INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 4 - V7I4-1775)
Available online at: https://www.ijariit.com

Water turbidity assessment in parts of Ganga River in Allahabad Region (Prayag) during Kumbh Festival

Anju Bajpai
bajpai_a@nrsc.gov.in
Regional Remote Sensing Centre-Central, Nagpur, Maharashtra

Dr. G. Sreenivasan
sreenivasan_g@nrsc.gov.in
Regional Remote Sensing Centre-Central, Nagpur, Maharashtra

Dr. C. S. Jha
jha_cs@nrsc.gov.in
National Remote Sensing Centre, Hyderabad, Telangana

ABSTRACT

Turbidity can be defined as the opaqueness of water due to presence of suspended materials. The higher 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 also defined as the reduction of clarity in water due to the presence of suspended or colloidal particles. Monitoring of turbidity becomes extremely important during events like Kumbh Mela which causes a sudden rise in river turbidity. Remote sensing obtains an optical measure of water turbidity in terms of Backscattering Units. 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. WHO, The World Health Organization, establishes that the turbidity of drinking water should not be more than 5 NTU, and should ideally be below 1 NTU. But Ganga river flowing through Allahabad shows a sudden increase in turbidity up to 13-14 BU during the Kumbh mela Event. Turbidity increase results in harming the habitat areas for fish and other aquatic life. Turbid Particles also provide attachment places for other pollutants, notably metals and bacteria which makes the water contaminated and not suitable for drinking.

Keywords: *Turbidity, Water Quality, Pollution, Monitoring, Assessment, Ganga, Allahabad, Prayag, Triveni Sangam, Kumbh Mela, River Water.*

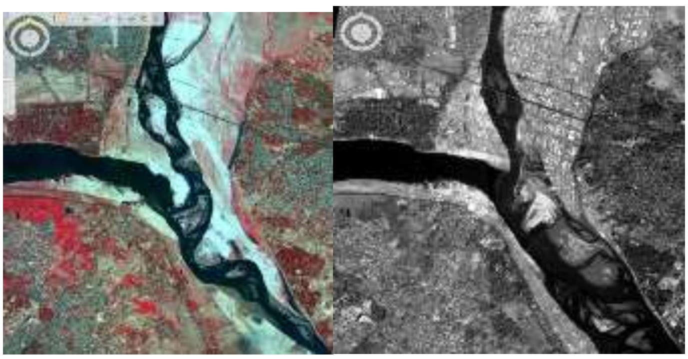
1. INTRODUCTION

Kumbh Mela (the festival of the sacred bathing) is the largest public gathering and the sacred bathing in ganga river is considered the most auspicious act of faith in India. It is a very ancient festival, which also finds its name as Magha mela in Allahabad Pillar (Ashoka Stambha) built by Ashoka in 3rd Century BCE. The Mela draws millions of pilgrims over the period of approximately 48 days to bathe at the sacred confluence of the Ganga, Yamuna and the mythical Sarasvati Rivers. Crowd gathering, varying between 2.0- 2.5 crore people were estimated on each of the 6 sacred bath days (14 Jan/ 21 Jan/ 04 Feb/10 Feb/ 19 Feb/ 04 March, 2019) during the mela in 2019. However, gathering of such huge crowds on sacred bath days made a significant impact on the quality of water of the area by increasing the soil erosion from the river banks into the water. The primary impact of such festivals is on the turbidity of Ganga river waters. Subsequently, it effects the river ecosystem and increases the pollution of the drinking water source[3,4,7].Large number of settlements were established along the river Ganga just before Sangam area. Figure 1 shows the course of river Ganga in March 2018 (before Kumbh) and January 2019 (During Kumbh) and sample establishment works carried out to felicitate Kumbh Mela as can be seen using LISS IV and Cartosat 2E data.

2. DATA USED

Sentinel 2 data has been used to derive time series turbidity of river Ganga in Allahabad region during Kumbh Mela 2019.

Large number of settlements were established along the river Ganga just before Sangam area. Figure 1 shows the course of river Ganga in March 2018 (before Kumbh) and January 2019 (During Kumbh) and sample establishment works carried out to felicitate Kumbh Mela as can be seen using LISS IV and Cartosat 2E data.



