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Pollution abatement studies related to municipal solid waste management in India: Past and future scope (A GIS based case study)

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ABSTRACT

Municipal Solid Waste (MSW) management has been posing a major challenge to India due to rapid increase in urban population. Previously CPCB studies have been carried out on quantification and characterization of MSW, impact assessment on ground water, ambient air quality and health of the conservancy staffs and accordingly suggestions were also made for preparing the action plan at National level. The country is well equipped with the Rules/Regulation, planning, background data and possible financial resources to curb the MSW Menace; but the implementation part of the MSW Rules is taking place at a slower pace than expected. The role of entrepreneurs and other agencies could be invited preferably to keep momentum on implementation of the MSW schemes in accordance with the MSW Rules. Future relies on Geoinformatics Technology (GIS) based approach for effective and fast Municipal Solid Waste Management in India. Accordingly an innovative GIS based approach for identification of sites for setting up of Regional Landfill facilities in National Capital Region (NCR) viz., Delhi, Haryana, Rajasthan and Uttar Pradesh, India was carried out. This exercise is first of its kind to analyze the identified States in India for its feasibility in locating MSW Landfills with high accuracy.

KEYWORDS

Municipal solid waste (MSW);
Pollution abatement studies;
MSW management status;
Geological information system (GIS);
Landfill siting;
Central pollution control board (CPCB).

INTRODUCTION

Municipal Solid Waste (MSW) is defined to include refuse from the households, non-hazardous solid waste discarded by the industrial, commercial and institutional establishments, market waste, yard waste and street sweepings which are collected by the municipal authorities for disposal[1]. Wastes that arise from a typical urban society comprises of garbage, rubbish (package materials), construction and demolition wastes, leaf litter, hazardous wastes etc[2].

About 1.3×10^9 t of Municipal Solid Waste (MSW) was generated globally in 1990[3] and at present, the annual generation is 220.82 million metric tonne per year in 2012[4]. The urban population in Asia generates around 760×10^3 t of MSW per day, and this is ex-

pected to increase to 108 x 10^6 t by 2025[5]. The total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW[6].

Urbanization directly contributes to waste generation, and unscientific waste handling causes health hazards and urban environment degradation. Solid Waste Management, which is already a mammoth task in India is going to be more complicated with the increase in urbanization, changing lifestyles and increase of consumerism[7]. Municipal solid waste (MSW) is one of the challenges which all the local bodies are facing in India. Consequently, the management of the MSW needs to be revamped to accommodate the changes in the quantity and quality to ensure the longevity of the environment[8]. Following are the overview of the quantity of waste processed and number of disposal facilities in India;

Total Quantity Waste processed	: 308599 MT per day
Waste Processed in Semi Mechanized compost plant	: 86 Nos.
Vermi-compost	: 20 Nos.
Refuse Derived Fuel plants with energy recovery	: 2 Nos.
Refuse Derived Fuel Plants	: 2 Nos.
Total Wastes landfilled	: 193630 MT per day
Existing Landfills	: 24 Nos.

The Municipal Solid Wastes (Management and Handling) Rules, 2000 has mandated the urban local bodies to segregate, collect and transport the wastes for processing and scientific disposal to a designated site, often termed as Sanitary Landfill (SLF) site. Due to rapid urbanization coupled with sky-rocketing land prices, the urban bodies are finding it difficult to locate sites for Sanitary Landfill. Even the identified sites are facing stiff public resistance, resulting in vertical rise of garbage heaps posing threat to the environment. On an average, each Indian city/town operates 2 to 3 open dumping sites, and the National Capital Region, Delhi is no exception having three old landfill sites, which have already been saturated with garbage heaps.

The paper aims to self-assess the status of Municipal Solid Waste Management with particular reference to Landfilling taking into account CPCB studies on Pollution Abatement in the past and looks for a future scope on Geo-graphical Information System (GIS) approach for landfill siting. GIS has very distinguishing, a very powerful functions and can play an important role in decision making and planning process. "The most distinguishing parts of a GIS are its functions for spatial analysis, i.e. operators that use spatial data to derive new geoinformation. Spatial queries and process models play an important role in satisfying user needs. The integration of database, GIS software, rules, and reasoning mechanism (implemented as a so-called inference engine) leads to what is sometimes called a spatial decision support system (SDSS)"[9]. The attempt of Geoinformatics based approach was made to locate the regional landfill sites of National Capital Regions viz., Delhi, Haryana, Rajasthan and Uttar Pradesh in India which is environmentally suitable with no adverse effect on human life.

