Remote Sensing as a Tool in Assessing Water Quality

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Abstract: Remote sensing techniques can be used to detect the water quality against different dates. The aim of this study is to determine the relation between the water quality of AL-Abshiet drain and its reflectance using satellite images. Four different dates of SPOT satellite images and an image of World View satellite are used to measure the reflectance of the water through the selected 6 points along Al-Abshiet drain. The results of monitoring the water reflectance of 6 points along Al-Abshiet drain (as polluted water) and one point taken from Nile River (Damietta Branch as clear water) show that there is a high effect of the growth of aquatic plants and suspense-materials in the year 2011 in the all year and there is high difference with the clear water sample (Damietta Branch). There are high differences in the water reflectance which is mainly due to the growth of aquatic plants as well as the suspended water in Al-Abshiet drain. The results of the chemical analyses of Al-Abshiet drian water show that the Nitriate-Nitrogen values in sites 5 and 6 ranged from 18.03 mg/l to 18.68 mg/l were higher than the maxiumum limit value (15 mg/l). The ammonia-N value in sites 5 and 6 ranged from 5.10 mg/l to 5.52 mg/l) was less than the maxiumum limit value (5 mg/l). The ECw of Al-Abshiat drain in all sites (ranged from 2.6 dS/m to 3.2 dS/m) were higher than the maximum limit value (2 dS/m). The Boron element was very high increase in Al-Abshiet drain in all 6 sites (ranged from 5.16 mg/l up to 32.99 mg/l) than the maxiumum limit (0.75 mg/l). Therefore, the water quality of Al-Abshiet drian is not recomended to be used it for irrigation (Accoding to Ayers and Westcst, 1994).

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Keyword: water and aquatic plant reflectance; water quality and pollution; remote sensing; Al-Abshiet drain.

1. Introduction

Suspended sediments and aquatic plants are the most common pollutant both in terms of weight and volume in surface waters of freshwater systems. Suspended sediments may serve as a surrogate contaminant in agricultural watersheds since phosphorus, insecticides, and metals adhere to fine sediment particles. Suspended sediments increase the radiance emergent from surface waters in the visible and near infrared proportion of the electromagnetic spectrum (Ritchie and Schiebe 2000). Significant relationships have been shown between suspended sediments and radiance or reflectance from spectral wave bands or combinations of wave bands on satellite and aircraft sensors (Brando, V.E., & Dekker, A.G. 2003). Aquatic plants are the main sources of loosing water in the open water channels as a result of their high evapotranspiration due to its viperous vegetative growth.

Phosphorous and nitrogen are both key parameters for aquatic plant life. The ammonium ion is the preferred nitrogen source for plant growth (Smolders et al. 2002; James et al. 2004; Jampeetong and Brix 2009). Several studies have shown that phosphate and ammonium concentrations in water affect the composition of aquatic plant communities (Kohler 1975; Carbiener et al. 1990).

Remote sensing techniques can be used to assess several water quality parameters (e.g., suspended sediments (turbidity), chlorophyll, temperature). Monitoring the concentration of the chlorophyll (algal/phytoplankton) is needed to manage eutrophication in lakes, water bodies, irrigation and drainage canals. Remote sensing can be used to measure chlorophyll concentrations and patterns in water bodies. As with suspended sediment measurements, remote sensing of chlorophyll in water is based on developing relationships between radiance/reflectance in narrow bands or band ratios and chlorophyll (Greulich S, Bornette G 1999).

Remote sensing techniques, ground truth, and laboratory analysis are used in this study to determine the relation between the water of Al-Abshiet drain and its reflectance using satellite images.

2. Materials and methods

2.1. Materials used:

2.1.1. Satellite images:

Four different dates of SPOT satellite images and an image of World View satellite are used to measure the reflectance of the water through the selected 6 points along Al-Abshiet drain as polluted water and one clear water sample from Nile River (Damietta Branch). The following satellite images were used.

