J. Soils and Crops 32 (2) 345-348, December 2022

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

LAND SURFACE TEMPERATURE MODELLING OF MUNICIPAL SOLID WASTE DUMPSITES USING REMOTE SENSING

J. Ramachandran[1] and K. Sivasubramanian[2]

ABSTRACT

This paper presents land surface temperature modelling of municipal solid waste dumpsites located at Ariyamangalam, Trichy and Vellalore, Coimbatore, Tamil Nadu and its impact on surrounding areas using freely available Landsat 8 satellite data. The surrounding areas of dumpsites had LST between 5-8^{o}c which was higher than areas away (Non-Urban) from dumpsite. The gases emanated from waste decomposition may be the possible factor that contributes to dumpsite LST increase. From Normalized Difference Vegetation Index map, it was also identified that the presence of vegetation on northern part of Vellalore Dumpsite reduces the effect of LST remarkably. This comparative study recommends, planting suitable tree species around the dumpsite will reduces effects of LST of surrounding atmosphere, controls air pollution and other ill effects caused by dumpsites.

(Key words: Land Surface Temperature, Normalized Difference Vegetation Index, Dumpsite)

INTRODUCTION

Waste management is a core challenge for cities in developing countries, owing to population growth, industrialization and urbanization (Annepu, 2012). Also parallel to these issues, there is a financial burden for waste management and lack of technical capacity (Guerrero *et al.,* 2013). Municipal Solid Waste (MSW) emanate from industrial and residential activities and generally consist of food, plastic, metal, paper, textile, glass, etc. Municipal solid waste management in cities necessitates waste collection, transportation, and disposal or recycling (Igbinomwanhia and Ideho, 2014) which if implemented unsystematically result in the exposure to pollution of environment (air, water and land) and human health.

Geospatial Technology (GT) plays an important role in waste management, and also helps in understanding the extent of exposure of people and the environment to waste pollution and/or contamination due to poor waste management practices.

The wide application of GT in waste management (Hannan *et al.,* 2015) includes (i) Geographic Information System (GIS): Site selection; planning; management; Waste collection bin distribution optimization; (ii) Global Positioning System (GPS): Route and collection optimization; vehicle tracking; planning; scheduling; billing; (iii) Remote Sensing (RS): Site selection; environmental impact assessment; features monitoring; and (iv) Sensor Imaging (SI): Sorting; optimization; moisture; energy and odour measurement; scheduling waste sorting; route and collection optimization; and monitoring.

Land Surface Temperature (LST) is defined as how hot the "surface" of the Earth would feel to the physical touch in a particular location and depends on land use activities and land cover (Zhang *et al.,* 2013). Solid Waste Dumpsite is one of the oldest and the most common method of waste disposal, which is still followed in many places around the world. Dumpsites increase the LST significantly comparing to the average air temperature due to gases released during the decomposition process.

Currently, there are many satellites with varying spatial and spectral resolutions captured images that can be used for mapping and monitoring dumping sites. Multispectral imageries are used to map its spatial extent, land surface temperature, vegetation cover and chemical composition of the surface. This provides valuable information on the changes within dumpsites and the surrounding areas. Ekeu-wei *et al.* (2018) estimated indicators like Land Surface Temperature (LST), Soil Adjusted Vegetation Index (SAVI) by using a remote sensing approach from freely available Landsat 8 satellite data products, Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) and assessed the impact of dumpsites on the environment in Benin City, Nigeria. Ramachandran *et al.* (2019) has estimated different kind of vegetation index to study the crop behavior, crop monitoring and planning. Potdar *et al.* (2020) studied the spatial variation of soil quality in Shegaon Watershed, Dist. Chandrapur (MS) and proposed suitable conservation measures and interventions to improve the soil productivity.

The objective of this study was to estimate the LST of municipal solid waste dumpsites (Ariyamangalam

1. Teaching Assistant, Dept. of Agricultural Engineering, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai 624 104
2. Assoc. Professor (ENS), Office of Controller of Examination, Tamil Nadu Agricultural University, Coimbatore, India

Dumpsite, Trichy and Vellalore Dumpsite, Coimbatore) and its impact on surrounding areas using freely available Landsat 8 satellite data.

