Estimating Water Quality from Satellite Image and Reflectance Data

Ass. Prof
Dr. Abdul Razzak T. Ziboon
University Of Technology
Building & Construction Engineering Department

Abstract

The useful of remote sensing techniques in Environmental Engineering and another science is to save time, Coast and efforts, also to collect more accurate information under monitoring mechanism. In this research a number of statistical models were used for determining the best relationships between each water quality parameter and the mean reflectance values generated for different channels of radiometer operate simulated to the thematic Mappar satellite image.

Among these models are the regression models which enable us to as certain and utilize a relation between a variable of interest. Called a dependent variable; and one or more independent variables.

1. Introductions

During the last few years, there has been great emphasis on environmental and neutral phenomena that influence earth resource and especial great deal energy has been expanded in such studies in order to find the right solutions for such environmental problems.

Remote sensing by satellite and high altitude air-born surveys provide an important source of information which can be used for natural resource management and disaster monitoring in an effective way. The coast effective of the remote sensing techniques have been proved in various application indicating an efficient method of surveying identifying, classifying, mapping of natural resource in many countries. Multibands and multi date satellite imagery and aerial photographs have been extensively used for water bodies monitoring.

2. Spectral Reflectance Characteristics of Water

Considering the spectral reflectance of water, probably the most distinctive characteristics are the energy absorption at reflected infrared wavelength. In short, water absorbs energy in these wavelengths whether we are dealing with water features (such as lakes and streams) or water contained in vegetation or soil. Locating and delineating water bodies with remote sensing data is done most easily in reflected infrared wavelengths because of this absorption property. However, various conditions of water bodies manifest themselves primarily in visible wavelengths.

Spectral characteristics of water vary with wavelength and are the result of not only the molecular nature of water but also imparities within the water body. Visible wavelength data (0.4 to 0.7 μm) may provide information on certain physical condition within lakes, rivers, and wetlands because there is a significant amount of radiation in this wavelength region.

At the near - and middle infrared wavelength, even a very thin layer of water display several distinct, strong absorption bands. In natural setting, water bodies absorb nearly all incident energy in both the near infrared and middle-infrared wavelengths. Even when the water is very shallow. Therefore, since water absorbs energy in the above wavelengths so effectively, there is very little energy available to be reflected al these wavelengths. This is very advantageous for remote sensing purpose since it cause water features to have a significant and reflective infrared portion of the spectrum. As indicated in fig (1) such distinct differences in infrared reflectance allow water bodies to be easily identified and mapped. In the visible portion of the spectrum the energy -matter interaction to water bodies become more complex at it is still helpful to think of these interaction in terms of energy-balance equation:

$$I_{\lambda}=R_{\lambda}+A_{\lambda}+T_{\lambda} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

