A RESEARCH STUDY ON HAZARD RATING SYSTEM FOR ILLEGAL DUMPING (ORPHAN) SITES

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ABSTRACT

Landfill is considered as the simplest, cheapest and the most cost effective technique of solid waste disposal both in developed and developing nation (Barrett and Lawlor, 1995). But illegal and unregulated landfills are becoming a problem being faced by every country on varying scales. When poverty, population growth and high urbanisation rate combines with ineffective and under-funded solid waste management technique, the result is always some orphan sites and unregulated landfills. In most of the developing countries, these unregulated landfills do exist adjacent to large cities, releasing harmful contaminants thereby polluting underlying aquifers, Surface water bodies, soil and air. Be it percolation of leachate affecting the ground water, downwash of waste to water bodies severely affecting the aquatic life, release of harmful chemicals into the atmosphere or hazards associated with direct contact, illegal landfills are posing a great threat in almost every dimensions.

KEYWORD: Solid Waste Management, Illegal Dumping, Hazardous Waste

Illegal and unregulated landfills are a problem being faced by every country, developed or developing on varying scales. In most of the developing countries, to larger areas, these unregulated landfills do exist adjacent to large cities, releasing harmful contaminants thereby polluting underlying aquifers, Surface water bodies, soil and air. Be it percolation of leachate affecting the ground water, downwash of waste to water bodies severely affecting the aquatic life, slope failure, fire hazards, release of harmful chemicals into the atmosphere or hazards associated with direct contact, illegal landfills are posing a great threat in almost every dimensions.

Growing concerns about public health and degradation of qualities of air, surface or sub surface water, from these unregulated landfills in various countries have resulted in undertaking of appropriate control measures at such sites. However, because of financial constraints these control measures cannot be applied to all polluting landfills simultaneously. Therefor a site hazard assessment system for identifying high hazard landfills and prioritizing them for required measure is essential. In addition because of the reason that these site do affect a large spectrum of life directly or indirectly (be it air, surface or subsurface water, flora or fauna) , the system proposed should be such that it takes into account all these dimensions with the appropriate weightage and should be rational in approach.

In this project, some of the existing rating system has been studied and a new system has been proposed which will incorporate a wider spectrum of concerns. The system is essentially not a quantitative risk assessment tool but indeed screens sites with respect to need for further action in terms of characterization, risk assessment, removal action (emergency, time-critical, non-time critical), Remedial actions etc. So, it is to be emphasized that this system is only a screening tool.

LITERATURE REVIEW

Illegal dumping site or orphan site is defined as a toxic waste area where the polluter could not be identified or the polluter refuses to take action or pay for the cleanup. According to an Estimate total illegal waste dumping round the world is approximately 98,995,672 tons with the larger fraction shared by developing countries like India and China which has an approximate dumps of around 21,441,270 tons and 22,037,858 tons respectively. In addition such problem do exist in developed countries like US (1,458,150 tons), United Kingdom (252,427 tons), Japan (541,091 tons). The figure below shows the approximate quantity of waste being illegally dumped worldwide.

These illegal/ unregulated dump sites need to be prioritized to undertake necessary control and remedial measures. Prioritizing or ranking based on the threat it poses to the environment is often a challenging task and a question of rationality is raised. A lot of work in this area has been undertaken and various ranking systems have been proposed. The table below shows various ranking systems along with the route of migration.

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Figure 1: Depiction of Illegal waste dump quantities worldwide

Table 1: Various ranking systems along with the route of migration

S.No.	Hazard Rating System	Hazard mode/migration route
1	Le Grand (1964) Method	Groundwater
2	Soil water Interaction Matrix (Phillips and Nathwani,1977)	Groundwater
3	Drastic Method (canter,1966)	Groundwater
4	Hazard ranking System(HRS-1982, Wu and Hilger, 1984)	Groundwater, Surface water, Air, Fire & explosion, direct contact
5	Hazard ranking System(HRS-1990,USEPA,1990)	Groundwater, Surface water, Air, soil exposure
6	Standardized Risk Assessment Protocol (SRAP, Marsh and Day,1991)	Groundwater, Surface water, Air, soil
7	Defense Priority Model (National Research Council,1994)	Groundwater, Surface water, Air/soil volatiles, air/soil dust
8	Washington Ranking Method (WARM, Science Applications International Corporation, 1990)	Groundwater, Surface water, Air, marine sediment
9	National Classification System (NCS, Canadian Council of Ministers for the Environment, 1992)	Groundwater, Surface water, Direct Contact
10	National Corrective Action Prioritization System (NCAPS, DOA, 1996)	Groundwater, Surface water, air
11	Hazard Ranking using Fuzzy Composite Programming (HR-FCP, Hagemeister et al.,1996)	Groundwater, Surface water, Air

Most of these existing systems considers groundwater as the main pathway of contamination and calculates the hazardness rating according to various parameters related to groundwater. Besides, the other systems which also involves air and surface water fails to include parameters related to receptor (Flora, fauna, human beings etc.) and other parameters like slope failure and fire & explosion hazards. So, a need comes for a system which will include all these parameters and can lead to a rational ranking.