EXPERIMENTAL MATERIALS AND METHODS

Municipal solid waste generation & management in India: CPCB studies in the past

Central Pollution Control Board (CPCB), Ministry of Environment and Forests (MoEF), Government of India had undertaken a detailed survey on 59 cities in India to assess the status of solid waste management (SWM)[10]. The field studies included survey of SWM practice adopted by each city and assessing waste generation through weighment[11] exercise for five consecutive days. Physical and chemical analyses of solid waste samples were carried out for each city and a total number of 1156 samples were collected for analysis. The 59 cities selected for study covers 35 metro cities (cities with population more than one million) and 24 state capitals (having population ranging from 0.1 to less than a million).

Systematic data were not available on assessment of environmental quality and impacts viz., ground water quality, ambient air quality around the landfills in cities and towns. A selected landfill site of 2400 tons day^{-1} solid waste was considered for the CPCB study on quantitative methane measurement. Gas samples were collected fort-nightly during June-November 2004 using closed chamber technique and subsequently analyzed using gas chromatograph fitted with Flame-Ionization Detector (FID) to estimate the methane (CH_4) flux. Studies were also carried out for assessment of ground water quality and methane emission at landfill

sites of Delhi. The study on the assessment of health status of conservancy staffs and other communities associated with MSW management was carried out by CPCB at Kolkata[12] and Chennai.

MSW rules and regulations with particular reference to landfilling in India

Municipal Solid Wastes (Management and Handling) Rules, 2000 was framed under the Environment (Protection) Act, 1986 for the first time in the country, which has laid comprehensive specifications on management and handling of wastes. Schedule III of these Rules has laid down criteria for site selection for landfilling, facilities to be provided at the site, operating specifications, pollution prevention, water and air quality monitoring at the site, plantation and closure of site and post-care. Besides, rules specifying details on landfills, standards have been prescribed for composting, treatment of leachate from compost plants, landfills and Incineration too.

Future scope: Geo-informatics approach for landfill siting – A case study

To make the MSW disposal through landfilling a successful method, GIS based Landfill siting was attempted in National Capital Region, which is to be followed in future by other cities in India. Geo-graphical information system (GIS) and Remote Sensing (RS) is a very useful method used for selection of landfilling sites at the regional level based distance criteria. The detailed information regarding the method used for selection of the available site which satisfies the decided criteria are given below.

Study area and methodology

The study area is the National Capital Region (NCR) which comprises an area of 33,578 sq. km, covering the states of Haryana (13,413 sq km), Uttar Pradesh (10, 853 sq km), Rajasthan (7,829 sq km) and the National Capital Territory of Delhi (1,483 Sq Km) with a population density of 1,105 persons/sq km. The part of Haryana includes districts of Panipat, Sonipat, Rohtak, Jhajjar, Rewari, Gurgaon, Mewat and Faridabad and covers an area of 13413 Sq.Km. Rajasthan includes district Alwar and covers an area of 7,829 Sq.Km. Uttar Pradesh includes districts of Baghpat, Meerut, Ghaziabad, Gautambudh Nagar and Bulandshahar and covers an area of 10,853 Sq.Km. The National Capital Territory of Delhi covers an area of 1,483 Sq.Km.

Indian remote sensing satellite data was procured for the study area called NCR. Settlement and Road-rail linkages were mapped using the remote sensing satellite data and available natural resources by image interpretation technique. Mapping was carried out for entire NCR area. Distance based criteria was applied for habitat, various infrastructure and various environmentally sensitive features in the study area. Required information created using the geo-informatics technology as well with the secondary information collected. The information collected and generated was analyzed based on the over lay and buffer technique in the GIS environment. The flow sheet depicting the above methodology used to generate the data is given in figure 1.

RESULTS

Municipal solid waste generation & management in India: CPCB studies in the past

The main objective of the survey was to assess the compliance status of 59 cities with the Municipal Solid Wastes (Management and Handling) Rules, 2000 (MSW Rules) and initiatives taken by the municipalities for improving Solid Waste Management (SWM) practices. The results of the survey on 59 cities in India to assess the status of solid waste management (SWM) with details on quantities of waste generation and population ranges are given in TABLE 1.

It has been observed that per capita of waste generation rate and quantities of waste generation differ from city to city and do not have correlation with population. A maximum of per capita waste generation rate has been reported for the city of Kochi (0.67 kg capita^{-1}day^{-1}) and whereas, waste generation as low as 0.17 - 0.19 kg capita^{-1}day^{-1} were observed at Kohima, Imphal and Nashik. As per the weighment exercise conducted, 35 metro cities generate wastes of 36,353 Metric Ton day^{-1} and remaining 24 towns are generating waste of 2678 MT day^{-1}. Waste characterization study in respect of 59 cities has indicated that after segregation, the waste could be utilized for composting and for biogas generation. The physical and chemical characteristics of wastes are summarized in TABLE 2.