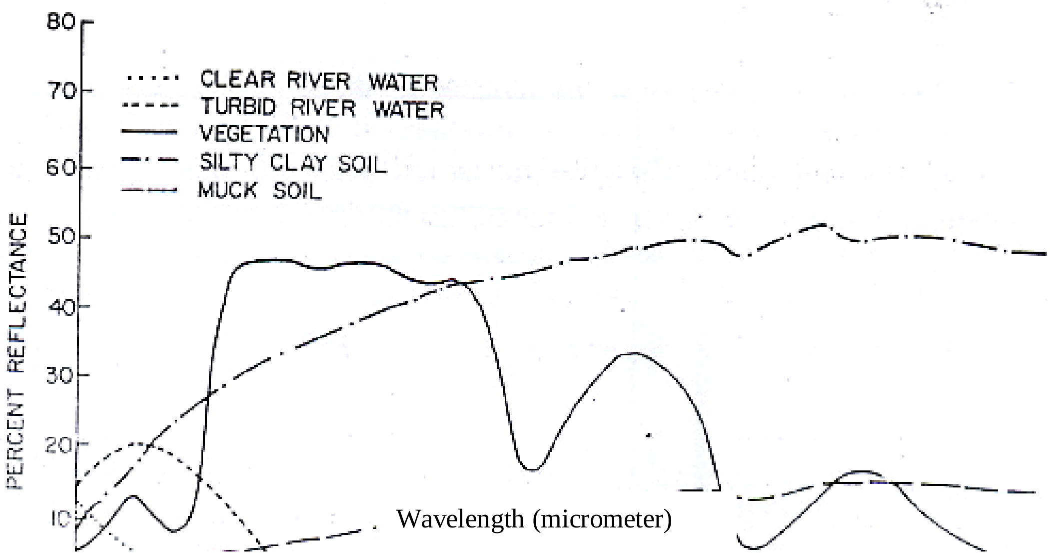


Figure (1) Spectral reflectance of basic cover types

3. radiometric measurements:

Reflected irradiance from the surface of water bodies represented Tigris River, the study area was measured using four channels filter corresponding to the land sat-TM and SPOT satellites. The spectral bands of "thematic Mappar" are: 0.4-0.52, 0.52-0.6, 0.63-0.69. and 0.76-0.9 µm, while for SPOT: 0.5-0.59, 0.61-0.68, and 0.79-0.89 µm.

Measurements were down under clear-sky condition in all study sites at times between 9:30 to 12:30 in the morning, and the water was illuminated directly by sunlight. The hand-held radiometer was used in the field measurements in three cases:

1. Boat survey.
2. Near the banks of river, by hand.
3. Over the bridges.

The following Tables give the result of radiometric measurements for the selected study types:

Three characteristics can be taken care of by radiometer performances which are:

1- Radiometer (responsivity) (R) is the change in output voltage DV divided by the change in incident flux.(input) on the detector.
2- Radiometer (detectivity) (D) is the reciprocal of the nise-equivalent flux incident by the noise voltage (Vn).
3- Referring the radiation level of incident radiation corresponding to the zero output reading.

From the three characteristics mentioned above the output radiant flux and others are referred to as (the measurements equation). The measurement method for spectral reflectance of target under test in terms of to the conditions of experimental field work is shown below.

4. Spectral Reflectance Mathematical Models:

Any ground target receives sun rays (E) irradiance (unit measure) Watt/m^2 and reflects rays (L) .radiance (watt/m^2), the radiometer records these rays as electric signals (Volt). (R).

where $L=C1\ V1$ ……………………..(2)

C1 = Constant (for each bands).
VI = electromagnetic ray reaching the radiometer from the targets.

Also the same way for calculating radiance from the sun

$E=C2V2$ ………………….(3)

So the spectral reflectance can be estimated as below:

$$\text{Spectral reflectance } (R\%) = \frac{\text{Radiance } (V) \times \text{calibration factor}}{\text{Irradiance } (V) \times \text{calibration factor}}$$

Reflectance measured by this method is called (Aperture Reflectance).

Table (2) gives the calibration for each wavelength according to type of sensor (TM and SPOT).

Sensor type	Channel	Wavelength (Mm)	Calibration Factor	
			Sun	Target
TM	TM1	0.45-0.52	21.1	9.22
Thematic Mapper	TM2 TM3 TM4	0.52-0.60 0.63-0.69 0.76-0.90	11.8 8.72 7.71	4.93 4.48 4.5
SPOT	SPOT1 SPOT2 SPOT3	0.50-0.59 0.61-0.68 0.79-0.89	12.9 10.3 8.55	5.29 5.24 5.02

Table (2) Spectral bands of radiometer with sensor type

4.1 Computer Work Minitab Program

Minitab was the soft-ware program used in our regression analysis. This program is stored in the Computer Laboratory of the Building and Construction Department (University of Technology).

