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Integration of geology, drainage and lineament on suitable landfill sites selection and environmental appraisal around Mysore city, Karnataka, India through remote sensing and GIS

H.T. Basavarajappa[1], Tazdari Parviz[2], M.C. Manjunatha[1] and A. Balasubramanian[1]
[1]Dept. of Studies in Earth Science, University of Mysore, Manasagangothri, Mysore – 570 006, India
[2]Khak Azma Oil Company, End of Shahre Ziba, 1487932571, Tehran, Iran
Email: basavarajappaht@gmail.com; mcmanju1@gmail.com

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Abstract: Urban environmental appraisal is a complex process involving the interplay of geological, hydrological and several other environmental parameters including geospatial data. Mysore urban exhibits flat to gently undulating topography with the elevation varying from 700-725 m above MSL with a gentle slope towards the South. The perennial river, Cauvery flows from west to east in the northern parts of the study area. The spectral signature of satellite images (7 bands) of IRS-1D, PAN+LISS-III and geospatial data from SoI toposheet (scale-1:50,000) were processed by GIS analysis, to classify the study area into two zones i.e., buffer zone and core zone. Mysore is one of the major cities in Karnataka producing nearly 600 tons of solid wastes everyday that need more landfill sites. The existing landfill site in the study area is operating within the core zone above a major lineament and affecting the groundwater, human health and surrounding environment. This study aims to delineate the safe disposal sites of municipal & industrial wastes in the city of Mysore, Karnataka, India through Remote Sensing (RS) and Geographical Information System (GIS) along with ground level data. The integration of RS, GIS analysis, GPS survey including Ground Truth Check (GTC), demarcates seven alternative safe locations to the existing landfill site, considering the environmental, biophysical and socio-economical factors.ail.com)

Keywords: Geology, Drainage, Lineament**,** Environmental appraisal, Mysore city, RS & GIS

1. Introduction

The rapid growth of population in a city demands for an increase in waste disposal and also larger area for disposal of effluent and toxic waste from different sources (Allen et al., 2002; Azadhe and Basavarajappa, 2010, 2011, 2013 and Parviz et al., 2013). This becomes a major environmental issue posing threats to the existence of human being and surrounding environment (Kontos et al., 2005). Applications of RS and GIS provide the alternative method of minimizing operational costs (Ogra, 2003; Kyessi and Mwakalinga, 2009) and digital data bank for long-term monitoring in selection of safe sites and fast evaluation (Miles et al., 1999). Buffering is a spatial (proximity) analysis that generates a polygon around a point, line or polygon theme by locating boundaries at a specified distance (Adeofun and Nwagu, 2006 and Sani et al., 2010). Using spatial analysis, a buffer zone of 25km radius was created around the study area from the city centre (Krishna-Raja circle) for extensive study. Drainage and lineament form the basic geological structures which are easily identifiable in the satellite imagery and helps in understanding the nature of lithology,

demarcating the groundwater potential zones and in landfill sitting. The main factors considered to keep away the disposal sites are indicated as lakes, ponds, rivers, groundwater table, air quality index, geology, fault line, elevation, land use, habitation, highways and sensitive sites (Sumathi, 2006; Siddique et al., 1996; Basavarajappa et al, 2012). Mysore city is declared as second cleanest city in India in 2010 by Nationwide Union Urban Development Ministry (NUUDM). However only 200 tons of solid waste is treated at the sewage farm (Excel plant) daily to produce compost, remaining nearly 400 tons of garbage dumped as untreated (Akolkar, 2005). There will be a need to create a new landfill site every few years due to increase in waste generation. The currently operating landfill in the study area is located within the core zone and is rapidly running out of space. Hence, new landfill sites are needed urgently in the outskirt of core zone to avoid its effects on groundwater, human health and other environmental parameters. The landfill sites should have sufficient capacity to meet the current and projected waste to be deposited within the next 10years.