MATERIALS AND METHODS

Landsat 8 is the most recently launched satellite of the Landsat series. The Landsat 8 satellite images were downloaded from the USGS Earth Explorer website. The detail of the image used is shown in the Table 1. The study was conducted during the year 2018 in Ariamangalam dumpsite located in the Trichy district, Tamil Nadu, India and Vellalore Dumpsite, located in Coimbatore district, Tamil Nadu, India. The dumpsites were demarcated from the Google Earth and imported to ArcGIS. A 5 km buffer was created around the dumpsites and bands are extracted for this 5 km buffer area for this study.

Table 1 Details about Landsat 8 images used in this study

Sr. No.	Dumpsite location	Acquisition Date (yyyy mm^{-1} dd^{-1})	Latitude	Longitude	Cloud cover in study area (%)
1	Ariyamangalam	2018-01-30	10° 48' 12" N	78° 43' 37" E	0.00
2	Vellalore	2018-01-22	10° 57' 27" N	77° 0' 6" E	0.00

LST was calculated from the thermal band (band 10) radiance values of Landsat 8 image. The equation for estimation of surface temperature is as follow as:

$$T_s = \frac{K_2}{\ln\left(\frac{\varepsilon_s * K_1}{\rho_b}\right)}$$

The radiance ñ$_b$ of the thermal band (band 10) was calculated from Equation 2. The constants K_1 and K_2 for band 10 are 774.8853 and 1321.0789 which was taken from the metadata file. The surface emissivity (å$_s$) is calculated from equation 3. The radiance (ñ$_b$) was calculated from the pixel values of different bands (DN_b) using the following equation:

$$\rho_b = Add_{rad\ b} + \left(Mult_{rad,b} * DN_b\right)$$

Where $Add_{rad,b}$ is additive and $Mult_{rad,b}$ is multiplicative terms related to different band radiance. The values of Add_{rad} and $Mult_{rad}$ terms of band 10 are 0.10000 and 3.3420E-04. Surface emissivity (å$_s$) is the ratio of the thermal energy radiated by the surface to the thermal energy radiated by a blackbody at the same temperature.

$$\varepsilon_s = \begin{cases} 1.009 + 0.047\left(\ln\left(NDVI\right)\right) \rightarrow \left(NDVI > 0\right) \\ 1 \rightarrow \left(NDVI < 0\right) \end{cases}$$

Thus, the surface emissivity was empirically derived from NDVI. NDVI is the ratio of difference in reflectivity of near-infrared (NIR) band and red band to their sum. The expression for estimation of NDVI is given by

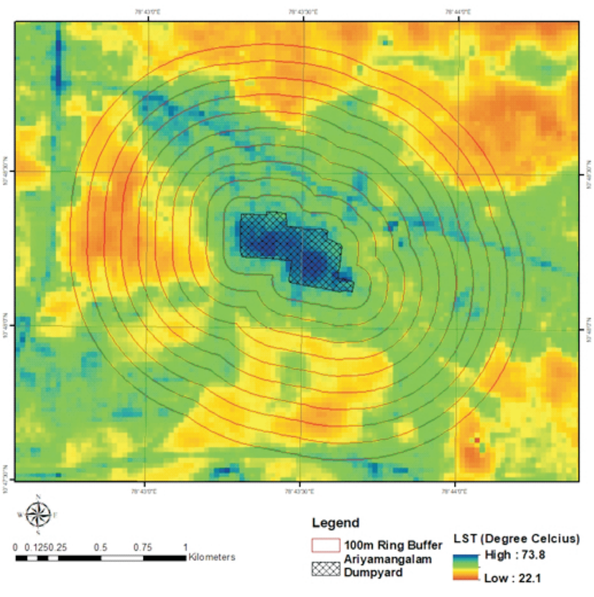
$$NDVI = \frac{NIR - RED}{NIR + RED}$$

In Landsat 8 image, the near infrared is band 5 and the red is band 4. Using Raster Calculator tool in ArcGIS, NDVI raster was obtained. In order to precisely study the effect of surface temperature of dumpsites, multiple buffer rings of 100 m radius from the dumpsite were created up to 1km around the dumpsites.