METHODOLOGY

For developing the Hazard ranking system of illegal/unregulated landfills, Source-Pathway-receptor model has been adopted.

Source: The (e.g. industries, dumping site etc.) reason behind the production of contaminant or pollutant which propagates through the pathway and affects the receptor.

Pathway: A route along which a particle of water, substance or contaminant

Moves through the environment and comes into contact with or otherwise affects a receptor.

Receptor: An entity (e.g. human, animal, controlled water, plants, building, air) which is vulnerable to the adverse effects of a hazardous substance or agent.

Characteristics of the Source

Quantitative Characteristics of the Waste

It covers Total area under the orphan site connected directly or indirectly affected by it, Average Heap Height and Age of the Waste.

It covers Type of industry producing the waste which is dumped, Total number of such industries and Size of such industries

Characteristics of Pathway

It includes surface water characteristics, ground water characteristics and ambient air quality

Characteristics of the Receptor

It includes characteristics of the human population, flora and fauna and water bodies

PROPOSING A FRAMEWORK

Minimum Data Required

Before proceeding further for the classification, the following minimum data about the site should be ensured.

i. Description of the site location
ii. Type of the contaminant or the material likely to be present at the site (Can be prepared by listing all the historical activities and all the industries responsible for it too)
iii. Approximate size of the site , the average heap height and total quantity of contaminants
iv. Approximate age of the contaminant and its physical state
v. Approximate depth of the GW Table
vi. Hydraulic conductivity of the confining layer
vii. Annual rainfall data
viii. Accessibility of the site
ix. Position of various echo-geological features (River, Lake, Pond, Creeks etc.) from the site.
x. Position of various protected sites, airports, historical monuments from the site
xi. Various parameters related to the receptor (ground water, surface water, air, soil etc.)
xii. Proximity to the drinking water supply
xiii. presence of any sensitive receptor to the site

Numerical Weighting

To access the hazard of a particular site, a scoring system has been used with a maximum of 100 points. The three categories of the model (source, pathway and the receptor) have been given equal importance and thus equal weighted equally (a score of 33, 33 and 34 respectively). The sub-factors (waste quality, topography, rainfall etc.) have been given scores ranging from 0 to 10 depending upon the potential or actual relevance.

Information Insufficiency

In a case when necessary information is not available for a particular evaluation factor, it should be given a score which is one half of the maximum allowable score (using a confidence factor of 0.5). The score should be followed by a "?" to indicate the insufficiency in information. While getting the total score, these estimated scores are added with the other score to give the total site score. These estimated score are also added exclusively and written with "+" to indicate the margin of error incorporated into it.

For instances in a score of 10+4? + 8+2.5? =24.5+ 6.5.

This indicates that the score in this case could be as low as 18 and as high as 31, but it is estimated as 24.5 till further information is not available.

Site Classification Category

I. Class A

- Total Score : 85-100
- The available information indicates that the site is an utmost in priority for carrying out remedial measures
- Action to be taken on emergency basic

II. Class B

- Total Score : 70-84.9
- The available information indicates that the site has very high potential impact to the environment and human life.
- Action required to be taken (risk management, remediation etc.)

III. Class C

- Total score : 50-69.9
- The available information indicates that there is a high potential to adverse off site impacts, although the threat to life and environment is not imminent.
- Action likely required

IV. Class D

- Total score : 25-49.5
- The available information indicates that the site is currently not a high concern. However, additional investigation may be carried out to confirm the site classification.
- Action may be required if sufficient finance is available.

V. Class N

- Total score <25
- The available information indicates that there is probably no threat to life of environment from the site under consideration
- Action not likely required until fresh information is available indicating greater concerns.

Characteristics of the Source

Quantity of the Waste and Emission

The estimation of the total quantity of the waste forms the first part of source characteristics. It comprises of three parameter which are mutually exclusive but when multiplied together gives a measure of the waste and emission quantity.

