IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 3 (March. 2019), ||S (I) || PP 23-30

River Sediment Monitoring Using Remote Sensing and GIS

Kasra Hossein Mostofi[*A] Mohamadamin Oyar Hossein[a] Seyed Hamid Bayat Ghiasi[a]vahid Khiali[a] Mostafa Adineh[a]
[a]Civil Engineering Department, University of Aveiro, 3810-193 Aveiro, Portugal
Corresponding Author: Kasra Hossein Mostofi

Abstract: Since the volume level of the reservoir and impounding of the reservoir depend on the amount of sediment deposition, so the calculation of sediment has a great importance in the design of reservoirs and hydraulic structures. Soil erosion in the catchment and subsequently sedimentation in rivers, lakes and reservoirs is the main concern for two reasons; first, the basin surface soil loses its fertility, second, reservoir capacity is reduced and downstream water quality is reduced. Many studies have shown that the suspended sediments can be received, processed and estimated by remote sensing techniques and related software such as ENVI and GIS. Since applying the remote sensing technique has a greater speed and precision compared to traditional methods, it is used as an efficient technique in the modern world and in order to develop this matter all developed countries try to use satellites with appropriate spatial resolution and bands that are appropriate for water studies. The purpose of the present study is to estimate the amount of suspended sediment in the dam basin using the remote sensing facilities and satellite images of powerful sensors in the field of water studies and then comparing the results with sediment data from Sira hydrometric stations. In this study using the images of Landsat 8 satellite sensors the correction operations and the required processing are performed by applications such as GIS and ENVI and then the results are compared by two different methods to obtain the best and closest results so that an accurate estimation of the volume and type of suspended sediments in rivers and dam reservoirs is obtained in the shortest time and with the lowest possible cost and manpower so that they would be controlled by the most cost effective result. The results obtained are compared with Karaj dam lake hydrometric station and the results were as follows: The annual average of suspended sediments obtained by the best method of calculation by the remote sensing was equal with 320490 tons and this value was 350764 in hydraulic calculations.

Keywords: Sediments, Karaj Dam, remote sensing, GIS

Date of Submission: 21-02-2019 Date of acceptance: 07-03-2019

I. INTRODUCTION

Soil erosion is a process during which the soil particles are separated from their substrate and transported to another location using a transfer agent. If the separation agent of the particles from the substrate and their transfer is water it is called water erosion. Other types of erosion include wind erosion and glacial erosion. There are various factors effective on erosion the most important of which include climatic factors, soil type, vegetation and topography. Climatic conditions such as temperature, humidity, solar radiation, wind and rain in addition to the direct impact by evapotranspiration affect the amount of erosion by runoff changes. But the relationship between rainfall and erosion characteristics is relatively complex and needs further discussion. Building fabric and characteristics are other factors that affect its erosion versus erosive factors. Water erosion in cohesion less soils (such as sand) with cohesion soils like (clay) is different. Erosion is primarily mechanical in the first type whereas the physicochemical factors are involved in the second case. The vegetation leads to changes in kinetic energy of raindrops or the surface flow of water and thus affects the erosion speed. For example, erosion in forests is far less than the desert regions and areas devoid of vegetation. Natural terrains such as slope, the form of the land and the length of movement of water affect the intensity of erosion. In the steep lands the Water power is greater than the flat lands and this condition is also true about the slopes. The process of soil erosion by water is composed of three basic steps including the reducing the soil particles from the substrate, carrying the separated particles and their settlement, these processes have their own menus and create the important issues of the science of erosion.

The purpose of study

The purpose is to identify remote sensing methods in sediment calculation and evaluate the obtained results by river sediment data for a hydrometric station. The procedure is based on obtaining the satellite images by GIS software and using these data to obtain river sediment. Remote sensing a useful tool for monitoring suspended sediments in surface waters due to various reasons such as multispectral nature, the coverage of a wide area, the existence of a time line and the repetitive nature of satellite imagery. Many researchers have analyzed surface waters by satellite imagery and showed that there is an experimental relationship between the reflectance and suspended sediments. Using remote sensing technique in soil erosion studies and basins' sedimentation has higher speed and accuracy than the traditional methods, therefore it is considered as a more efficient technique. In this study we obtain the amount of sediment using remote sensing and interpretation and processing of satellite images.