Except larger cities, local bodies of medium and smaller towns have not undertaken regular exercises

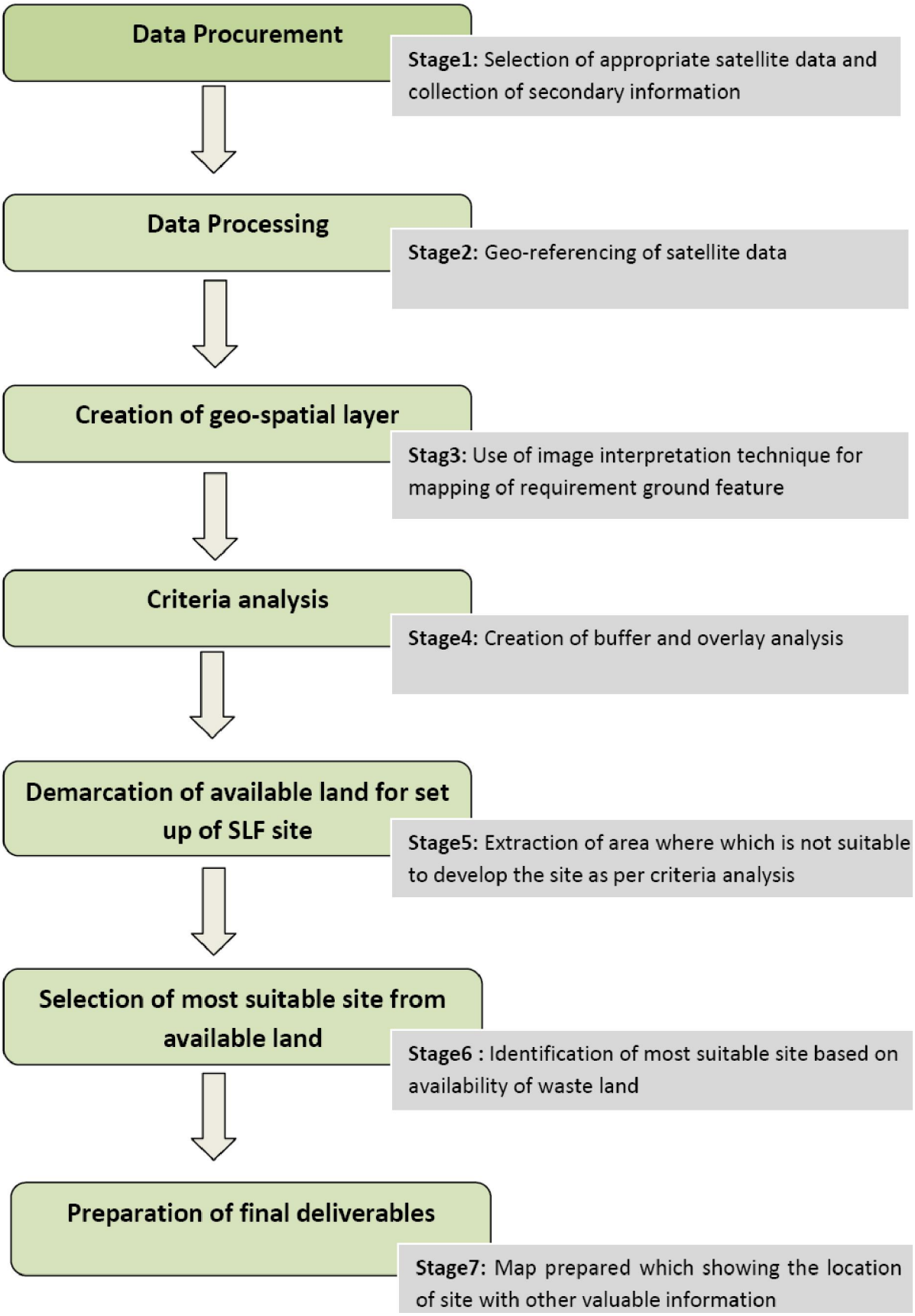

Figure 1 : Methodology of GIS based landfill siting

TABLE 1 : Status of solid waste generation

Sr. No.	Number of Cities Surveyed	Population Range	Area of City (sq. Km.)	Quantity of Waste Generation (Ton/Day)	Waste Generation Rate (kg/capita/day)
1	8	10,119-99,984	4-69	3-76	0.17-0.76
2	11	132,867-475,439	10-127	39-207	0.19-0.59
3	16	595,575-982,904	52-341	166-584	0.20-0.67
4	11	1,055,938-1,474,986	64-286	200-735	0.19-0.53
5	13	2,052,066-11,978,450	112-1483	475-5922	0.22-0.62

TABLE 2 : Physical and chemical characteristics of solid wastes

Parameters/ constituents	Range of parameters (59 cities)	Average Values (59 Cities)
Compostable (%)	29-72	51.30
Recyclables (%)	12-36	17.48
C/N Ratio	14-52	28.61
Moisture content (%)	17-65	51.37
HCV (Kcal kg^{-1})	520-3766	1746.76

on quantification and characterization of wastes. Since the waste segregation is not practised, it is becoming difficult to set up adequate composting plants and other processing facilities. Entire waste generated by the cities is disposed through open dumping. Further, inert content in MSW is also high (average 22%). Street sweeping, construction and demolition debris are quite often mixed with the wastes. In future, to reduce the burden on landfills, local bodies would be required to set up effective segregation system.

