Water Quality of Inland Water Bodies of Mumbai using Hyperspectral Remote Sensing Hyperion EO1

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Abstract*:* The objective of this work is to monitor the water quality of inland water bodies of Mumbai, Maharashtra using Hyperion Earth-observing one (EO1) hyperspectral satellite which provides us the high spatial resolution hyperspectral images in 242 bands which were launched in November 2000. In the past several decades the water quality of inland water bodies of Mumbai is deteriorating due to the high rate of urbanization and industrialization which is affecting the environmental health and river ecosystem. For analyzing the water quality of different inland water bodies of Mumbai, the hyperspectral images of 2016 are used. The Spectral signature of Ulhas River, Mithi River, and Powai Lake are developed by combining bands of Hyperion EO1 and analyze for determining the water quality. The Methodology includes developing the spectral signature using supervised classification of the image analysis tool. The 20 samples of different water bodies are collected for supervised classification. The spectral signature of Inland water bodies is then compared to the spectral signature of potable water. The spectral signature of Powai Lake is highly correlated with the potable water and chlorophyll content due to high surface vegetation. The R^2 value of potable water properties and Powai Lake water is 0.9944 which shows the low content of water pollutant. The Mithi River is the least correlated to the spectral signature of potable water and possibly polluted by heavy metal due to its proximity to different industries. The R^2 value of the Mithi River is lowest among other inland water bodies of about 0.98 due to heavy water pollution. The reflectance of the Ulhas River also shows the different results than potable water due to its heavy domestic pollution. The R^2 value of 0.9935 is observed for the Ulhas River. This study is important because of over 3 million residents are depending on the Ulhas river from a suburban area of Mumbai and the Mithi River flows through the heart of Mumbai and is important to maintain the city's hygiene. The regular monitoring of water quality will require the sample collection and big investment to develop the testing laboratories but the combination of remote sensing and in situ observations of water pollutant will help to monitor the water quality efficiently over Mumbai region.

Keywords: Water quality; Hyperspectral remote sensing; Hyperion EO1; spectral signature; Image analysis; Mumbai.

1. Introduction

Water quality monitoring is termed as collecting the samples of the water body and analyzing the quality of water (EPA). Water is a limited natural resource, therefore, preservation of water is very important for the protection of our environment various water quality monitoring systems have been developed to measure the concentration of constituents in quantity for characterization of water for different uses (IJARCS-DIVYA BHARDWAJ & NEETU VERMA). Water quality is degraded due to the concentration of pesticides or fertilizers which affect marine life. (Water quality analysis of surface water: Indrani Gupta).

From the 1970s the quality of water is monitored by using Remote sensing technology. Remote sensing refers to the science of acquiring information about any area or object by using electromagnetic radiations as a medium of interaction (NOAA's). Even if there are the variability of the parameters of remote sensors the calculation of quality parameters of inland

water bodies can be done successfully by remote sensing (USGS). So remote sensing is used for the betterment of GIS application. A Geographic Information System is an application is used to derive manipulate and analyze various data. The information gathered by using GIS is stored in the form of a raster and vector form. GIS sometimes refers to geographic information science underlying geographic concepts, applications, and systems. GIS gives people the ability to create their digital map layers to help solve real-world problems. A simple definition may read: "a computer system capable of holding and using data describing places on the earth's surface." In actuality, GIS encompasses more than just computer system Geographic information systems (GIS) have many applications in hydrology that use spatial analytic tools to a greater or lesser extent.

Hyperspectral imaging is elaborated as a sequence statement of spectral bands. This is a technique that obtains a digital image of the earthly object in various spectral narrow contiguous Spectral signature is developed without wavelength omissions. Image develop by Multispectral sensors and spectral signature developed is almost similar except pixel band of red, green, blue.