1. The field of research and methodology

Amirkabir (Karaj) Dam on Karaj Lake is Strait of Varian at 51°5'N35°7'E in 23 km from the city of Karaj. This reservoir dam is multipurpose and has been constructed to provide Tehran's drinking water and energy and irrigate agricultural lands. And it is one of the biggest dam in Iran.

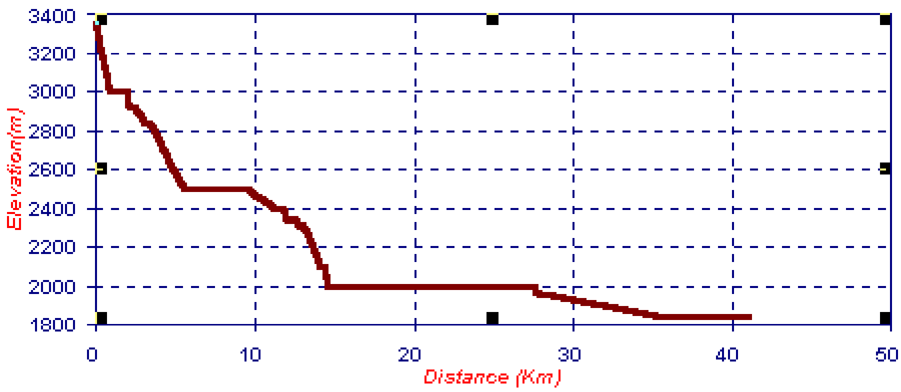

Figure 1 Longitudinal profile of the main stream

The hydrometric sediment station of Karaj is called Sira. The measurements of flow in this station have started since 1954 and sediment sampling has started since 1967. The average annual long term discharge in Sira station is about 12.35 cubic meters per second. The hydrometric station at the dam output is called Bilaqan. This station is located at the downstream of Karaj Dam and established in the planning and distribution of drinking water and agricultural water.

In this study we use OLI in Landsat 8

The Operational Land Imager (OLI), built by the Ball Aerospace & Technologies Corporation, will measure in the visible, near infrared, and short wave infrared portions of the spectrum. Its images will have 15-meter (49 ft.) panchromatic and 30-meter multi-spectral spatial resolutions along a 185 km (115 miles) wide swath, covering wide areas of the Earth's landscape while providing sufficient resolution to distinguish features like urban centers, farms, forests and other land uses. The entire Earth will fall within view once every 16 days due to LDCM's near-polar orbit.OLI's design is an advancement in Landsat sensor technology and uses an approach demonstrated by the Advanced Land Imager sensor flown on NASA's experimental EO-1 satellite. Instruments on earlier Landsat satellites employed scan mirrors to sweep the instrument fields of view across the surface swath width and transmit light to a few detectors. The OLI will instead use long detector arrays, with over 7,000 detectors per spectral band, aligned across its focal plane to view across the swath. This "push-broom" design results in a more sensitive instrument providing improved land surface information with fewer moving parts.

With an improved signal-to-noise ratio compared to past Landsat instruments, engineers expect this new OLI design to be more reliable and to provide improved performance

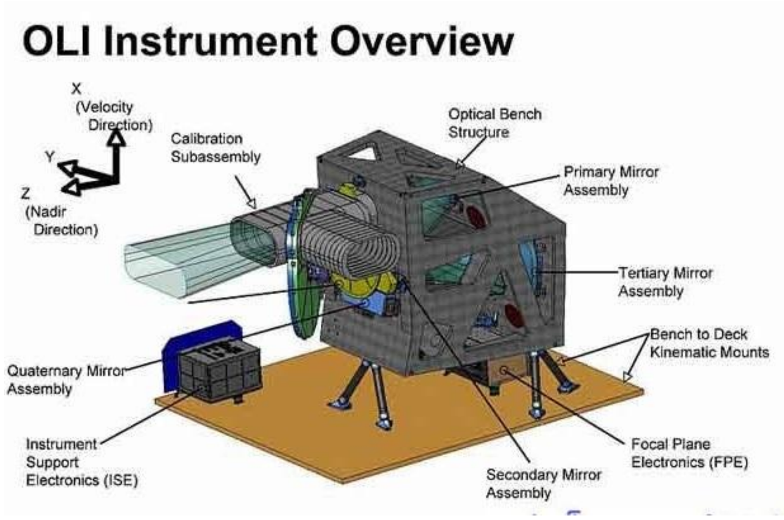

Figure 2 Operational Land Imager

II. METHODOLOGY

At the first should use ENVI for atmospheric and geometric correction . Removing the influence of the atmosphere is a critical pre-processing step in analyzing images of surface reflectance. Properties such as the amount of water vapor, distribution of aerosols, and scene visibility must be known. Because direct measurements of these atmospheric properties are rarely available, they must be inferred from the image pixels. Hyper spectral images in particular provide enough spectral information within a pixel to independently measure atmospheric water vapor absorption bands. Atmospheric properties are then used to constrain highly accurate models of atmospheric radiation transfer to produce an estimate of the true surface reflectance.

