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Evaluating and Estimating, Water Turbidity in Sefidroud Dam's Lake, by Using Remote Sensing Data

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Abstract: Remote sensing has been defined as the technology and science of determining, measuring, analyzing and interpreting the characteristics of an object or phenomena without any direct contact with that object or phenomena. In this study the lake of Sefidroud dam is selected due to it's high turbidity problems. At first by using IRS satellite images and previous LISIII images and unsupervised classification method the lake was classified into 4 classes to establish an area for sampling. In the next step, in co-operation with Geographical Organization of Iran's Army and management of Sefidroud dam, 67 samples were gathered. Then turbidity concentration values of samples harvested from the lake dam was determined in the laboratory. To study the turbidity and determine the relationship between remote sensing data and terrestrial data, first by KMO test the suitability of the bands in determining regression is being identified, then regression between suspended solid's density and each of the , ratio and band combination in simple, and natural logarithm was obtained. The regression results show a high accuracy in regulations achieved from natural logarithm than the simple state.

Key words: Remote sensing · IRS satellite imagery · Turbidity · Sefidroud dam · Iran

INTRODUCTION

For studying the earth we live on, using all the sciences helps us to understand the environment and effective items on it's changes. It is obvious that the necessity of reaching a sustainable development and management is by identifying the environment and it's effective items.one of the effective tools on earth science and environment is using remote sensing technology and exploiting satellite data. Identifying a lot of storages such as water, soil, plant covrage and monitoring ruining phenomena's like spates, water salinity and turbidity, water erosion, jungles and pastures destruction, is the necessity of reaching to sustainable development. Using remote sensing technology and satellite datas often causes a reduction in costs and an increase in speed and accuracy, so that we can conduct an extended range of global, national, provincial and regional projects in the least time. In addition the ability of receiving satellite datas repeatedly in a time distance of a few hours or days in a month or year, makes the earthy phenomena monitoring and changes, probable. Water is the most extensive phenomena on earth which has covered 71% of the earth surface [1] Sefidroud basin with a 56700m^2 area is one of the biggest and most important basins in the country which has a high variety of more than 25 types in sedimentary geology structures [2] high turbidity of the water has caused serious problems for the implanted lands on the river bank and also has caused the fullness of the dam and a reduction in the dam's lifetime. Also one of its important branches e.g. Ghezel-o-Zan which is very vital for cities like Mahneshan, because of passing from areas with high minerals it's water becomes salty and unusable. Finally we can mention that this rivers turbidity and salinity is a very high risk for the ecosystem in some region, and has caused the extinction of the fish and ecosystem.

Ritchie *et al*. [3], studied about the usages of remote sensing techniques on different parameters of water quality such as turbidity, chlorophyll and temperature and

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concluded that a 700-800 nanometer wave length is best for studying on suspended sediments. Dekkler (1993) has studied on water turbidity and the Secchi depth device (a device for estimating the sample's depth) and presented a regression regulation for the reflection rate of Secchi depth device, CASI and CAESAR sensors. Bijay *et al*. (1996) evaluated the TM landset sensor's data and measured turbidity. After gathering water samples from four regions and determining the turbidity rate in the lab, they presented a multivariable regression between TM landset sensor's different band lightning degrees and measured amounts. Smith (1992), by using TM Landset satellite data, evaluated different parameters of water quality such as suspended solids, salinity, total phosphorus and temperature and according to the relation between the sensing bands of field datas TM, the water quality parameters were modeled. Yang and Skyes (1996) evaluated the features of using remote sensing in water quality according to SPOT images in a 1400m length of Ta-chia river. Hellwegar *et al*. (2004) evaluted the band combining feature of the Envisat and Tera sensors in Finland lakes and shores. After specifying the proper depth of the samples by using the Secchi disk device, they produced 85 water samples from lakes and 107 water samples from oceans, and indicated that the band combination of the Envisat sensor is more accurate in determining the turbidity, lakes and shores' Chlorophyll rate. And also band 9 with a 705 nanometer spectrum reflection has a high efficiency in determining the chlorophyll rate. O'Reolly *et al*. (1998) determined the turbidity and quality of the water samples taken from the Erkan lake in the lab, by using TM sensors of satellite images. Afterwards they made a regression between remote sensing data and field samples and presented a regulation for estimating the turbidity and chlorophyll data. Guofeng *et al*. (2007) studied on how to evaluate the turbidity by remote sensing. They produced 30 samples of water simultaneously from the study area and they used MODIS & TM landset sensors for evaluating. The results which came out of the regression between the sensors data and turbidity samples show that remote sensing has a high accuracy in estimating and evaluating the water turbidity. Zhiqiang *et al*. [4] started to develop a map for the turbidity of gulfs by using simultaneous turbidity data and MODIS photos with a 250 meters resoulation power. After atmospheric, geometrical and radiometric corrections, regression was done between the turbidity amounts and the remote sensing data and by using 45 water samples they presented regression regulations for estimating the amount of turbidity according to sensor's data. Hassanlou [5] started his field studies and used remote sensing data for evaluating the turbidity of Sefidroud dam's lake, after classifying the suspended solids of Sefidroud dam's lake, according to the unsupervised classification method, he started his samplings and after defining the suspended solids' density in the lab, he made a regression between the measured amounts and presented regression regulations. Taheri-e Shar Aeini [6], in his study he extracted the water quality parameters by using satellite photos and reversal modeling of the radiance transition equation with the active learning method (ALM[2]). Alavi Panah & Khodaee [7] studied the duad effect of sediment density and water salinity of Urumieh lake on spectrum reflections by using remote sensing and indicated that both repercussion and thermal bands have a high ability in recognizing the salinity and turbidity. But TM_3 and TM_6 compared with other bands, have a more important role in spectrum reflection of the sediment and salinity waters. Aghighi [8], evaluated the Caspian sea's turbidity by using MODIS satellite photos and earth data. After gathering data and conducting tests and atmospheric and geometric corrections on photos, he started to develop regression regulations between field data and remote sensing.

