Islamic Azad University
Mashhad Branch

B. Mohammed Hashim and M. Abdullah Sultan/ Iranian Journal of Earth Sciences 2 (2010) / 20-24

Using remote sensing data and GIS to evaluate air pollution and their relationship with land cover and land use in Baghdad City

B. Mohammed Hashim*[1] and M. Abdullah Sultan[2]

1. HAZMAT Office /Ministry of Science and Technology/Baghdad, Iraq
2. P.O. Box 46019, AL Mustansiriyah University, Baghdad, Iraq
Received 25 November 2009; accepted 25 February 2010

Abstract

The research used the satellite image (Landsat 7 ETM$^+$) within the thermal infrared sixth band (TIR6) and geographic information system (GIS) to determine the air pollution and its relationship with the land cover (LC) and land use (LU) of Baghdad city. Concentration of total suspended particles (TSP), lead (Pb), carbon oxides (CO, CO2), and sulphur dioxide (SO2) were obtained from 22 ground measuring stations, where the stations are classified into industrial, commercial and residential and are distributed within the city of Baghdad. The digital number (DN) corresponding to the sites of groundtruth stations for measuring air pollutants was converted to the values of the spectral radiation (Lr), brightness temperature sensor (T) and land surface temperature (LST) of the satellite image (Landsat 7 ETM$^+$) within TIR6. The results indicated a significant correlation between air pollutants and satellite image data have also shown results of the spatial analyst air pollutants and the satellite image data by using GIS and supervised classification results. They show a relationship between the concentration of air pollutants and land surface temperature with the land cover and land use classification (LC, LU) for Baghdad city. The results of the research gives evidence of a link between air pollutants derived from the measurement stations of ground and satellite data within the range of Thermal IR.

Keywords: *Air Pollution, GIS, Remote Sensing, Land Cover and Land Use*

1. Introduction

Air pollution is one of the features of the modern age, with increasing use of fuels from oil and natural gas in various fields of life. Spread in the environment in which we live are many air pollutants such as gases resulting from industrial activities or different modes of transport. Some studies have addressed the use of GIS and remote sensing data in the study of air pollution. Weng [1,2] has used satellite data (Landsat) for sensors (TM,ETM$^+$) within TIR6 to extract the values of land surface temperature (LST) and linked it with air pollutants (from ground stations) the proportion of land cover and land use to study area.
The aims of this research are:
1. Assessment the air quality of Baghdad city through determining the concentration of air pollutants.
2. The possibility of linkages between Landsat 7 ETM data within TIR6 and the concentration of air pollutants that are recorded in the ground stations by using GIS.

1-1. Study area

Baghdad city is located in central Iraq, within the sector of flat sedimentary plains.

---
*Corresponding author.
E-mail address (es): bassim_saa22@yahoo.com

The borders of the municipality of Baghdad encompass fourteen administrative units, eight in Rusafa (east of Tigris river) and six in Karkh (west of Tigris river), and the area of the municipality of Baghdad (870 km^2). Advantages of the characteristics of study area are: essentially great extremism in temperature, little precipitation, low relative humidity and high brightness of the sun. The population of Baghdad is more than 6 million from governmental statistics.
.

1-2. Methods

22 measurement stations (Fig.1-a) which are distributed in different areas within the municipality of Baghdad were selected for the purpose of measuring the concentration of total suspended particles (TSP), lead (Pb) and gases (CO, CO2, SO2). Stations were distributed on a regular basis to cover most areas of the city.

1-3. Image Processing

The satellite image used (Fig.1-b) is that obtained by Landsat 7 ETM on 1/11/2008. The image covers six spectral bands (three visible, one NIR, one SIR and one TIR). The ERDAS 8.4 program was used to perform digital processing of the image through converted digital number (DN) corresponding to the real sites

measuring stations, to Spectral Radiance (Lr) per unit (W/m2/Sr/µm) [3] using the following formula:

$$Lr = 0.0370588\ DN + 3.2 \ldots\ldots\ldots (1)$$

The second step is to convert (*Lr*) to Land Surface Temperature (LST) by using the following two equations [4, 5]:

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L_r} + 1\right)} \ldots\ldots\ldots\ldots\ldots (2)$$

$$LST = \frac{T}{1 + \left(\frac{\lambda . T}{\rho}\right).\ln \varepsilon} \ldots\ldots\ldots\ldots\ldots (3)$$

T: At-Sensor Brightness Temperature per unit (k); constant calibration for Landsat 7 ETM such that K1= 666.09 (W/m^2 /Sr/µm) ; K2=1282.71 k.