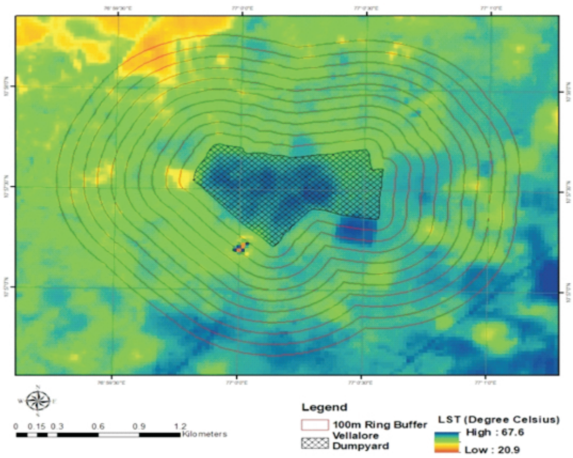
RESULTS AND DISCUSSION

LST (Figure 1) depicts surrounding temperature of dumpsites and its environs, while NDVI (Figure 2) portrays the presence vegetation cover around the dumpsites. In Ariyamangalam dumpsite, it was noted that LST varied from 37 to 41 °c . It was higher than the areas away from dumpsites which have LST around 32 °c . Igbinomwanhia and Ideho, (2014) suggested that open burning of waste widely practiced at Benin city dumpsites and dumpsite gases that emanate from waste decomposition were identified as the two possible factors that contribute to dumpsite temperature increase.

The influence of LST was seen up to 400 m around the Ariyamangalam dumpsite. Whereas in Vellalore dumpsite, it was noted that LST varied from 34 to 43 °C. The effect of LST is seen in the southern part of dumpsite up to 1 km. But the effect of LST is not seen on the Northern part of Vellalore dumpsite because of the dense vegetation (NDVI=0.5) located at 1 km from the dumpsite.



