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Site Sensitivity Index Analysis for Dumping Site in Shimla

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Abstract—*Solid waste is growing as a hazard in our country. From metropolitan cities to small towns all are suffering because of it. The situation becomes more complex when we have to look at small hilly towns. Shimla is a typical example of this type which has historical background also known as queen of hills. The studies were carries out to find the solid waste management options for the town. The place has an area of 25 Sq. Kilometers and as per census 2011 has population of 1,71,817 fixed and 76,000 floating. The place produces 86.01 MT of solid waste per day of which almost 10 MT per day goes unattended. The growth in rate of generation of waste is 3.8 % per year as per last 10 years statistics. The disposal and dumping of this waste is a problem in itself. The alternative of reuse and recycling is being used to a minimum level. The option being used was at Dharni ka Bagicha in the form of open dumping and treatment plant for quite sometime now. The closeness of open dumping site to the population is against the norms and specifications so the quest of a new dumping site was inevitable. The alternative site established is in Bharial (near Taradevi) where the available volume is thought to be sufficient to accommodate waste for several decades. The comparative studies carried out through site sensitivity index were based on the specifications in solid waste management manual. The sites suggested are within within 10 Kms. Distance from collection area and local roads were leading to site where the traffic was not too heavy. Both the sites are at natural areas in the seismic zone II with moderate environmental, socio-economical and geological effects. The overall scores suggested moderate effects from both sites but neither of the two can be cleared because of one being too close to water resource and other being too close to road and public protest. It has already invited legal hurdles for that reason. So the quest for effective dumping site and treatment plant is still on.*

1. INTRODUCTION

Since the time unknown all the living beings (human beings, animals, birds etc.) are generating solid waste to make their lives easy. Since then till now municipal solid waste has grown as a major problem all over the world. Different countries have found different methods, mechanism and ways to dispose it or to reuse it so that any kind of hazards can be avoided and the pollution which can be cased by these wastes can be minimised. The best possible alternatives found so far have been to generate energy by different methods and utilize it in different ways or to recycle it for different purposes. In India also MSW is growing as a big problem which can become hazardous if proper steps are not taken in time. In the metropolitan cities and other major cities some steps have been taken for the collection of it and efforts have been made to put it through recycling and reuse. But the results are not very enthusiastic. Even now the disposal and the land filling are supposed to be the best possible alternatives to get rid of the solid waste. In smaller cities the situation is worse and the same thing holds truth for the hill stations. In the last few decades the problem of solid waste has grown many folds in these areas because of these places being tourist spots and migration population. According to a study done in the past it was found that the solid waste generation in India reached the level of 960 million tons annually in the year 2006 as by products during industrial, mining, municipal, agricultural and other processes. Of this quantity 350 million tons are organic waste from agricultural sources, 290 million tons are inorganic waste from industrial and mining sectors and 4.5 million tons are hazardous in nature. By the year 2047, MSW only will reach 300 million tons and the land requirement for its disposal 169.6 square kms as against 20.2 square kms which was occupied in 1997 for the management of 48 million tons. (Akolkar, 2005) Unfortunately open dumping areas are still observed in developing countries- where the waste is dumped in an uncontrolled manner, which can be detrimental to the environment. Large communities can afford to use a combustor for the volume reduction, but the smaller towns cannot afford the capital investment of such scale. (Asnani, 2000) The options and facts discussed above were kept in mind for the studies in the concerned area. Shimla is the capital of Himachal Pradesh. This place is a very famous hill station called as “Queen of Hills” and lies along longitude 31°6′12″N 77°10′20″E. The average elevation above MSL is 2205 meters. The municipal area of the city is 25 Sq. Kilometres. It has been divided in 25 wards and as per census 2011 the population is 1,71,817. The city has historical background and fame because of which it is a famous tourist place. The sources include municipal solid waste coming from households, commercial places, institutions and other fields.

