Landfill Site Selection Using GIS and Landfill Design in Trivandrum District

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***Abstract*: One of the serious and growing potential problems in Trivandrum is the shortage of lands for waste disposal. An inappropriate landfill site may have negative environmental, economic and ecological impact. Therefore it should be selected carefully by considering both regulations and constraints on the sources. Many criteria like distance from the residential areas, presence of water bodies etc...are taken into consideration while planning for suitable sites. Spatial Analyst Tool like GIS [Geographic Information System] along with AHP [Analytic Hierarchy Process] model is extremely useful in such multi-criteria decision making process.**

Keywords: Trivandrum, Landfill site, GIS, AHP.

1. INTRODUCTION

Source reduction, recycling and waste transformation methods are widely used to manage solid waste, however in all of these methods, there is always residual matter even after the recovery process to disposal. The necessity of getting rid of these wastes yields in an economic approach which is called as Land filling.

However, municipal landfill siting is becoming increasingly difficult due to growing environmental awareness, decreased government and municipal funding and extreme political and social opposition. The increasing population densities, public health concerns, and less land available for landfill constructions are also the difficulties to overcome.

Landfill siting is an extremely difficult task to accomplish because the site selection process depends on different factors and regulations. Environmental factors are very important because the landfill may affect the surrounding biophysical environment and the ecology of the area.

Economic factors must be considered in the siting of landfills as well. Economic factors of landfill siting

Trivandrum district has a reserve forest area of 495.1 square km.About 55% of population resides in urban areas.According to the census of 2011, the Thiruvananathapuram corporation generates about 240 tons per day.

2. SOLID WASTE MANAGEMENT

Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes. Integrated solid waste management includes the selection and application of suitable techniques, technologies and management programs to achieve specific waste management objectives and goals.

Current solid waste management technologies can be summarized as:

1) Source reduction

2) Recycling

3) Waste transformation

4) Land filling

2.1 Land filling

It is the process by which the solid wastes that cannot be recycled nor further used; the residual matter remaining after the recovery facility and after the recovery of conversion products and energy is placed in a landfill. Although there is a public opposition to landfills, it is necessary and there is no combination of waste management technique that does not require land filling to make them work. Land filling includes monitoring of the incoming waste stream, placement and environmental the compaction monitoring and of waste, control and facilities.

In the past, the term sanitary landfill is used to describe a landfill in which the waste placed in the landfill was covered at the end of each day. Today, sanitary landfill refers to an engineered facility for the municipal solid waste designed and operated to minimize public health and environmental impacts

Table 1: Advantages and Disadvantages of Landfill (source: Thesis, Basak Sener)

Advantages	Disadvantages
Independence from other facilities.	Land Depreciation.
Post-closure land development(eg:parks)	Wind borne paper, plastics etc...
Tipping fees from imported wastes.	Imported waste reducing landfill lifespan.
Local employment opportunities.	Public/political opposition.
Potential tax from landfill.	Traffic of large vehicles.
Disposal strategy upto 30 years.	Erosion of waste and/or soil cover.

3. LANDFILL SITE SELECTION

The major goal of the landfill site selection process is to ensure that the disposal facility is located at the best location possible with little negative impact to the environment or to the population. For a sanitary landfill siting, a substantial evaluation process is needed to identify the best available disposal location which meets the requirements of government regulations and best minimizes economic, environmental, health, and social costs. Evaluation processes or methodologies are structured to make the best use of available information and to ensure that the results obtained are reproducible so that outcomes can be verified and defended.

Geographic Information Systems (GIS) are ideal for preliminary site selection studies because it can manage large volumes of spatially distributed data from a variety of sources and efficiently store, retrieve, analyze and display information. Using GIS for site selection not only increases the objectivity and flexibility but also ensures that a large amount of spatial data can be processed in a short time. Relatively easy presentations of GIS siting results are also one of the advantages.

3.1 Criteria for Landfill Siting

There are a number of criteria for landfill site selection. These are environmental criteria, political criteria, financial and economical criteria, hydrologic and hydro geologic criteria, topographical criteria, geological criteria, availability of construction material and other criteria. The Highways and surface waters should be 200m away from such a site.

4. GIS PHASE

4.1 Map Collection

The Base map of Trivandrum district is collected.

4.2 Analysis by GIS Software

Fig1: Digitized map of study area

Collected maps are georeferenced, digitized and analyzed so as to obtain the suitable candidate sites, as per the criteria given. Here the QGIS Software is used for the aforementioned purpose.

4.2.1 QGIS Software

QGIS (previously known as Quantum GIS) is a free and open-source cross platform desktop Geographic Information System (GIS) application that supports viewing, editing and analysis of geospatial data.