The scenario of setting up of waste processing facilities by the local bodies is not very satisfactory. As many as 86 compost plants of processing capacity of range 50 - 500 TPD are set up in the country. These plants are based on aerobic windrowing with semi-mechanized system for waste handling. Rejects of these plants are either stored in own premises or disposed off through open landfilling. The Compost produced is not popular amongst the farmer community as it is not considered to be a substitute or a suitable alternative for fertilizers in agriculture. Further, compost produced is not regularly monitored for its compliance with prescribed standards under the MSW Rules[13]. Waste-to-energy projects particularly using garbage as Refuse Derived Fuel (RDF) is practiced in selected cities and there exists only three such plants in India viz., Hyderabad, Vijayawada and Lucknow.

There exists various types of MSW treatment technology option, however sanitary landfilling is the final and environmentally sound disposal method of municipal solid waste. Studies carried out by CPCB on assessment of groundwater quality around landfill sites in a few cities have indicated that there has been some impact on groundwater quality due to geogenic or anthropogenic reasons[14]. However, the findings are further taken up for confirmation through detailed investigation[15]. Further, ambient air quality around landfill sites has not been studied extensively. Attempts have been made by CPCB to assess methane emission at landfill sites of Delhi[16]. The studies on the quantitative measurement of CH_4 flux revealed that the Methane flux was maximum in June (37.14 g $m^{-2}d^{-1}$) at heap temperature 36^0C and was minimum (8.62 g $m^{-2}d^{-1}$) in November at 23^0C heap temperature[17]. It is worthwhile to mention that landfill sites in India are not notified as prohibited areas and large number of conservancy staffs and rag-pickers work on these open dump sites. Many economically weaker communities live around dump sites. The study, first-of-its-kind on assessment of health status of conservancy staffs and other communities associated with MSW management has clearly indicated that persons engaged in MSW management especially in disposal as well as rag-pickers of the city were reported to be suffering from array of respiratory, gastrointestinal, dermatological, hematological, immunological and neurobehavioral problems along with depleted antioxidant level.

The present practices adopted by local bodies are very crude and sites are not well maintained. Each city and town is having one or more sites. Such sites are not notified and often remain unprotected. Moreover, there is no criteria followed for selection of sites for landfilling, as a result, there are always public grievances and even attract Public Interest Litigations (PILs). Further, huge area of land is occupied for disposal of wastes. Availability of site depends on land allocation by the Town and Country Planning Department or Development Authorities of that city or town. By and large, the currently

operated sites do not meet the "Siting Criteria" as prescribed under the MSW Rules[18]. According to CPCB survey, majority of landfill sites do not have approach road, inspection facility to monitor quantity of waste received, weigh-bridge, drinking water for staffs and safety provisions to prevent fire hazards and health of the staffs. After day-to-day activities of landfilling operation, daily cover of soil is not provided. None of the site possesses leachate collection and treatment facilities. Venting system of landfill gases (LFG) is not provided and these landfill sites are experienced with bad odors.

MSW rules and regulations with particular reference to landfilling in India

Prior to notification of the Municipal Solid Wastes (Management and Handling) Rules, 2000 (MSW Rules) in India, management of municipal solid waste was performed under the State Municipal Corporation and Municipal Acts. The State Acts were primarily focusing on the activities on solid waste management under the 'Sewage' and 'Sanitary' provisions. The emphasis was on cleansing of streets, removal of refuse, collection of wastes, provision of temporary deposit etc, but none of the State Acts has been addressing on method to be followed for proper treatment and disposal of solid wastes in a scientific manner to protect the environment and health.