Area Under Orphan Site

Table 2: Hazard Score for area under the site

Area under the site (m^2)	Hazard Score (Q_1)
0 -500	0.5
500-1000	1.0
1000-10000	1.5
>10000	2.0

Average heap height

Table 3: Hazard Score for average heap height

Heap Height (m)	Hazard Score (Q_2)
<5	0.5
5-15	1.0
15-30	1.5
>30	2.0

Gaseaus Emission from the Waste

According to a study more gases are released from waste stored for less than 10 years as a result of bacterial degradation, evaporation and chemical reactions than from that stored for more than 10years. The highest emission of gases from landfills occurs 5–7 years after the start of storage (Source: Szentgyorgyi E.,Pawlowsca M., Environment Protection Engineering, 2011, 37 (4))

Table 4: Hazard Score for age of the waste of the site

Average age of the waste (Years)	Hazard Score (Q_3)
New (<5)	1.0
Young/Active (5-10)	2.0
Moderately Old (10-30)	1.5
Old (>30)	0.5

Waste Quantity score (Q_n) = $Q_1 \times Q_2 \times Q_3$

(Maximum Waste Quantity score = 2×2×2= 8)

Quality of waste and emission

Classification of waste

In classifying the waste quality, rather than adopting the USEPA model of classification as:

1) General Solid Waste (Putrescible)
2) General Solid waste (Non Putrescible)
3) Hazardous Waste
4) Special Waste

(Source: www.environment.nsw.gov.au/resources/waste/09281classifywaste.pdf)

A new methodology of classification has been adopted based on the following parameter,

Concern of the Contaminant

a) High Concern Contaminants (H)

- Radioactive Waste
- Pathological Waste and animal carcasses
- Materials defined by the USEPA as hazardous waste
- Special wastes as described below

b) Medium Concern Contaminants (M)

- Food processing waste , not referred above
- Liquid waste (not referred above) , petroleum products, septic tank pumping, agriculture and chemical containers
- Non-hazardous incinerator residue
- Municipal solid waste
- Organic and vegetables waste
- Mining Residues (not referred above)

c) Low Concern contaminants (L)

- Industrial and commercial solid wastes not referred above (Construction & Demolition waste materials such as wood, metal, hay etc.)
- Other nearly inert wastes

1) Concentration of the contaminants

a) High Concentration (h)

- The contaminant concentration in soil, groundwater or surface water exceeds 2 times the Indian or EPA standard (given in the worksheet).
- Material deposited in highly concentrated form (>5000 ppm).

b) Low Concentration (l)

- Concentration less than as stated above.

Hazardous Waste

A Waste can be classified as hazardous if it exhibits one or more of the following characteristics:

Flammability

Flammable wastes are those wastes that create fire under certain condition. Example include liquids that readily catches fire, substances which are friction sensitive and ignitable compressed gases.

Corrosivity

Those wastes which are strongly acidic or basic and are capable of corroding metals (such as containers, drums and barrels etc.).

Reactivity

These wastes are unstable under normal conditions. They can create explosions, toxic Fumes, gases and vapors when mixed with water or heated in confinement.

Toxicity

These wastes are harmful or fatal when ingested or absorbed. The toxicity can be Chronic or acute. Toxic wastes can cause carcinogenic, mutagenic and teratogenic Effects on human or other forms of life.

In case of heterogeneous pile of waste, the hazardous percentage of waste can also be found out by knowing the type of Industry which has contributed; in addition the percentage of contribution can also be found using daily production values

Following is the List of some of the industries producing Hazardous wastes.

1) lead-acid or nickel-cadmium batteries (being waste generated or separately collected by activities carried out for business, commercial or community services purposes)
2) Leather tanning and finishing
3) Petroleum Refining
4) Timber Product Processing
5) Iron and Steel Manufacturing
6) Inorganic Chemicals Manufacturing
7) Textile Mills
8) Organic Chemicals Manufacturing, including

- Adhesive
- Gum and wood Chemicals
- Pharmaceuticals
- Explosive
- Pesticides

9) Paint and ink formulation and printing
10) Soap and detergent manufacturing
11) Plastic and synthetic material industries
12) Rubber processing
13) Machinery and Mechanical product manufacturing, such as

- Aluminum forming
- Battery manufacturing
- Copper Forming

14) Electrical and Electronic component manufacturing
15) Electroplating
16) Extraction industries , such as,

- Ore mining and dressing
- Coal mining

Special Wastes

'Special waste' is a class of waste that has unique regulatory requirements. The potential environmental impacts of special waste need to be managed to minimize the risk of harm to the environment and human health. Special waste means any of the following:

1. Clinical and related waste
2. Asbestos waste

1. Clinical and related waste

   Clinical and related waste means:

   • Clinical waste, or

   • Cytotoxic waste, or

   • Pharmaceutical, drug or medicine waste, or

   • Sharps waste.

