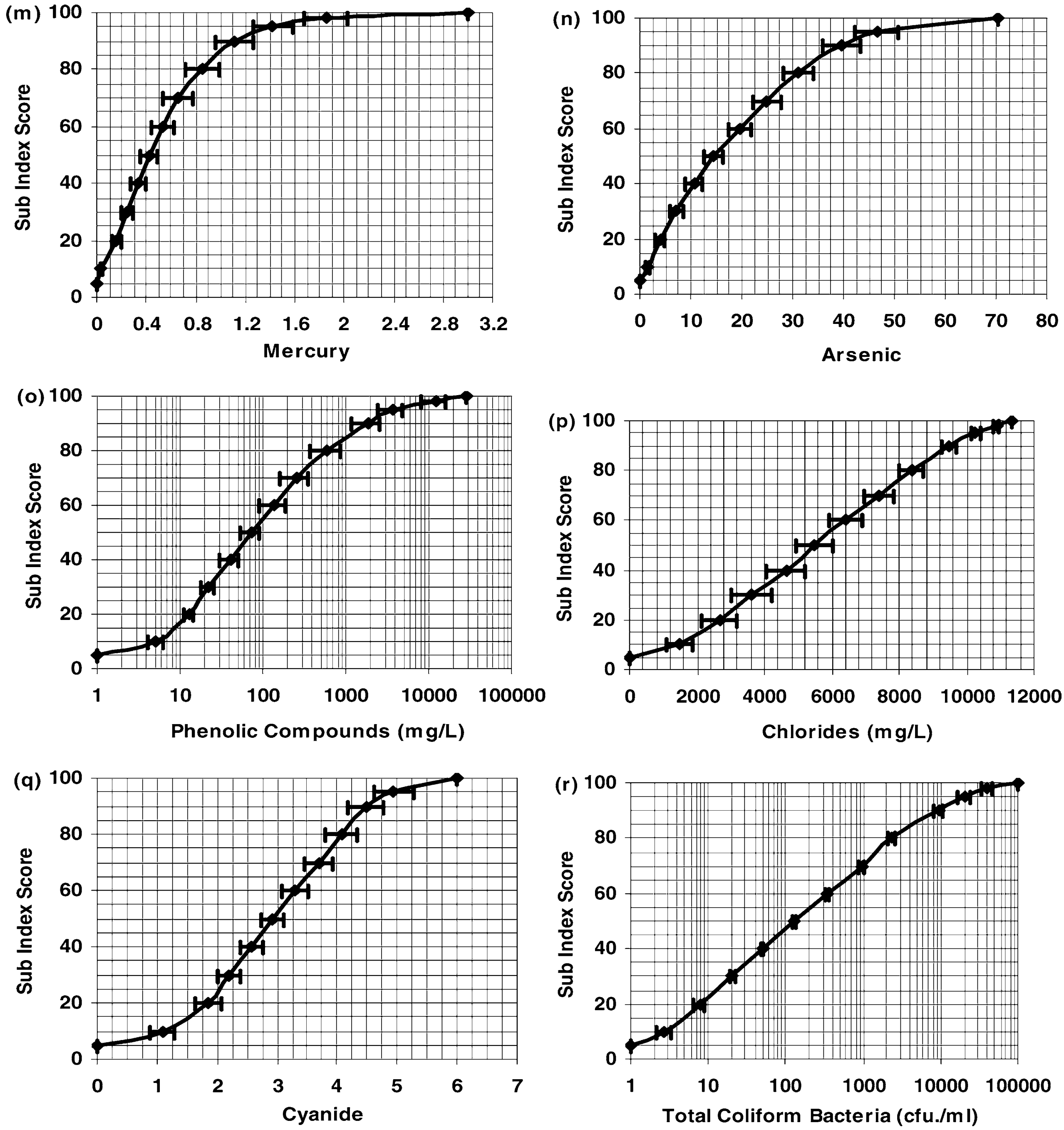
(m)
Sub Index Score
Mercury
(n)
Sub Index Score
Arsenic
(o)
Sub Index Score
Phenolic Compounds (mg/L)
(p)
Sub Index Score
Chlorides (mg/L)
(q)
Sub Index Score
Cyanide
(r)
Sub Index Score
Total Coliform Bacteria (cfu./ml)

Fig.2.5: The averaged sub index curves for the leachate pollutant variables [13]
(m) mercury (n) arsenic (o) phenolic compounds (p) chlorides (q) cyanide (r) total coliform bacteria.

