



Water Turbidity Assessment in Part of Gomti River Using High Resolution Google Earth's Quickbird satellite data

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Abstract

Turbidity can be defined as the cloudiness of water or interference in passage of light, caused by suspended materials. The greater the amount of total suspended solids in the water, the higher the measured turbidity. Causes of turbidity include soil erosion, waste discharge, urban runoff, and algal growth. Turbidity is the reduction of clarity in water due to the presence of suspended or colloidal particles. Remote sensing obtains an optical measure of water turbidity. Remotely sensed image from satellite has the potential to provide crucial information to offer considerable advantages for the study of large areas, determination of current and circulation patterns, and monitoring of sedimentation, water productivity, and eutrophication. The present study was conducted in the Gomti River Lucknow and parts of Sitapur and Barabanki districts lies between 27°12'13" to 27°43'19"N latitude 80° 46'40" to 81°12' 59" E longitude and having an area of 815.10 ha with the aim of retrieval of turbidity, from the Google Earth's Quickbird satellite data. The nature of remotely sensed signal from a turbid can be best studied by modelling either qualitative or quantitative estimates of water turbidity, because pollutants affecting turbidity must be detectable. The aquatic vegetated area in the Gomti River was masked and water spread area extracted from the image for the modeling. The water spread covers an area of 783.03 ha which is 96.07% of the of study area. The water turbidity was estimated by Normalised Difference Turbidity Index (NDTI) and classified on the basis of mean and standard deviation of image using Erdas Imagine 9.1 software. Accordingly water turbidity were classified into three classes i.e. low, moderate and high having area of 3.22 ha, 774.85 ha and 4.96 ha respectively. The information generated in the present study could be used as an important input in the water quality management.

INTRODUCTION

Gomti River, an important tributary of Ganga River and perennial river of Awadh plains runs across the major parts of Uttar Pradesh, covering nine districts and a distance of approximately 940 km. During its course, Gomti River receives huge quantities of untreated sewage agricultural run offs which brings lot of pesticides, fertilizers, street washouts bringing oil, asphalt, sediments; industrial wastes all of which significantly alter the physico-chemical characteristics of its water. Before reaching Lucknow city, the Gomti River also receives wastes from sugar and distillery industries of Sitapur district. In Lucknow city, various industries like distillery, milk dairy, vegetable, oil, carbon etc are pouring effluents directly into the Gomti River (Singh, *et al.*, 2005). As Gomti river is the only source of surface water for the nearby

communities. Due to increased pollution levels water quality of Gomti River is deteriorating continuously. Increased level of turbidity makes Gomti River water unpalatable, hence making it a matter of concern.

It is possible to define turbidity as the cloudiness of water, which can be caused by suspended sediments in the water. These sediments include dirt, residue, excessive algal growth, phytoplankton, clays and silts. Turbidity can also be caused by land run-off, pollution, dredging operations, shoreline erosion, and the resuspension of bottom sediments. Water clarity and turbidity have a major effect on our ecosystem. Turbidity may very well be composed of inorganic and organic components that may contain high concentrations of viruses, protozoans, and bacteria. These components greatly increase the possibility for waterborne disease.

Traditionally, water quality monitoring of rivers relies on fixed stations by collecting water samples and analyzing in the laboratory. This method was tedious, time consuming and costly. The problems of point sampling at fixed stations may be overcome by the use of satellite images which potentially offer wide area coverage, as well as long-term and continuous water quality measurements. Factors that forced us to move to satellite surveillance of water quality are feasibility, cost, and value of information content. Remote sensing can be used to obtain either qualitative or quantitative estimates of water turbidity. Quantitative remote sensing of water turbidity is possible under some conditions, but a thorough understanding of the effects of all variables is necessary to interpret the remote signal. Remote sensing results in an optical measure of water turbidity. The integration of remote sensing with in situ sample data leads to the creation of dynamic maps of different water quality parameters including turbidity and facilitates research (Molo et al., 1989). That remote sensing can also be used to monitor the suspended mineral concentrations in water bodies (Han and Rundquist, 1998).

