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Solid Waste Disposal Site Selection for Bareilly District, India Integrating GIS And Risk Assessment

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Abstract: Open dumping is the most common method of solid waste disposal in many developing countries including urban areas. Appropriate landfill site selection is important to minimize negative impacts associated with open dump sites. Landfill siting is an extremely difficult task to accomplish due to strong public opposition and regulations. Developing countries do not have a systematic process for landfill site selection and hence unsuccessful landfill sitting leading to environmental degradation is typically the result especially in the developing world. Selection criteria include engineering, environmental and economic criteria. Geographical Information System(GIS) is a framework for storage, maintenance, management and analysis of geographical data and it has beendesigned for working with data that has spatial and descriptive dependency.No site selection study focusingon waste disposal has been performed in Bareilly town of Uttar Pradesh, India , which is located at 250 Km East of Delhiand have a population of over 9.5 lakh people and total waste production ofapprox.129813Metric tons per year. This study hasbeen done using Guidelines for Selection of site on different factors in which criteria such as distance from residential areas,distance from roads, land use, distance from ground water, distance from faults, geology, distance from sensitiveecosystems, etc. were used and after data geo referencing, the weighting of the criteria and adjusting them with the geographical features of the area, data overlaid and finally three locations proposed for landfill were introduced in Bareilly town. Among the proposed areas, one was selected as the best location according to thehypotheses. The obtained results of this study may be helpful for policy makers of Bareilly town.Data were collected from Bareilly district, India

Keyword: Solid Waste, Landfill Site Selection,BMC, Analytic Hierarchy Process ,GIS.

I. INTRODUCTION

The solid waste is rising in Bareilly Municipal Area.An increase in solid waste is observed because of increase in urbanization, population density and income, changing food habits, taste and pattern. The growth of industry, commercial units such as hotels, theaters, restaurants, malls are rising fast. Such units are positively contributing to the solid waste generation. There are 37 out of 70 wards Door to Door waste collection is being done by Bareilly Municipal Corporation, No segregation at source and disposal facility of Bareilly Municipal Corporations is nil because of Municipal Solid Waste Treatment Facility is not functioning and only dumping of waste is the final disposal of waste without treatment. At present open dumping at Bakarganjduming site is continuing and the site is situated nearby the community area and over exhausted.Therefore Bareilly Municipal Corporation must adopt scientific methods for collection, segregation and disposal of solid waste and proposed new site for treatment & Landfilling for Municipal Solid Waste.Urgent steps in this direction will reduce the water, air, soil pollutions and health hazards. It will improve the quality life of people nearby the site of Bakarganj Dumping site. Leachate generation due to open dumping is polluting the ground water and also creating the health problem for residents of that area.

II. MATERIALS AND METHODOLOGY

Bareilly Municipal Corporation area is located at 28°10′N, 78°23′E, and lies in northern India. It borders Pilibhit and Shahjahanpur on east and Rampur on west, Udham Singh Nagar (Uttarakhand) in north and Badaun in south and area coverage of about 106.10 sq km (**Figure 1)**