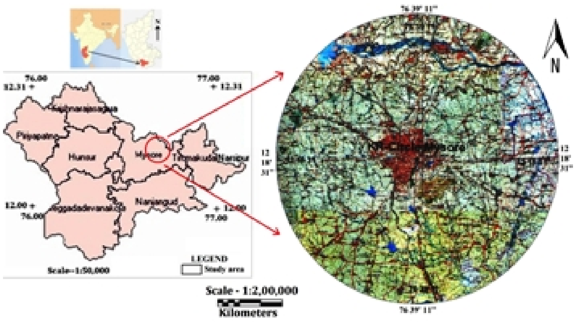

Figure 1: Location map of the study area

2. Study area

The study area is located between 12^0 18’ 31” N and 76^0 39’ 11” E with 25km radius from the centre of the city (fig.1). The total area extent is 83.21 km^2. The study area is classified into two zones viz., buffer zone and core zone for environmental appraisal and suitable landfill site selection. The extensive study was carried out in buffer zone (20.51 km^2) while core zone (13.42 km^2) for intensive study using visual image interpretation and thematic layers. Buffer zone also covers a small part of Mandya district in the northern part of the study area. The majority of the area is covered by agricultural fields with moderate plantations. The main crops grown are sugarcane, maize, ragi, paddy, jowar, vegetables and flowering plants etc.

Table 1: Climatological parameters of Mysore city

Month	Relative Humidity (%)		Temperature (^{0}C)		Rainfall (mm)	
	17:30	8:30	Min.	Max.	Avg. no. of Rainy days	Normal
January	30	75	16.4	28.3	0.4	4.3
February	25	69	18.2	31.2	0.4	6.6
March	21	71	20.2	33.5	0.9	13.2
April	34	75	21.4	34.0	4.6	63.5
May	51	79	21.2	32.6	8.1	151.1
June	66	81	20.2	28.9	5.5	60.5
July	70	84	19.7	27.3	7.5	69.1
August	67	84	19.6	27.3	7.5	87.1
September	61	83	19.3	28.7	7.8	117.1
October	61	85	19.6	28.4	9.0	153.7
November	54	80	18.3	27.4	4.6	71.6
December	43	78	16.5	27	0.9	11.9

Source: Department of Mines & Geology, Mysore (2005-10)

4. Methods & Materials

Factors considered for suitable landfill sites are geological structure, bedrock & overburden lithology. Hydrological parameters including infiltration, percolation rates, pathways of rainwater passing through subsurfaces and hydrogeological characteristics. Topographic height above MSL, as surface slopes, exposure to the elements, particularly rain and wind were considered. Economic distances from waste sources, road networks, site access, management costs arising from the physical characteristics of the site etc (Allen and McCarthy, 1991).

- Satellite Imagery – IRS-1D, PAN+LISS-III, TM & ETM+ (year-2000), Path-144 & Row-51 with 52m resolution (USGS).
- Toposheets - TIFF Images of 57D/11, 57D/12, 57D/15, 57D/16 (scale - 1:50,000)
- GIS Tools - ERDAS IMAGINE 9.2 & ArcGIS 9.2.
- GPS - A field survey using GPS (Garmin-12) was conducted to check the conditions of the suggested alternative sites and exact locations.

5. Geology

The study area is composed of gneissic terrain belonging to Dharwar Craton (fig.2) representing four major formations as:

- Younger pink & grey granite (CH-Chamundi hill).
- Amphibolites & Metasedimentary BIF's.
- Ultramafic-mafic rocks and
- Older Peninsular Gneisses (Srikantappa et al., 1992).

The rocks should be impermeable to ensure protection of ground water resources. The parameters considered for suitable landfill sites are lithological characters like bedrock lithology, rock type, structure, fractures, grain size, texture, thickness, homogeneity unconsolidated overburden, bedding characteristics etc. Hydrological properties like porosity, permeability, hydraulic conductivity, attenuation potential of both bedrock and overburden, conditions/depth and their effect on groundwater table around Mysore city were also considered (Allen and MacCarthy, 1991).