MATERIALS AND METHODS

The Studying Area's Location: Sefidroud dam is located in north of Iran and in a distance of 110km from the caspian sea and between 49'26 to 49'16 longitude from east and 36'41 to 36'46 latitude from north and is constructed on the junction of Ghezelozan and Shahroud rivers. The Sefidroud basin hemisphere is mainly moderate and dry and the basin area is usually without plants and the land is formed with high erosion soils [2]. The area of this zone is about 56000m^2 which 50000m^2 is related to Ghezelozan's branch which emanates from Kordestan, Hamedan, east and west Azerbayjan mountains and after passing 400km, it enters the Sefidroud lake from Gilvan. Shahroud branch has a area of 6000m^2 and emanates from Taleghan mountains and after passing 180 km it enters the lake from Loshan. Figures 1 and 2 show the studying area according to Iran's map, and a view of the lake with the sampled points.

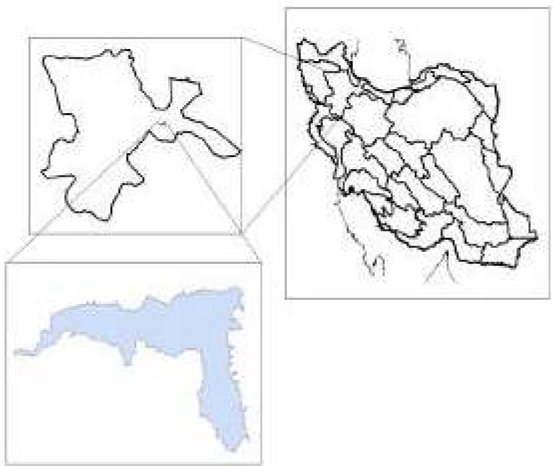

Fig. 1: The studying area location according to Iran's map

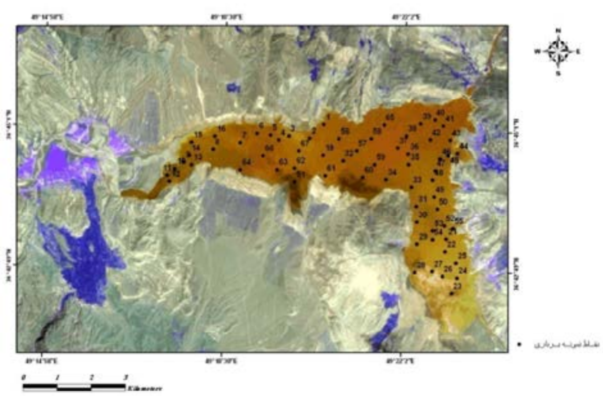

Fig. 2: A view of Sefidroud dam's lake with the sampled points(August 17th , 2007)

The Used Materials:

