

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

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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. Been obtained to concentration of total suspended particles (TSP), lead (Pb), carbon oxides (CO, CO₂), Sulphur Dioxide (SO₂) from (22) ground measuring stations, where the stations are classified into (industrial, commercial and residential) are distributed within the city of Baghdad. Also convert the digital number (DN) corresponding to the sites of truth stations for measuring air pollutants 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 result, finding a relationship between the concentration of air pollutants and (LST) with the 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.

Key Words: Air Pollution –GIS –Remote Sensing- Land Cover and Land Use

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 many air pollutants such as gases resulting from industrial activities or different modes of transport. Some studies have addressed the using (GIS) and remote sensing data in the study of air pollution (Weng, 2004 and 2006), has used satellite data (Landsat) for sensors (TM, ETM⁺) within (TIR6) to extract the values of (LST) and linked with air pollutants (from ground stations) the proportion of land cover and land use to study area.

The aims of research:

1. Assessment the air quality of Baghdad city through determines the concentration of air pollutants.
2. The possibility of linkages between (Landsat 7 ETM⁺) data within (TIR6) and the concentration of air pollutants that recorded in the ground stations by using (GIS).

Study area

Baghdad city is located in central of Iraq within the sector of flat sedimentary plain. The borders of the municipality of Baghdad encompass fourteen an administrative unit, eight in Rusafa (east of Tigris river) and six in Karkh (west of Tigris river), and area of the

municipality of Baghdad (870 km²). Advantage of the characteristics of study area is essential extremism great in temperature, few precipitations, few relative humidity and high brightness of the sun. Baghdad population is more than (6 millions) with governmental statistics.

Methods

Were selected (22) measurement stations, figure(1-a) that distributed in different areas within the municipality of Baghdad for the purpose of the process of measuring the concentration of (TSP) , (Pb) and gases (CO, CO₂, SO₂), where stations were distributed on a regular basis to cover most areas of the city.

Image Processing

The satellite image used, figure (1-b) that mediated by (Landsat 7 ETM⁺) on (1/11/2008). The image is cover six spectral bands (three visible, one NIR, one SIR and one TIR). The Program was used (ERDAS 8.4) 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) (Landsat Project Science Office, 2000) using the following formula:

$$Lr = 0.0370588 \text{ DN} + 3.2 \dots \dots \dots (1)$$

Second step is converted (Lr) to Land Surface Temperature (LST) by using two following equations (Artis and Carnahan, 1982; Markham & Barker, 1985):

$$LST = \frac{T}{1 + \left(\frac{\lambda.T}{\rho}\right). \ln \varepsilon} \dots \dots \dots (3) \quad T = \frac{K_2}{\ln\left(\frac{K_1}{L_r} + 1\right)} \dots \dots \dots (2)$$

T: At-Sensor Brightness Temperature per unit (k); constant calibration for (Landsat 7 ETM⁺) and equal (K₁= 666.09 (W/m²/Sr/μm) ; K₂=1282.71 k).

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

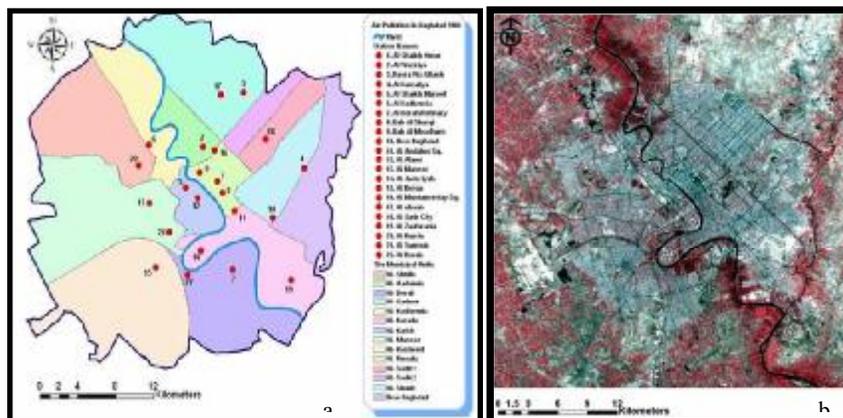


Figure (1): a -Measurement stations of air pollution in Baghdad city and municipal units- Satellite image to Baghdad city by using the spectral bands (2,3,4)