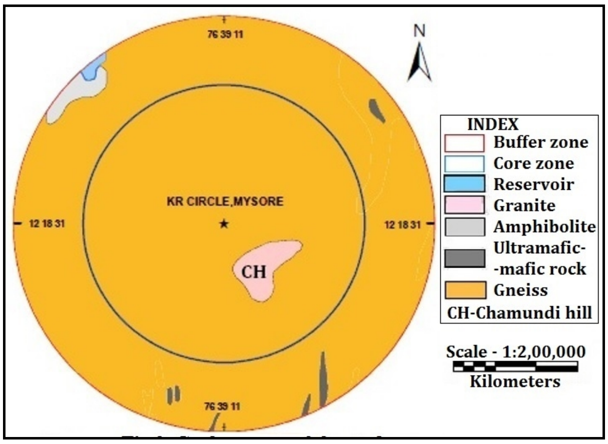

Figure 2: Geology map of the study area

6. Drainage and tanks

Deep ground water table (atleast 50m) region is suitable to avoid contact between leachate and water. Groundwater levels, distribution of aquifers, aquicludes, groundwater flow patterns, size and discharge of streams are controlled by topography of the site. Water bodies like tanks, ponds, streams, lakes and river were identified and digitized (fig.3). A landfill sites should be kept 100m away from drainage channels (Lunkapis et al., 2010; Agnes 1997; Despotakis and Economopoulos, 2007). The total area on basin extent of Cauvery river in the buffer zone is about 1,509.84 ha. The total water bodies cover an area of 293.3 ha in the core zone. Most of the drains are of dendritic type and converging into the river along N-E and S-E direction. The total length of drainages is 11.02 km^2 representing the excellent and moderate ground water potential zones in the study area. Unscientific way of waste disposal affects surface/ground water, change in soil P^H and blocks the drainage systems nearby (Basavarajappa et al., 2012).

7. Lineaments

Faults are geological structures that cause limitation for sitting a safe landfill (Gemitzi et al., 2007). The landfill site should be kept at least 100-200 m away from any faults, fissures, joints, stream/lakes and other shear zones to avoid environmental damages of any area. Lineaments are classified into minor, medium & major lineaments and were digitized from the satellite imagery (fig. 4 & 5). The average directions of lineaments are towards NW, NE and SW direction; two major lineaments located towards NE and SW direction in the study area, (Basavarajappa and Pushpavathi, 2007; Basavarajappa et al., 2012).