No.	Satellite Type	Date	Resolution
1	World Veiw2	Summer 2011	2 meters
2	SPOT5	Summer 2005	2.5 meters
3	SPOT4	Summer 2000	20 meters
4	SPOT4	Summer 1995	20 meters
5	SPOT2	Summer 1989	20 meters

2.1.2. GIS Software

Dynamic SWERI data collector system (SDC) using Global Position System (GPS) is developed to define the location of the 6 sites. Water samples of water of Al-Abshiet drain (as polluted water), and one sample from Nile River (Damietta Branch as clear water) were collected. The ERDAS Imagine 9.1 is used for image enhancement, correction and cut purposes, while Arc.GIS 9.2 and ILWIS 3.7 software's are used as a system provides its users with state of the art data gathering, data input, data storage, data manipulation, analysis, and data output capability by integrating conventional GIS.

2.1.3. Location of the studied area

The area located between Tanta city and El Mahalah city. Al-Abshiat drain is passing from the southern to northern part. Figure (1) and Table (1) show the Location and the coordinates of the 6 Sites along Al-Abshiet drain.

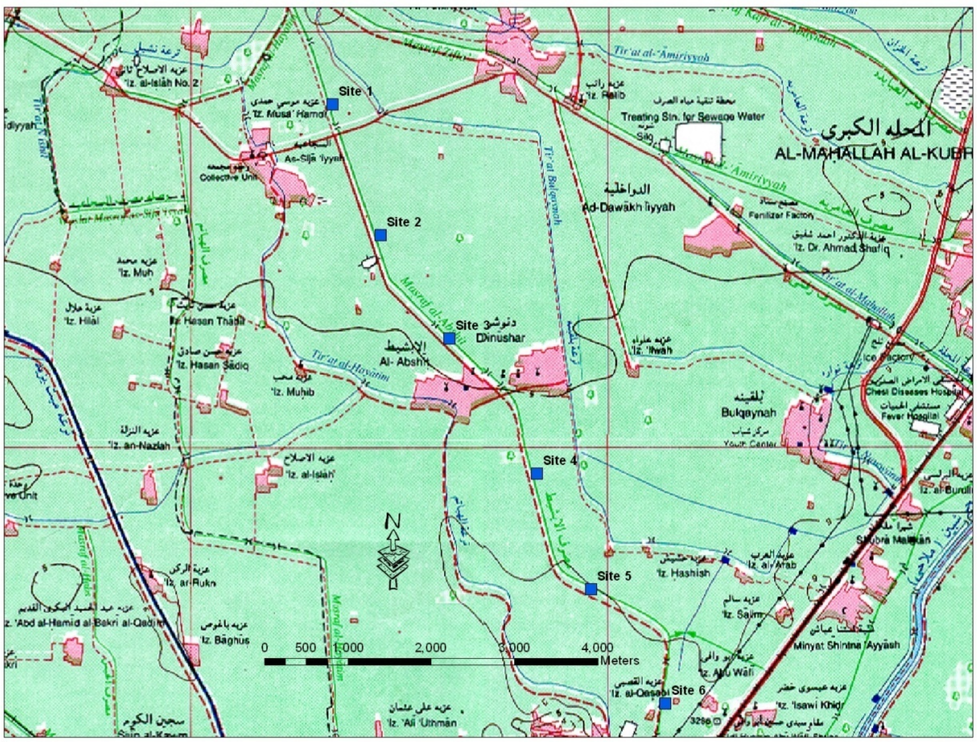


Figure (1) The Location of the 6 Sites along Al-Abshiet drain

Table (1) the Longitudes and Latitudes of the 6 Sites along Al-Abshiet drain and Nile River (Damietta Branch)

Sites	Long	Lat
Site 1	31°0 4' 12.872" E	30° 59' 02.997" N
Site 2	31°0 4' 34.675" E	30° 58' 11.972" N
Site 3	31° 05' 05.659" E	30° 57' 31.613" N
Site 4	31° 05' 45.433" E	30° 56' 38.650" N
Site 5	31° 06' 09.725" E	30° 55' 53.484" N
Site 6	31° 06' 43.353" E	30° 55' 09.029" N
Nile River (Damietta Branch)	31° 14' 06.207" E	30° 54' 17.180" N

2.1.4. Image Processing

Image processing techniques were followed to produce the best possible, enhanced image. Colour enhancement was done to create new images from original in order to increase the amount of information that can be visually interpreted from the data. In this procedure three bands were selected for red, green and blue to create false colour composite (3, 2, 1) for all SPOT images and false colour composite (7, 5, 3) for World View image. For each site the reflectance of the three bands used to plot in graphs to see the effects of growth the aquatic plants and suspense-materials on Al-Abshiet drain.