Clinical Waste

It means any waste resulting from medical, nursing, dental, pharmaceutical, skin Penetration or other related clinical activity, being waste that has the potential to cause injury, Infection or offence, and includes waste containing any of the following:

•Human tissue (other than hair, teeth and nails)

• Bulk body fluids or blood

• Visibly blood-stained body fluids, materials or equipment

• Laboratory specimens or cultures

• Animal tissue, carcasses or other waste from animals used for medical research but does not include any such waste that has been treated by a method approved in writing by the Director-General of the Department of Health.

Cytotoxic Waste

It means any substance contaminated with any residues or preparations that Contain materials that are toxic to cells principally through their action on cell reproduction.

a) Pharmaceutical, drug or medicine waste

It means waste that has been generated by activities carried out for business or other commercial purposes and that consists of pharmaceutical It does not include pharmaceutical, drug or medicine waste generated in the home.

b) Sharps waste

It means any waste collected from designated sharps waste containers used in the course of business, commercial or community service activities, being waste resulting from the use of sharps for any of the following purposes:

• Human health care by health professionals and other health care providers

• Medical research or work on cadavers

• Veterinary care or veterinary research

• Skin penetration or the injection of drugs or other substances for medical or non-medical reasons but does not include waste that has been treated on the site where it was generated, and to a standard specified in an EPA gazettal notice.

Asbestos waste

Asbestos means the fibrous form of those mineral silicates that belong to the serpentine or amphibole groups of rock-forming minerals, including actinolite, amosite (brown asbestos), anthophyllite, chrysotile (white asbestos), crocidolite (blue asbestos) and tremolite. Asbestos waste means any waste that contains asbestos.

Waste Classification Score

List of all the possible responsible source of contamination and the quantity disposed off

1) List of all the industries / sources responsible for contamination
2) Total quantity disposed off
3) Classification of the Contaminant on basis of concern
4) Classification of the contaminants on the basis of concentration

Table 5: Hazard Score for type of the waste and its percentage

Waste Quality	Quantity percentage	Hazard Weight	Hazard Score
High Concern- High concentration contaminants	A	14	14 A
High Concern- Low Concentration Contaminants	B	8	8B
Medium Concern – High Concentration Contaminants	C	8	8C
Medium Concern – Low Concentration Contaminants	D	4	4D
Low Concern Contaminants	E	2	2E

Waste classification Score (Q_a) = 14A+8B+8C+4D+2E

Physical State of Contaminant

Contaminant in the liquid form has greater mobility in soil and water than solids. Some water-soluble solid wastes are however more mobile than the viscous liquids and hence needs to be evaluated individually. Therefor the physical state of the contaminants shall be given due acknowledgement while accessing the waste quality scoring.

Table 6: Hazard Score for physical state of waste

Physical State of Contaminant when disposed or deposited	Hazard Score
Solid	1.0
Sludge	2.0
Liquid / Gas	3.0

Total waste quality score = waste classification score + Waste State Score

(Maximum Score =14 +3= 17)

Characteristics of the area

Position of ground water table

Table 7: of ground water

Depth of ground Water Table (m)	Hazard Score (A_1)
<5	1
5-25	0.75
25-50	0. 0.50
>50	0.25

Hydraulic conductivity of confining layer

Table 8: Hazard Score corresponding to the hydraulic conductivity of confining layer

Hydraulic Conductivity	Hazard Score (A_2)
>10^{-4} cm/sec	1
10^{-4} - 10^{-6} cm/sec	0.6
<10^{-6} cm/sec	0.3

Annual precipitation

Table 9: Hazard Score for annual precipitation of the site

Annual Precipitation (cm)	Hazard Score (A_3)
<20	0.25
20-60	0.50
60-100	0.75
>100	1

Topography of the area

Table 10: Hazard Score for topography of the area

Topography	Hazard Score (A_4)
Contaminant above ground level	
Steep slope	1.0
Flat slope	0.75
Contaminant below ground level	
Steep slope	0.50
Flat slope	0.25