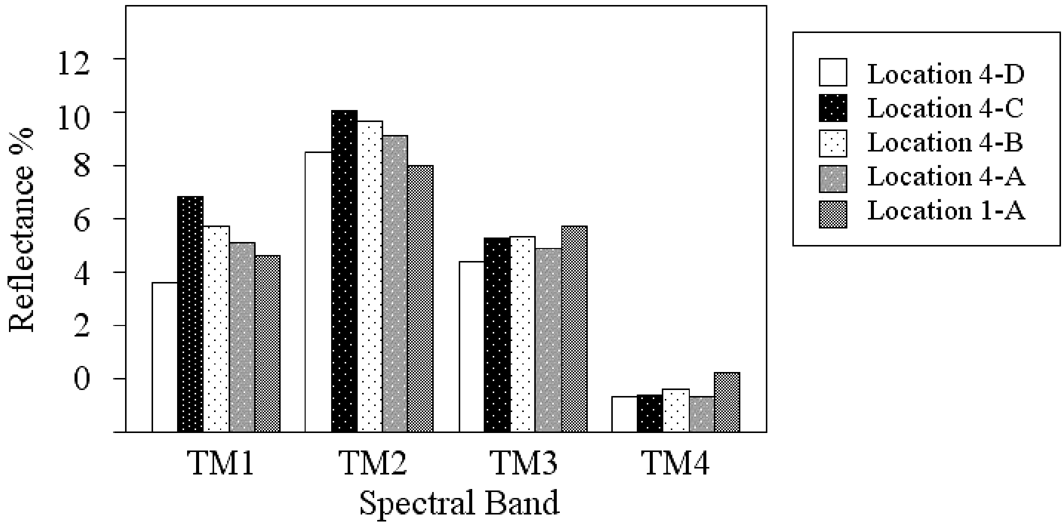
This program is a general purpose data analysis system that has been installed on a wide variety of mainframe, mini and micro computers. It contains power and flexible statistical analysis routines which are very easy to use due to the program being simple, straight-forward command syntax.

Minitab also has an on-line HELP facility, which gives short explanation of commands and syntax.

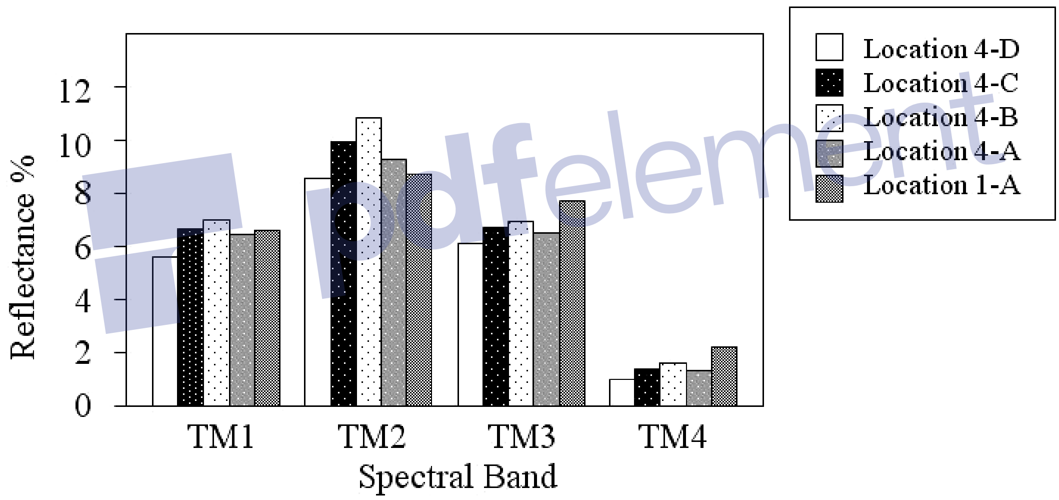
This program has been found especially useful for exploring data in the early phases of analysis, for plotting, and for regression analysis.

Some Minitab commands have subcommands. These are used for special options or to convey additional information in complicated analysis.