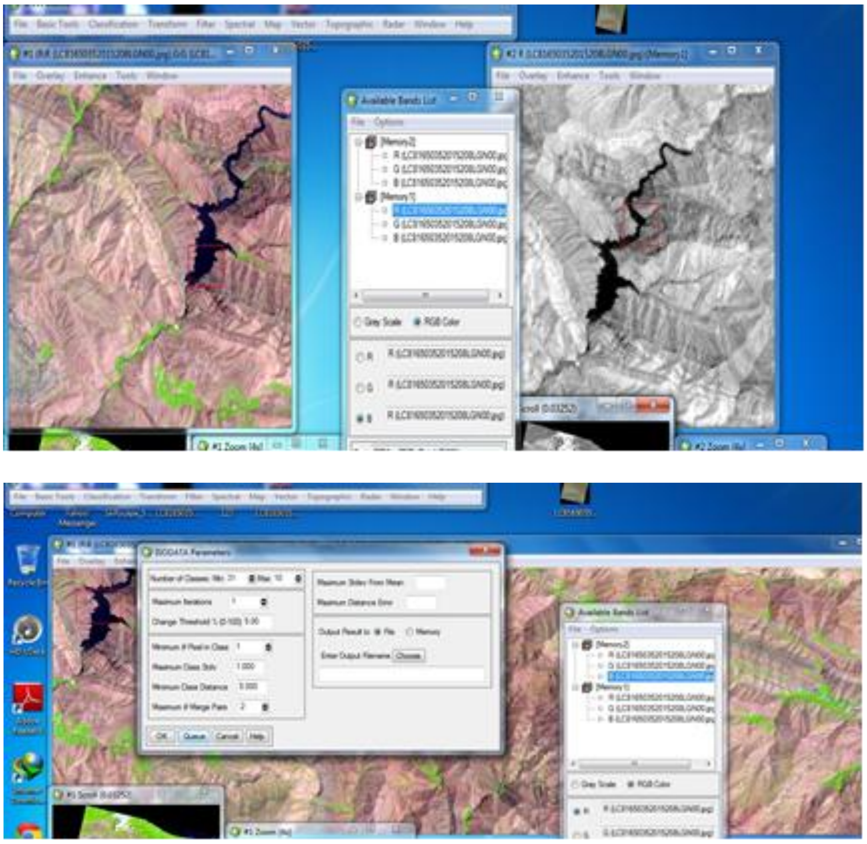

Figure 3 atmospheric and geometric correction

Features are geographic objects with well-defined shapes (such as political boundaries). Surfaces are geographic phenomena with values at every point across their extent. Elevation is a common example, but surfaces can also represent temperature, chemical concentrations, and many other things.

A GIS represents both features and surfaces. Features are geographic objects with well-defined shapes (such as political boundaries). Surfaces are geographic phenomena with values at every point across their extent. Elevation is a common example, but surfaces can also represent temperature, chemical concentrations, and many other things.

Surfaces are usually modeled with raster datasets. A raster is a matrix of cells, also called pixels, organized in rows and columns and covering some part of the world (or even the whole world). Each cell in the matrix represents a square unit of area and contains a numeric value that is a measurement or estimate for that location. Before continuing GIS for pixel values in this step we can use digital elevation