8 MARCH 2018; CARTOSAT 2E MERGED | 15 JANUARY 2019; CARTOSAT 2E

3. PRINCIPLES AND FORMULA USED

Physical and Chemical constituents of Water that affect the energy levels detected by a satellite sensor are color and turbidity. Differences in water color and turbidity affects the sate llite signal in the visible, very near ultraviolet and infra-red wavelengths. An increase in water color decreases the radiation reaching a sensor, because hiher amount of the sun's energy is absorbed in the water. An increase in turbidity increases the energy flux reaching a Satellite remote sensing sensor, since more solar radiation is reflected or backscattered by the turbid particles. An increased reflectance is also caused however, in clear, shallow water due to reflection from the bottom of the waterbody. In order to use remote sensing to measure water turbidity, it is important to understand the principles of light and water interaction. If the solar energy that reaches a water surface is represented by Io, the interaction is expressed by:

$$I_o = I_{SR} + I_A + I_B \qquad (1)$$

where I_{SR} is the solar flux that is specularly reflected at the water surface, I_A is the absorbed flux by water, and I_B is the flux backscattered to the water surface and which is thus available for remote sensor. Specular reflection by definition is equal at all wavelengths, but absorption and backscatter produce distinctive spectral signatures. Specular reflection from a water surface is also known as the sun glint. Details on the water surface is clearly visible in the areas of sun glint, but underwater details are obstructed. The % of solar energy that is specularly reflected from steady water depends on sun-elevation angle :

Table -1

Solar elevation Angle	Percentage Reflection
Horizon(0°)	100%
5°	58%
10°	35%
20°	13%
30°	6%
40°	3.4%
50°	2.1%
90°	2.0%

Sun glint only changes the intensity of measured flux; the relative spectral signature is only slightly affected.

Addition of Noise in remotely sensed signals by sun glint has not been considered as a major problem in water turbidity studies, but corrections are needed for absolute turbidity calculations. Skylight is also specularly reflected to a multispectral scanner. The intensity of skylight, however, is typically less than 10 per cent of sunlight, and reflected skylight typically constitutes less than 5 per cent of the remotely measured signal from water. Some more noise removals are required under hazy conditions and for sun-elevation angles of less than 30°. The solar energy that is not specularly reflected, is then refracted down through the water surface and gets affected by absorption and scattering. Energy absorbed by the water is converted to heat, and thus a water body temperature rises in sunlight. Some of the wavelengths of light are absorbed more than others. In deep clear water, near infra-red light is absorbed within 0.2 m of the surface, and red light is fully absorbed within the depth of 2 m. Most sunlight is scattered at small angles and thus the light that continues to travel down; some part of that light is reflected upward which is known as backscattering. The light remaining at any wavelength and any depth can be calculated from the equation:

$$I = I_S / e^{KX} \qquad (2)$$

where I_S is the flux entering the water surface, X is depth, and K is the coefficient of extinction. The coefficient of extinction accounts for both absorption and scattering, and its value varies with the wavelength of light [9]. Scattering in clear water is caused by molecules and is strongly wavelength dependent. This is also known as Rayleigh scattering and is similar to the process that produces a blue sky. In natural waters, most solar energy is scattered in a forward direction and eventually is absorbed by the water.

About 2 per cent of the light flux is backscattered in a clear,deep water. The part of the backscattered energy that returns to the water surface is detected by the remote sensor. In clear, deep water, 50 per cent of the signal for blue light comes from a depth of 15 m, whereas for red light, most of the signal comes from a depth of less than about 1.1m.

4. METHODOLOGY

Time series Turbidity mapping for getting the spatio- temporal patterns can also be done using POI based in-situ measurements of turbidity[1]. In this study, we have attempted satellite data based turbidity assessment. Many indices like Normalized Difference Turbidity Index are also used for such studies[2]. But they can’t be linked to absolute values of turbidity. Firstly, Atmospheric correction was done using Scene based Dark Object Subtraction method. Afterwards using SNAP Toolbox for Sentinel-2 Data processing, the turbidity was calculated using Optical Bands (mainly Red Band) [5,6]. Thus the unit of measurement will be BU(Backscattering Unit).

The Kumbh mela was celebrated from 14th January to 4th March 2019. To assess the water turbidity levels, Sentinel 2 data was used. Due to cloud cover, eight satellite scenes of

(9/1/2019,14/1/2019,19/1/2019,29/1/2019,13/2/2019,23/2/2019 ,28/2/2019,10/3/2019) dates could be used in this study.