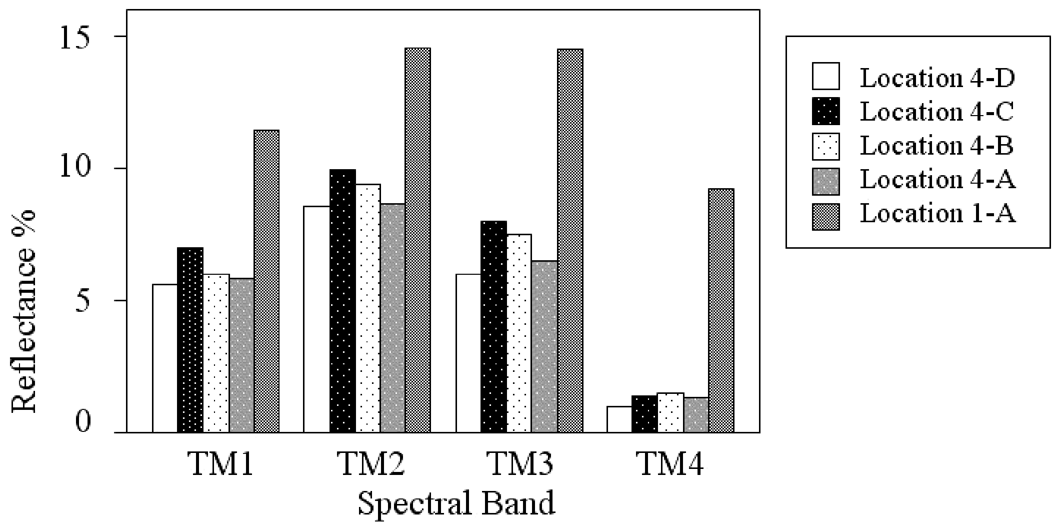
a) Karkh bank



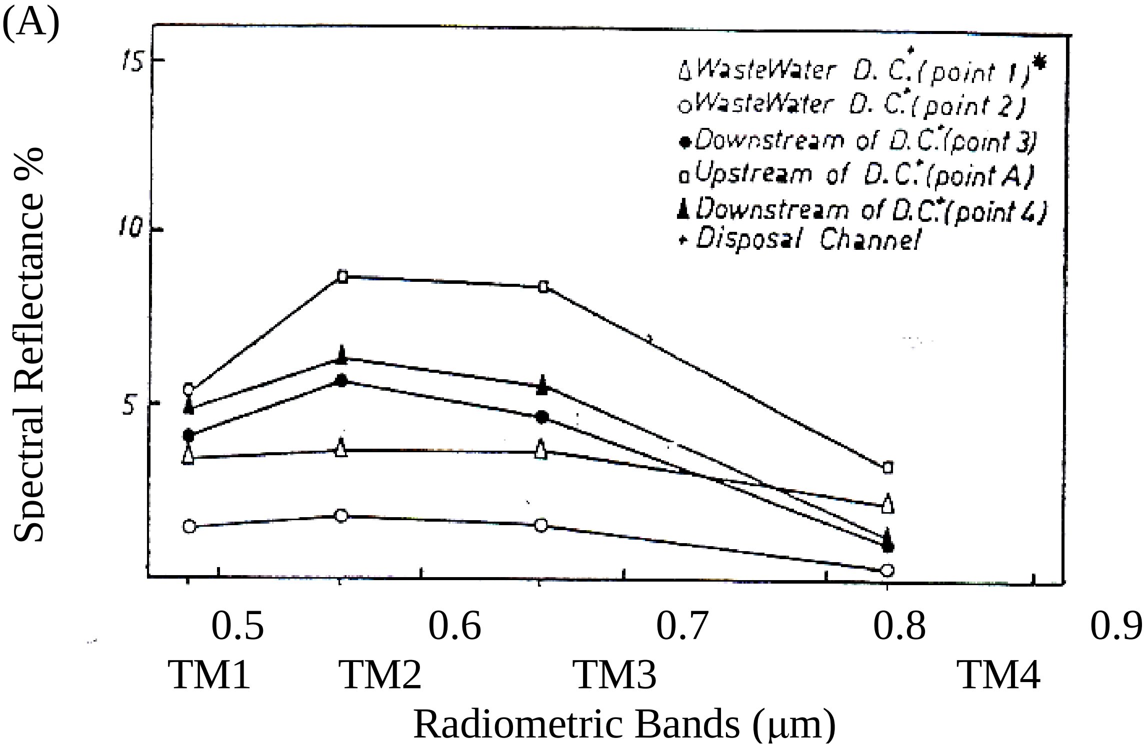
b) Mid. Of river



c) Rasafa bank



(A)