Turbidity is mainly caused by suspended sediments in surface waters. Suspended sediments are the most common pollutant both in terms of weight and volume in Gomti River. Sediment load is an important environmental parameter used in determining water quality (Kuo & Cheng, 1978). It may serve as a surrogate contaminant in agricultural watersheds since phosphorus, insecticides, and metals adhere to fine sediment particles. Relationship between suspended sediments and remotely sensed signals course established and flow pattern of suspended solids and total suspended load can be estimated through regression analysis. The transmittance in visible wavelength region for natural water decreases rather significantly as the level of turbidity in the water increases. Wavelengths between 600 and 800 nm were most useful for determining suspended sediments in surface waters (Ritchie et al, 1976). There is a positive correlation between suspended sediment concentration and spectral reflectance in the visible and near infra red (NIR) wavelengths (Alfoldi, 1982; Ritchie and Schiebe, 1986). The optimum wavelength for quantifying suspended sediment concentration is 600–650 nm (Novo et al., 1989). In highly turbid waters there is sufficient scattering to overcome the strong absorption by water at these NIR wavelengths. The correlation coefficient between suspended sediment and remotely sensed data peaks in the green/red wavelengths. Using developed algorithms suspended sediments could be mapped (Novo et al., 1991). The absorption and scattering properties of sediment types affect water reflectance (Novo et.al., 1989). Suspended sediment has greater absorption of radiation at longer wavelengths (Chen et al., 1991). The suspended sediment concentration relationship with reflectance depends on many factors including physical and optical properties of the sediment type and sensor observation angle (Kuo & Cheng 1978; Hoyler, 1978; Chen et al., 1991).

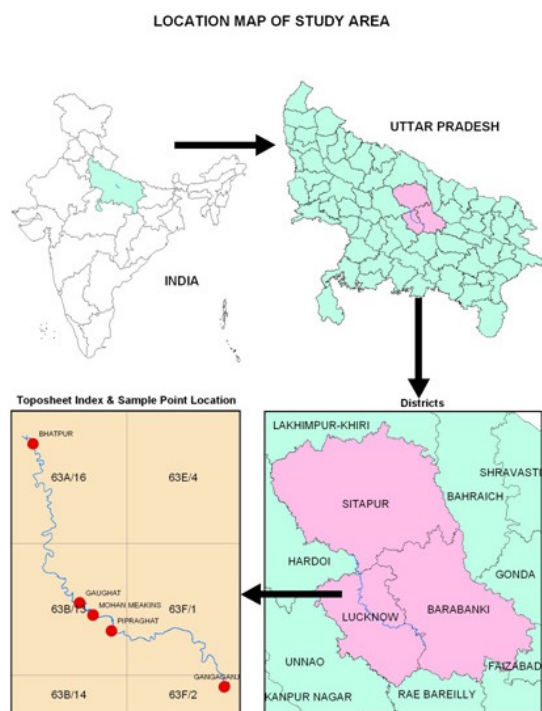


Figure 1 Sampling Sites of Gomti River

The present work deals with the study of Gomti River water turbidity using remote sensing techniques. The water turbidity was estimated by Normalised Difference Turbidity Index (NDTI) and classified into three classes i.e. low, moderate and high on the basis of mean and standard deviation of Google Earth's Quickbird satellite image of the study area.

STUDY AREA

The study area covers Gomti River in Sitapur, Lucknow and Barabanki districts of Uttar Pradesh having an area of 8151021.29 m² and lies between 27° 12' 13" to 27° 43' 19" N latitude 80° 46' 40" to 81° 12' 59" E longitude. The study area covers parts of 63A/16, 63B/13 and 63F/02 topographical maps of Survey of India on 1:50,000 scale. The location map of study area is shown in Figure 1.

MTHODOLOGY

The digital image classification procedure automatically categorizes all pixels into classes or themes. Normally multi-spectral information present within the digital data for each pixel is used as numerical basis of categorization. A digital thematic map is a special type of image, where each pixel is given a colour or grey level value representing a user-selected "class".

During this study Google earth Quickbird image with 60cm spatial resolution of 26th March 2006 was used for the mapping turbidity of the Gomti River. In order to get the river from the image onscreen digitization was done on Google earth as shown in figure 2.



Figure 2 (a) Google Earth image of 26th March 2006 (b) Onscreen digitization on Google Earth

Land/water interface was identified and masked so that only water would be analyzed. Pixel values corresponding to land were set to zero as a result of the masking function. Only



water spread in the river was extracted from the Google earth image and rectified it for it for the modeling, using Erdas Imagine 9.1. NDTI model was run on the image in order to enhance the image quality as shown in figure 3.

$$\text{NDTI} = \frac{(\text{RED}-\text{GREEN})}{(\text{RED}+\text{GREEN})}$$

Values of Mean and Standard Deviation were computed using the statistics of the image with the help of the software. Values for low, moderate and high turbidity was calculated using following formulas:

Figure 3 NDTI Model

$$\begin{aligned} \text{Low} &= \text{Mean} - \text{Standard deviation} \\ \text{Moderate} &= \text{Mean} + \text{Standard Deviation} \\ \text{High} &= \text{more than moderate} \end{aligned}$$

Accordingly low, moderate and high values were assigned to the image and converted in GIS environment.