Due to the past several decades, the water quality of inland water bodies of Mumbai is deteriorating due to the high rate of urbanization and industrialization which is affecting the environmental health and river ecosystem. An increase in primary productivity of impurities has already been observed in several water bodies. There are several water bodies in Mumbai but we are working on Mithi River, Powai Lake and Ulhas River because these water bodies are highly polluted and many of the Mumbai suburban depend mainly on these water bodies so it is important to maintain city hygiene and environmental health. So, we are concentrating on the method to be used over inland waters.

The paper describes the water quality monitoring of the inland water bodies of Mumbai by analyzing the spectral signature. The paper is divided into three sections that are Methodology, result & discussion, and conclusion. In methodology, the study area and its detail description are given. The section also talks about the data, its sources and the technique to process the data to acquire the spectral signature. The spectral signatures are analyzed and the detail discussion is mentioned in the next section that is result and discussion. This section includes the comparison of the different spectral signature of water bodies and its correlation with the spectral signature of potable water of Vihar Lake. The objective of this paper is to judge the ability of hyperspectral remote sensing in the field of water quality monitoring. The combined analysis of remotely sensed data with filed observation can be a dynamic solution for water quality monitoring. In conclusion the interpretation of result and its future scope is mentioned. This paper will be useful for the scholars who want to study the hyperspectral remote sensing for analysis of water quality and its multiple application.

2. Data and Methodology

Study Area

The study area for monitoring water quality of Inland water bodies is the Mithi River, Ulhas River, Powai Lake and Vihar Lake in Mumbai Maharashtra. The Mithi River is a River on Salsette Island in the Mumbai region which expands from North latitude 19°00'15" to 19°15"00 and East longitude 72°45' to 73° and its total length is about 18 km and the catchment area is 7295 hectares. The Ulhas river is West flowing river in a western India in Maharashtra state

which expands from North latitude 18°44' to 19°42' and East longitude 72°45'59" to 73°48'and its total length of river from its origin to its outfall in Arabian sea is 122 km and area of 4637 km². Mumbai's 125 years old Powai Lake is situated in Powai Valley in Mumbai which expands from North latitude 19°07'48' and east longitude covered is 2.1Km² and depth is 12 m. Vihar lake located in Vihar village in North Mumbai build in 1860 having an area of 7 Km² and expands from 19°08'38" and eastern longitude 72°54'36.