(B)

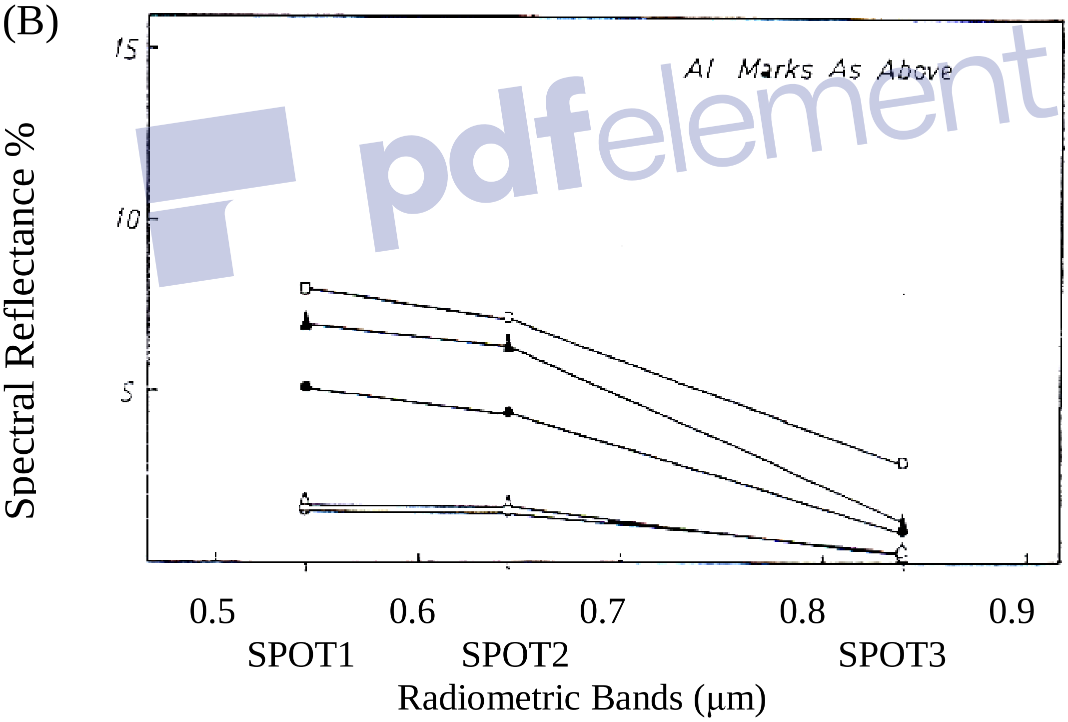
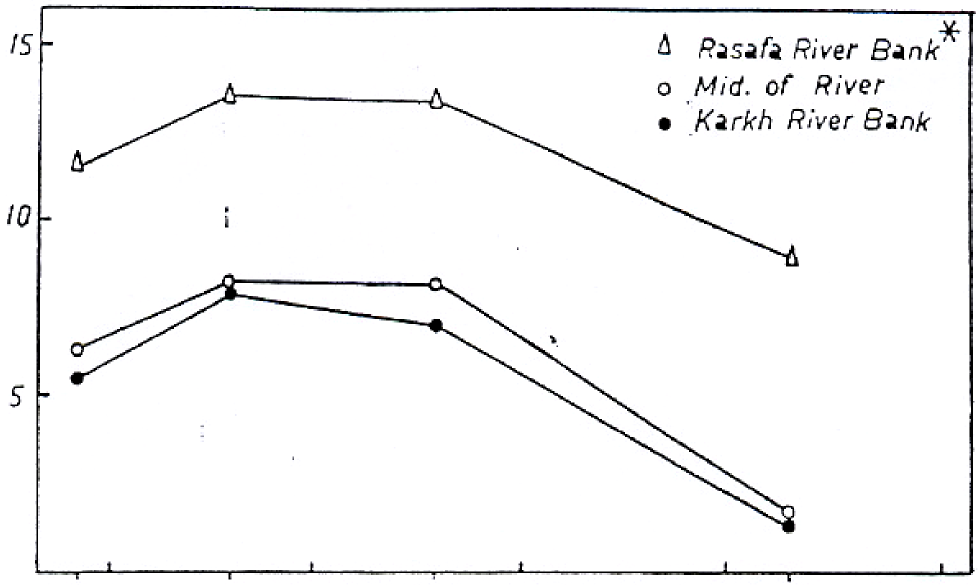