LST: Land Surface Temperature per unit (k); λ: wavelength of emitted radiance is equal to 11.5 µm; ρ: is equal to 1.438×10^{-2} mk; ε: Emissivity (0.92).

2. Results and Discussion

2-1. Air Pollutants

The results of air pollutants concentrations in Baghdad city are shown in Table 1. The highest concentrations of TSP, Pb, CO, CO_2, and SO_2 are recorded in many stations (4, 6, 8, 10, 16, 17, 18), which are characterized by high population and increase in the number of cars as well as poor fuel, the age of the vehicles and industrial activities inside the city.

2-2 Land Surface Temperature

The results of Simple Linear Correlation Coefficient (r) between LST derived from satellite image (Landsat 7 ETM$^+$) and the concentration of air pollutants (Fig. 2a) showed a positive and significant relationship between LST and the concentrations of CO, CO_2, TSP, and Pb. Similar results were found by Zhang et al. [6] when studying the phenomenon of the surface urban heat island (SUHI) of Shanghai city, where the relationship between LST and TSP reached r =0.672. The current results indicated a weak relationship between LST and SO_2. Weng et al. [2] when studying urban air pollution pattern with LU and with urban thermal landscape using (GIS) in Guangzhou city (China), found a similar relationship between LST and SO_2concentration, which reached r = 0.374. Figure 2b represents the distribution of LST in relation to the land cover and land use (LC, LU) of Baghdad. The highest values of LST shown by the contour lines were between 306-317 K were recorded in residential stations on the Rusafa side (16, 17, 18), in addition to industrial and commercial stations (2,4,8,10), while the lowest values of LST are generally recorded on the Karkh side, especially in stations 15 and 21, where values of LST between 287-293 K may be due to low population density and the absence of industrial activities in these areas. The station 22 that represents Dorah has a value of LST between 300-311 K ; the reason may be due to the existence of an electrical power station in this region in south west of Baghdad city and close to residential areas.