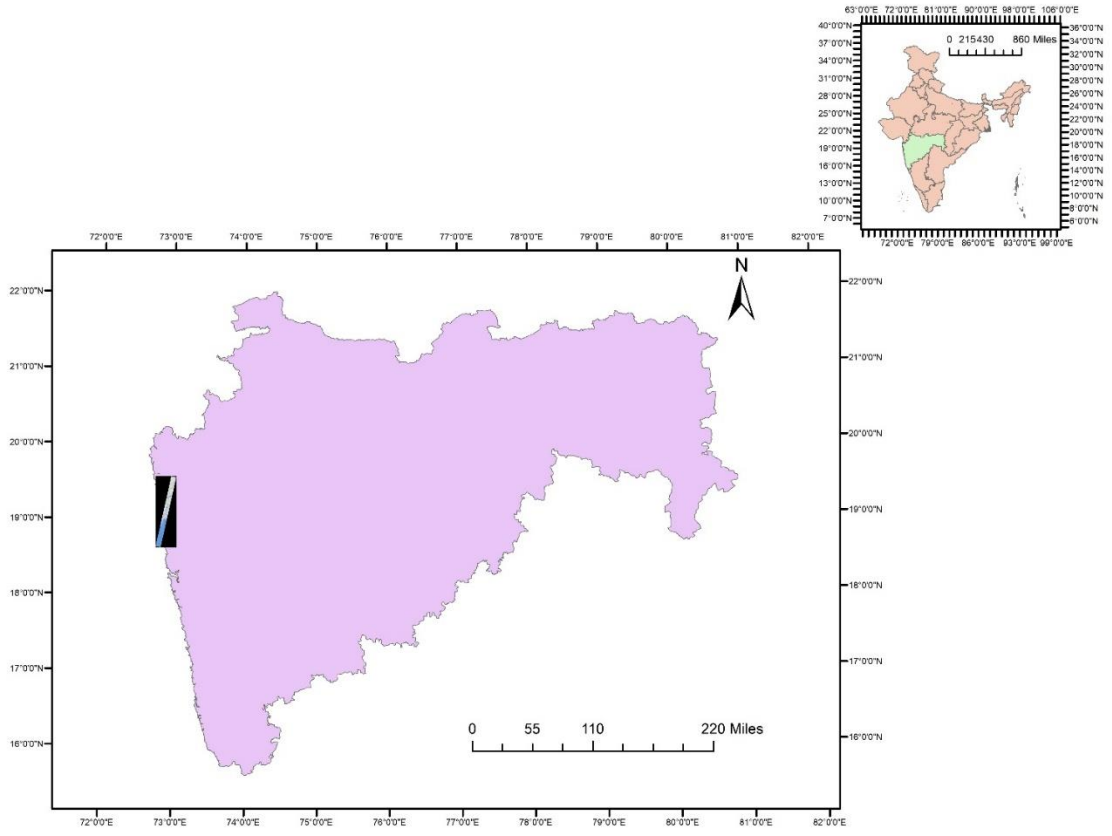

Fig 1 The Study area for water quality monitoring of inland water bodies of Mumbai. The strip shows the extent of Hyperion EO1 Hyperspectral data

Methodology

The water quality is analyzed on the principle of Spectral Signature which represents the uniqueness of every object. The Spectral Signature of potable water is compared with the Spectral Signature of various water bodies in Mumbai. The water quality of inland water bodies is judged by concerning the spectral reflectance of different pollutants. Every pollutant has a different Spectral Signature and with the help of that, the pollutants can be determined with the percent amount present in the water. Turbidity can also be analyzed with spectral reflectance. The Hyperion EO-1 gives reflectance in 242 bands which helps us to analyze the Spectral Reflectance at a very fine resolution. The Hyperion E0-1 launched in 2000 as a Hyperspectral Remote Sensing satellite. The number of bands in Hyperion E0-1 is 142, which ranges from

400 nm to 2.5 µm with a resolution of 30m. The data is downloaded from USGS earth explorer (https://earthexplorer.usgs.gov/).