The main aim of the study was to find the realistic idea of the waste being generated depending upon its physical characterization and to find the mechanisms and techniques by which its energy potential can be utilised efficiently and the area which was being used for the landfilling and dumping can be minimised. So the surveying and sampling was done from all over the place and the detailed analysis was carried out for the solid waste management and to find a proper place for safe dumping of waste which is being generated now a days. Doubtlessly we all agree that municipal solid waste management (MSWM) is one of the major environmental problems throughout the world. Very few indices are developed so for to quantify the impacts of different waste management activities. Kumar and Alappat (2003) developed a technique to quantify the leachate contamination potential of sanitary landfill on a comparative scale in terms of the leachate pollution index(LPI). Landfill site selection is one of the important tasks for MSWM planners. Air, water and soil pollution from the unscientifically selected disposal sites have been well known fact (Kumar and Alappat, 2005). Central Pollution Control Board (CPCB) under the Ministry of Environment and Forest (MoEF) with National Environmental Engineering Research Institute (NEERI), Nagpur, India has developed a technique to quantify the suitability of site for sanitary landfilling on a comparative scale in terms of the Site Sensitivity Index (SSI) (CPCB, 2003). The SSI is an increasing scale index, wherein a lower value indicates that site has less sensitivity to the impacts (Preferable) and higher value indicates that site has high sensitivity to the impacts (Undesirable). The SSI has many possible applications including ranking of potential landfill sites, prioritization of management plan initiatives and public information. CPCB (2003) reported comparison and rankings of two potential municipal sites at Kannahallo and Seegehalli in Banaglore based on SSI estimation following this approach, Ohri and Singh (2009) attempted evaluation of two possible sites (Padaw and Karsada) in Varanasi for landfill. For MSW the landfill site selection index (SSI) is an aggregated value based on 32 attributes and their relative significance. Hence for calculating SSI, values of all 32 attributes are to be ascertained regardless of their high or low weight.

2. METHODOLOGY ADOPTED

The main concerned agency CPCB had selected a set of 32 attributes for the calculation of an integrated index for ranking of municipal solid waste disposal sites. The selected attributes are grouped into7categories viz accessibility, receptor, environmental, socioeconomic, waste management practices, climatological and geological. Sensitivity Index is a scale indicating degree of sensitivity of individual attribute. This scale ranges from ‘0’ (indicating low or very less potential hazard) to ‘1’ (indicating a high potential hazard). Thus, for each attribute a four level sensitivity scale (00.25, 0.25-0.50, 0.50-0.75 and 0.75-1.00) has been considered. A numerical value called weight has been assigned to each category, in accordance with the relative magnitude of impact using a pairwise comparison technique.Within a category, the weight of each attribute is assigned by following the same procedure of pair wise comparison. A total of 1000 point weights are assigned to all the 32 attributes grouped into 7 categories as shown in Table1.

Table 1: Attributes and calculation of site sensitivity index for land filling (CPCB 2003)

Sr. No.	Attribute	Wts.	0.0-0.25	0.25-0.5	0.5-0.75	0.75-1.0
Accessibility Related (No of Attributes 2, Total Weight 60)						
1	Type of road	25	National highway	State highway	Local road	No road
2	Distance from collection area	35	< 10 km	10-20km	20-25km	>25 km
Receptor Related (No of Attributes 8, Total Weight 250)						
3	Population within 500 meters	50	0 to 100	100 to 250	250 to 1000	>1000
4	Distance to nearest drinking water source	55	> 5000 m	2500 to 5000m	1000 to 2500 m	<1000 m
5	Use of site by nearby residents	25	Not used	Occasional	Moderate	Regular
6	Distance to nearest building	15	> 3000 m	1500 to 3000 m	500 to 1500 m	<500 m
7	Land use / Zoning	35	Completely remote (zoning not applicable)	Agricultural	Commercial or industrial	Residential
8	Decrease in property value with respect to distance	15	> 500 m	2500 to 5000m	1000 to 2500 m	<1000 m
9	Public utility facility within 2 km	25	Commercial and industrial area	National heritage	Hospital	Airport
10	Public acceptability	30	Fully accepted	Acceptance with suggestions	Acceptance with major changes	Non Accdeptance