2.1.5. Water samples

Six sites water samples were collected. Its cover the distance from the connection with drain No.8 (sites 1-3), to the north of Al-Abshiet Village and three sites from the south of Al-Abshiet village to the nearest point to textile factor on the Al-Abshiet drain (sites 4-6), and the distance between the sites is 2 Km. One water sample was taken from Nile River (Damietta Branch) as clear water to test the difference of the spectral reflection and water analysis.

The pH value was determined in water samples using pH meter according the procedure described by Jackson (1976). The electrical conductivity (EC) was determined using the conductivity meter as described by Jackson (1976) and the values were corrected at 25º C.

Harvey and micro elements (B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, P, Pb, and Zn) in the water samples were extracted by AB-DTPA according to Soltanpour, (1991). The Harvey and micro elements in extracts were determined using Inductively Coupled Spectrometry Plasma (ICP) Model Ultima 2-Jobin Yvon.

Nitrogen forms (NH_4^+ and NO_3^-) were determined using Technicon Auto Analyzer II.

2.2.5. Water Quality for irrigation used

The guidelines are general in nature, and should not be with any specific type of irrigation method. Ayers and Westcst, 1994 have been based mainly on guidelines for the Food and Agricultural Organisation (FOA). Table (2) shows the maximum limit of water quality parameters were used for irrigation.

2.1.6. Laboratory activities

Table (2) The guidelines of maximum limit of water quality parameters were used for irrigation (source: Ayers and Westcst, 1994)

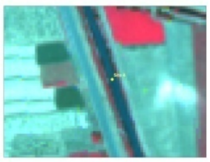
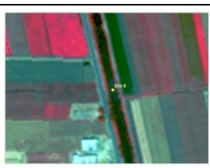
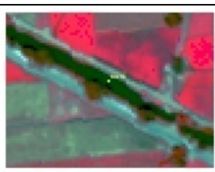
Parameters	Unit	Maximum limit
Chloride (Cl)	mg/l	250
Sulphate (S)	mg/l	500
Nitrate-Nitrogen (NO3-N)	mg/l	15
Ammonia-N (NH4-N)	mg/l	5
Electrical Conductivity	dS/m	2.0
Boron (B)	mg/l	0.75
Cadmium (Cd)	mg/l	0.01
Chromium (Cr)	mg/l	0.10
Cobalt (Co)	mg/l	0.05
Copper (Cu)	mg/l	0.20
Iron (Fe)	mg/l	5.0
Lead (pb)	mg/l	5.0
Manganese (Mn)	mg/l	0.2
Molybdenum (Mo)	mg/l	0.01
Nickel (NI)	mg/l	0.2
Zinc (Zn)	mg/l	2.0

3. Results and Discussion

3.1. Al-Abshiet drain reflectance

The selected six sites out of 6 sites were used to determine the reflectance of the three bands which are used to create false color composite (3, 2, 1) for all SPOT images (SPOT5, SPOT4, and SPOT2) and false color composite (7, 5, 3) for World View image. The DN values of the false color composite satellite images were collected and create in Excel sheet (Table 3). Figure (2) show the results of the reflectance graphs of polluted of Al-Abshiet drain.