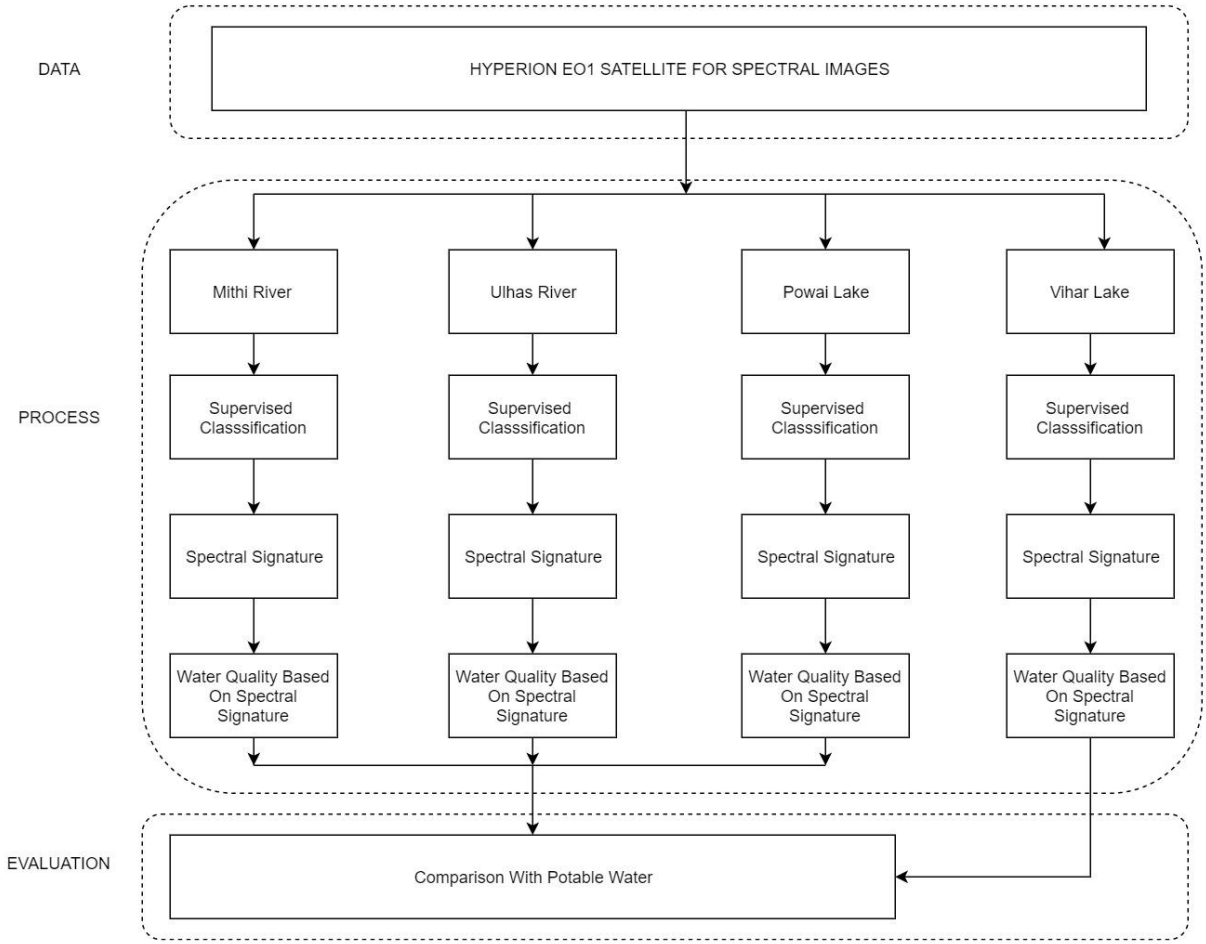

Fig 2 The flowchart of Methodology describing the technique and method which was implemented for assessing the water quality of inland water bodies of Mumbai.

For analyzing the water quality 242 bands are used out of which some bands are discarded due to null reflectance value. The bands from 1-7, 58-76 and 225-242 are neglected and Spectral reflectance is calculated using Hyperion image of 2016. The preprocessing of Hyperion EO-1 images is done by composing 242 bands. The composed image formed is used for supervised classification. The atmospheric correction is already performed by Hyperion level-1B. To analyze the water quality, we developed the spectral signature of different water bodies in 198 bands. For developing Signature Supervised classification is performed in the Geoprocessing tool. In supervised classification, the samples of different inland water bodies were collected using polygon in a supervised classification tool. The developed Spectral Signature of different water bodies like the Mithi River, Ulhas River, Powai Lake is compared with the spectral signature of potable water of the Vihar lake.

3. Result and Discussion

The water quality monitoring of inland water bodies of the Mithi River, Ulhas River, Powai Lake is done by calculating spectral reflectance. Due to the growth of urbanization and industrialization from the past 3 to 4 centuries resulted in contamination of inland water bodies which leads to environmental health and hygiene of the surrounding area of water bodies. The result includes the spectral signature of inland water bodies' analysis and comparison with the spectral signature of potable water.