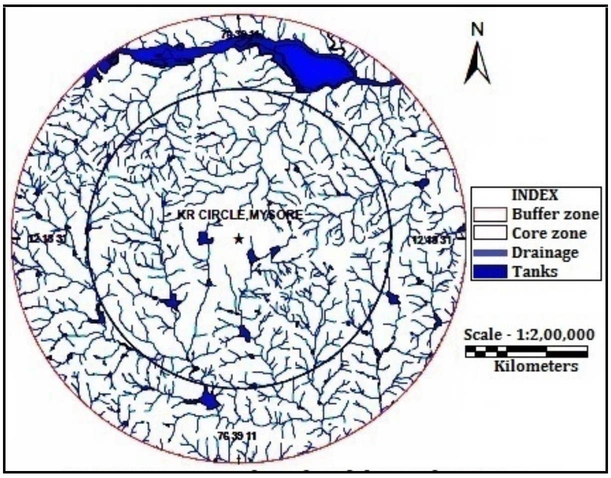

Figure 3: Drainage and Tanks of the study area

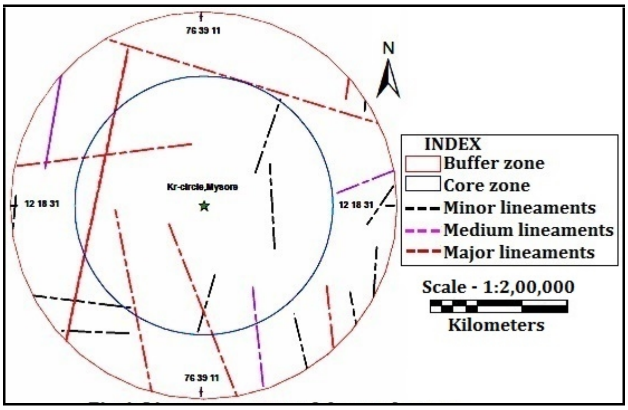

Figure 4: Lineament map of the study area

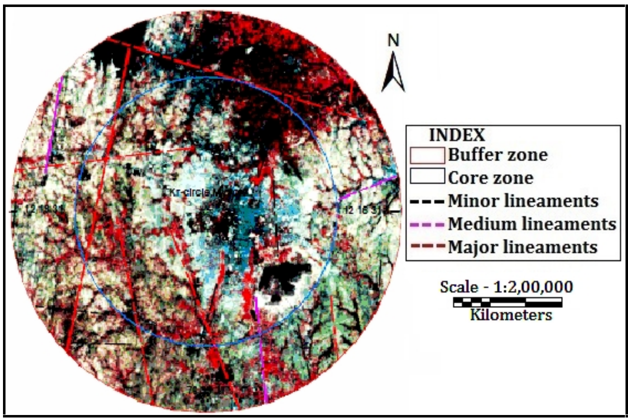

Figure 5: Lineament map overlaid Satellite Imagery (IRS-1D) LISS III

8. Factors Considered

The factors affect or interplay with other important parameters that should kept away atleast about 100 m for landfill criteria (Church, 2002) such as environmental, biophysical, ecological (plant, animal habitat and bio-diversity), geology, elevation, land use, (climatic (local microclimate, air quality index, wind velocity, humidity, temperature), geotechnical (foundation characteristics, side slope stability relation, site design, mitigation of risks), socio-economic (noise, smell, dust, litter, vermin, insects, birds, visual impact, proximity to housing, domestic waterwells, highways, habitations, sensitive sites, distance from waste source, site access, management cost and physical characteristics of the site) (Chang et al., 2008; Rahman et al., 2008; Lukapis 2010; Nishanth et al., 2010).

9. Results and Discussions

This paper reveals an approach for suitable landfill site selection in a typical city like Mysore keeping away the factors (lakes, ponds, rivers, drainage systems, groundwater table, air quality index, geology, fault line, elevation, land use, habitation, highways and sensitive sites) about a minimum of 100 m outside the core zone. Overlay and buffer analysis have been performed in ArcGIS 9.2. Excellent groundwater potential zones are found in northern region (Cauvery river) while excellent to moderate found towards eastern and southern regions. The existing treatment plant is operating within the core zone above a major lineament, affecting the groundwater table by adding effluents and toxic materials present in the huge wastes, when heavy rainfall occurs (Azadhe and Basavarajappa, 2010, 2013). Landfill should be avoided in northern part due to the presence of major (Cauvery) lineament, however it is possible in southern part due to the gneissic terrain with gentle slope area. The southern region is much drier when compared to the irrigation land in northern region.

The existing treatment plant was set up at Vidyaranyapuram layout in 1996, located about 6 km from the centre of the city which produces unbearable stink emanating from these wastes proving a health hazard to the locals. The plant covers an area of 5 hectares, accumulating 12 lakh tons of garbage which adversely affecting over 2 lakh people living in the radius of 3 km. Residents of JP Nagar, Vishveshwara Nagar and Vidyaranyapuram have been suffering from different ailments like nausea, eye infection, giddiness, headache and asthma. The plant also burns plastic which emits bad smell and carbon dioxide. Students are also under health risks and dropping out of schools in the vicinity. There is also a small vermin-composting (5 tons per day) is operational in Mysore (Jayachamarajendra Wodeyar) Zoo.