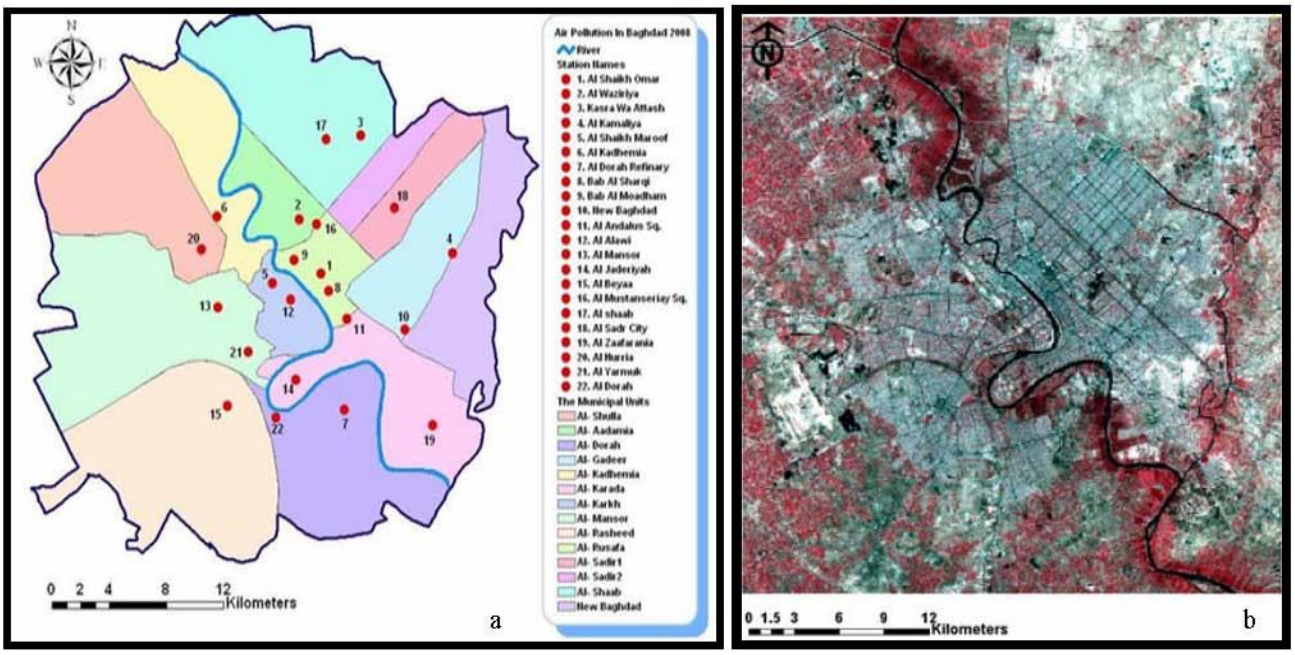

Fig.1. a. Measurement stations of air pollution in Baghdad city and municipal units b. Satellite image to Baghdad city using the spectral bands 2, 3 and 4

Table 1. Concentration of air pollutants (TSP, Pb, CO, CO_2 and SO_2) within current study

Station No.	Name of Station	Type of station	TSP µ/m3	Pb g/m3	COppm	CO_2 ppm	SO_2 ppm
1	Shaikh Omer	Industrial	1474.8	1.73	31.2	356	0.33
2	Waziriya	Industrial	1228.7	1.5	44.9	318	0.6
3	Kasra wa Atash	Industrial	809.5	2.26	51.9	315	0.4
4	Kamaliya	Industrial	4049.3	3.08	22.8	317	0.6
5	Shaikh Maroof	Industrial	748.3	1.4	26.2	336	0.5
6	Kadhimiya	Industrial	1879.8	3.62	28.9	355	0.43
7	Dorah refinery	Industrial	1029.4	2.62	12.3	310	0
8	Bab Al Sharqi	Commercial	2672.7	2.15	40.6	375	0.5
9	Bab Al Moadham	Commercial	1483.6	1.4	39.6	360	0.2
10	New Baghdad	Commercial	3061.2	2.04	37.8	447	0.3
11	Andalus Sq.	Commercial	810.8	1.7	34.7	376	0.4
12	Alawi	Commercial	811.5	1.5	29.3	352	0.6
13	Mansor	Commercial	1806.8	3.75	15.3	357	0.1
14	Jaderiya	Commercial	1716.4	1.61	15.9	372	0.2
15	Bayaa	Commercial	1790.5	1.15	26.6	353	0.2
16	Mustansiriya Sq.	Residential	2418.1	1.2	50.2	411	1
17	Shaab	Residential	5174.2	3.54	49.3	322	0.2
18	Sadr city	Residential	3144.3	2.14	42.7	311	0.1
19	Zaafaraniya	Residential	3427.3	0.95	18.9	375	0.1
20	Hurria	Residential	1443.2	0.37	9.8	320	0
21	Yarmook	Residential	1866.6	0.7	13.7	319	0
22	Dorah	Residential	2493.1	0.39	24.5	349	2.3