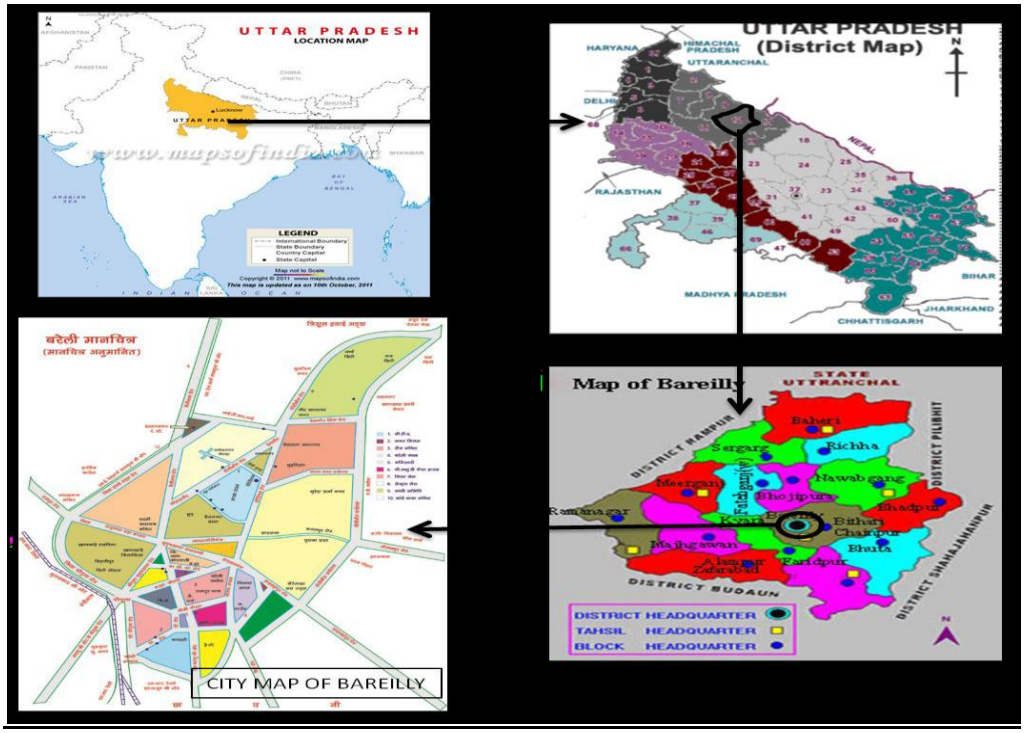


Fig-1 Location Map

Bareilly lies entirely in the Ganges plains. The low-lying Ganges plains provide fertile alluvial soil suitable for agriculture. However, these some lower part of plains is prone to recurrent floods. Bareilly lies on the bank of river Ramganga and there are seven rivers passing through this district. The lower Himalayan range is just 40 km from it and it lies in north of it. Bareilly is a city in Bareilly district in the northern Indian state of Uttar Pradesh. The city is 252 kilometres (157 mi) north of the state capital, Lucknow, and 250 kilometres (155 mi) east of the national capital, New Delhi. Bareilly is the fourth city in Uttar Pradesh with compressed natural gas (CNG) filling stations (after Lucknow, Kanpur and Agra).

The Temperature of Bareilly ranges between 30°C and 42°C, and the rainfall ranges between 600 mm and 1000 mm and annual mean of 750 mm. The population of the town has been estimated to be about 9,40,895 [7]. Most recently the increase in population as well as the economic growth in the study area has transformed and urbanized the area and led to Change in landuse and a substantial increase in municipal solid waste generated. Solid waste management system in the town is not effective as wastes are seen dumped on all manner of places including roads, near sensitive areas, and on private properties. It is therefore of importance that solid waste collected are properly disposed at designated sites in the city in order to avoid environmental degradation. In locating proper sites (Landfills), consideration is giving to environmental factors mainly to avoid environmental risk. Again landfill site should be located far from residential areas and settlement. The site should be away from areas that are susceptible to flooding, as this could result in washout of disposal waste into groundwater or stream and would pose risk to human health, the local aquifer [8] and the environment. Other factors relating to land use, roads, slope, wind direction etc are considered in locating a risk free and environmentally friendly waste disposal site. These spatial information and other related factors have been used in identifying and selecting landfill site in Bareilly.

Recent research work on the application of GIS for the siting of waste disposal sites include [9,11,12] and [13]. Landfill siting basically considers multiple data and from different sources as may be observed in the next segment of data collection and processing.

Qualitative research generally involves interactive and participatory methods of data collection; strong emphasis is given to the need for the researcher to build report with the participants and involvement of the participant in the discussions.The study was undertaken from November 2015 to April 2016. The study was developed to understand the solid waste management system in an urban settlement in a developing country framework in order to suggest ways the system might achieve higher level of sustainability. It have examined in depth the nature and features of the system and problems associated with it. In order to gain knowledge of the system being studied, interviews were conducted in conjunction with other methods for obtaining qualitative data. The main approach employed for this study is a qualitative case-study, Bareilly Municipal Corporation, India. The case study approach allows use of inductive methods, such as interviews, focus group discussions, which allows for general conclusions to be drawn from particular facts. This research helps in unraveling the

problems related to solid waste management in Bareilly, which in turn provides direction for people to change the system towards greater sustainability.

