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Rapid impact assessment matrix (RIAM) analysis as decision tool to select new site for municipal solid waste disposal: A case study of Dehradun city, India

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ABSTRACT

The selection of appropriate site for creation of new MSW disposal facility is an important task of waste management engineering. The ecological, social and economical issues pertaining to new project should be analyzed in order to measure the overall impact of the new waste disposal project. In this study rapid impact assessment matrix (RIAM) which comes under one of the options of environmental impact assessment (EIA) was used to see the overall rating of the site to establish a possible new MSW disposal site for the city. The suitability of the site was evaluated considering ecological, social, cultural and economical as components in decision support system. Different components were used to produce a cumulative score, i.e. environmental score (ES) for each option of the site for the new project. Results suggests that RIAM can be a reliable tool to identify the suitability of the site for MSW disposal facility creation in accordance with ecological, physical, biological, social/cultural and economic quality of the project. In this city, for physical/chemical component the forest distribution was the major factor in site selection while biological/ecological components showed the negative impact of project in all sub-sectors. Socio-cultural and economical components showed the different ranges of ES. This study extends the possibility of utilizing RIAM as tool in decision supporting system for establishing MSW disposal facilities in any urban center.

1. Introduction

Many cities in developing Asian countries have been facing serious problems originated due to urban solid wastes management practices. The increasing human population, rapid economic growth and rise in community living standards are the major drivers of increasing municipal solid waste (MSW) generation rate within Indian cities. The present annual quantity of MSW generated in Indian cities has increased from 6 million tons in 1947 to 48 million tons in 1997 with an annual growth rate of 4.25%, and it is expected to increase to 300 million tons by 2047 (CPCB, 2004). The annual waste generation increases in proportion to the rise in population and urbanization, and issues related to its safe disposal have become challenging as more land is needed for the ultimate disposal of such wastes (Idris, Inanc, & Hassan, 2004). On the other hand, the modern waste treatment/management practices like: incineration, sanitary landfilling, biogas system, pyrolysis, etc. require a huge budget for facility creation as well as for its annual maintenance. In sub-urban centers and small towns of developing countries the land availability is not a big issue as large proportion of available land around the urban centers is either wastelands or agriculture/forest lands. Nevertheless, open dumping or land filling is traditionally considered to be only practice to dispose the MSW of urban centers in majority of developing and low income countries. In India, more than 90% of MSW is directly disposed of on the land in an unsatisfactory manner (Das, Srinivasu, & Bandyopadhyay, 1998).

The disposal of MSW unscientifically in open dumps and landfills has created the issues like public health safety and ecosystem services qualities. In the majority of the Indian urban centers the waste landfill sites are located within the territory of the urban settlements which not only creates the problems of health and hygienic in local population but at the same time also pose several ecological health risks. In order to ensure the health safety and the quality of services provided in project the impact assessment of landfill/waste disposal sites must be analyzed using any appropriate tool. Rapid Impact Assessment Matrix (RIAM) (Pastakia, 1998; Pastakia & Jensen, 1998), which comes under one of the options for the execution of Environmental impact assessment (EIA) work, is becoming an important tool to measure the

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quality of the developmental projects and its benefits. In this system a structured matrix is used to make a judgment (both subjective and those based on quantitative data) on a like-by-like basis. IN MSW management system RIAM can be used as decision support system. Although, few earlier workers have also demonstrated the EIA of MSW management system using RIAM (Buttol et al., 2007; Güereca, Gasso, Baldasano, & Jimenez-Guerrero, 2006; Mondal, Rashmi, & Dasgupta, 2009). The impact significance is modeled as a multicriteria problem in RIAM, in which the complex nature of the concept is broken down into smaller, more accessible attributes (criteria) for the decision makers to work with. Evaluating the significance of impacts this way is a widely used approach in the literature on environmental decision-making, when constructing systematic methods for impact evaluation (Bojorquez-Tapia, Ezcurra, & Garcia, 1998; Cloquell-Ballester, Monterde-Diaz, Cloquell-Ballester, & Santamarina-Siurana, 2007; European Commission, 1999; Thompson, 1990).

This paper illustrates the utilization of RIAM as tool for selection of new waste disposal site for disposing of urban solid wastes in Dehradun city, India. A comparison of environmental score of both sites was made in order to select the appropriate site for waste disposal.