Table (3) The Digital Number (DN) values of the three bands Green (G), Red (R), and Near Infra Red (NIR) for five years

World veiw2 2011	Sites	Bands		Years				
				1989	1995	2000	2005	2011
	Site 1	DN value	G	62	67	60	37	151
			R	34	63	45	22	63
			NIR	56	78	41	58	91
	Site 2	DN value	G	51	54	51	32	175
			R	34	41	35	21	76
			NIR	56	83	31	43	105
	Site 3	DN value	G	52	50	59	38	146
			R	35	34	45	26	61
			NIR	59	113	41	46	82
	Site 4	DN value	G	55	61	61	37	120
			R	38	52	44	23	65
			NIR	59	98	41	78	89
	Site 5	DN value	G	55	62	58	37	121
			R	39	42	46	24	60
			NIR	61	86	42	61	83
	Site 6	DN value	G	55	52	60	48	160
			R	39	44	59	30	85
			NIR	62	80	46	63	119
	Nile River (Damietta Branch)	DN value	G	40	42	46	30	10
			R	23	29	25	19	6
			NIR	20	24	19	14	4

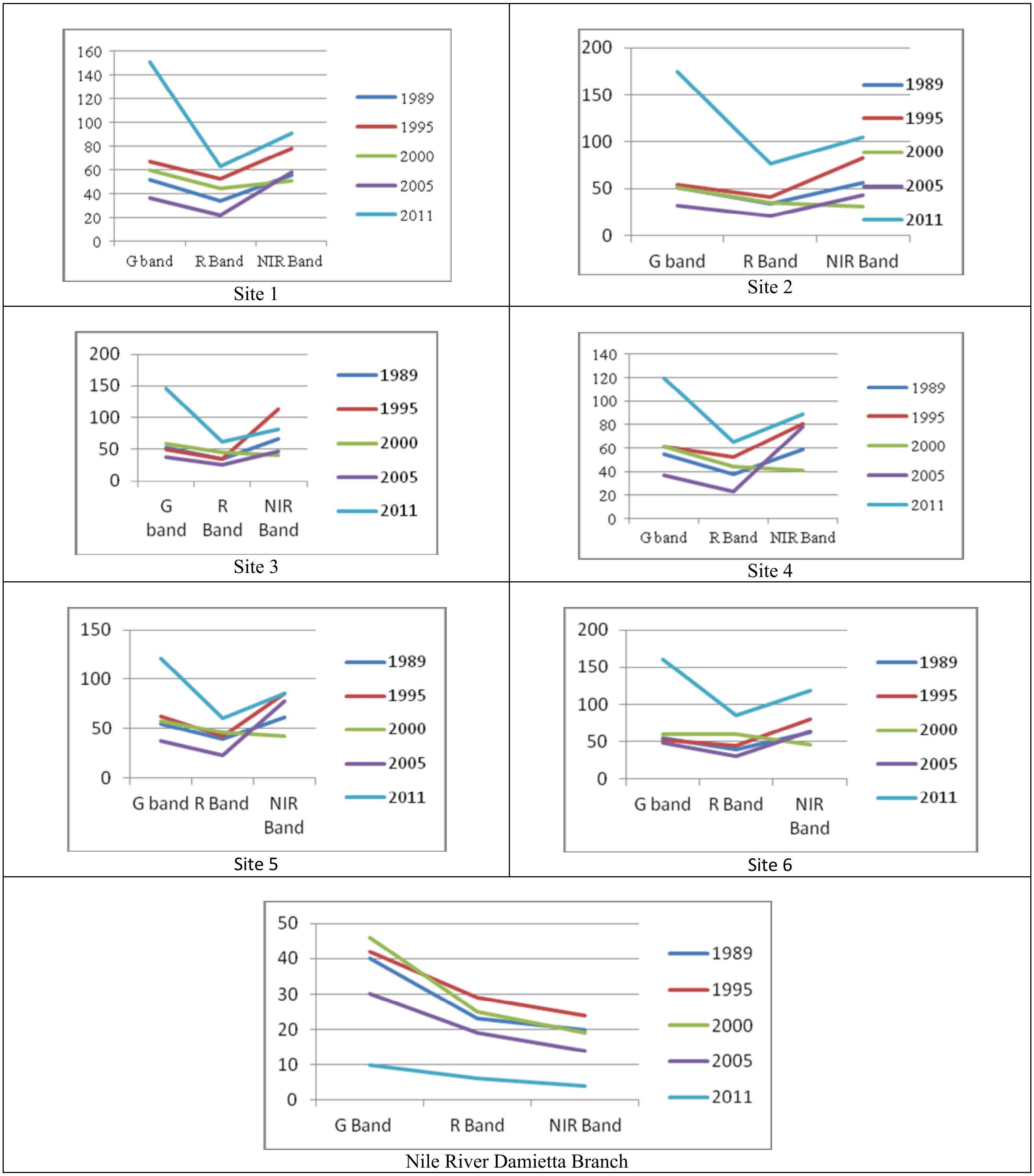


Figure (2) the reflectance graphs of the DN value of three bands in 6 sites on Al-Abshiet drain and clear water sample

The results illustrated the following remarks:

(1) the graph of year 2000 give the normal distribution of the three bands of water reflectance curve which is higher in Green band and goes down in the Red band and Near Inferred band. This can be explained as the cleaning of Al-Abshiet drain from the grow plants.

(2) The graph of years 1989, 1995, and 2005 give the normal distribution of the three bands of plant reflectance curve which is high in Green band and goes down in the Red band and higher in Near Inferred band, but stile within the ranges of water reflectance. This can be explained as the grow plants along Al-Abshiet drain.

(3) The graph of year 2011 gives the normal distribution of the three bands of plant reflectance curve which is high in Green band and goes down in the Red band and higher in Near Inferred band, and higher from the ranges of water reflectance curve and lower than the plant reflectance curve. This can be explained due to two main reasons which are the grow plants along Al-Abshiet drain and the effects of polluted water from the textile factory.

(4) The graph of Nile River (Dumyat Branch years) of years 1989, 1995, 2000 and 2005 give the normal distribution of the three bands of water reflectance curve which is high in Green band and goes down in the Red band and downer in Near Inferred band, Also year 2011 give the same ranges of water reflectance but they are very low. This can be explained as the percentages of the sediments in the water are low in year 2011 and the water much deeper in this year.