Fig. (5-6)
Spectral Reflectance Curves (SITE-3)

(a) TM Sensor
(b) SPOT Sensor

(A)

Spectral Reflectance %



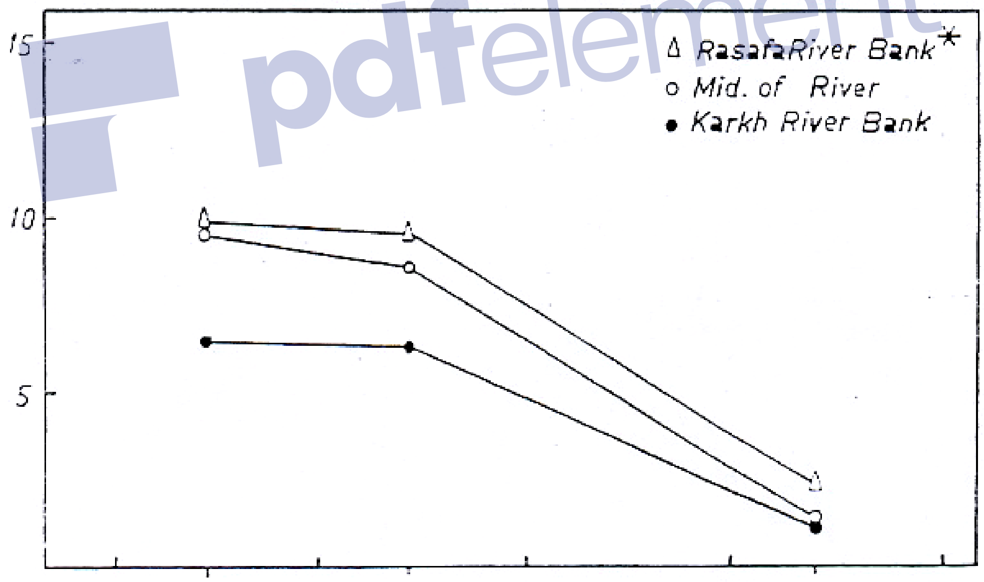
0.5 0.6 0.7 0.8 0.9

TM1 TM2 TM3 TM4

Radiometric Bands (μm)

(B)

Spectral Reflectance %



0.5 0.6 0.7 0.8 0.9

SPOT1 SPOT2 SPOT3

Radiometric Bands (μm)

Fig. (5-7)
Spectral Reflectance Curves (SITE-1)