Accessibility of the site

Table 11: Hazard Score for annual precipitation of the site

Accessibility	Hazard Score (A_5)
Uncovered contaminants , Limited or no barrier to prevent site access	1.0
Moderate accessibility or intervening barriers , Covered contaminants	0.66
Controlled access or remote location , Covered Contaminants	0.33

Position of various echo geological features from the area

Table 12: Hazard Score for various echo-geological features of the site

Distance from the Site (m)	Hazard Score (A_6)
<500	1
500-1500	0.75
1500-3000	0.50
>3000	0.25

Prominent wind direction

Table 13: Hazard Score for prominent wind direction

Wind Direction	Hazard Score (A_7)
Towards the Population	1
Opposite to the Population	0

Position of various protected sites, airport, and historical monument

Table 14: Hazard Score for age of the waste of the site

Distance from the Site (m)	Hazard Score (A_8)
<500	1
500-1500	0.66
>1500	0.33

Total Areal Hazard Score (A_h) = A_1 +A_2 + A_3 + A_4 + A_5+ A_6+A_7+ A_8

(Maximum areal hazard score = 1+1+1+1+1+1+1+1+1=8)

Source Score (S) = Quantity Score (Q_n) + Quality Score (Q_a)+ Areal Score (A_h)

(Maximum source score = 8+17+8=33)

Characteristics of Pathway

Surface water characteristics

pH

A pH value of 6.5-8.5 is assumed as normal for drinking as well as for propagation of wildlife and fisheries (Source: Central pollution Control Board of India guidelines, http://cpcb.nic.in/Water_Quality_Criteria.php)

Table 15: Hazard Score for pH of the water Sample

pH	**Hazard Score (S_1)**
6.5-8.5	1
4-6.5, 8.5-10	2
<4, >10	3

Dissolved Oxygen

Dissolved oxygen (often referred to as D.O.) is essential for healthy lakes and impounded rivers. The presence of oxygen in water is a positive sign, while the absence of oxygen is a signal of severe pollution. Rivers range from high to very low levels of D.O. in the water - so low, in some cases, that they are practically devoid of aquatic life. A minimum DO level of 4mg/l is necessary for propagation of aquatic life (Source: Central pollution Control Board of India guidelines, http://cpcb.nic.in/Water_Quality_Criteria.php)

Table 16: Hazard Score for Dissolve Oxygen of the water Sample

D.O.(mg/l)	**Hazard Score (S_2)**
<4	3
4-8	2
>8	1

Biological Oxygen Demand

Biochemical oxygen demand or B.O.D is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. The term also refers to a chemical procedure for determining this amount. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water.

(Source: http://en.wikipedia.org/wiki/Biochemical_oxygen_demand)

Table 17: Hazard Score for B.O.D. of the water Sample

B.O.D.(mg/l)	**Hazard Score (S_3)**
<8	3
8-20	2
>20	1

Chemical Oxygen Demand

Chemical Oxygen Demand (COD) method determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature, and time

Table 18: Hazard Score for C.O.D. of the water Sample

C.O.D.(mg/l)	**Hazard Score (**

	S_4)
<10	3
10-20	2
>20	1

Total Surface water hazard Score (P_S) = $S_1+S_2+S_3+S_4$

Ambient air quality (Source: Central Pollution Control Board of India data for ambient air quality standards, http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php)

SO_2 (($\mu g/m^3$, 24 hour data)

Table 19: Hazard Score for SO_2 concentration

SO_2 Concentration ($\mu g/m^3$)	Hazard Score (H_1)
<80	**1**
>80	**2**

Particulate matter (PM_{10} concentration ($\mu g/m^3$) (24 hour)

Table 20: Hazard Score P.M.$_{10}$ Concentration

PM_{10} Concentration ($\mu g/m^3$)	Hazard Score (H_2)
<100	**1**
>100	2

Particulate matter ($PM_{2.5}$ concentration ($\mu g/m^3$) (24 hour)

Table 21: Hazard Score P.M.$_{2.5}$ Concentration

$PM_{2.5}$ Concentration ($\mu g/m^3$)	Hazard Score (H_3)
<60	1
>60	2

NO_2 Concentration ($\mu g/m^3$) (24 hour data)

Table 22: Hazard Score for NO_2 Concentration

NO_2 Concentration ($\mu g/m^3$)	Hazard Score (H_4)
<80	1
>80	2

O_3 Concentration ($\mu g/m^3$)(8 hour data)