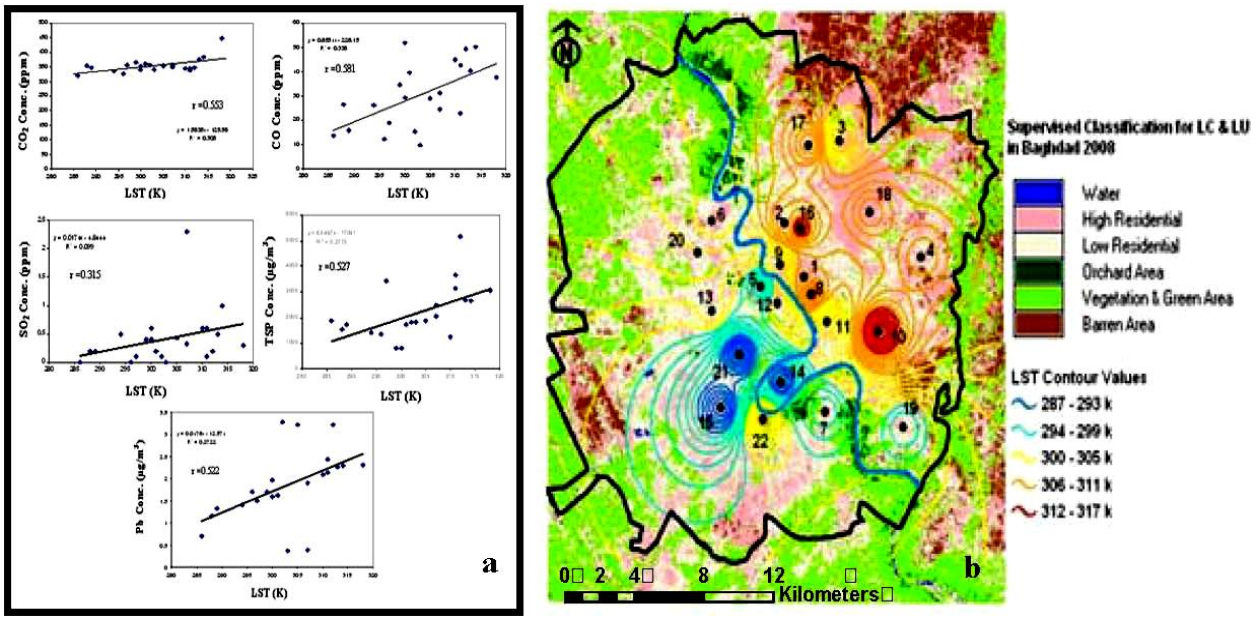

Fig. 2. a. Correlation Coefficient(r) between (LST) and air pollutants concentrations; b. (LST) values the proportion of (LC, LU) of Baghdad

2-3. Spatial Analysis

For the purpose of use of the possibilities offered by ArcGIS 9.2 program, as well as Landsat 7 ETM+ image, contour lines were used (one of the spatial analyst tools) to view and analyze the concentration of air pollutants and linkages with LC and LU of Baghdad city. Figure 3 shows that high concentrations of TSP are recorded in residential stations 17, 18, and 19 and some of industrial and commercial stations (4, 10) due to increased non-cultivated areas and bare soil around and inside Baghdad city, in addition to industrial and commercial activities in the city. High concentrations of Pb (Fig. 3) are recorded in different stations, especially in 4, 6, 13, and 17 due to the spread of industrial workshops in Kamaliya and Kadhimiya areas, as well as the increase in cars and traffic jams in Mansor and Shaab stations. The highest concentration of CO (Fig. 3) was recorded in industrial stations 2 and 3, as a result of industrial activity (smelting foundries and repair of cars) in Waziriya and Kasra wa Atash areas and in residential stations 16 and 17 due to fuel burning by cars. The highest concentration of CO_2 (Fig. 3) is recorded in the commercial station (New Baghdad) and residential station (Mustansiriya Sq.). The increased concentrations of CO and CO_2 in the air of Baghdad are due to the burning of the fuel used in various types of vehicles, as well as the low quality of fuel and the age of the vehicles and the use of generators. The highest concentration of SO_2 (Fig. 3) is recorded in a residential station (Dorah). The reason for increases in SO_2 is due to the presence of an electrical power station in Dorah, as well as the contribution of the fuel burning inside different vehicles in Baghdad city.