2.2 Data collection and analysis

Data collection of the study started with discussion with Municipal Corporation, Bareilly Development Authority, UPPCB, Town & Planning Department were used to extract the following information layers of the town: the Land use which comprise of residential areas, settlement, roads, water bodies, groundwater, commercial areas, sensitive areas, recreation, educational institution, agricultural, etc. Others are slope from the contour intervals as extracted from the topographic maps, rainfall data, wind direction and speed, and soil. The geographic data and features required for the preliminary stage of the screening of the sites are extracted using ArcGIS processing software, the primary processing steps are describe below.

The following procedures were used to ascertain needed digital thematic maps:

- Scanning of the primary maps available
- Review the Bareilly Master Plan 2021 for proposed land for Landfill site.
- Inspection of available land with Municipal Corporation and BDA
- Georeferencing the scanned maps based on the ground coordinates collected through ground truth.
- On screen digitizing of the primary maps, were done in order to generate the digital thematic maps, each representing the influencing factor for landfill site selection.
- Locating the global positioning system (GPS) co-ordinates and entering in the database as latitude and longitude with nearest water bodies as per the CPHHEO.
- Link the data with guidelines for selection of site on different factors.

1. Accessibility to the site
2. Receptor related
3. Environmental Related
4. Socio-economic
5. Waste Management Practices related
6. Climatological Related
7. Geological Related

2.3Sitting Criteria

Selection of site is a very important process for a successful operation of a waste disposal using landfill method. Landfill involves an extensive evaluation process in order to identify the optimal available disposal location. This location must satisfy basic government regulations, and also take into cognizance how to minimize important factors like health, economic, environmental and social cost [13]. In fact, different researchers have used varying criteria for site selection purposes due mainly to the fact that different criteria applies to different region and all to the fact that different criteria applies to different region and allfacilities [14,15].

Evaluation criteria such as water permeability, depth of the underground water table, and distance from rivers, distance from residential areas, and distance from roads, slope, and wind orientation were considered in [11]. In another study, the land slope, soil characteristics, depth to groundwater, surface water, environmentally rare or endangered species breeding areas, distance to residential, religious and archaeological sites, land use, major infra-structure systems (e.g. electric transmission lines, water or sewer pipelines), seismic activity, land cost, distance from high way, distance from waste generation source, site capacity, distance from air port run way [9] were used. However, addition factors to the aforementioned may be considered based on the local conditions and circumstances [9] or may be modified based on the geo-graphic and demographic constraints of the research area [16].

In this study, criteria considered were based on MSW rule 2016 and discussion with all Government departments. The selection of waste disposal site was carried out through some screening process. However most of the data and spatial information are in the analogue or hardcopy format. In order to determine landfill suitability analysis data layers were converted from one form to the other, e.g. vector to raster. Site Inspection& Site sensitivity index is the main specific tool for the selection of site.

Site Sensitivity Index (Table-1)

Worksheet For Evaluation Of Sanitary Landfill Site					
Sl.No.	**Attributes**	**0.0-.025**	**.25-0.5**	**.5-.75**	**.75-1.0**
Accessibility Related					