- The Military Geographical Organization's 1:25000 topographical maps were used to identify area's terrain like road junctions, tunnels and other points to make the satellite photos, reference grounded.
- Garmin etrex vista GPS with a 4 to 5 meters fault for specifying the sample point's coordination and exploiting the GCP points in geometric correction of satellite datas.
- Secchi disk which is made of a circular plate was first invented by Fr Pietro Angelo Secchi and was used to measure the Mediterranean water's transparency on April 20th 1865. For making this device an iron plate with a 4mm thickness and 20mm diameter was used (Carlson, 1995). Then in the center there was a handle fixed for the carrier rope's installation, and 27 holes with a 10mm diameter which had symmetrical variance were created on it to let the water pass and the device to sink horizontal in water. Finally the plate was divided in for parts and the quarters in front of each other were painted black and white. Figure 3 shows a sample of the Secchi disk.

Fig. 3: A Secchi disk sample, used in this study

Methods: In this study first the existing photos from the area (which were produced on 11th of June 2006 & 30th of June 2007) were received from the military geographical organization for non- observing gradations and classifying the samples. Then by using the non-observing gradation method, regional surveys and technical suggestions, 6 classifications with different suspended material's density rate was specified, so while sampling from classifications, sufficient samples would be produced. In the next step by coordinating with the military's geographical organization, 67 samples were exploited simultaneously from the studying area with a systematic- random method, from these 6 classifications. For exploiting the needed water, the sampling water container was entered in the water with an unvarying speed and a combined sample was exploited from different depths [9]. As the time for sampling is 2 hours before and after photography, therefore enough samples with different volumes and numbers were exploited in the area. For identifying the number and volume of samples, Kokraan regulation was used and 67 necessary samples were produced with a 10% allowed error. For specifying the total suspended solids (TSS) in lab, an spectrometer was used. And for this the 2100p model was used as shown in fig. 4.

Fig. 4: A sample of the spectrometer used in this study.

The procedure was like this, that first the water sample was poured into a glass and was placed in a device so that the turbidity amount of the samples were measured by NTU. Afterwards the KMO test was surveyed on all the bands' data, to evaluate the sufficiency of forecast variables (number of bands) and the samples. Then started to make a relation between, light degrees in simple and natural logarithm states with suspended solids density.

RESULTS

- Results of KMO test on the sample's DN:

The results from this method are mentioned in table (1) .

The coefficient table resulted from the KMO test on the DN of the sampled points show that the KMO coefficient is more than 0.5, so all the bands have the qualification to be used in the equation and also the number of the samplings are acceptable.

- Multivariable regression between suspended sediment amounts and the bands light degree.

The results from this method are mentioned in Table (2) & Figure(5).

By using coefficient table and related equations of the suspended solids' natural logarithm, the bands' natural logarithm is being specified, which the suspended solids' amount only has a punctual solidarity with the light degrees of band 5 with a safety level of 1%. And doesn't have a punctual solidarity with other bands or maybe they are located in the next levels. The results have a good adjustment with the results of [5, 7, 8].

Regulation1: TUR: $75.376DN_5$- 1054.77

- Multivariable regression betweenturbidity amounts and the bands natural logarithm.

The results from this method have been shown in Table (3) & Figure (6).

By using coefficient table and related equations of the suspended solids' natural logarithm, the bands' natural logarithm is being specified, which the suspended solids' amount only has a punctual solidarity with the light degrees of bands 2,3 and 5 with a safety level of 5%.

Table 1: KMO tests coefficients on DNs and DN natural logarithms in sampled points.

Kaiser-Meyer-Olkin Measure		0.82	Natural Logarithm of DN's in Sampled Points
Bartlett's Test of Sphericity	Approx. Chi-Square	220.83	
	Sig.	0.000	
Kaiser-Meyer-Olkin Measure		0.7	Sampled Points DN's
Bartlett's Test of Sphericity	Approx. Chi-Square	225.81	
	Sig.	0.000	

The results from this method are mentioned in table (1) .