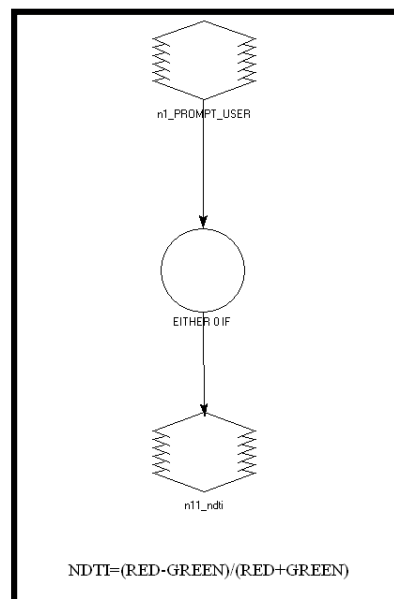


Fig 3

RESULT AND DISCUSSION

Turbidity cover map was prepared on digital basis, wherein mean and standard deviation values were derived for the image and using them high, medium and low turbidity range was assign to the image. Values of mean and standard deviation were as follows:

Mean - 0.04

Standard deviation - 0.53

Different formulae were used for calculating high, medium and low range of turbidity.

Low = Mean - Standard deviation = -0.49

Moderate = Mean + Standard Deviation = 0.57

High = more than moderate = > 0.57



By applying these ranges to the image, turbidity cover map was prepared on 1:2000 scale and reduced for presentation (Figure 4). This turbidity map encodes each category of turbidity (low, moderate and high) with a unique pixel value. Total area covered by our study area was 815.06 ha. The water spread covers an area of 783.03 ha which is 96.07% of the of study area. With the help turbidity cover map we calculated the area covered by turbidity. Accordingly water turbidity were classified into three classes i.e. low, moderate and high having area of 3.22 ha, 774.85 ha and 4.96 ha respectively, as shown in table 1.

Figure 4 Water Turbidity Cover Map

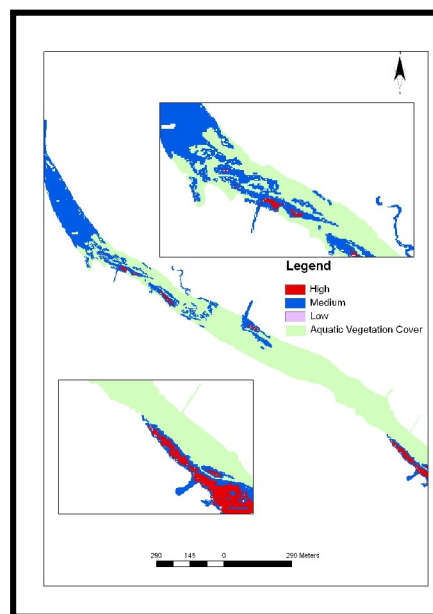


Table 1 Area covered by and turbidity in ha

Water Quality parameters		Area ha
Turbidity	High	4.96
	Medium	774.85
	Low	3.22
	Total	783.03
Total Area		815.06

Result of the present study also highlighted that maximum turbidity is found in the places where the sewage drains and industries are discharging their wastes. Stretches of Gomti River from Daliganj bridge to Gomti Barage in Lucknow city is highly polluted and is not suitable for most beneficial uses except for irrigation, fish culture and industrial cooling (Singh et al., 2005).

CONCLUSION

With the increasing awareness in the field of water pollution control and the desire to maintain rivers at their highest quality levels, it is expected that the approach described in this paper will prove a useful tool in evaluating the quality of the river to be utilized for various beneficial uses. The advantages of remote sensing for assessing the water quality of a river is:

1. Remote sensing makes it possible to collect data from inaccessible areas.
2. Measurable observations possible, which help to acquire quantitative as well as qualitative data.
3. Data can be permanently recorded and reproduced at any time.
4. Remote sensing also replaces costly and slow data collection on the ground, ensuring in the process that areas or objects are not disturbed.
5. Large area information is obtained in a very short time.
6. Dynamic measurement possible which helps in monitoring change.

Thus remote sensing technology as part of this research, provided a precise picture of turbidity, a water quality parameter and also facilitated the development of best management practice

Repetitive remote-sensed data may be considered by agencies as having the potential to provide an alternative method for gathering and processing surface water quality information. Further studies can be done using higher resolution satellite data for the monitoring of water quality parameters of surface water.

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