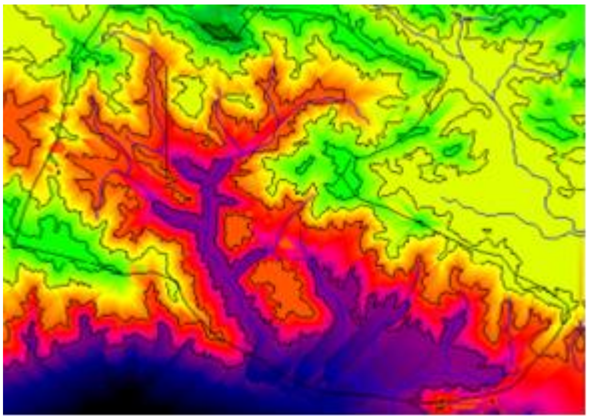

Figure 4 Digital elevation in GIS

And then we can see Altimetry curve

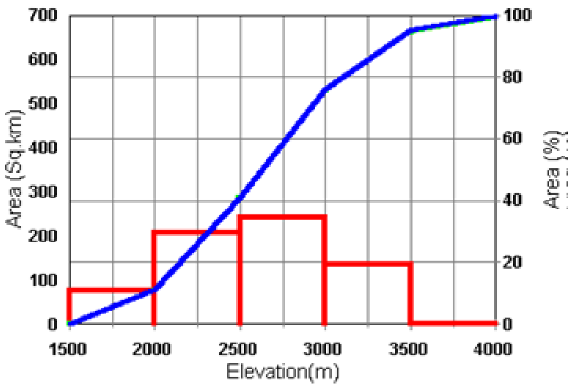

Figure 5 Altimetric curve

See the photo below that is catchment area with different elevation

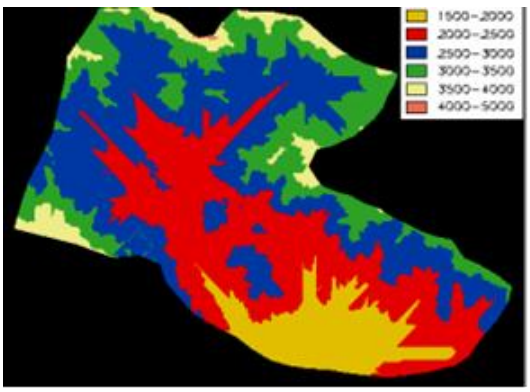

Figure 6 catchment area with different elevation

Even we can analysis DEM temperature in our region with GIS

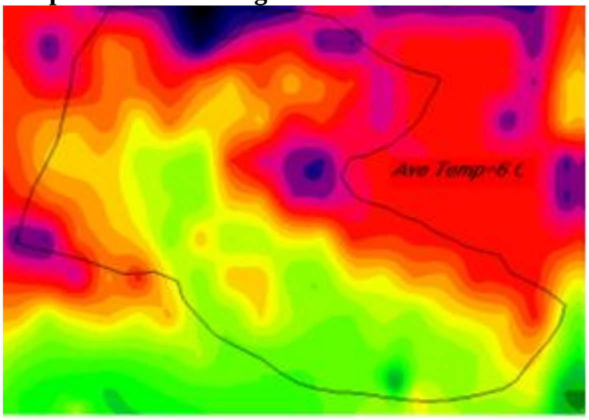

Figure 7 DEM temperature

Satellite images include pixels or the components of image that in this pixel the reflectance values are recorded. These values are 0-255. In this thesis using ARCGIS Software we calculated the reflectance values in each Landsat band and number of repetitions. Then the mean of the reflectance values for each band were calculated in the Lake basin.

BAND		The mean reflectance Landsat bands
BAND 1		**150.1**
BAND 2		**145.2**
BAND 3		**70.12**
BAND 4		**85.11**
BAND 5		**123.1**
BAND 6		**121.34**
BAND 7		**19.20**
BAND 8		**83.12**
BAND 9		**87.02**

Table 1 the average value of Landsat bands reflectance are presented in this image of the intended area

The calculation of sediment based on the samples measured at the hydrometric stations

Due to the lack of accurate statistics of the erosion and deposition of sediment at the watershed in most cases the sediment measurement curve prepared by discharge and sediment concentration data or sediment discharge are used. At the hydrometric stations sampling suspended sediment concentration is performed at the base discharges or in low flood discharges. However, the variability of flow and sediment relationships in flood discharges is much higher due to changes in rainfall and catchment (soil moisture, presence of sediment and subcortical water content and …) thus the efficiency of rating curve depends on the accuracy of the obtained data. In addition, changes in the relationship between discharge and sediment concentration by Sediment graph leads to underlying errors in the field of using simple equations based on discharge. However, sediment rating curves are widely used and the most common methods of preparation are introduced below.

Single line sediment rating curve

In this method sediment concentration (weight in runoff volume) or sediment discharge (weight in the time) are a function of flow rate and the power equation is fitted to the total data as follows.