Table 2: Coefficients and regulations of suspended sediment amounts and the bands light degree

		UN STD		STD			
Band	R^2	B	Std. Error	Beta	t	sig	MODEL
5	0.693	-1054.77	293.89	0.493	-3.59	0.001	$TUR = 75.376DN_5 - 1054.77$
		75.376	18.43		4.09	0.001	

Table 3: Coefficients and regulations of suspended solids natural logarithm and the bands natural logarithm

		UN STD		*STD*			
Band Natural Logarithm	R^2	*B*	*Std. Error*	*Beta*	*t*	*sig*	*MODEL*
2,3,5	0.823	6.295	14.44	0.417	0.436		$LNTUR = 2.958LNDN_5$
		-9.41	4.1		-2.296	0.026	$+ 9.4LNDN_3 - 9.41LNDN_2$
		9.4	2.247	1.036	4.185	0.000	
		2.958	1.457	0.489	2.03	0.028	

Table 4: Validation of the achieved equations using the lab measurment results

$LNTUR = 2.958LNDN_5 + 9.4LNDN_3 - 9.41LNDN_2$			$TUR = 75.376DN_5 - 1054.77$		
Point number	Measured turbidity	Turbidity produced from the above equation	Point number	Measured turbidity	Turbidity produced from the above equation
1	25	22	1	25	40
2	35	38	2	35	45
3	60	57	3	60	56
4	75	77	4	75	68

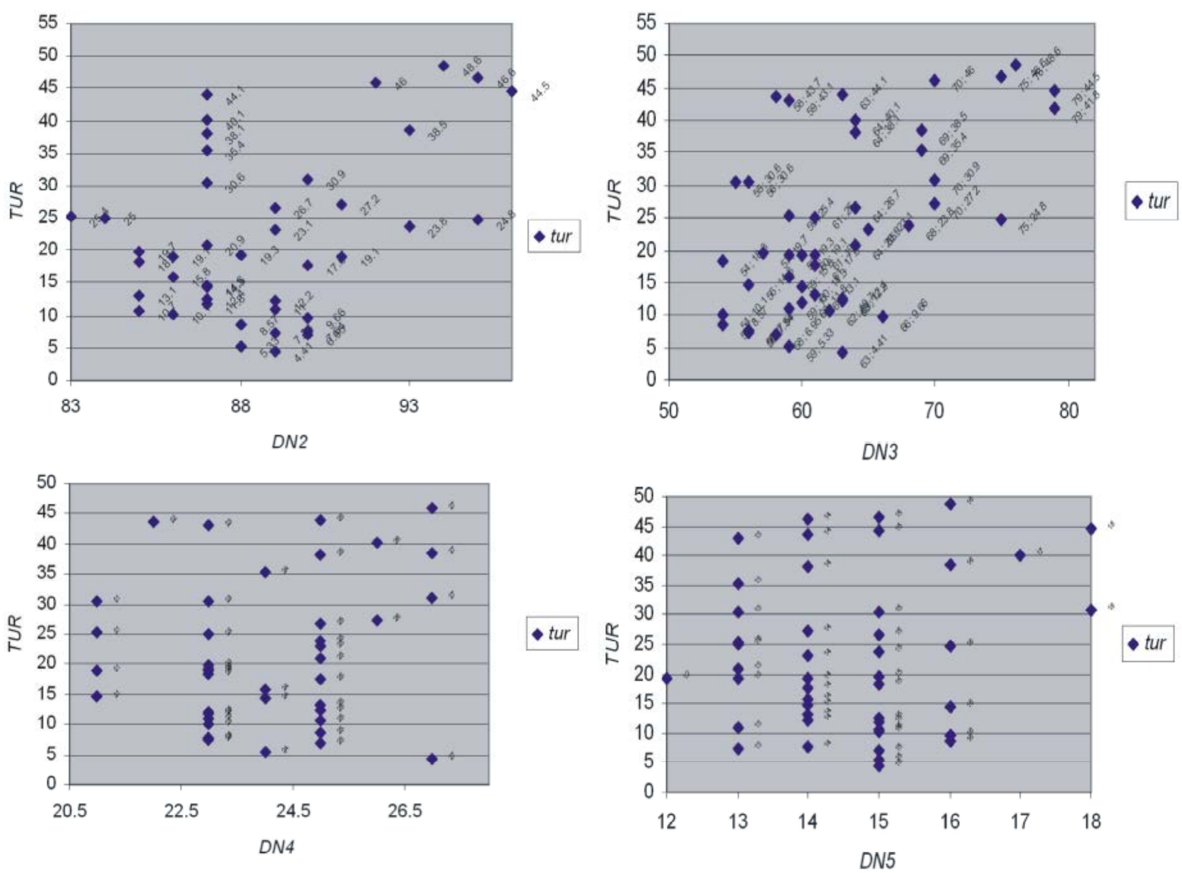

Fig. 5: 2D graph of the bands natural logarithm and turbidity of sampled points in Sefidroud lake

And doesn't have a punctual solidarity with other bands or maybe they are located in the next levels. By comparing the results, it is clear that there is a big difference between the simple and logarithm state and by using the natural logarithm the accuracy of the equation increases. It should be mentioned that The results have a good adjustment with the results of [5, 6, 8, 9].