(c) TM Sensor
(d) SPOT Sensor

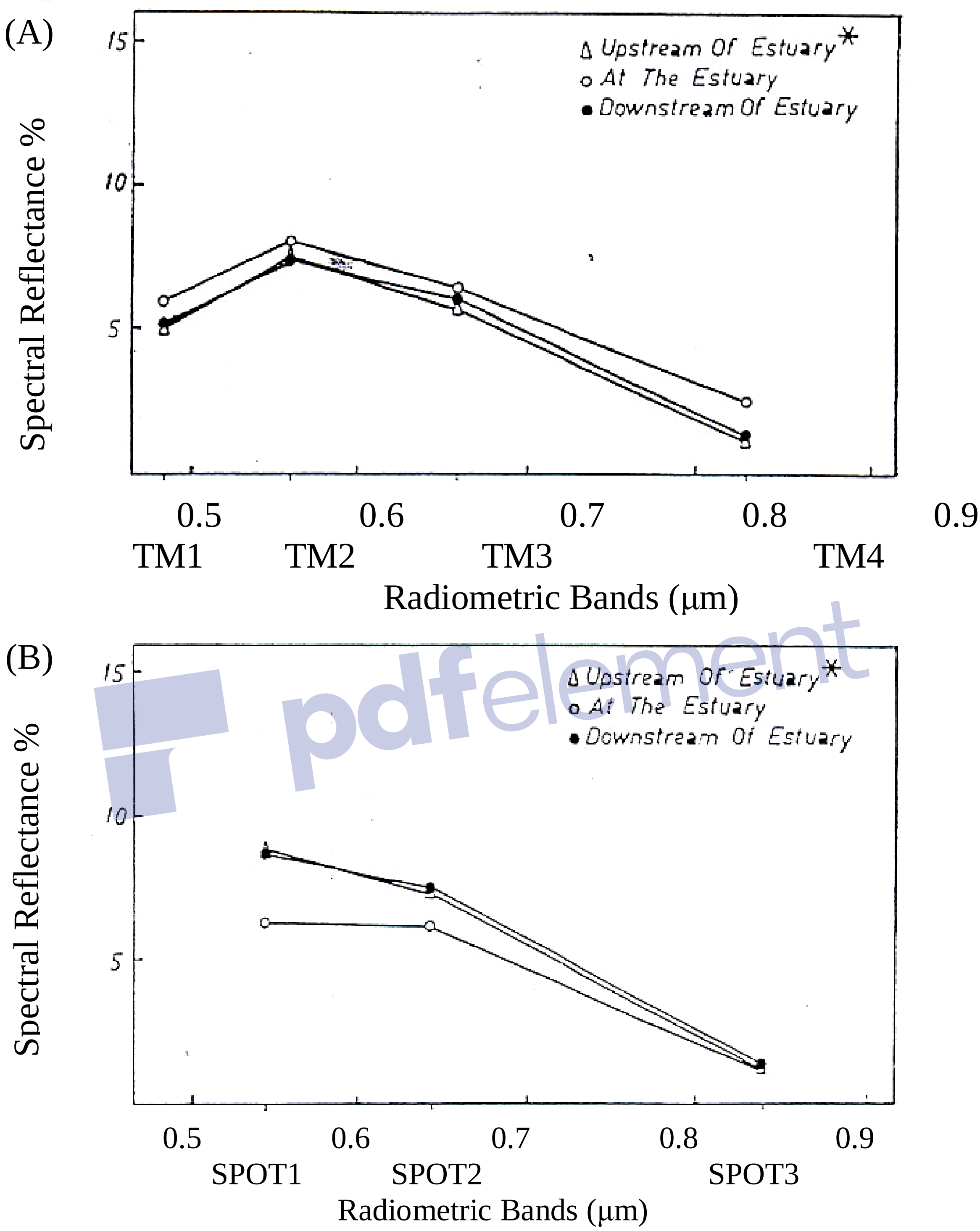


Fig. (5-8)
Spectral Reflectance Curves (SITE-1)

(a) TM Sensor
(b) SPOT Sensor

Table (1)

Radiometric measurements (watt/m^2)*

Site: Over Al-Jadriah Bridge

Core: N 33 16
E 44 22

Date:

Targ.: Sun

Sky: Clear

Type of Sensor:

A) TM:

Time	Satellite Channel Number			
	TM1	TM2	TM3	TM4
9:35	0.3852	0.6912	0.8662	1.3440
	0.3782	0.6752	0.8472	1.3030
	0.3752	0.6712	0.8422	1.2970
AV.	0.3795	0.6792	0.8518	1.3146

B) SPOT:

Time	Satellite Channel Number			
	TM1	SPOT 1	SPOT 2	SPOT 3
10:05	0.3242	0.6552	0.7602	0.8060
	0.3452	0.6771	0.7902	0.8380
	0.3542	0.6882	0.8002	0.8430
AV.	0.3412	0.6735	0.8518	0.8290

* Location 1-A, Point 1 (over the bridge) see Figures (2)

Table (2)
Radiometric measurements (watt/m^2)*

Site: Over Al-Jadriah Bridge
Core: N 33 16
E 44 22

Date:
Targ.: Water-Rasafa River Bank
Sky: Clear
Type of Sensor:

A) TM:

Time	Satellite Channel Number			
	TM1	TM2	TM3	TM4
9:35	0.0982	0.2162	0.2192	0.1980
	0.1102	0.2352	0.2392	0.2260
	0.0912	0.2062	0.2032	0.1730
AV.	0.0998	0.2182	0.2205	0.1990

B) SPOT:

Time	Satellite Channel Number			
	TM1	SPOT 1	SPOT 2	SPOT 3
10:05	0.612	0.1712	0.1582	0.0460
	0.0512	0.1542	0.1372	0.0220
	0.0542	0.1582	0.1412	0.0270
AV.	0.0555	0.1612	0.1455	0.0316

* Location 1-A, Point (1) (over the bridge) see Figures (2)

Table (3)
Radiometric measurements (watt/m^2)*

Site: Over Al-Jadriah Bridge
Core: N 33 16
E 44 22

Date:
Targ.: Water-Near the Estuary
Sky: Clear
Type of Sensor: SPOT

A)

Time	Satellite Channel Number			
	TM1	TM2	TM3	TM4
9:35	0.0602	0.1762	0.1522	0.0270
	0.0602	0.1772	0.1522	0.0260
	0.0592	0.1752	0.1492	0.0250
AV.	0.0598	0.1762	0.1512	0.0260

B)

Time	Satellite Channel Number			
	TM1	SPOT 1	SPOT 2	SPOT 3
10:05	0.0602	0.1762	0.1492	0.0270
	0.0592	0.1732	0.1462	0.0260
	0.0572	0.1672	0.1402	0.0270
AV.	0.0588	0.1722	0.1452	0.0266

A) Location 1-B, Point 1 , see Figures (2).
B) Location 1-B, Point 2 , see Figures (2).

Table (4)
Radiometric measurements (watt/m^2)*

Site: Over Al-Jadriah Bridge
Core: N 33 16
E 44 22

Date:
Targ.: Water-Near the Estuary
Sky: Clear
Type of Sensor: SPOT

A) Location 1-B, Point (1), see figures (2).

Time	Satellite Channel Number			
	TM1	TM2	TM3	TM4
9:35	0.3952	0.7722	0.9072	0.9770
	0.3952	0.7732	0.9072	0.9770
	0.3952	0.7732	0.9092	0.9790
AV.	0.3952	0.7728	0.9078	0.9776

B) Location 1-B, Point (1), see figures (2)

Time	Satellite Channel Number			
	TM1	SPOT 1	SPOT 2	SPOT 3
10:05	0.0282	0.0842	0.0562	0.4690
	0.0252	0.0752	0.0512	0.4340
	0.0242	0.0712	0.0492	0.424
AV.	0.0258	0.0768	0.0522	0.4423

A) Location 1-B, Point (1) see Figures (2).
B) Location 1-B, Point (2) ,see Figures (2).

Appendix

Location of measurements from Baghdad satellite image

References:

1. Water and land Resources (1998). Available on line of: http://dnr.metrokc.gov/wlr.

2. U.S. Environmental Protection Agency (2005). Available on line of: http:// www.epa.gov/owow/wetland/types/marsh.

3. M. Lillian, (2004). "Remote Sensing and Image Interpretation". fifth ed, New York.

4. Mohamed, M.R, (1999). "Prediction of Pollution from Spectral Reflectance of Tigris River at Water Treatment Plants Intakes in Baghdad Using Statistical Models". University of Technology/Iraq. (M.Sc Thesis).

5. Gibson, P.J & Power, C.H, (2000). "Introductory Remote Sensing Principles and Concept". Toyler and Francis Group, London.

6. Sabins, F.F, JR. (1987). "Remote Sensing Principles and Interpretation"2 nd ed, Remote Sensing Enterprise, Inc, New York.
7. Swain, P.H. (1978). "Remote Sensing: The Quantitative Approach", Mc Graw- Hill Inc., New York
8. Kenny, (2004). "Principles of Remote Sensing" ITC, Educational Textbook series.