2. Background and context

2.1. Overview

Dehradun city is located in the foothills of Shivalik mountain ranges of Uttarakhand State, India. The city has an area of about 67 km^2. Dehradun is the administrative center and the interim capital of the State Uttarakhand. The Himalayas borders the Dehradun in north, the Shivalik forest range in south, the sacred river Ganga in east and the river Yamuna in west. The city is surrounded by river Song on the east and river Tons in west. The population of Dehradun is 0.45 million (Census of India, 2001). The drastic change (about 39.7% increment) in population has been recorded in the city during the period 1981–1991. Probably this was due to heavy migration of people from adjoining rural and sub-urban areas to Dehradun city. The climate of this part is generally temperate and it varies greatly from tropical to severe cold depending upon the altitude of the area. The area receives an average annual rainfall of 2073.3 mm. Most of the annual rainfall in the district is received during the months from June to September, July and August being rainiest. The winter months are colder with the maximum and minimum temperatures touching 23.4 °C and 5.2 °C, respectively.

The city is covered with dense forest from three sides and one side is lined by agriculture plots with seasonal crops. Apart to that open forest and barren land patches can also be seen around the city.

2.2. Municipal waste management practices in city

As per the report of local Municipal Corporation, i.e. Nagar Nigam Dehradun, the total waste generation in the city is about 92 MT/day. The waste transportation capacity is inadequate in the city and as per the record of the local municipality total waste transported per day is about 48.5 MT (NMD Report). This difference is mainly due to inadequate facilities (e.g. collection point's distances, open dumping of wastes beyond secondary collection points, inadequate metallic containers, staff and vehicle shortage, etc.) available in the city with waste management agency. A project report of local municipality clearly states that "Municipal Corporation is not in a position to transport the entire quantity of waste generated in the city on a day to day basis on account of the inadequacy of fleet of vehicles and inappropriate management for transportation of waste". The uncollected waste is either unavailable for waste collection facilities or being dumped in areas where in general, the municipal corporation staff unable to collect it. The main waste disposal/landfill side of the city is located at Daandalakhon. The area of land fill site is about 3.7 ha. Geographically the land fill site is located between N 30°20′32.0 and E 078°04′38.5″. This is a newly established landfill site of the city and being used for city waste disposal since November 2002. The base of land fill sites is a wide shallow depression lined by large rounded pebbles. Some part of the land fill site seasonally flooded due to heavy rainfall and a channel, though water raises to only 1 ft height in the narrow low-flow streamlet flows through the center of the older upstream portion the site. The available machine at this site includes – 10 frontend loaders which help to dispose the city garbage here. The disposed waste is then settled by JCB which usually adjust about 100 tons waste per day. The recyclable and reusable items are picked up/segregated by rag pickers and other communities who are actively involved in waste recycling industry in the city. To dispose municipal solid waste about 10 municipal vehicles visit every day to this site. The majority of MSW consisted of household wastes, hospital waste, waste from slaughter house, construction waste, etc. But main proportion of waste received at landfill site is of biodegradable nature.

3. Methodology

3.1. Survey and baseline data collection

There are two possible sites for city's new land fill sites establishment – The Site 1 – Dudhli range and Raipur range (Fig. 1). A RS & GIS based analysis was made in order to identify the landfill site. One site is currently in use as trench ground for open dumping of MSW of the city.

Site I – Dudhli range: is geographically located at 78°01′22.8″ E and 30°14′36.96″ N and is 400 m far from the forest area, settlement is about half of the kilometers away from the site. Its elevation is 559 m approximately and it located nearby to one of the major drainage of this region, i.e. Suswa River. River Suswa flows just close to the proposed area. Land-use pattern is barren type with transported soil from river and small growth of lantana over there. Agricultural land is 2–3 m in distance from the site.

Site II – Raipur range: Raipur range is geographically located at 78°07′50.88″ E and 30°17′37.4″ N. It is 300 m away from the proposed site so it is 100 m near to the forest than site I of Dudhli range. The human settlement is not at all near to this site. The total area for proposed landfill site is comparatively larger than Dudli. Its area is bigger than the site I area and faraway from famous river Song which is about 310 m away from the site. Land-use pattern is open type forest grassy land with pebbles and has tree outside forest. No agricultural land is present in nearby areas of this newly proposed landfill site. The elevation of this site is about 610 m, slightly higher than site as recognized at Dudhli.

The research group visited the site 4–5 times (during March–May) in order to collect the baseline data of landfill sites. A detailed investigation on basic features required for RIAM analysis were collected like: overall health of landfill site, facilities available at landfill sites, environmental merit and demerits of current situation, activities at landfill site, location of urban settlement in nearby places of landfill site, vegetation aground landfill sites, waste deposition mechanism, quality of waste, hazardous waste presence or absence, etc. The care was also taken to evaluate the impact on human settlements like breathing air quality, problem of mosquitoes, houseflies, drinking water quality, possibility of disease incidences, etc. An available scientific literature was also