As per MSW Rules, each local body is required to set up waste processing and disposal facility. Thus local bodies will have to move progressively from open dumping to sanitary/engineered landfills. However, there has not been any fixed time schedule to achieve this target. There are 4377 local bodies in the country and each one of them has to comply with MSW Rules. It has also been observed that smaller local bodies having population of less than 50,000 population and waste generation less than 50 tons day^{-1} are also required to follow same specifications as compared to bigger cities where population is more than a million and generating waste more than 1000 tons day^{-1}. In view of the requirement of the MSW Rules, there appears to be a good scope for Private Entrepreneurs to venture in setting up of waste processing and in operation of landfills on contract (Build Own & Operate/ Build Own, Operate & Transfer) basis. Yet, the issue that how far this business would be economically profitable, needs proper assessment and particularly with reference to financial status of local bodies. Further, attempts would also be required to set up joint or common landfill facilities by the local bodies wherever feasible. Such offer will reduce burden of local bodies to identify sites on individual basis.

Future scope: Geo-informatics approach for landfill siting – A case study

Scarcity of land for waste disposal and inappropriate landfill site is one of the biggest problems in most of large urban areas in India which has its negative impact on environment[19]. The spurt in urbanization in past few decades with urban growth rate increasing from 45.87 during 1971-1981 to 56.25% during 1991-2001, in addition to urbanizing the large number of rural areas has posed several associated environmental problems. The data on solid waste generation at NCR region is provided at TABLE 3.

The National Capital Region (NCR) Map covering an area of 33578 Sq km which includes parts of

TABLE 3 : Municipal solid waste generation at NCR

NCR	MSW Generation (MT/day)	
	Year 2001	Year 2021
NCT-Delhi	9,488	15,413
Haryana	1,540	4,569
Rajasthan	201	1,116
UttarPradesh	2,270	6,138
Total	13,499	27,236

Haryana, Rajasthan and Uttar Pradesh besides the entire NCT of Delhi is shown in figure 2.The map shows the extent of land feature and available infrastructure in NCR. The selection of the area is as below;

- The National Capital Territory of Delhi (1483 sq. km)
- Haryana Sub-region: Faridabad, Gurgaon, Rohtak, Sonepat, Rewari, Jhajjar, Mewat & Panipat districts.
- Rajasthan Sub-region: Alwar District.
- Uttar Pradesh Sub-region: Meerut, Ghaziabad, Gautam Buddha Nagar, Bulandshahr & Baghpat districts.

The issue of landfill site selection was complicated and time consuming. During the last few decades and particularly when environmental planning emerged, site selection became systematic and technical. The evolution of GIS made this field much easier and manageable. GIS gave the ability and functionality to find best location for certain purposes. The project area covers