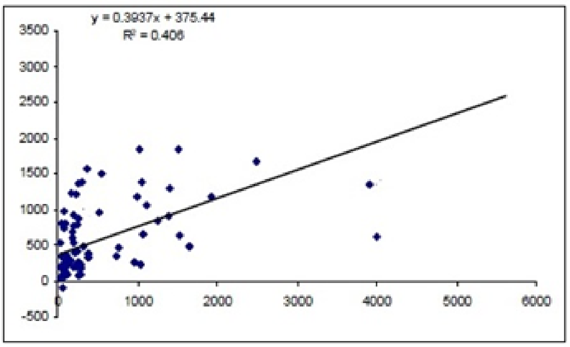

Figure 8 sediment rating curve in Sira hydrometric station

$$Q_s = aQ_w^b$$

Q_s is sediment characteristic that can be based on sediment concentration (g/l), sedimentation (ton/day) or any other unit. Q_w is river discharge in cubic meters in second and a has no specific range and indicates soil erosion (mostly data log is used). The use of power relationship has been confirmed by many researchers, while other researchers have considered the use of a variety of equations between the original form and modified form of the discharge and sediment data to obtain better results. It should be noted that due to the variability and available uncertainties, the use of sediment rating curve to estimate the long-term base sediment had fewer errors.

Sira station of Karaj catchment	**575533.732**

Table 2 shows the annual sediment load in tons for Karaj Dam

The result of remote sensing method
In this study the methods that are described in the last chapter are used and their results will be compared with each other.

The first method
In this method the numerical value recorded in the pixel of the band 7 which is between 0-255 are obtained for Karaj Station by ARC GIS and using the following equation we convert the numerical value to the modified reflectance.

1) $(0.9655 * \mathrm{DN}) - 5.1$

Then the modified reflect values in the band 7 are calculated and using the following equation we obtain the sediment concentration in milligrams per liter:

2) Concentration of suspended sediments = $(4.17 * \mathrm{L}) - 43.22$

In Sira catchment the average modified reflectance was 178.538 and based on the above equation the sediment values are obtained as follows:
3) Concentration of suspended sediments = $(4.17 * 190.20) - 43.22 = 701.283$

Now given that the upstream catchment area is 720 square kilometers and a mean annual runoff of sira station according to annual regional water information is wqual with 12.452 cubic meters per second and also according to the time of one year which is 31536000, the value of annual sediment load in tons per square kilometer is calculated according to the following equation.

4) $\frac{701.283*(12.452*1000)*(31536000)}{10^9} = 275384.551\ Ton$

5) Specific sediment : $\frac{275384.551}{720} = 382.478\ \ ton/km^2$

III. Results

Since there is a possibility that the satellite images are prepared in different climatic conditions and different days of the year, given that the land has its own conditions in various conditions, different reflectance is reflected from the land. As a result, there is a possibility of change in the average reflectance of Landsat bands. So different situation should be considered; in this thesis the 10 and 15% of applied coefficients for sensitivity analysis are applied on the average value of the Landsat reflectance band and then analyze the changes that had occurred in sediment values.

The analysis of sensitivity analysis by applying the coefficient of 10 and 15% of increase and decrease in the average reflectance of Landsat band 7 and the values obtained by the first method in Sira catchment station with annual sediment of 275384.551 tins are presented based on the following table.

annual sediment (ton)	Average changed reflectance	Average band 7 reflectance	Applied coefficients (%)
305455.322	209.22	190.21	10
320490.707	218.73	190.21	15

Table 3 the suspended sediments if Sira station in the first method

Based on sensitivity analysis by applying the 10 and 15% of increase and decrease in the average reflectance of Landsat band 1 and the average sediments obtained by second method in Sira catchment station with annual sediment of 2455.7.849 ton are presented based on the following table.

annual sediment (ton)	Average changed reflectance	Average band 1 reflectance	Applied coefficients (%)
286826.338	165.11	150.1	10
320490.707	172.6	150.1	15

REFERENCES

[1]. Kondolf, G.M.; Rubin, Z.K.; Minear, J.T. Dams on the mekong: Cumulative sediment starvation. Water Resour. Res. 2014, 50, 5158–5169

[2]. Meade, R.H.; Moody, J.A. Causes for the decline of suspened-sediment discharge in the Mississippi River system, 1950–2007. Hydrol. Process. 2010, 24, 35–49

[3]. Feng, L.; Hu, C.; Chen, X.; Tian, L.; Chen, L. Human induced turbidity changes in Poyang Lake between 2000 and 2010: Observations from MODIS. J. Geophys. Res. 2012, 117, 1–19.