2.11 Aggregation Function

Aggregation methods are critical in the field of natural records, as they influence the nature of result in different ways. Conglomeration has been defined as the way toward including units or factors with comparative properties to think of a solitary number that speaks to the inexact general estimation of its individual segment.

Accumulation works as a rule comprise of both of the accompanying three structures :

1. Additive form (summation function), in which individual variables are added with each other.

2. Multiplicative form (multiplication function), in which a product is formed of some or all of the variables present.

3. Maximum or minimum operator form, in which just the minimum or the maximum sub index value of the variable is directly used.

2.12 Procedure for Selecting Appropriate Aggregation Function

The following aspects need to be considered for selection of the appropriate aggregation method.

2.12.1 Functional Form of Index

An index can be a decreasing scale index or an increasing scale index. In the case of an increasing scale index, usually called an "environmental pollution index," higher values indicate a worse state than its lower values. In the decreasing scale indices, higher values are considered in a better state than lower values and are usually referred to as "environmental quality indices."

2.12.2 Strength and Weaknesses of Aggregation Function

The two potential problems associated with aggregation functions are[13] :

1. An overestimation (ambiguity) issue, where just the total record I surpasses the basic level with no of the subindices surpassing the basic levels

2. An underestimation (eclipsing) problem, where only the aggregate index *I* does not exceed the critical level despite one or more of the subindices exceeding the critical levels. These two

problems lessen up only with dichotomous subindices. The most appropriate aggregation function will minimize one or both the underestimation and overestimation problems.

2.12.3 Parsimony Principle

When competing aggregation functions produce similar results with respect to underestimation and overestimation, but the most appropriate aggregation function will be that which is mathematically simple[14].

2.12.4 Transparency of Aggregation Function

Finally, an aggregation approach is said to be successful if all assumptions and sources of data are identified correctly, the methodology is transparent, and an index can be readily disaggregated into the separate components with no amount of information lost in it [15]. In addition to the earlier mentioned procedure, the aggregation function selected for any environmental index shall also meet the following criteria.

(a) Should be sensitive to the changes in an individual variable throughout its range.

(b) Not be biased towards bad or good environmental quality.

(c) Consider weighting factors, as all variables that have been included in the index are not equal contributors to the pollution done to environment.

(d) Be relatively easy to use.

2.13 Variable Aggregation

The weighted sum linear aggregation function was used to sum up the behaviour of all the leachate pollutant variables present. The various possible aggregation functions were studied to select the best possible aggregation function[13]. The Leachate Pollution Index can be calculated using the following equation.

$LPI = \sum_{i=1}^{n} w_i p_i$ ..... eq (1)

where LPI = the weighted additive leachate pollution index,

w i = the weight for the ith pollutant variable,

pi = the sub index value of the ith leachate pollutant variable,

n = number of leachate pollutant variables used in calculating LPI

$\sum_{i=1}^{n} w_i$=1

However, when the data for all the leachate pollutant variables included in LPI is not available completely, the LPI can be calculated using the data set of the available leachate pollutants. In that case, the LPI can be calculated by the following equation:

$$LPI = \frac{\sum_{i=1}^{m} w_i p_i}{\sum w_i} \quad \text{..... eq (2)}$$

where m is the number of leachate pollutant parameters for which data is already available, but in that particular case, m < 18 and w_i< 1.