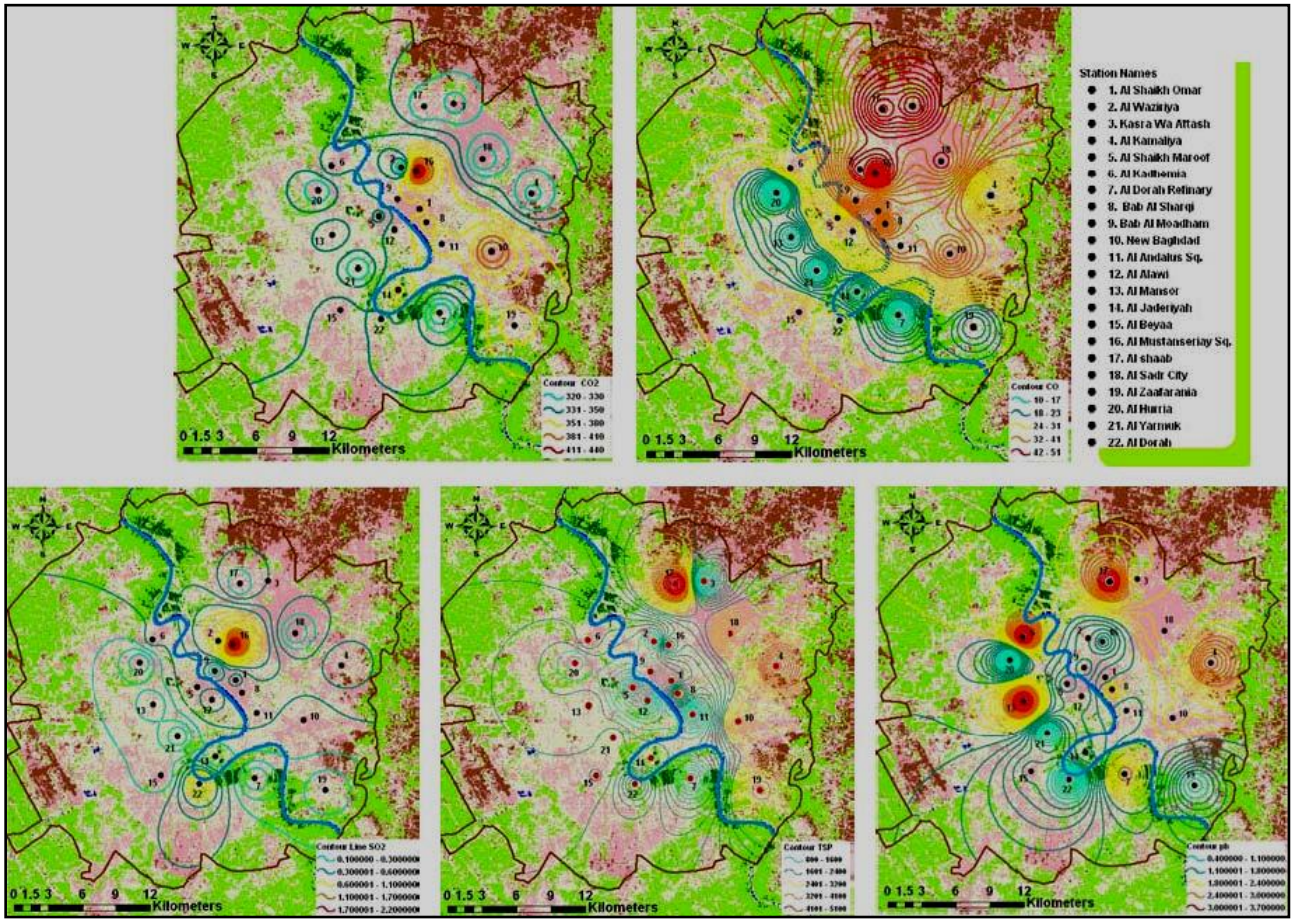

Fig. 3. Concentrations of air pollutants related to and LC, LU in Baghdad city

4. Conclusions

1. The results of air pollution in Baghdad show that high concentrations of TSP, Pb, CO, CO_2 and SO_2 were recorded in different regions especially in residential areas.
2. The results of the correlation coefficient (r) show the relations between land surface temperature (LST) and the concentration of CO, CO2, TSP and Pb which were measured from ground stations.
3.The results of the distribution of LST in Baghdad city related to land cover and land use show that areas with high population density, industrial and commercial areas, especially in Rusafa (east of the River Tigris) recorded higher values of LST, which are consistent with the results of air pollutants from ground stations in the same areas.

References

[1] Weng, Q., et al., 2004, Estimation of land surface temperature – vegetation abundance relationship for urban heat island studies, Remote Sensing of Environment, v.89 (4), p. 467-483,
[2] Weng, Q., et al., 2006, Urban air pollution patterns, land use and thermal landscape: an examination of the linkage using GIS Environmental Monitoring and Assessment, v.117 (4), p.463-489,
[3] LANDSAT PROJECT SCIENCE OFFICE, 2002, Landsat 7 science data user's handbook, Goddard Space Flight Center, NASA , Washington , DC.
http://landsathandbook.gsfc.nasa.gov/handbook.html
[4] Artis, D.A., et al., 1982, Survey of emissivity variability in thermography of urban areas. Remote Sensing of Environment, v.12, p.313– 329.
[5] Markham, B.L., et al.,1985 Spectral characteristics of the Landsat Thematic Mapper, International Journal of Remote Sensing, v.6, p.697– 716, Sensors
[6] Zhang, Z., et al., 2008, Surface urban heat island in Shanghai ,China : Examination the relationship between land surface temperature and impervious surface fractions derived from The International J. of Photogrammetry, Remote Sensing and imagery Landsat ETM Spatial Information Science, Beijing
www.isprs.org/congresses/beijing2008/proceedings/8_pdf/3_WG_VIII-3/23.pdf