[4]. Petus, C.; Chust, G.; Gohin, F.; Doxaran, D.; Froidefond, J.M.; Sagarminaga, Y. Estimating turbidity and total suspended matter in the Adour riverplume (south bay of biscay) using MODIS 250-m imagery. Cont. Shelf Res. 2010, 30, 379–392.

[5]. Ritchie, J.C.; Zimba, P.V.; Everitt, J.H. Remote sensing techniques to assess water quality. Photogramm. Eng. Remote Sens. 2003, 69, 695–704.

[6]. Shen, F.; Verhoef, W.; Zhou, Y.; Salama, M.S.; Liu, X. Satellite estimates of wide-range suspended sediment concentrations in Changjiang (Yangtze) Estuary using MERIS data. Estuaries Coasts 2010, 33, 1420–1429.

[7]. Montanher, O.C.; Novo, E.M.L.M.; Barbosa, C.C.F.; Renno, C.D.; Silva, T.S. Empirical models for estimating the suspended sediment concentration in Amazonian white water rivers using Landsat 5/TM. Int. J. Appl. Earth Obs. Geoinf. 2014, 29, 66–77.

[8]. Wu, G.; Cui, L.; Liu, L.; Chen, F.; Fei, T.; Liu, Y. Statistical model development and estimation of suspended particulate matter concentrations with Landsat 8 OLI images of Dongting Lake, China. Int. J. Remote Sens. 2015, 36, 343–360.

[9]. H. K. Cigizoglu, M. Alp, "Generalized regression neural network in modelling river sediment yield", Advances in Engineering Software, vol. 37, pp. 63-68, 2006.

[10]. Zhang, M.; Dong, Q.; Cui, T.; Xue, C.; Zhang, S. Suspended sediment monitoring and assessment for Yellow River Estuary from Landsat TM and ETM+ imagery. Remote Sens. Environ. 2014,

[11]. Zheng, Z.; Li, Y.; Guo, Y.; Xu, Y.; Liu, G.; Du, C. Landsat-based long-term monitoring of total suspended matter concentration pattern change in the wet season for Dongting Lake, China. Remote Sens. 2015, 7, 13975–13999

[12]. Chebud, Y.; Naja, G.M.; Rivero, R.G.; Melesse, A.M. Water quality monitoring using remote sensing and an artificial neural network. Water Air Soil Pollut. 2012, 223, 4875–4887.

[13]. Haghighat, M.; Abdel-Mottaleb, M.; Alhalabi, W. Fully automatic face normalization and single sample face recognition in unconstrained environments. Expert Syst. Appl. 2015, 47, 23–34.

[14]. Verrelst, J.; Camps-Valls, G.; Muñoz-Marí, J.; Rivera, J.P.; Veroustraete, F.; Clevers, J.G.; Moreno, J. Optical remote sensing and the retrieval of terrestrial vegetation bio-geophysical properties—A review. ISPRS J. Photogramm. Remote Sens. 2015, 108, 273–290.

[15]. Aqrawi ZA (2003). Hydrological and hydrogeological study of Etot-Aloka basin, Duhok governorate. University of Salahadeen, Erbil.

[16]. Chen G, Hay GJ, Carvalho LMT, Wulder MA (2012). Object-based change detection. Int. J. Rem. Sens. 33(14):4434-4457.

[17]. Duan H, Ma R, Hu C (2012). Evaluation of remote sensing algorithms for cyanobacterial pigment retrievals during spring bloom formation in several lakes of East China. Rem. Sens. Environ. 126:126-135.

[18]. Gao B-C (1996). NDWI - A normalized difference water index for remote

[19]. American Society for Photogrammetry and Remote Sensing(ASPRS), Proceedings:10th William T.Pecora Memorial Remote Sensing Symposium, ASPRS, Ft. Co, 2013.

[20]. E. K. Lafdani, A. M. Nia, A. Ahmadi, "Daily suspended sediment load prediction using artificial neural networks and support vector machines", Journal of Hydrology, vol. 478, pp. 50-62, 2013.

[21]. C. Allène, J.-Y. Audibert, M. Couprie, R. Keriven, "Some links between extremum spanning forests watersheds and min-cuts", *Image and Vision Computing*, vol. 28, no. 10, pp. 1460-1471, 2010

Kasra Hossein Mostofi. “River Sediment Monitoring Using Remote Sensing and GIS.” IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 03, 2019, pp. 23-30.