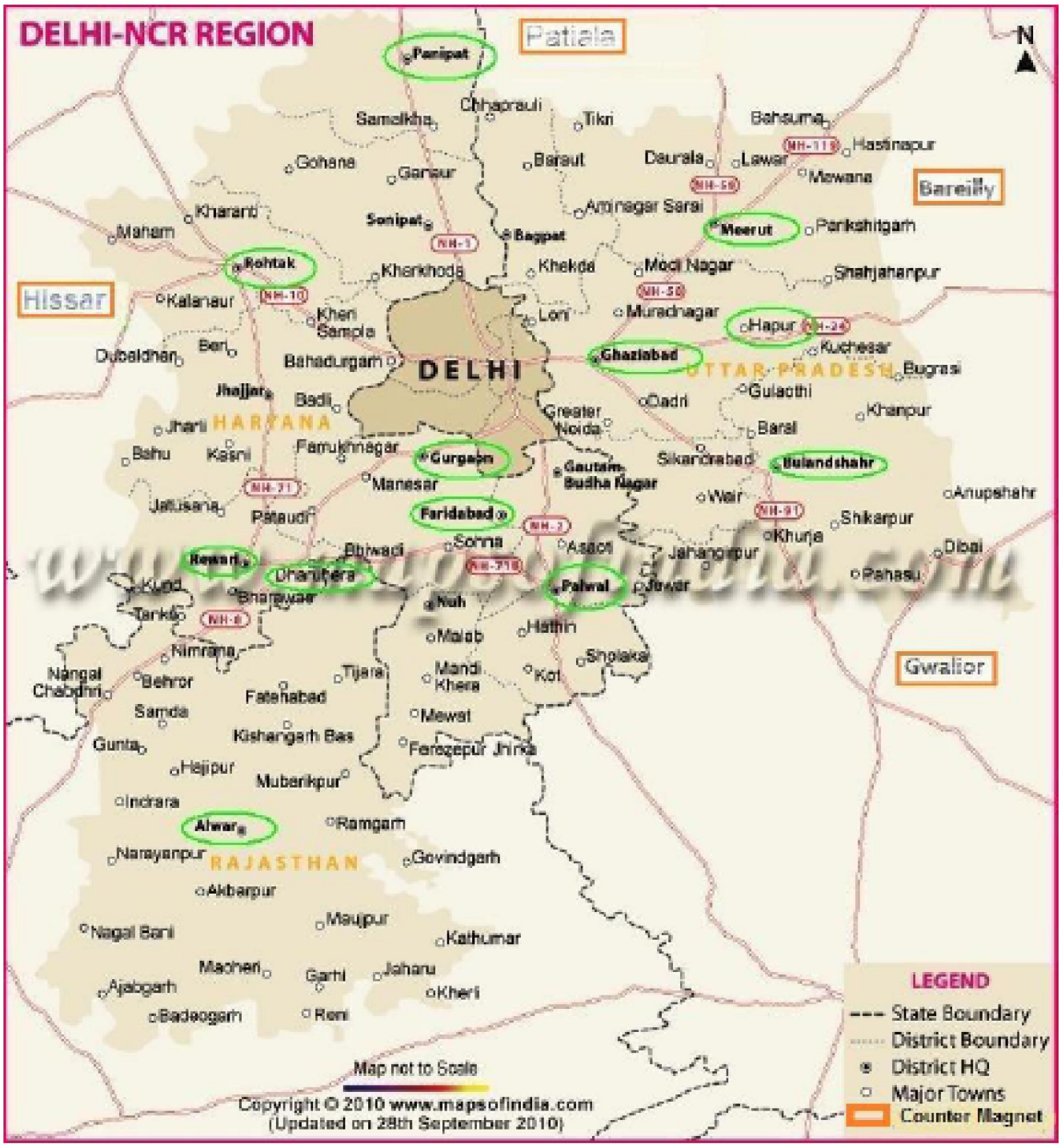

Figure 2 : Map showing towns of NCR region included in the project area

the following towns of the NCR Region as earmarked at TABLE 4.

The distance based criteria is applied for habitat, various infrastructure, environment sensitive features. The required information was created using the Geo-informatics technology as well as secondary information collected. The information was analyzed based on the overlay and buffer technique in GIS environment. A list of selection criterion is provided as below at TABLE 5;

To achieve the above mentioned objective, number of geo-spatial layer is created using the remote sensing technique. Additional value added information was integrated with created layer in GIS environment. Since the created database was on the com-

TABLE 4 : List of towns in the national capital region (NCR)

State	Delhi Metropolitan Area	Priority Towns
Haryana	1. Gurgoan	5. Panipat
	2. Faridabad	6. Rewari
	3. Kundli	7. Palwal
	4. Bahadurgarh	8. Dharuhera
		9. Rohtak
Uttar Pradesh	10. Ghaziabad	11. Hapur
		12. Meerut
		13. Bulandshahr
		14. Khurja
Rajasthan		15. Alwar
		16. Bhiwandi

TABLE 5 : Selected criteria for distance based analysis.

S.No	Feature	Distance in (meter)
1	Habitation	500
2	Canal/Drainage	30
3	Railway line (From centre)	300
4	Earth Quake zone (Fault line)	500
5	Flood plain area	Non permitted
6	Airport	20000
7	Road right of way	200
8	Lake	200
9	Water stream	300
10	Public park	300

mon platform of GIS it was easy to analyze. Application of distance based criteria for identification of regional level landfill site is time saving scientific approach. Use of GIS and remote Sensing technology in such an approach which is very effective and enables a quick decision making process. Use of Geoinformatics technology gives higher accuracy with such a systematic approach. Total 29 sites are identified in NCR area which is presented at TABLE 6.

DISCUSSION

Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of MSW daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020[20-22]. As per the Report of The Energy Resources Institute[23] (TERI) "Green India 2047", the country was generating six million tons of MSW in the year 1947 which has now gone up drastically in recent times. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook and corner. The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities. The waste characteristics are required to be carried out regularly at frequent intervals, because such information enables to decide the type of treatment process to be adopted. However, characterization of MSW is not done by the municipalities due to lack of facilities and skilled man-power. As a result, there is absence of a comprehensive database resulting in improper planning and uncontrolled waste management practices.

At National level, a very few cities like Greater Mumbai and Ludhiana are collecting entire waste generated in cities for complete 100 % disposal into the dumpsites. Collection efficiency widely differs from city to city and ranges from 50 to 70 %. Uncollected wastes either remain in bins or littered in parks, drains or elsewhere. There is great deal of variation in waste collection and citizens are either having their privately engaged agent for collection of waste or they themselves put the waste in the bins set up by the local bodies. Due to unorganized waste collection and segregation system, cities are littered. It would be prime need that local bodies set up efficient system of waste segregation, collection, storage and transportation system. Another important task should be to dispense with manual handling of garbage and thus is necessary to set up mechanized system of waste handling to avoid health hazards to the MSW workers.