Table 23: Hazard Score for O_3 Concentration

O_3 Concentration ($\mu g/m^3$)	Hazard Score (H_5)
<100	1
>100	2

CO Concentration ($\mu g/m^3$)(8 hour data)

Table 24: Hazard Score for CO Concentration

CO Concentration ($\mu g/m^3$)	Hazard Score (H_6)
<2	1
>2	2

Pb Concentration ($\mu g/m^3$) (24 hour data)

Table 25: Hazard Score for Pb Concentration

Pb Concentration ($\mu g/m^3$)	Hazard Score (H_7)
<1	1
>1	2

Air Receptor Hazard Score (A_R) = $H_1 + H_2 + H_3 + H_4 + H_5 + H_6 + H_7$

Pathway Score (P) = Surface water Hazard Score (P_s) + Air Receptor Hazard Score (A_R)

Characteristics of Receptor

Known adverse effect on human or domestic animals as a result of contaminated sites

An adverse effect is considered to be any one or more of the following:

a) Injury or damage to plant or animal life.

b) Impairment of the safety of any person.

c) Rendering any property or plant or animal life unfit for use by humans.

d) Impairment of quality of the natural environment for nay use that can be made of it.

Table 26: Hazard Score for effect of the site to human or domestic animals

Effect on human or domestic animal	Hazard Score (R_1)
Known adverse effect on human being or domestic animal	10
Strongly suspected effect	6
No effect known or suspected	0

Known adverse effect on sensitive environment as a result of contaminated sites

Table 27: Hazard Score for effect of the site to sensitive environment

Effect on sensitive environment	Hazard Score (R_2)
Known adverse effect on sensitive environment	10
Strongly suspected effect	6
No effect known or suspected	0

Total number of people being affected by illegal site

Table 28: Hazard Score for number of people affected by the site

Number of People Affected	Hazard Score (R_3)
<10000	2
10000-50000	1.5
50000-100000	1
>100000	0

Distance by which sensitive location exist (school, hospitals etc.)

Table 29: Hazard Score for distance of Sensitive receptor

Distance of Sensitive Location (m)	Hazard Score (R_4)
<500	3
500-2000	2
2000-5000	1
>5000	0

Presence of Endangered Species of Flora/Fauna around the site

Table 30: Hazard Score for Endangered Species of Flora/Fauna

Presence of Endangered Species	Hazard Score (R_5)
YES	1
NO	0

Cultural and religious importance of affected the water body

Table 31: Hazard Score for cultural/religious importance of the water body

Cultural/Religious importance	Hazard Score (R_6)
YES	1
NO	0

Potential impact on drinking water supply

Table 32: Hazard Score for potential impact on drinking water supply

Proximity to drinking water supply(m)	Hazard Score (R_7)
0-100	3
100-1000	2.5
1000-5000	1.5
>5000	0.5

Availability of alternative water supply

Table 33: Hazard Score availability of alternate drinking water supply

Availability	Hazard Score (R_8)
Alternate drinking supply is not available	2
Alternate drinking water supply would be difficult to obtain	1
Alternate drinking water supply available	0.5

Use of water resource

Table 34: Hazard Score for the use of water resources

Water Use	Hazard Score (R_9) Frequent	Hazard Score(R_9) Occasional
Recreational (Swimming, fishing)	2	1
Commercial Food preparation	1.5	1
Livestock Watering	1	0.5
Irrigation	1	0.5
Other domestic uses	0.5	0.25
Not currently used but likely future use	0.5	0.25

Receptor Score (R) = $R_1+R_2+R_3+R_4+R_5+R_6+R_7+R_8+R_9$

(Maximum Receptor Score = 10+10+2+3+1+1+3+2+2 = 34

Hence the hazard scores of the source, pathway and the receptor is achieved which is reported as,

Model Parameter	Hazard Score
Source	S
Pathway	P
Receptor	R

Total Hazard Score = S+P+R

FUTURE WORK AND CONCLUSION

The different weights for different hazard potentials may be further improved. Sensitive Analysis need to be done to check the performance of the proposed framework. This report can be useful for other metropolitan north indian cities. A number of mathematical formula need to be given and their suitability needs to be checked under various circumstances. More complex parameters need to be included and their relationship to the propose Source-Pathway-receptor model needs to be looked. Some 5-6 site shall be chosen and this system of screening be applied to them to see the outcomes. In some particular cases special consideration may be given in, hence a provision for special consideration may further be added to the proposed system A help table need to be added to make the process of data entry simpler.

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