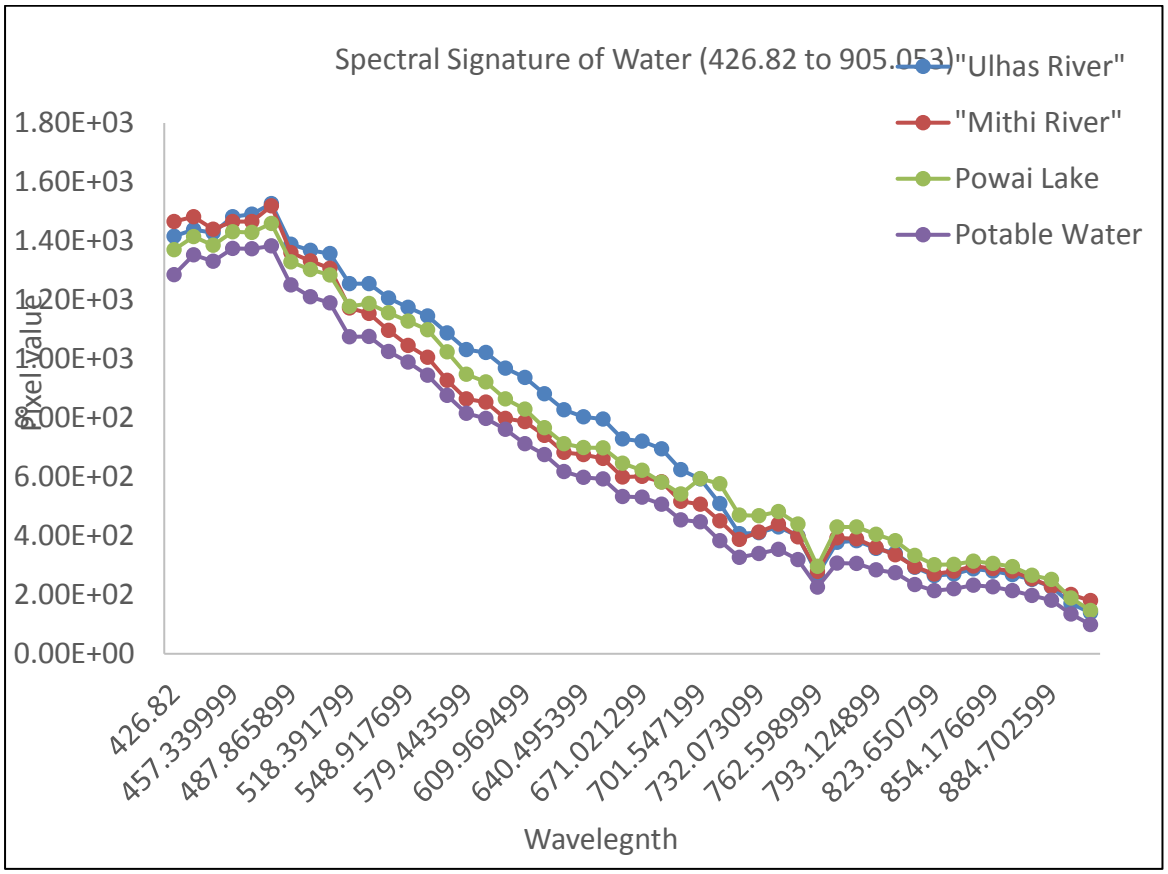

Fig 3: The graph represents the comparative analysis of spectral reflectance of all inland water bodies of Mumbai.

Water quality of Mithi River

The water quality of the Mithi River is compared with potable water as shown in the graph below.