Results and Discussion

1. Air Pollutants

The results of air pollutants concentrations in Baghdad city are showing in table (1), that the highest concentrations of (TSP,Pb,CO,CO₂,SO₂) are recorded in many stations (4,6,8,10,16,17,18), which recognized with high population and increase in the number of cars as well as poor fuel, the age of the vehicles and industrial activities inside city.

Table (1): Concentration of air pollutants (TSP,Pb,CO,CO₂,SO₂) within current study

Station No.	Name of Station	Type of station	TSP µg/m ³	Pb µg/m ³	CO ppm	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

2. LST

The results of (Simple Linear Correlation Coefficient) (r) between (LST) derived from satellite image (Landsat 7 ETM⁺) and the air pollutants concentrations, figure (2a) showed a positive and significant relationship between (LST) and the concentrations of (CO, CO₂, TSP, Pb). Found (Zhang et al, 2008) when studying the phenomenon of surface urban heat island (SUHI) of Shanghai city relationship between (LST) and (TSP) reached (r =0.672). The current results indicated a weak relationship between (LST) and (SO₂). Found (Weng et al., 2006) when studying urban air pollution pattern with (LU) and with urban thermal landscape using (GIS) to Guangzhou city (China) a similar relationship between (LST) and (SO₂) concentration reached (r = 0.374). The figure (2b) represents the distribution of (LST) the proportion of (LC,LU) of Baghdad, as we note that the highest values of (LST)

by using contour lines were between (306-317 k) were recorded in residential stations in 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 in Karkh side, especially in stations (15,21), 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 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.

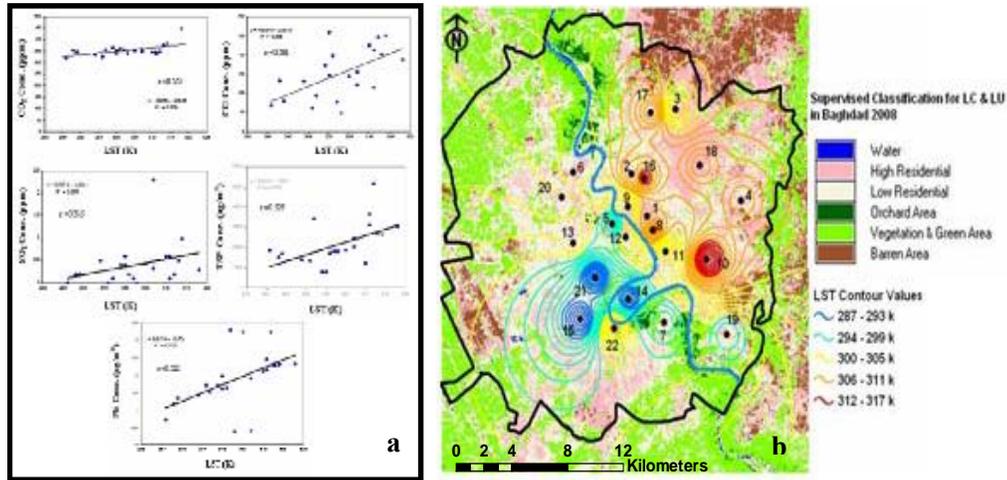


Figure (2): a - Correlation Coefficient(r) between (LST) and air pollutants concentrations
b - (LST) values the proportion of (LC, LU) of Baghdad