2.14 Procedure to calculate LPI

The stepwise procedure to calculate LPI is given below:

Step 1 Testing of Leachate Pollutants

Analytical laboratory tests were performed on leachate samples collected from the landfill sites to find out the concentration of the leachate pollutants present in them.

Step 2 Calculating Sub-index Values

To calculate the LPI, one first computes the ‘p' value or sub-index value of the parameters from the sub-index curves based on the concentration of the leachate pollutants obtained during the tests. The ‘p’ values are obtained by marking the concentration of the leachate pollutant on the horizontal axis of the sub index curve for that pollutant and also noting the leachate pollution sub-index value where it intersects the given curve.

Step 3 Aggregation of Sub-index Values

The ‘p’ values which were obtained were multiplied with the respective weights assigned to each given parameter. The equation (1) is used to calculate LPI if the concentrations of all the eighteen variables included in LPI are known to us. Otherwise, equation (2) is used when data for some of the pollutants is not available to us. It has been observed that LPI values can be calculated with some marginal error using equation (2), when the data for some of the pollutants is not available to us [17]. In the present study, out of 18, 8 significant parameters were recovered, so equation (2) is used.

CHAPTER 3

MATERIALS AND METHODS

3.1 Landfill Site

1. Nurpur is one of the biggest cities in Himachal Pradesh, as far as region and population. Nurpur is situated at 32.3°N 75.9°E. It has a normal height of 643 meters (2109 feet). Starting at 2001, Nurpur had a population of 9045. Nurpur Municipal Council has add up to organization more than 2,137 houses to which it supplies fundamental comforts like sewage and water. Nurpur has a decent atmosphere. Summer season is minimal sweltering yet morning and night both are extremely lovely with cool wind from the snow clad Dhauladhar mountain range. Amid rainstorm there is great measure of precipitation due to Dharamsala which gets second most elevated precipitation in India, which is simply nearby. Dharamshala is extremely cool due to crisp breezes originating from the mountains. The Temperature amid the summers ascends to 40 °C for some days as it were. Storms touch base in before the finish of July and stays till end of September.

Fig.3.1: Disposal site in Nurpur.

2. Pathankot is a city in the Punjab territory of India. Pathankot has a normal elevation of 332 meters (1,089 ft). It is a green town encompassed by the Ravi and Chakki streams of Indian land. The temperature in summer (from Mid-May to Mid-June) may ascend to a most extreme of stunning 46 °C (once in a while). Temperatures by and large stay between 34 °C to 46 °C (91 – 115F). Pathankot encounters direct to substantial precipitation and in some cases overwhelming to substantial precipitation (by and large amid the long stretch of August or September). More often than not, the rain bearing rainstorm blow from south-west/south-east. For the most part, the city gets substantial rain from south yet it for the most part gets the greater part of its rain amid rainstorm either from North-east or North-west. Most extreme measure of rain got by the city of Pathankot amid storm season is 195.5 mm in a day. Winters (November to Mid-March) are mellow yet now and again it gets very cold in Pathankot. Normal temperatures in the winter stay at (max) 7 °C to 15 °C and (min) 0 °C to 8 °C. Rain

Fig.3.2: Disposal site in Pathankot.

Leachate sample for the present study is collected from designated MSW landfill sites available at pathankot City, Punjab and Nurpur city, Himachal Pradesh. No front of any portrayal is set over the spread waste to possess the entrance of surface water or to limit litter blow and scents or to diminish the nearness of vermin and bugs.

Rag pickers frequently set fire to waste to isolate non-ignitable materials for recuperation. Since, there are no particular game plans to anticipate stream of water into and out of landfill site, the breakage of contaminants discharged amid corruption of landfill waste, may continue uninhibited. None of these two landfill destinations are lined and squander is specifically dumped (without isolation) into the site. To pack the loss into the site no appropriate compaction is finished.