1	Type Of Road	National Highway	State Highway	Local Road	No Road
2	Distance From Collection Point	< 10 Km	10-20 Km	20-25 Km	>25 Km
Receptor Related					
1	Population Within 500 Meters	0-100	100 To 250	250 To 1000	>1000
2	Distance To Nearest Drinking Water Source	> 5000 M	2500 To 5000	1000 To 2500	<1000
3	Use Of Site By Nearby Residence	Not Used	Occasional	Moderate	Regular
4	Distance To Nearest Building	>3000 M	1500 To 3000	500 To 1500	<500
5	Land Use/Zoning	Completely Remote	Agricultural	Commercial Or Industrial	Residential
6	Decrease In Property Value With Respect To Distance	>5000 M	2500 To 5000	1000 To 2500	<1000
7	Public Utility Facility Within 2 Km	Commercial And Industrial Area	National Heritage	Hospital	Air Port
8	Public Acceptability	Fully Accepted	Acceptance With Suggestions	Acceptance With Major Changes	Non Acceptance
Environmental Related					
1	Critical Environment	Not A Critical Environment	Pristine Natural Areas	Wetlands, Flood Plains And Preserved Areas	Major Habit Of Endangered Or Threatened Species
2	Distance To Nearest Surface Water	> 8000 M	1500 To 8000	500 To 1500	< 500
3	Depth To Ground Water	>30 M	15 To 30 M	5 To 15 M	<5 M
4	Contamination	Air, Water Or Food Contamination	Biota Contamination	Soil Contaminati on Only	No Contaminat ion
5	Water Quality	Highly Polluted	Polluted	Potable	Confirming To Standard
6	Air Quality	Highly Polluted	Polluted	Confirming To Industrial Standard	Confirming To Residential Standard
7	Soil Quality	Highly Contaminated	Contaminated	Average	No Contaminat ion
Socio-Economic Related					
1	Health	No Problems	Moderate	High	Severe
2	Job	High	Moderate	Low	Very Slow
3	Odour	No Odour	Moderate	High	Intensive Foul Odour
4	Vision	Site Not Seen	Site Partly Seen (25%)	Site Partly Seen (75%)	Site Fully Seen
Total					
Waste Management Practice Related					
1	Waste Quantity/Day	< 250 Tonnes	250-1000	1000-2000	>2000 Tonnes
2	Life Of Site	> 20 Years	10-20 Years	2-10 Years	< 2 Years
Climatologicallyrelated					
1	Precipitation Effectiveness Index	<31	31 To 63	63 O 1 2 7	>127
2	Climatic Features Contributing To Air Pollution	No Problem	Moderate	High	Severe
Total					
Geological Related					
1	Soil Permeability	>1x10-7 Cm/Sec	1x10-5 To 1x10-7	1x10-3 To 1x10-5	<1x10-3cm/Sec

			Cm/Sec	Cm/Sec	
2	Depth To Bedrock	> 20 M	10 To 20 M	3 To 10 M	< 3m
3	Susceptibility To Erosion & Run Off	Not Susceptible	Potential	Moderate	Severe
4	Physical Characteristic Of Rock	Massive	Weathered		Highly Weathered
5	Depth Of Soil Layer	>5m	2-5	1-2	<1m
6	Slope Pattern	<1%	1-2%	2-5%	>10 %
7	Seismicity	Zone 1	Zone Ii	Zone Iii	Zone Iv And V

There are 7 site were available with the Municipal Corporation and Other 4 site which has been proposed by Bareilly Development Authority under their Master Plan 2021. The entire Site has been visited and after obtaining the information about these sites, data put in the table. Main factors during site selection are given below-

2.3.1. Road Network Map

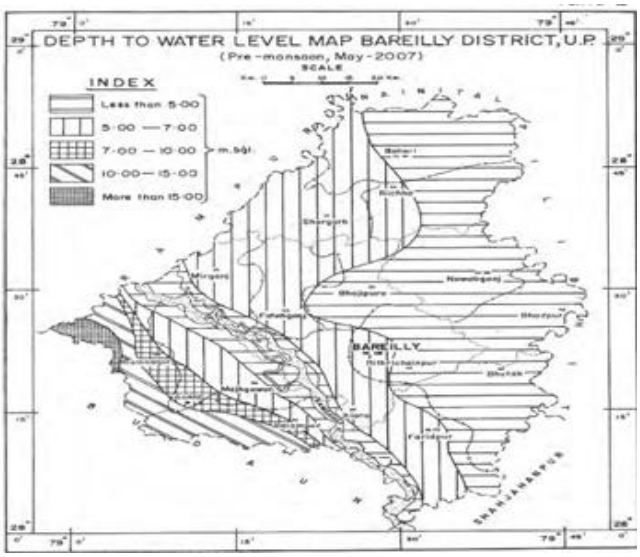
The road network map delineating the national highways and other major roads crisscrossing the town of Bareilly was prepared. There are four national roads high-ways passing through the town. The Bareilly-Lucknow road moving along the eastern part of the town, the Bareilly-Moradabad along the western part of the town, the Bareilly-Pilibhit road along the northern part and the Bareilly-Badaun road along the southern part of the town. Others are minor roads within the town.