Observation of water turbidity in Rivers: Majority of pilgrimage reaching the Kumbh takes a dip in the river Ganga. Thus, first major impact of a mass gathering shall be changes in the water turbidity. The turbid water is expected to enhance the backscattering ratio reaching the satellite. This principle is used in the Sentinel-2 data at red wavelength. Figure 2 shows the turbidity changes during 9th to 19th January 2019.

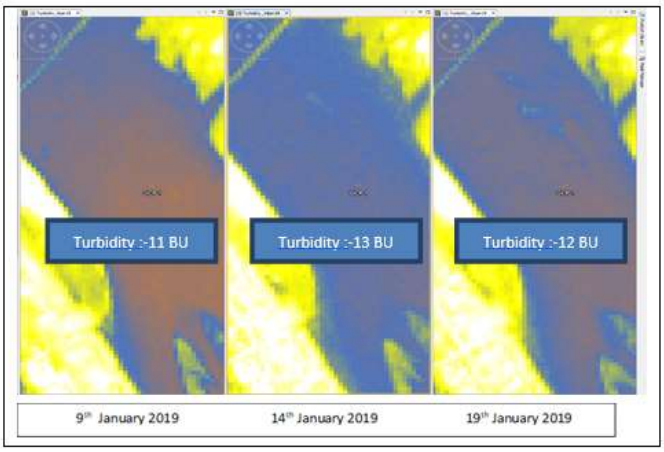


Figure 2

This work was further carried over for other important days and results for turbidity assessment obtained are shown in figure 3.

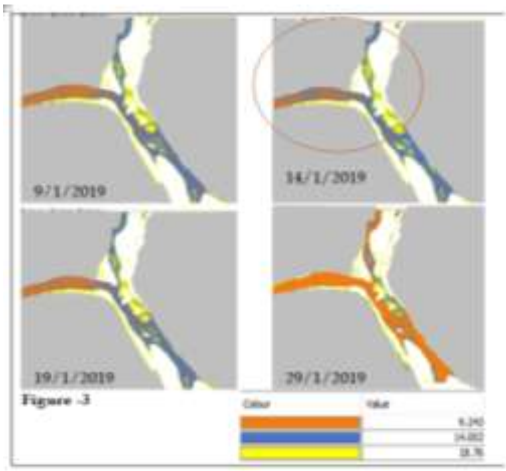


Fig. 3

It is noted that turbidity was highest on 'Makar Sankranti' day. After that there was decrease in turbidity till the end of the 'Mela'. It also matches with the number of pilgrims reaching Prayagraj, which was maximum during January (greatest rush for taking bath in Sangam area) and decreased afterwards with a small increment on Mahashivaratri day.

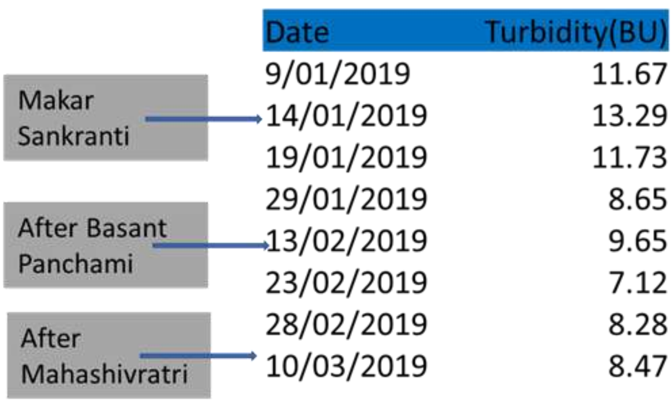
4. RESULTS

The calendar of events of kumbh mela is shown in Figure 4 –

Figure -4

As per the data obtained from satellite at various dates the following three trends were seen which shows the sudden increase in turbidity due to such events.

- Turbidity value in the central part of the Ganga river was around 11.67 BU on 9th January, 2019(before kumbh started) which changed to 13.29 BU on Makar Sankranti (14th January 2019) and reduced back to 11.73 BU on 19th January 2019(after event) as shown in figure 5 and figure 6.
- Turbidity value in the central part of the Ganga river was around 8.65 BU on 29th January, 2019(before Basant Panchami) which changed to 9.65 BU just after Basant Panchami(13th February 2019) and reduced back to 7.12 BU on 23rd February 2019(after event)
- Turbidity value in the central part of the Ganga river came down to 7.12 BU on 23rd February, 2019(in between) which increased to 8.28 BU on 28th February 2019 and increased upto 8.47 BU on 10th March 2019(due to Mahashivratri).