Authors have suggested that the medicare wastes from (8-10) major hospitals, should be treated in any one of the suggested alternate site separately due to their adverse effect on soil, water etc which is a difficult task to prevent. Environmental appraisal on waste disposal is more appropriate, based on geological, geotechnical, Remote Sensing, GIS and GPS survey study for rocky soil of gneissic terrains like Mysore city.

NEWLY SELECTED LANDFILL POINTS		
Site no's	Latitude	Longitude
1.	76^0 35' 26"	12^0 12' 12"
2.	76^0 37' 09"	12^0 11' 53"
3.	76^0 38' 40"	12^0 10' 43"
4.	76^0 40' 16"	12^0 13' 00"
5.	76^0 39' 41"	12^0 11' 08"
6.	76^0 41' 55"	12^0 12' 11"
7.	76^0 47' 16"	12^0 17' 49"

Applications of advent high-tech tool of Remote Sensing, GIS and GPS survey with ground truth check (GTC) by detailed field investigations, demarcates seven sites (fig.6) to avoid most of the water bodies and seepage areas through the fractures and lineament zones around Mysore city (Basavarajappa et al., 2012).

10. Conclusions

Integration of thematic map prepared by collateral data yields more accurate and effective results. The southern land is much drier when compared to the irrigation in northern part. Landfill should be avoided in northern part due to the presence of major (Cauvery) lineament; however the waste disposal is possible in southern part due to the gneissic with gentle slope area. Excellent groundwater potential zones are found in northern region (Cauvery river) while excellent to moderate are found towards eastern and southern regions (Kabini river). There is also a small vermin-composting is operational in Mysore zoo.

A set of seven most suitable sites were identified in the study area (Fig.6) which are more or less equally significant/potential for landfill construction and they also fulfills all the landfill criteria.

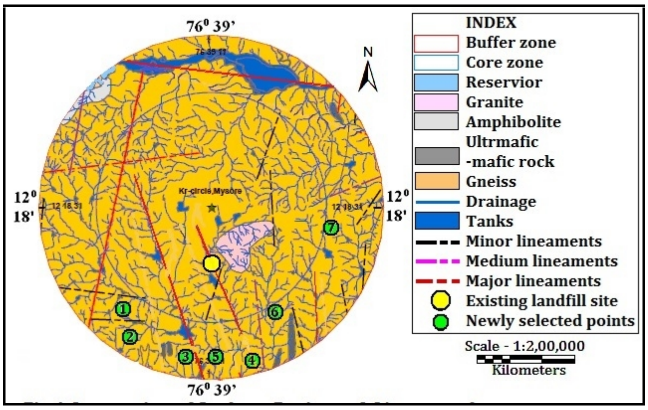

Figure 6: Integration of Geology, Drainage & Lineament layers for environmental appraisal

Solid wastes consist of everyday items such as product packaging, furniture, clothing, bottles, food scarps, newspapers, appliances, paint and batteries, burning these can generate energy reducing the volume of waste by up to 87%. At least 4 MW of electricity can be generated daily from 100 tonnes of solid wastes with 5 acres of land in any one of the newly selected site, by adopting an advanced version of pyrolysis technology which is an eco-friendly and cost-effective technology. All the suggested sites were clay-rich environment and bare lands, based on the present investigation data. The city waste should go from open dump to recycling at the source directly. Sorting of wastes from city at the source level, allows the incineration of residuals minimizing the environmental burden.

Implementation of recycling scheme where the papers are collected separately improves the material recovery of eco-friendly. Majority of the solid waste from construction and demolition of old buildings should be sorted, crushed using machines and these may used as good quality construction bricks by recycling methods. The best benefits of landfill is to dig a basin shape depression at certain depth depositing the huge solid wastes which generates electricity and should be sealed at all directions except providing a pipe to generate GAS, BOOM energy and compost in low cost and other benefit to prevents greenhouse gases being emitted into the atmosphere.

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