3. Kangra is situated on southern escarpment of Himalayas . The Altitude varies from 500m to 5000m above sea level. Small water channels are the major sources of irrigation in the city. Assured agriculture facilities are not given and agriculturist have to depend on weather. The climate of the district varies from sub-tropical to sub-humid. Winter extends from December to February and summer extends from March to June while July to September are the rainy months.

Soil Type :

Kangra comes under Mid-hill soil zone. This zone is found in areas 910 to 1517 m above sea level. These soils are mainly developed in areas of chil pine trees and mixed deciduous forests. Soil is greyish brown in colour, loam, clay loam in texture. This type of soil is rich in potash, ron, carbon and nitrogen but it lacks lime and phosphorus. It is neutral to slightly acidic in reaction andare suitable for cultivation of maze, wheat and tobacco.

Ground Water :

The perennial kuhls in these areas continually recharge the ground water. Of late the hand pumps dug in these areas are using the ground water.

3.2 Leachate sampling and analysis

Integrated samples to determine the leachate quality were collected from these three sites. Samples were collected from Kangra city, Nurpur City and Pathankot city to determine the LPI. The sites were non-engineered and were open dumps. No bottom liner was given and there was no leachate collection and treatment system. All the leachate generated seeps through the dumps and was dispersed into the environment. All leachate was colleted under the heap of solid waste. Leachate drained out by gravitational force. Leachate samples were collected in August end, 2017. Leachate pollutant variables viz pH, TDS, BOD5, COD and Chloride (Cl-), Lead, Chromimum, Copper were analyzed to determine pollution potential.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 General

Leachate pollutant variables viz pH, TDS, BOD5, COD, Chloride (Cl), Lead, Chromimum, Copper were analyzed to estimate its pollution potential. The concentration of these leachate pollutant variables exceeded the permissible limits. The comparative results of leachate parameters of Pathankot landfill site and Nurpur landfill site and standards for the disposal of leachate to inland surface water, public sewers and land disposal as per Municipal Solid Waste (Management and Handling) Rules, 2000, Government of India were shown in Table.

Table 4.1: Comparative leachate pollutant variables of landfill sites of Nurpur City, Pathankot city and leachate disposal standards

Leachate Pollutant Variables	Nurpur landfilling site	Pathankot landfilling site	Standards (Mode of Disposal)		
			Inland surface water	Public sewers	Land disposal
pH	9.2	7.85	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
TDS	5612	3540	2100	2100	2100
BOD5	315	218	30	350	100
COD	1086	720	250	-	-
Chloride	1450	1140	1000	1000	600
Lead	13.4	6.3	-	-	-
Chromium	0.12	0.05	-	-	-
Copper	0.01	0.02	-	-	-

4.2 Calculating LPI

The LPI for the given MSW landfill sites is calculated by above procedure. Sub-index curves of the given leachate pollutant variables were given above. The LPI value of Nurpur site, Himachal Pradesh and Pathankot site, Punjab (India) were calculated as per the given procedure. Notified by Government of India was calculated using the above procedure and reported in Table 4.2, 4.3 which are MONSOON READINGS . Table 4.4 , 4.5, 4.6 give us the WINTER SEASON READINGS.

Table 4.2: Calculating LPI for landfill site, Pathankot City, Punjab (India) MONSOON SEASON

LPI of leachate from landfill site					LPI of leachate disposal standards		
Leachate Pollutant Variables	**Variable Weight (wi)**	**Pollutant Conc. (Ci*)**	**Pollutant Sub Index Value (pi)**	**Aggregat-ion (wi.pi)**	**Leachate Disposal Standards for Inlandsurface water (Cs*)**	**Pollutant Sub Index Value (Ps)**	**Aggregation (wi.ps)**
pH	0.055	7.85	4	0.22	5.5 - 9.0	5	0.28
TDS	0.05	3540	6	0.3	2100	7	0.35
BOD_5	0.061	218	9	0.549	30	6	0.37
COD	0.062	720	18	1.16	250	10	0.62
CHLORIDE	0.049	1140	9	0.44	1000	8	0.39
LEAD	0.063	6.3	68	4.28	0.1	5	0.32
CHROMIUM	0.064	0.05	5	0.32	2.0	9	0.58
COPPER	0.05	.002	5	0.25	3.0	18	0.9
TOTAL	**0.454**			**7.51**			**3.81**
LPI VALUE				**16.56**			**8.39**