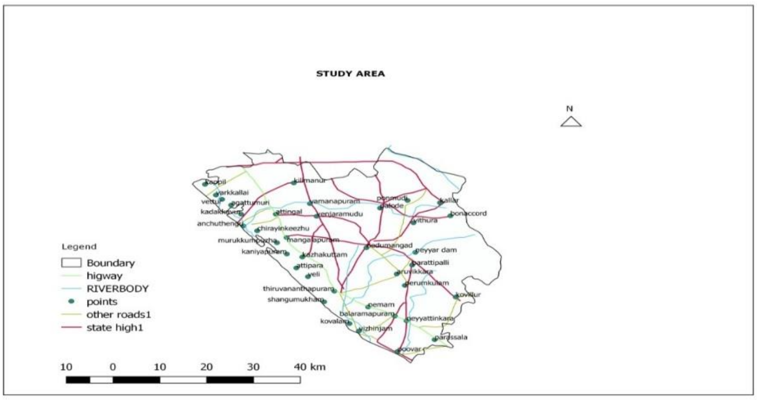
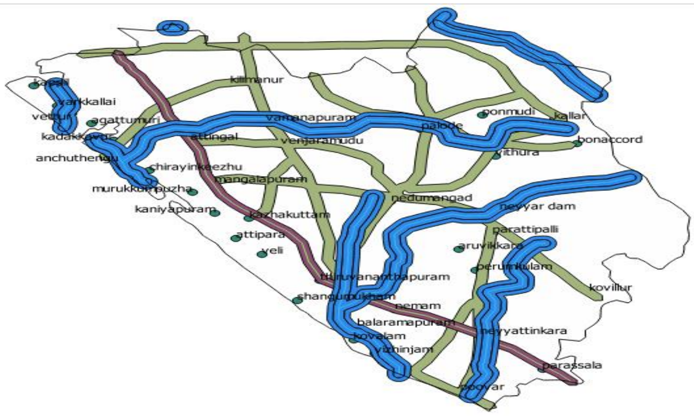


Fig2: Buffer map of study area



5. ENVIRONMENTAL PHASE

5.1 DESIGN PHASE

The following tests are to be carried out to determine the suitability of the candidate sites. Permeability tests, Causes of potential slope failure and probable settlement, Determination of Water table level.

5.2 LANDFILL DESIGN

The site selection of a landfill site depends on the design of a landfill. There are two major types of landfill design: (1) Sanitary landfills (2) Natural attenuation landfills. The main difference between these two types is the control of the entrapment and release of the leachate generated by a landfill. A sanitary landfill uses artificial liners to control the release of leachate while a natural attenuation landfill utilizes the surrounding environmental characteristics in order to decompose released fluids.

5.2.1 Sanitary Landfills

Sanitary landfills are designed to protect humans and the environment from harmful gases and fluids by using methane collection vents and leachate liners and collection pipes. Many landfills are designed for 20 or 30 year lifespan and still require post closure monitoring up to 30 years to ensure the environmental health. The landfill is usually double-lined to trap leachate. Synthetic liners include plastic geomembranes, geomats, geogrids, and geotextiles that commonly contain bentonite clays. In a sanitary landfill, waste is contained in a cell which is covered with a layer of soil and compacted at the end of each working day. The dimensions of the cell depend on the volume of waste received and the availability of cover material. The cell thickness may range from 8 to 30 ft (2.4 – 9.1 m) but typically it is 15 ft (4.6m). The usual slope of the working face is 3 horizontal to 1 vertical (3:1) which allows reasonable compaction and easier capping and vegetative growth on the side slopes of the landfill. The width of the working face is usually limited to 2 ft (0.6 m). The first lift of the waste is usually 5 ft (1.5 m) or less with careful removal of the oversize pieces to prevent damage of the underlying leachate collection system. The compaction equipment moves from the bottom to the top of the working face. The thickness of the daily cover is 6-12 in (150- 300 mm). If a lift surface is expected to be exposed over 30 days then an intermediate cover is applied. The intermediate cover is typically 1 ft thick and more resistant to erosion than the daily cover.

5.2.2 Natural Attenuation Landfills

A natural attenuation landfill which allows the liquid wastes to migrate from the landfill uses the natural geological and hydro geological characteristics of the subsurface. It takes the advantage of the natural subsurface processes of biodegradation, filtration, sorption, and ion exchange which help the purification of the groundwater. The other advantages of using natural insitu geological and hydro geological barriers are that natural barriers do not encapsulate waste and inhibit its degradation, and the natural infiltration and percolation characteristics of the subsurface are not disrupted. In addition, this method has relatively minor cost of construction, operation and maintenance compared to the sanitary landfills. Attenuation landfills are based on the dilute and disperse principle of leachate management. Natural low permeability and attenuation characteristics of geological barriers in the subsurface, especially low permeability clay rich overburden and to a lesser extent consolidated mudrocks are preferable for this method to prevent groundwater pollution.

6. RESULTS AND DISCUSSIONS

Ongoing project.

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