2.1.2. Infiltration Map

An infiltration map was produced taking into cognizance the various soil types existing in the town. The infiltration rate is an important determinant in assessing the potential risk of contamination of groundwater and thus is a major criterion for the development of landfill in the study area. Bareilly town fall within the clay and granular material aquifers which remain exposed to continuous loss of rain, high evapotranspiration and less infiltration rate [20].

2.1.3. Groundwater Table Map

The groundwater table is said to be the distance between the ground surface and the water table. The depth of groundwater table is a significant parameter in determining the contamination risk of groundwater in order to limit potential contamination. Research has shown that precipitation, site topography and soil type affects the rate of infiltration into the water table [21]. From available data, it shows that the groundwater table is shallow as the depth ranges between 1.7 m and 15.0 m, with the exception of few areas where the water table is between 10 m and 30 m. Areas within 5 m distance from water table are considered to be unsuitable for siting landfills. Based on the analysis, suitability is found in areas greater than 5 m, that is, 5-15 m and 15-20 m as less and more suitable respectively.There are site like Bihar Man Nagla, Harunnagla, Rithura having water table between 5 to 7 meter and some site having water table between 10-15 m.



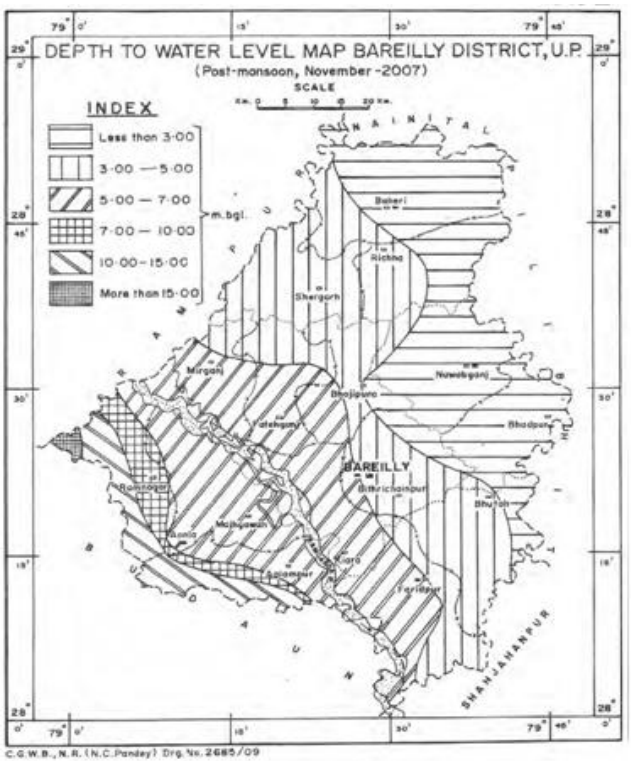


Fig -2 & 3 Water Table Map of Bareilly

2.1.4. Wind Orientation and Pattern

The wind orientation and pattern is not known to be subject to any legal restrictions but based on the premise that landfill site should not be in the direction of the wind [22]. It is also an established fact that the direction and velocity of winds vary with altitude, slope, aspect, and terrain roughness [23]. The site morphology, wind orientation frequency and pattern of the study area were taking into consideration when developing the site selection criteria. The morphological aspect was determined in degrees, and the wind frequency is in meters/seconds. The wind speed is generally highest (7.3 Km/hr) during the month of Junewhile it is lowest (2.2 Km/hr) during November, the average annual wind speed is 4.8
Km/hr.