Environmental Related (No of Attributes 7, Total Weight 305)						
11	Critical environment	45	Not a critical environment	Pristine natural areas	Wetlands, flood plains, and preserved areas	Major habitat of endangered or threatened species
12	Distance to nearest surface water	55	> 8000m	1500 to 8000m	500 to 1500m	< 500 m
13.	Depth to ground water	65	> 30m	15 to 30m	5 to 15m	< 5m
14	Contamination	35	Air, water or food contamination	Biotacontamination	Soil contamination only	No contamination
15	Water quality	40	Highly polluted	Polluted	Potable	Confirming to standard
16	Air quality	35	Highly polluted	Polluted	Confirming to industrial standards	Confirming to residential standards
17	Soil quality	30	Highly contaminated	Contaminated	Average	No contamination
Socioeconomic Related (No of Attributes 4, Total Weight 110)						
18	Health	40	No problem	Moderate	High	Severe
19	Job opportunities	20	High	Moderate	Low	Very low
20	Odour	30	No odour	Moderate odour	High odour	Intensive foul odour
21	Vision	20	Site not seen	Site partly seen(25 %)	Site partly seen (75%)	Site fully seen
Waste Management Practice Related (No of Attributes 2, Total Weight 85)						
22	Waste quantity/ day	45	< 250 tons	250 to 1000 tons	1000 to 2000 tons	> 2000 tons
23	Life of site	40	> 20 years	10-20 years	2-10 years	< 2 years
Climatological Related (No of Attributes 2, Total Weight 40)						
24	Precipitation effectiveness index*	25	< 31	31 to 63	63 to 127	>127
25	Climatic features contributing to Air pollution	15	No problem	Moderate	High	Severe
Geological Related (No of Attributes 7, Total Weight 150)						
26	Soil permeability	35	$>10^{7}$ cm/sec	10^{5} to $1x10^{7}$ cm/sec	$1x10^{3}$ to $1x10^{5}$ cm/sec.	$< 1 x10^{3}$ cm/sec.
27	Depth to bedrock	20	> 20m	10 to 20m	3 to 10 m	< 3m
28	Susceptibility to erosion and runoff	15	Not susceptible	Potential	Moderate	Severe
29	Physical characteristics of rock	15	Massive	Weathered		Highly weathered
30	Depth of soil layer	30	> 5 m	2-5m	1-2m	< 1m
31	Slope pattern	15	< 1%	1-2%	2-5%	>10%
32	Seismicity	20	Zone 1	Zone II	Zone III	Zone IV&V

*Precipitation effectiveness index is the ratio of annual precipitation to annual evaporation.

After doing the calculations based on this table the decision criteria was established as shown in Table 2.

Table 2: Decision criteria for a landfill site selection (CPCB, 2003)

Total Score of SSI	Site Description
< 300	Less sensitive to the impacts (Preferable)
300 to 750	Moderate
>750	Highly sensitive to the impacts (Undesirable)

3. OBSERVATION AND CALCULATION

The brief summary about the place and studies has been given previously. The current practice on is still that of open dumping at Dharni ka Bagicha which is against norms and regulations. So it was necessary to find an alternative place for this purpose also. Looking at the surrounding one such place was found near Bharial (near Taradevi) where the space and volume available was enough to accommodate the waste for a long time. The Table 3 gives the observations made for the site at Dharni ka Bagicha as shown below:

Table 3: Development of site sensitivity index (Dharni ka Bagicha)

Sr. No.	Attribute	Attribute Measurement	Sensitivity Index	Wt.	Score
Accessibility Related (No of Attributes 2, Total Weight 60)					
1	Type of road	Local road	0.6	25	15
2	Distance from collection area	<10 km	0.12	35	4.2
Receptor Related (No of Attributes 8, Total Weight 250)					
3	Population within 500 meters	0-100	0.07	50	3.5
4	Distance to nearest drinking water source	<1000 m	0.85	55	46.75
5	Use of site by nearby residents	No	0.01	25	0.25
6	Distance to nearest building	<500 m	0.09	15	1.35
7	Land use / Zoning	remote	0.20	35	7
8	Decrease in property value with respect to distance	2500-5000 m	0.40	15	6
9	Public utility facility within 2 km	National heritage	0.80	25	20
10	Public acceptability	With major changes	0.7	30	21
Environmental Related (No of Attributes 7, Total Weight 305)					
11	Critical environment	Pristine, natural area	0.40	45	18.0
12	Distance to nearest surface water	<500 m	1.0	55	55
13.	Depth to ground water	10-15 m	0.65	65	42.25
14	Contamination	Air, Water	0.70	35	24.5
15	Water quality	Highly Polluted	0.80	40	32
16	Air quality	polluted	0.60	35	21
17	Soil quality	contaminated	0.60	30	18
Socioeconomic Related (No of Attributes 4, Total Weight 110)					
18	Health	Moderate	0.50	40	20
19	Job opportunities	moderate	0.30	20	6
20	Odour	Moderate	0.60	30	18
21	Vision	partial	0.6	20	12
Waste Management Practice Related (No of Attributes 2, Total Weight 85)					
22	Waste quantity/ day	< 250 tons	0.04	45	1.8
23	Life of site	10 years	0.6	40	24
Climatological Related (No of Attributes 2, Total Weight 40)					
24	Precipitation effectiveness index*	<127	0.60	25	15
25	Climatic features contributing to Air pollution	moderate	0.40	15	6
Geological Related (No of Attributes 7, Total Weight 150)					
26	Soil permeability	10^{-3} to 10^{-5} cm/sec	0.40	35	14.0
27	Depth to bedrock	3-10 m	0.60	20	12
28	Susceptibility to erosion and runoff	Potential	0.30	15	4.5
29	Physical characteristics of rock	Weathered	0.40	15	6
30	Depth of soil layer	>5 m	0.6	30	18.0
31	Slope pattern	1-2%	0.40	15	6
32	Seismicity	Zone IV	0.90	20	18