Table 4.3: Calculating LPI for site, Nurpur city, Himachal Pradesh(India) MONSOON SEASON

LPI of leachate from landfill site					LPI of leachate disposal standards		
Leachate Pollutant Variables	**Varia-ble Weight wi**	**Polluta-nt Conc. Ci***	**Pollutant Sub Index Value pi**	**Aggregati-on wi.pi**	**Leachate Disposal Standards for Inlandsurface water Cs***	**Pollutant Sub Index Value Ps**	**Aggregatio-n wi.ps**
pH	0.055	9.2	18	0.99	5.5 - 9.0	5	0.28
TDS	0.05	5612	11	0.55	2100	7	0.35
BOD_5	0.061	315	10	0.61	30	6	0.37
COD	0.062	1086	30	1.86	250	10	0.62
CHLORIDE	0.049	1450	12	0.588	1000	8	0.39
LEAD	0.063	13.4	95	5.985	0.1	5	0.32
CHROMIUM	0.064	0.12	5	0.32	2.0	9	0.58
COPPER	0.05	0.01	5	0.25	3.0	18	0.9
TOTAL	**0.454**			**11.153**			**3.81**
LPI VALUE				**24.56**			**8.39**

Table 4.4: Calculating LPI for site, Pathankot city, Himachal Pradesh(India) WINTER SEASON

		LPI of leachate from landfill site standards `				LPI of leachate disposal	
Leachate Pollutant Variables	Variable weight Wi	Pollutant conc. Ci	Pollutant sub Index Value pi	Aggregation Wi.Pi	Leachate Disposal Satndards for inland Surface water Cs	Pollutant Sub Index Value ps	Aggregation wi.ps
pH	0.055	8.1	4	0.22	5.5-9.0	5	0.275
TDS	0.05	4328	9	0.45	2100	7	0.35
BOD_5	0.061	321	10	0.61	30	6	0.366
COD	0.062	948	30	1.86	250	10	0.62
CHLORIDE	0.048	1415	10	0.48	1000	8	0.384
LEAD	0.063	6.9	75	4.725	0.1	5	0.315
CHROMIMUM	0.064	0.08	5	0.32	2	9	0.576
COPPER	0.05	0	0	0	3	18	0.9
CYANIDE	0.058	1.1	8	0.464	0.2	6	0.348
MERCURY	0.062	0.2	20	1.24	0.01	6	0.372
ARSENIC	0.061	0.9	4	0.244	0.2	5	0.305
TOTAL	0.634			10.61			4.811
LPI VALUE	**16.74**						7.58

Table 4.5: Calculating LPI for landfill site, Nurpur city, Himachal Pradesh(India) WINTER SEASON

	LPI of leachate from landfill site				LPI of leachate disposal standards		
Leachate Pollutant Variables	Variable weight Wi	Pollutant conc. Ci	Pollutant sub Index Value pi	Aggregation Wi.Pi	Leachate Disposal Satndards for inland Surface water Cs	Pollutant Sub Index Value ps	Aggregation wi.ps
pH	0.055	9.9	20	1.1	5.5-9.0	5	0.275
TDS	0.05	6120	12	0.6	2100	7	0.35
BOD5	0.061	395	13	0.793	30	6	0.366
COD	0.062	1230	51	3.162	250	10	0.62
CHLORIDE	0.048	1519	10	0.48	1000	8	0.384
LEAD	0.063	13.9	96	6.048	0.1	5	0.315
CHROMIMUM	0.064	0.15	5	0.32	2	9	0.576
COPPER	0.05	0.02	4	0.2	3	18	0.9
CYANIDE	0.058	1.3	12	0.696	0.2	6	0.348
MERCURY	0.062	0.3	30	1.86	0.01	6	0.372
ARSENIC	0.061	1.1	5	0.305	0.2	5	0.305
TOTAL	0.634			15.564			4.811
LPI VALUE	**24.5489**						7.58