Date	Turbidity(BU)
9/01/2019	11.67
14/01/2019	13.29
19/01/2019	11.73
29/01/2019	8.65
13/02/2019	9.65
23/02/2019	7.12
28/02/2019	8.28
10/03/2019	8.47

Figure – 5

Figure – 6

5. CONCLUSION

It ia observed that a significant increase in river water turbidity has been observed during Kumbh Mela 2019 measured using satellite data processing.Thus, to avoid the drastic increase in water pollution and water quality degradation during Kumbh Mela and such kinds of events, it is extremely important to bring more control mechanisms in such kinds of events as it deeply impacts the riverine ecosystem and makes the drinking water source polluted over this period.

6. LIMITATIONS

This method uses optical band (i.e., Red band) and so we can't get the turbidity values for cloudy days. But still, with high temporal resolution, most of the important dates of sacred bathing were captured. Also, the accuracy is dependent on the atmospheric correction[8].The Validation of the Turbidity values can also be done with the help of field instruments which could not be included in this study due to lack of field instruments at the time of Kumbh Festival.

7. ACKNOWLEDGMENTS

The authors wish to thank Director, NRSC for his encouragement and overall guidance. This work was supported in part by a grant from Regional Remote Sensing Centre –Central (Nagpur), National Remote Sensing Centre.

8. REFERENCES

[1] Manzo, Ciro & Braga, Federica & Zaggia, Luca & Brando, Vittorio & Giardino, Claudia & Bresciani, Mariano & Bassani, Cristiana. (2018). Spatio-temporal analysis of prodelta dynamics by means of new satellite generation: the case of Po river by Landsat-8 data. International Journal of Applied Earth Observation and Geoinformation. 66. 210 - 225. 10.1016/j.jag.2017.11.012.

[2] Elhag, Mohamed & Gitas, Ioannis & Othman, Anas & Bahrawi, Jarbou & Gikas, Petros. (2019). Assessment of Water Quality Parameters Using Temporal Remote Sensing Spectral Reflectance in Arid Environments, Saudi Arabia. Water. 11. 556. 10.3390/w11030556.

[3] Gernez, Pierre & Laurent, Barillé & Lerouxel, Astrid & Mazeran, Constant & Lucas, Axel & Doxaran, David. (2014). Remote sensing of suspended particulate matter in turbid oyster-farming ecosystems. Journal of Geophysical Research: Oceans. 119. 10.1002/2014JC010055.

[4] Jalón-Rojas, Isabel & Schmidt, Sabine & Sottolichio, Aldo & Bertier, Christine. (2016). Tracking the turbidity maximum zone in the Loire Estuary (France) based on a long-term, high-resolution and high-frequency monitoring network. Continental Shelf Research. 117. 10.1016/j.csr.2016.01.017.

[5] Hung Trinh, Le & R. Zablotskii, V & Giang Le, Thi & Thu

Hien Dinh, Thi & Trinh Le, Thi & Thi Tham, Trinh & Thu Nga Nguyen, Thi. (2018). Estimation of suspended sediment concentration using VNREDSat – 1A multispectral data, a case study in Red River, Hanoi, Vietnam. GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY. 11. 49-60. 10.24057/2071-9388-2018-11-3-49-60.

[6] Aguilar-Maldonado, Jesús A. & Santamaría-Del-Angel, Eduardo & Sebastiá, M.T.. (2017). Reflectances of SPOT multispectral images associated with the turbidity of the Upper Gulf of California. Revista de Teledetección. 2017. 1. 10.4995/raet.2017.7795.

[7] Shivangi Somvanshi , P. Kunwar, N.B. Singh, and T.S. Kachhwaha, Water Turbidity Assessment in Part of Gomti River Using High Resolution Google Earth's Quickbird satellite data, Geospatial World Forum, 2011, Hyderabad

[8] Gernez, Pierre & Lafon, Virginie & Lerouxel, Astrid & Curti, Cécile & Lubac, Bertrand & Cerisier, Sylvain & Laurent, Barillé. (2015). Toward Sentinel-2 High Resolution Remote Sensing of Suspended Particulate Matter in Very Turbid Waters: SPOT4 (Take5) Experiment in the Loire and Gironde Estuaries. Remote Sensing. 7. 9507. 10.3390/rs70809507.

[9] GERALD K.MOORE (21 may 1980) Satellite remote sensing of water turbidity, Hydrological Sciences-Bulletin-des Sciences Hydrologiques, 25, 4, 12/1980.