3.2. Water analysis

To correlate the data of water reflectance with the quality of the water the pH and EC of the water of Al-Abshiet drin, in the twelve sites were represented in Table (4). The results illustrated that the ECw of Al-Abshiet drain were higher in the 6 sites and the domint salt is soudum chloride. The pH is normal and ranged from 7.1 up to 7.7. There is siginfican differece between the EC of the Nile River (Damietta branch) as clear water and the EC of the water of Al-Abshiet drain.

Table (4) The chemical analysis of the water samples

Site No.	Water type	pH	EC dS/m
1	Al-Abshiet drain	7.6	2.5
2		7.6	2.9
3		7.6	2.9
4		7.5	2.8
5		7.5	3
6		7.7	3.2
Nile River Damytta Branch		7.7	0.3

3.3. The Micro, Heavy, NH_4, NO_3, and K Elements of the water samples

Table (5) shows the results of the Micro Elements (Fe, Zn, Mn, and Cu), heavy elements (Pb, Cd, Ni, Co, B, Mo, and Cr), NH_4, NO_3, and K Elements of the water sample and clear water sample from Nile River (Damietta Branch). The results show that there is high differece between the micro elements, heavy elements, and elements of NH_4, NO_3, and K of the water of the Nile River (Damietta branch) as clear water than the same elemants of the water of Al-Abshiet drain.

Table (5) The Micro Elements, Heavy Elements, and Elements of NH_4, NO_3, and K of the water samples

Water type	Point location	Micro Elements in mg/l				Heavy Elements in mg/l							Elements		
		Fe	Zn	Mn	Cu	Pb	Cd	Ni	Co	B	Mo	Cr	NO_3	NH_4	K
Al-Abshiet drain	Site No.1	0.071	0.009	0.186	0.007	0.005	0.001	0.075	0.003	5.664	0.017	0.005	9.83	0.39	13.57
	Site No.2	0.077	0.018	0.183	0.011	0.005	0.001	0.079	0.003	7.399	0.021	0.003	11.42	0.26	14.3
	Site No.3	0.091	0.046	0.156	0.01	0.006	0.002	0.083	0.002	13.21	0.022	0.003	6.99	0.01	13.57
	Site No.4	0.117	0.075	0.116	0.006	0.009	0.002	0.081	0.003	23.87	0.022	0.009	12.62	0.13	15.6
	Site No.5	0.119	0.079	0.118	0.009	0.009	0.002	0.094	0.004	32.87	0.025	0.01	18.15	5.15	38.6
	Site No.6	0.139	0.089	0.138	0.009	0.009	0.003	0.098	0.006	32.99	0.027	0.011	18.68	5.52	38.82
Nile River Damietta Branch		0.022	0.012	0.005	0.004	0	0	0.001	0.0001	0.002	0.001	0	0.014	Nil	0.021