2.1.5. Distance from Residential Areas

Research has shown that as the distance from residential areas increases, the issues of public opposition to siting of waste disposal facility diminishes [11,24]. It is as a result of this fact that the suitability of site increases as public opposition diminishes. The waste disposal sites should not be sited or located in populated urban or rural areas. It is for this reason that the residential areas were categorized into high dense, medium dense and low dense areas and digitized accordingly based on the development plan available of the study area. The extent of the residential areas were derived from reclassification, and distance of 500 m and above are considered as suit-able while 200 m and below were considered unsuitable. Hence the land suitability for landfill increases with the increase in distance from the residential areas. Some sites is very close to residential area like HarunNagla, Bihar man Nagla, Parsakhera, SaraiTalfiahmotoli and some having very far away from the residential like Babia.

2.1.6. Distance from Road Network

This criterion is concerned with the distance from the road network. The road network in the city consists of major roads, minor roads and others. The waste disposal sites should not be too close to the road networks [10, 25]. In deriving the roads layers, on-screen digitizing was performed in order to generate the vector layers and buffer of 600 m, 450 m, and 300 m is applied to the different road networks, and thereafter converted into raster format. After which roads within 450 m were considered unsuitable for the siting of landfills. In this situation the suitability decreases as the distance from road network increases. There are some area which is very close to National & State Highway and distance from the highway road is less than 500 m to 3000 m but it is very important to mentioned that accessibility road to accessible for Truck and dumper because if heavy traffic of vehicle to be come in the area.

2.1.7. Surface Waterbody

Generally, waste disposal areas must not be sited near rivers, lakes, ponds or swamps. As per MSW rule 2016 it is clearly stated that **"The landfill site shall be 100 meter away from river, 200 meter from a pond, 200 meter from Highways, Habitations, Public Parks and water supply wells"**dumping of solid waste on any water surface be it river, or lake is prohibited. However, a lake do not exist in the study area, hence this criterion was extended to take into cognizance other type of surface water like pond. Hence water body layer bearing the available pond is digitized and converted into raster format where distance of within 100 m from the pond was considered unsuitable, and further away as suitable. During it was found that Site location Babia is about 3 Km away from the Ramgangariver and other are very close to the river and water body.

Fig-4 BABIA

-5SaraiTalfiMustqil,

Fig-6PipariyaMustakil

2.1.8. Sensitive Areas

The sensitive sites layer was produced from on-screendigitization of areas of cultural and historical importance, these sites are exempted from landfill siting. This research considered as sensitive areas; Monuments, churches, Temple, islamic centre and graveyards and are therefore, restricted from siting landfill. In the Parsakhera (kahsra no 307 & 309), A Mazar and School is found nearby the site.

Parsakhera (kahsra no 307 & 309

Fig-1 Masjid

Fig-2 School

2.1.9. Precipitation (Rainfall)

The annual average rainfall data of the study area was collected and used in this study it which depicted the precipitation pattern of the study area which ranges between 750 mm and 1000 mm. Areas within 750 mm were adjudged to be suitable while areas above are not suitable for landfill siting.

III. RESULTS AND DISCUSSION

The study considered the use of decision rules for the location of suitable sites for solid waste disposal, and this has been with reference to research literature, study area criteria as well as multi-criteria evaluation procedure. To arrive at the major objective of this study the suitability of the sites were classified on the basis of criteria and sub-criteria. During the study and inspection of the sites, it was found that Babia site more suitable site for establish the Land fill site. A site is considered suitable for the locationcriteria such as; 450 m from roads, 500 m from residential, public amenity, agricultural land, administrative offices, and educational institutions. Others are 200 m away from recreational and commercial area, 500 m from sensitive sites. The suitability of sites must also satisfy the soil type land elevation or topography, wind direction, groundwater level, and rainfall criteria. A site is considered less suitable for solid waste disposal if it fulfil all the criteria of less suitable such as; as 1500 m from roads, 200 m from residential area, 300 m from commercial, administrative, educational, and sensitive sites. Other considerations are the soil type, land elevation or contour, topography, wind direction, groundwater level, and rain-fall. 12 sites were identified as those that fulfilled the required criteria but only Onesites met the land availability criteria of 20 hectares other sites having less land so that we can plan for 20 years Land fill site.