(a) Ariyamangalam Site - LST



(b) Vellalore Site - LST

Figure 1. Land Surface Temperature of Dumpsites

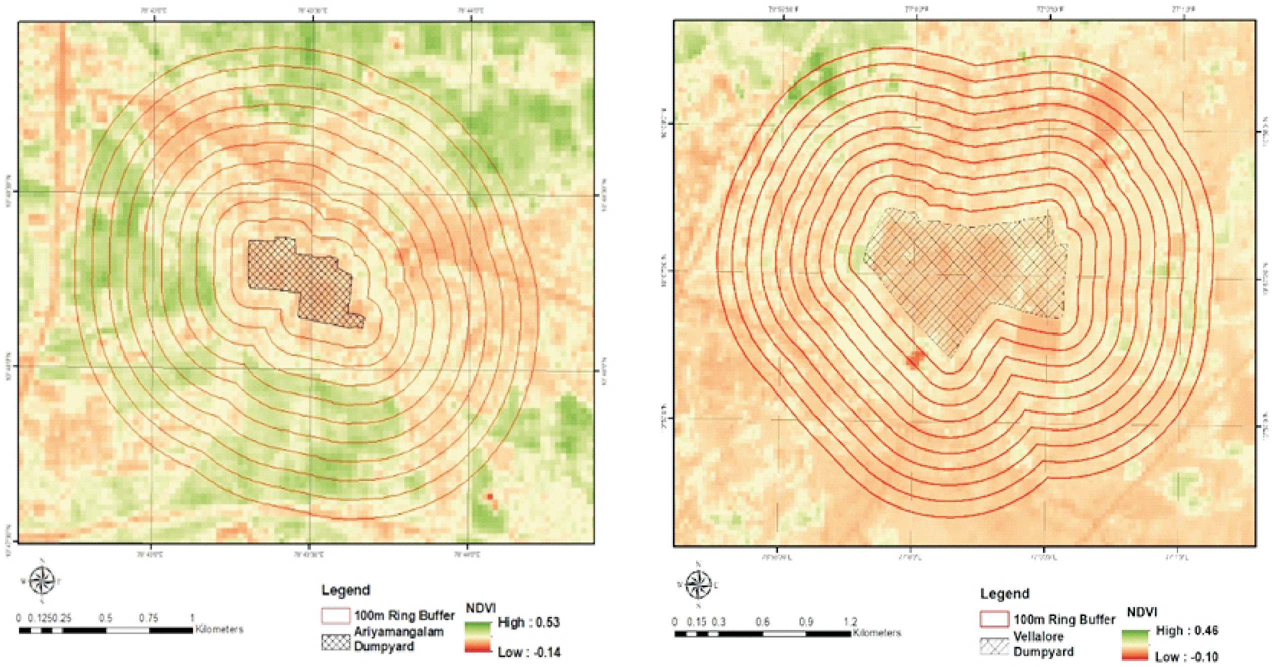


Figure 2. Normalized Difference Vegetation Index for Dumpsite Surrounding Areas

(a) Ariyamangalam Site - NDVI

(b) Vellalore Site - NDVI

The uncertainty in urban LST caused by the varying reflectance and emissivity of man-made features, makes it somewhat difficult to discriminate between urban and dumpsite temperatures. This is one of the difficulties faced in remote sensing application and it was also reported by Yang *et al.* (2015) and Chen *et al.* (2017). Hence, in this study also a close presentations of dumpsites was given to display clearer details on how dumpsite differ from and possibly affect the surrounding environment.

The gases emanated from waste decomposition shall be the possible factor that contributes to dumpsite LST increase. The LST of surrounding areas of dumpsites was 5-8 ^{o}C higher than areas away (Non-Urban) from dumpsite. The presence of vegetation on northern part of Vellalore Dumpsite reduces the effect of LST remarkably. Hence, this comparative study recommends for identifying suitable tree species and planting around the dumpsite will reduces effects of LST of surrounding atmosphere, controls air pollution and other ill effects.

REFERENCES

Annepu, R. K. 2012. Sustainable solid waste management in India. Columbia University, New York.

Chen, F.,S. Yang, K. Yin, and P. Chan, 2017.Challenges to quantitative applications of Landsat observations for the urban thermal environment. J. Environ. Sci.**59:** 80-88.

Ekeu-wei, I.T., K.I. Azuma, and F.B.B. Ogunmuyiwa, 2018. Assessment of Environmental Impact of Solid Waste Dumpsites.Nigerian J. Tech.**37**(1): 275-285

Guerrero, L. A., G. Maas and W. Hogland, 2013.Solid waste management challenges for cities in developing countries. Waste Mngt. **33**(1): 220-232.

Hannan, M. A., M. Abdulla Al Mamun, A. Hussain, H. Basri and R. A. Begum,2015.A review on technologies and their usage in solid waste monitoring and management systems: Issues and challenges. Waste Mngt. **43**:509-523.

Igbinomwanhia,D. and B. Ideho, 2014.A Study of the Constraint to Formulation and Implementation of Waste Management Policies in Benin Metropolis, Nigeria.J. Appl. Sci. and Environ. Mngt. **18**(2): 197-202.

Potdar, S.S., V.V. Gabhane, H. Potdar, S.P. Wagh, M. Pusdekar and S.R. Imade, 2020.Soil quality assessment and mapping for management of resources using geospatial techniques of ShegaonWatershed, Dist. Chandrapur (MS). J. Soils and Crops. **30**(2): 290-297

Ramachandran, J., R. Lalitha and S. Vallal Kannan, 2019. Remote Sensing Based Greenness Modelling of Different Crops In Lalgudi Block Using Landsat 8 Image. J. Soils and Crops. **29**(2): 232-235

Yang, J., M. S. Wong, M. Menenti and J. Nichol,2015.Study of the geometry effect on land surface temperature retrieval in urban environment.ISPRS J. Photogrammetry and Remote Sen. **109**:77-87.

Zhang, Y., I. A. Odeh and E.Ramadan, 2013.Assessment of land surface temperature in relation to landscape metrics and fractional vegetation cover in an urban/peri-urban region using Landsat data.Int. J. Remote Sen. **34**(1): 168-189.

Rec. on 30.03.2022 & Acc. on 29.05.2022