3.4. Water Quality for irrigation used

Accoding Ayers and Westcst (1985), the water quality of Al-Abshiet drian is not recomended to use it for irrigation for the following indecators:

1- The Nitriate-Nitrogen values in sites 5 and 6 ranged from 18.03 mg/l up to 18.68 mg/l were higher than the maxiumum limit value (15 mg/l).
2- The ammonia-N value in sites 5 and 6 ranged from 5.1 mg/l up to 5.52 mg/l) were small increase than the maxiumum limit value (5 mg/l).
3- The ECw of Al-Abshiat drain in all sites (ranged from 2.6 dS/m to 3.2 dS/m) were higher than the maximum limit value (2 dS/m).
4- The Boron element was very high increase in Al-Abshiet drain in all 6 sites (ranged from 5.16 mg/l up to 32.99 mg/l) than the maxiumum limit (0.75 mg/l). And the Boron element was increased from site 1 up to site 12 which is near the textile factory.
5- The 8 elements (Cd, Cr, Co, Fe, Pb, Mn, Ni, and Zn) were very low than the maxiumum limit value of these elements.
6- Molybdenum element was lettel higher than the maxiumum limit value (0.01 mg/l).

4. Conclusion and Recommendations

The integrated methodology of this study could be considered as a ready module for applying at different locations and represents a significant participatory management tool for detect water pollution in Egypt. As the results of this paper show that the important of using satellite images for monitoring the polluted water in lakes, water bodies, irrigation and drainage canals.

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5. References

1. Ayers R. S. And Westcot D. W. , 1994," Water Quality s for Agriculture" , FAO Irrigation and Drainage paper, 29, FAO, Italy.
2. Brando, V.E., & Dekker, A.G. (2003). Satellite hyperspectral remote sensing for estimating estuarine and coastal water quality. *IEEE Trans.Geosci.Remote Sens., 41*, 1378-1387.
3. Carbiener R, Trémolières M, Mercier JL, Ortscheit A (1990) Aquatic macrophyte communities as bioindicators of eutrophication in calcareous oligosaprobe stream waters (Upper Rhine plain, Alsace). Vegetatio 86:71–88.
4. Greulich S, Bornette G (1999) Competitive abilities and related strategies in four aquatic plant species from an intermediately disturbed habitat. Freshw Biol 41:493–506.
5. Jackson, M. L., 1967, "soil chemical analysis", Prentice hall of India private ltd., New Delhi.
6. James WF, Barko JW, Eakin HL (2004) Impacts of sediment dewatering and rehydration on sediment nitrogen concentration and macrophyte growth. Can J Fish Aquat Sci 61:538–546.
7. Jampeetong A, and Brix H (2009) Effects of NH_4^+ concentration on growth, morphology and NH4+ uptake kinetics of Salvinia natans. Ecol Eng 35:695–702.
8. Kohler A (1975) Submerse Makrophyten und ihre Gesellschaften als Indikatoren der Gewässerbelastung. Beiträge Naturkundlischen Forschung in Suedwestdeutschand Beihefte 34:149–159.
9. Smolders AJP, Lucassen ECHET, Roelofs JGM (2002) The isoetid environment: biogeochemistry and threats. Aquat Bot 73:325–350.
10. Soltanpour, P. N. (1991), "Determination of nutrient availability elemental toxicity by AB-DTPA soil test and ICPS Advanced in Soil Sci., 16: 165-190.