IV. CONCLUSIONS

The methodology employed in this study described the Site sensitivity Index and site inspection (include physical verification), the MSW generated in the Bareilly Municipal Corporation Area is 356 MT per day so the site must be require more land and all other site except Babia having less land than Babia. It is more suitable if treatment unit is also establish along with the Landfill site because establish MSW treatment facility is closed which is very close to the community area if this unit will be in operation, waste generation for Land fill will be very low. The techniques considered a number of siting criteria ranging from accessibility, land use, to natural factors which are very important in identifying as well as in locating sites which poses minimum or no risk to the environment. Finally, one sitewere selected for the management of solid waste in the study area. Research has shown that siting criteria can be modified based on local constraints, as such this study considered the available important criteria. Most of the data available and collected were in the analogue format hence most of the information was derived using the GIS techniques.

REFERENCES

[1]. A.B. Akolkar, A.K. Vidyarthi and B. Sengupta 2003 “Guidelines on the Selection of Site for Municipal Solid Waste Landfilling”

[2]. Zaveri C.2004. “Gorai Dumping Ground – An Urban Rejuvenation Project”.

[3]. M.P.Joshi, S.B. Patil&K.Mourya 2013 “Solid Waste Management on Dumping Ground in Mumbai Region – A Study”

[4]. Nigam Verma&Aditya N. Singh 2003 Quality Assurance & Quality Control in Landfill Management: An approach towards Long-term Environmental Protection”

[5]. Ayo Babalola, Ibrahim Busu 2010 “Selection of Landfill Sites for Solid Waste Treatment in Damaturu Town-Using GIS Techniques”

[6]. B M R S Balasooriya1*, M Vithanage2, N J Nawarathna3, Ken Kawamoto4, 5, M Zhang6, G B B Herath7, M I M Mowjood1 2014 “Solid Waste Disposal Site Selection for Kandy District, Sri Lanka Integrating GIS and Risk Assessment”

[7]. Er. Subhrajyoti Choudhury1, Er.Sujit Das 2012 “GIS and Remote Sensing For Landfill Site Selection- A CaseStudy on Dharmanagar Nagar Panchayet”

[8]. GenemoBerisaand YohanisBirhanu 2015 “Municipal Solid Waste Disposal Site Selection of Jigjiga Town Using GIS and Remote Sensing Techniques, Ethiopia”

[9]. Onuigbo, IfeanyiChukwudi& Bello, AbdulganiyuEtudaye 2014 “Assessment and Selection of Suitable Sites for Solid Waste Disposal using Surveying and Geoinformatics Techniques”

[10]. SahuAmiya Kumar, 2007. “Present Scenario of Municipal Solid Waste (MSW) Dumping Grounds in India”.

[11]. Rode Sanjay, 2000.Waste Management in Municipal Corporation of Mumbai Metropolitan Region.

[12]. Pradhan M. U., 2008, Sustainable solid waste management in a mountain ecosystem, Darjeeling, India.

[13]. Journal of Environmental and Resource Economics, 2001.

[14]. Journal of Environmental Economics and Management, 2005.

[15]. Journal of Environmental Assessment Policy and Management (JEAPM), 1999.

[16]. Frank K. and Tchobanoglous G., Handbook of Solid Waste Management. McGraw-Hill, 2002.

[17]. Garg. S. K, 2010, Environmental Engineering and Pollution Volume-I, Khanna Publishers.

[18]. Municipal Corporation Bareilly “Comprehensive plan for MSW and BMW 2015.

[19]. Municipal Solid Waste Management Rules 2016.

[20]. Choudhary N. 2007: "Sustainable Solid Waste Management", Proceedings of the international conference, Chennai, India.
[21]. Gautam A. and Pathak G.2011: "Assessment of ground water quality at Municipal Solid waste dumping site sewapura, Jaipur" Journal of solid waste technology and management, International conference on solid waste echnology and management, issue 1.
[22]. Lober D. 1996: "Informing the process and outcomes of recycling in the United States: the national municipal solid waste recycling symposium" Journal of solid waste technology and management, issue 4.
[23]. Muttamara S. and Sales C. 1996: "Solid waste recycling, disposal and management in Bangkok", Journal of solid waste technology and management, issue 4.

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