Majority of the local bodies simply collect the wastes and transport it to the open dump-sites for disposal. This is the common practice and has been continuing since many years[24]. The current practices of uncontrolled dumping of waste on the outskirts of towns/cities have created a serious environmental and public health problem in India. Unscientific disposal causes an adverse impact on all components of the environment and human health[25-32]. Further, impacts of MSW landfilling on the environment are not properly assessed.

Open dumps have been considered to be a potential threat to the environment as they cause groundwater pollution and affects ambient air quality[33]. Engineered landfills with proper leachate collection and extraction systems will minimize the groundwater contamination

TABLE 6 : Details of identified sites

Site No	Land use	Nearest Town	Distance from Nearest Town (km)	State	District	AREA (Sq.mt)	Perimeter (Km)	Latitude	Longitude
1	SCRUB	KHORI	4.2	HARYANA	REWARI	341111.81	3.5	28° 9.047'N	76° 27.706'E
1/1	SCRUB	KHORI	2.7	HARYANA	REWARI	435018.91	3.3	28° 10.717'N	76° 28.44'E
1/2	SCRUB	KHORI	2.1	HARYANA	REWARI	340980.15	2.8	28° 10.465'N	76° 27.938'E
1/3	SCRUB	KHORI	3.9	HARYANA	REWARI	573907.19	3.2	28° 9.350'N	76° 28.110'E
10	SCRUB	PARDHANA	2.2	HARYANA	PANIPAT	360996.23	3.0	29° 16.150'N	76° 48.416'E
11	SCRUB	JATAULA	2.4	HARYANA	PANIPAT	284058.27	2.6	29° 19.942'N	76° 49.500'E
12	SCRUB	MULHAIRA	8.8	UTTAR PRADESH	MEERUT	312474.56	2.6	29° 9.623'N	77° 26.632'E
12/1	PLANTATION	MULHAIRA	8.2	UTTAR PRADESH	MEERUT	356911.63	3.1	29° 10.254'N	77° 26.810'E
13	SCRUB	BINAULI	6.9	UTTAR PRADESH	BAGHPAT	445634.60	2.8	29° 7.789'N	77° 25.718'E
13/1	SCRUB	MULHAIRA	9.0	UTTAR PRADESH	MEERUT	976408.24	5.1	29° 8.729'N	77° 27.021'E
14	SCRUB	DAVATHWA	3.6	UTTAR PRADESH	MEERUT	2925533.33	6.9	29° 3.458'N	77° 37.810'E
15	SCRUB	MEERUT	9.5	UTTAR PRADESH	MEERUT	1392618.98	7.0	28° 53.402'N	77° 41.406'E
16	SCRUB	DANKAUR	5.4	UTTAR PRADESH	NOIDA	2571298.00	8.8	28° 24.239'N	77° 32.651'E
16/1	SCRUB	MANJHAULI	3.1	HARYANA	FARIDABAD	705729.54	4.7	28° 23.785'N	77° 29.189'E
17	PLANTATION	MANJHAULI	5.6	HARYANA	FARIDABAD	1293963.40	6.0	28° 25.054'N	77° 27.503'E
18	SCRUB	BADHKAL LAKE	3.0	HARYANA	FARIDABAD	9462401.13	1.7	28° 27.594'N	77° 21.393'E
19	SCRUB	NARAH	5.3	HARYANA	PANIPAT	550941.14	3.8	29° 21.029'N	76° 47.493'E
2	SCRUB	BASTHALA	5.7	HARYANA	REWARI	504431.06	3.3	28° 2.859'N	76° 39.415'E
20	SCRUB	ALIPUR	7.6	HARYANA	GURGAON	557760.31	3.2	28° 17.395'N	76° 59.625'E
21	SCRUB	SHATAWLI	3.6	HARYANA	SONIPAT	222829.54	2.6	29° 6.376'N	76° 53.484'E
22	SCRUB	MULHAIRA	4.5	UTTAR PRADESH	MEERUT	390562.96	2.9	29° 11.772'N	77° 29.000'E
3	PLANTATION	KOT QASIM	7.1	UTTAR PRADESH	ALWAR	2879815.16	7.2	28° 0.662'N	76° 39.166'E
4	PLANTATION	DADANPUR	2.4	HARYANA	JHAJJAR	756712.74	3.7	28° 28.975'N	76° 40.251'E
5	SCRUB	PAHRAWAR	8.0	HARYANA	ROHTAK	2268054.23	8.5	28° 49.628'N	76° 33.263'E
6	SCRUB	KURANA	2.3	HARYANA	PANIPAT	1258233.11	4.9	29° 19.960'N	76° 41.997'E
7	PLANTATION	BHAGWANPUR	1.9	HARYANA	ROHTAK	70442.39	1.1	28° 58.878'N	76° 34.668'E
7/1	PLANTATION	BHAGWANPUR	2.2	HARYANA	ROHTAK	198835.96	2.0	28° 59.393'N	76° 34.086'E
8	PLANTATION	KISHANPUR BARAL	4.7	UTTAR PRADESH	BAGHPAT	346381.23	2.8	29° 12.464'N	77° 14.530'E
9	SCRUB	SHERAH	1.3	HARYANA	PANIPAT	369039.71	3.5	29° 25.499'N	76° 50.074'E