3. Spatial Analyst

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 linked with (LC,LU) of Baghdad city. The figure (3) is showing that the high concentrations of (TSP) are recorded in residential stations (17,18,19) 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. From figure (3) the high concentrations of (Pb) are recorded in different stations, especially in (4, 6, 13, 17) due to the spread of industrial workshops in (Kamaliya and Kadhimiya) areas, as well as the increased of cars and traffic chokes in (Mansor and Shaab) stations. Recorded the highest concentration of (CO), figure (3) in industrial stations (2,3) as a result of industrial activity (smelting foundries and repair of cars) in (Waziriya and Kasra wa Atash) areas and residential stations (16,17) due to fuel burning by cars. The highest concentration of (CO₂), noted figure (3), is recorded in the commercial station (New Baghdad) and residential station (Mustansiriya Sq.).The increased concentrations of (CO,CO₂) in the air of Baghdad are due to the burning of the fuel used in various types of vehicles as well as poor fuel and the age of the vehicles and the use of generators. From figure (3), the highest concentration of (SO₂) is recorded in residential station (Dorah). The reason of increases of (SO₂) due to the presence of a electrical power

station in (Dorah), as well as contribution of the fuel burning inside different vehicles to increase the concentration of (SO₂) in Baghdad city.

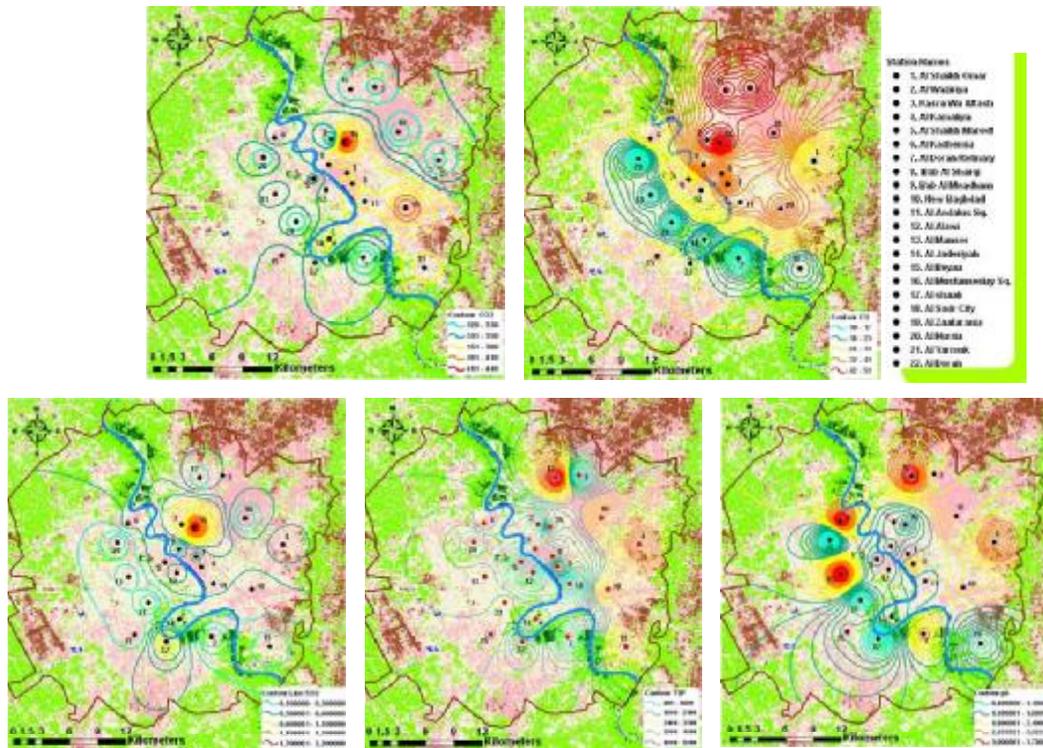


Figure (3): Concentrations of air pollutants related to (LC,LU) in Baghdad city

Conclusions

- 1.The results of air pollution in Baghdad showing that the high concentrations of (TSP,Pb,CO,CO₂,SO₂) recorded in different regions especially in residential areas
2. The results of the correlation coefficient (r) Showing existence the relations between (LST) and the concentration of (CO, CO₂, TSP, Pb) which measured from ground stations.
- 3.The results of the distribution (LST) in Baghdad city related to (LC/LU), which 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.

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