Grand Total = 517.1

The Table 4 gives the observations made for the site near Bharial (near Taradevi) as shown below:

Table 4: Development of site sensitivity index (Landfill site near Bharial (near Taradevi))

Sr. No.	Attribute	Attribute Measurement	Sensitivity Index	Wt.	Score
Accessibility Related (No of Attributes 2, Total Weight 60)					
1	Type of road	Local road	0.6	25	15
2	Distance from collection area	<10 km	0.12	35	4.2
Receptor Related (No of Attributes 8, Total Weight 250)					
3	Population within 500 meters	0-100	0.1	50	5
4	Distance to nearest drinking water source	<1000 m	0.90	55	49.5
5	Use of site by nearby residents	Not used	0.01	25	0.25

6	Distance to nearest building	<500 m	0.80	15	12
7	Land use / Zoning	Completely remote	0.20	35	7.0
8	Decrease in property value with respect to distance	<1000 m	0.40	15	6
9	Public utility facility within 2 km	Hospital	0.60	25	15
10	Public acceptability	Not accepted	1.0	30	30
Environmental Related (No of Attributes 7, Total Weight 305)					
11	Critical environment	Pristine, natural area	0.40	45	18
12	Distance to nearest surface water	<500 m	0.9	55	49.5
13.	Depth to ground water	15-30 m	0.50	65	32.5
14	Contamination	Air, Water	0.70	35	24.5
15	Water quality	Polluted	0.80	40	32
16	Air quality	Highly polluted	0.90	35	31.5
17	Soil quality	contaminated	0.7	30	21
Socioeconomic Related (No of Attributes 4, Total Weight 110)					
18	Health	severe	0.80	40	32
19	Job opportunities	moderate	0.50	20	10
20	Odor	Intensive foul	0.90	30	27
21	Vision	partial	0.70	20	14
Waste Management Practice Related (No of Attributes 2, Total Weight 85)					
22	Waste quantity/ day	< 250 tons	0.04	45	1.8
23	Life of site	>20 years	0.25	40	10
Climatological Related (No of Attributes 2, Total Weight 40)					
24	Precipitation effectiveness index*	>127	0.60	25	15
25	Climatic features contributing to Air pollution	No Problem	0.40	15	6
Geological Related (No of Attributes 7, Total Weight 150)					
26	Soil permeability	10^{-3} to 10^{-5} cm/sec	0.40	35	14.0
27	Depth to bedrock	3-10 m	0.60	20	12
28	Susceptibility to erosion and runoff	Moderate	0.30	15	4.5
29	Physical characteristics of rock	Weathered	0.50	15	7.5
30	Depth of soil layer	>5 m	0.60	30	18
31	Slope pattern	1-2%	0.40	15	6
32	Seismicity	Zone IV	0.90	20	18

Grand Total = 538.75

4. ANALYSIS

After doing the calculations and keeping all 32 attributes in mind the results show that the grand total for Dharni ka Bagicha site is 517.1 and for Bharial village site it is 538.75. The results are nearly equal as the places are not too far away from each other and for the two locations the parameters do not change very drastically, though as far as the impacts are concerned both are falling in the range of moderate effects. It is surprising that the current site has less aggregate than the alternative site but the former is clearly violating the norms can not used as it can deteriorate the water quality of river very drastically and adversely. Second option can be used but as it can be seen from the table that it is not being liked by the local population at all and it is just beside the road which is also not very good idea. So the analysis part does not favour either of the options.

5. CONCLUSIONS

- The comparative analysis does not support either of the options.
- The current site can not be used at all in the present circumstances.
- Somehow the alternative available at the moment is not favoured by the analysis but it has to be adopted to save the river, the nearby areas and for the lack of suitable options.
- As for the public protest the administration should look for the changes which can be implemented to make it acceptable.

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