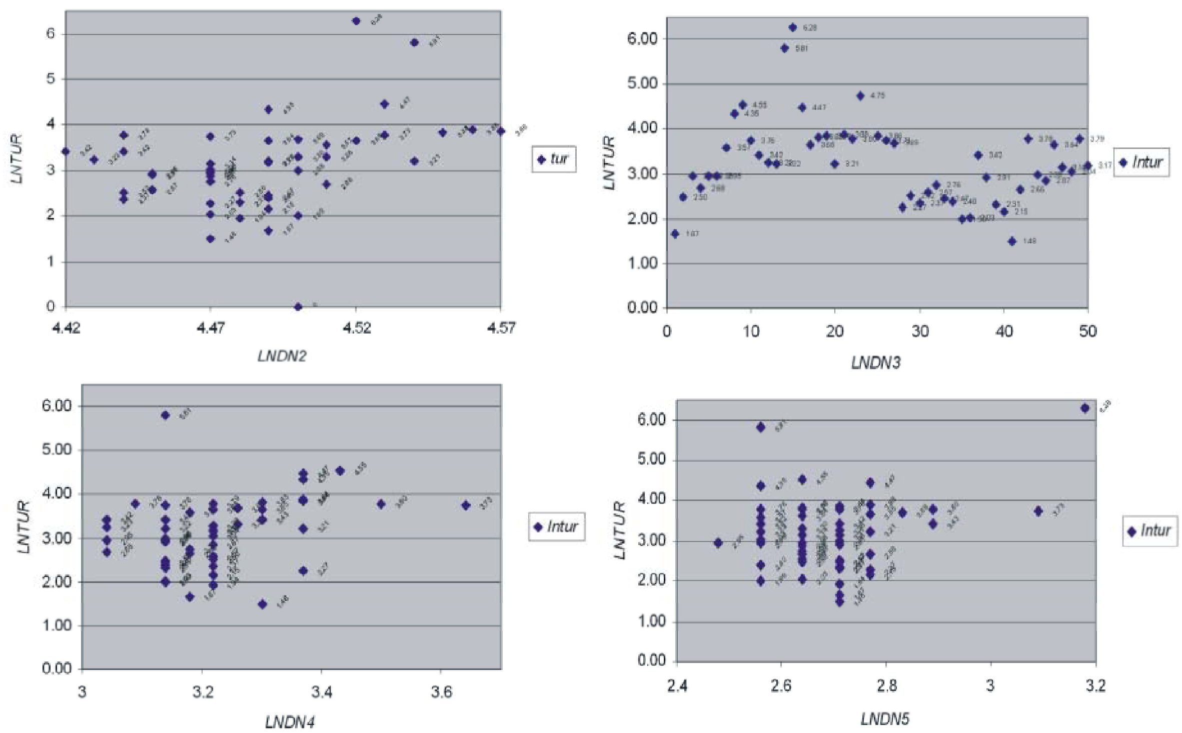

Fig. 6: 2D graph of the bands natural logarithm and suspended sediments of sampled points in Sefidroud lake.

Regulation 2: LNTUR: $2.958LNDN_5 + 9.4LNDN_3 - 9.4LNDN_2$

Validation of the New Formulas: Presenting a final regulation needs a lot of data and high accuracy. So for defining the accuracy of the regulations, validations according to lab data regressions were done. The results have been mentioned in Table 3.

Comparing the lab results with regression results indicates that the data achieved from the regression regulations of bands natural logarithm are much more closer to the data achieved from the bands simple state, so in such researches we can use this method. Comparing these results with other studies shows that these results are very near to the results of [4, 5, 8].

CONCLUSION

According to the equations and other results, between the measured and estimated amounts there is a punctual relation, and by a little accuracy the amount of suspended solids' density can be estimated. Also the satellite images have a good efficiency on evaluating and estimating the suspended solids and these images because of their availability could be always used. Finally the followings are suggested to be put in consideration in this kind of studies:

- As the results in logarithm method and natural logarithm are more accurate than the simple state, so it is recommended to be used in the similar works.
- Different limitations exist in these kinds of studies, like: limitation in using satellite data, time polarity between the xerography and sampling (simultaneous sampling) and limitations on sensors' data availability in the country. So in conducting this kind of studies these should be put into consideration.

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