problem[34]. Further, open dumps occupy a huge area of land which is posing problems to city planners. Quantity of MSW generation is often assessed solely on the basis of trips record of transportation vehicles (i.e number / frequency of to and fro trips of the MSW transportation vehicle). Each city and town has been using two or more dumping grounds for disposal of MSW through open landfilling. Further adding on to this, there is no control over the entry of ragpickers who carryout ragpicking in a haphazard and hazardous way[34].

Recently, FICCI conducted a survey[35] to gauge the current status of solid waste management in Indian cities. The survey was conducted among municipal corporations of 48 cities including 21 class I cities and 27 cities with population less than one million. A review of the status of dumpsites in the cities shows that, out of the 17 class I cities, 8 (Agartala, Ahmedabad, Guwahati, Indore, Kanpur, Kochi, Pune and Vaododara) have a single dumpsite, 5 (Asansol, Jaipur, Jamshedpur, Ludhiana and Surat) have 2 dumpsites, 1 city (Delhi) has 3 dumpsites and 2 cities (Faridabad and Greater Mumbai) have 4 dumpsites. The survey was about the cities only but if at all semi-urban or rural areas are considered the situation is even worse there the garbage is lying on the roadside with no sanitary landfills and inviting major threats to the health and environment of the residents[35].

Due to several legislative, environmental, economic

and social constraints, the identification of most sustainable disposal route for MSW management remains an important issue in almost all industrialised countries[36]. Waste treatment options such as composting and waste-to-energy plants are not being adequately explored by even those cities which are larger not just in terms of size and population but also generation of waste. The immense scope of treatment is not being exercised due to reasons such as lack of know-how, technical manpower and most importantly financial constraints faced by the Municipal corporations. The adoption of Best Available Technologies (i.e Biogas recovery and exploitation system in landfills and energy recovery system in Waste to Energy plants) can not only significantly reduce greenhouse gases emissions but, in certain case, can also make the overall process a carbon sink[37]. After all the treatment technology option for municipal solid wastes, sanitary landfilling is the final and ultimate disposal method of municipal solid waste[38].

A proposal for an innovative model for the collection and transportation of municipal solid waste management system using a spatial geo database, integrated in a geographical information system (GIS) environment was presented by Pallavapuram municipality, Chennai, India. Wherein, an attempt was made to develop an engineered design of solid waste collection using GIS with a vehicle tracking system and final disposal by composting with investment costs. The GIS was used to analyse existing maps and data, to digitize the existing ward boundaries and to enter data about the wards and disposal sites[39].

CONCLUSION

The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011, fuelled by changing lifestyles and increased purchasing power of urban Indians. The total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW. In the field of Municipal Solid Waste management, India is self-sufficient with Rules/Regulation, proven technology, infrastructure, planning and financial resources. Only initiative is required for motivating the implementing agencies and mobilizing the schemes as well as financial resources. The role of entrepreneurs and other agencies is essentially required in implantation of the schemes through public-private- partnership (P-P-P). The entrepreneurs/ other agencies may take initiative and motivate the implementing Agencies like Urban Local Bodies to come forward for addressing the sanitation as well as environmental problems in a sustainable manner. The collection method has to be made mechanized method rather than manual method to safeguard workers' health. However, the local bodies should identify the land on priority basis for MSW projects in consultation with Town and Country Planning Departments/Urban Authorities, which is on urgent need. Identification and inception of common landfill sites for sharing amongst Urban Local Bodies is equally important in view of scarcity of land in urban areas.

Presently, the Waste-to-Energy projects based Urban Waste is running at three cities viz., Hyderabad, Vijayawada and Lucknow in India. However, under the paradigms of converting 'waste to energy' and 'waste to wealth' various technologies have been tried out, however time and again it is seen that irrespective of the technology, MSW treatment plants run into difficulties. So the issues do not pertain just to technology but are systemic and encompass project development, feedstock delivery system including quality and quantity, climate, high life-cycle costs, low value realization on outputs and adverse environmental and social impacts[39]. Thus adoption of a robust, elastic and most forgiving option of sanitary landfill with appropriate collection, segregation, treatment and disposal as a dependable and safe method of disposal for MSW [37]. For which, a GIS based on-line management information system needs to be effectively implemented to optimize daily operating resource allotment and make Indian solid waste management system effective and sustainable.

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