Table 4.6: Calculating LPI for landfill site, Kangra city, Himachal Pradesh(India) WINTER SEASON

LPI of leachate from landfill site					LPI of leachate disposal standards `		
Leachate Pollutant Variables	**Variable weight Wi**	**Pollutant conc. Ci**	**Pollutant sub Index Value pi**	**Aggregation Wi.Pi**	**Leachate Disposal Satndards for inland Surface water Cs**	**Pollutant Sub Index Value ps**	**Aggregation wi.ps**
pH	0.055	8.3	4	0.22	5.5-9.0	5	0.275
TDS	0.05	4731	9	0.45	2100	7	0.35
BOD5	0.061	349	10	0.61	30	6	0.366
COD	0.062	961	48	2.976	250	10	0.62
CHLOR	0.048	1472	6	0.288	1000	8	0.384
LEAD	0.063	5.3	53	3.339	0.1	5	0.315
CHROMIMUM	0.064	0.1	5	0.32	2	9	0.576
COPPER	0.05	0.01	4	0.2	3	18	0.9
CYANIDE	0.058	0.9	8	0.464	0.2	6	0.348
MERCURY	0.062	0.1	15	0.93	0.01	6	0.372
ARSENIC	0.061	0.6	4	0.244	0.2	5	0.305
TOTAL	0.634			10.41			4.811
LPI VALUE	**16.41**						7.58

CONCLUSION

LPI value can be utilized as an apparatus to evaluate the leachate contamination potential from landfill destinations especially at places where there is a high danger of leachate movement and contamination of groundwater and in this way can take essential choices. In the present investigation, the LPI estimations of 16.56 and 24.56 for the of landfill locales in the rainstorm season showed that the waste kept has not yet balanced out ,same is the situation with winter season where the three destinations are having LPI values as takes after 16.74, 25.547 and 16.41 for Pathankot, Nurpur and Kangra separately . High estimation of LPI of these landfill destinations demonstrated that leachate created from these landfill destinations were tainted and appropriate treatment should be guaranteed before releasing the leachate. These landfill destinations don't have any base liner or leachate gathering and treatment framework. Leachate ought to be appropriately treated and these locales ought to be checked consistently.

It ought to be noted here that the LPI esteems demonstrate the leachate defilement capability of landfill locales in a given topographical territory on a near scale and is, best case scenario a peril recognizable proof instrument as different variables like dosage reaction impact, volume of leachate created, kind of liner gave if there should arise an occurrence of a lined landfill, presentation period, profundity of water aquifer, sort of soil strata and populace influenced likewise require watchful thought. An arranging record, particularly for basic leadership, might be additionally produced, as the one utilized by United States. Ecological Protection Agency for arranging waste treatment projects [18].

The LPI value of the standards for the disposal of leachate to inland surface water shall not exceed 7.378 which is the permissible limit for the disposal of leachate to inland surface water as per the standards given under Municipal Solid Waste (Management and Handling) Rules, 2000 notified by Government of India. But in our case we have examined 8 parameters instead of 18 due to lack of resources thus LPI value of standard for disposal of leachate to inland surface water shall not exceed 8.39 for the monsoon season and 7.58 for the winter season. The comparison of the LPI values of landfill sites i.e. 16.56 and 24.56 for the monsoon and 16.74, 25.54 and 16.41 for the winter season with the standards set for the disposal of leachate indicated that the leachate generated from the landfill is highly contaminated and will have to be treated before discharge so that the LPI value reaches below 8.39 for monsoon and 7.58 in the winters.

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