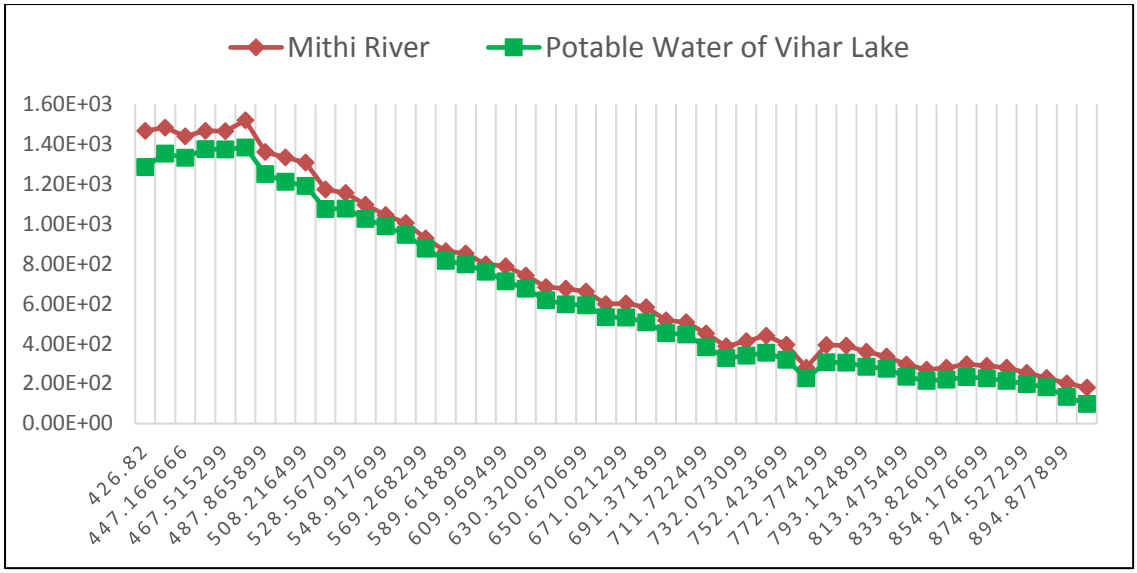

Fig 4: The graph representing the comparison spectral signature of Mithi River with potable water

The Mithi river has the highest infrared radiation wavelength value 477.69 nm and the pixel value is 1.52E+03, which lies in blue colour and the lowest infrared radiation wavelength value is 762.59 nm and the pixel value is 2.79E+02, which lies in red colour.

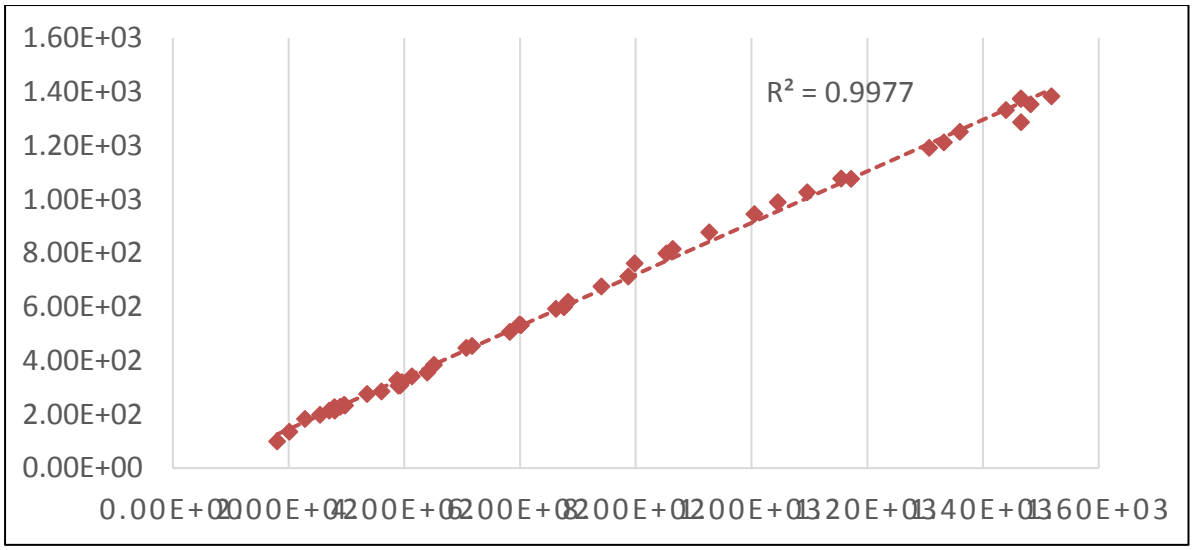

Fig 5: The graph representing the comparison spectral signature of Mithi River with potable water (The R^2 value of the Mithi River is 0.98 due to heavy pollution.)

Water quality of Ulhas River

The water quality of the Ulhas River is compared with potable water as shown in the graph below.

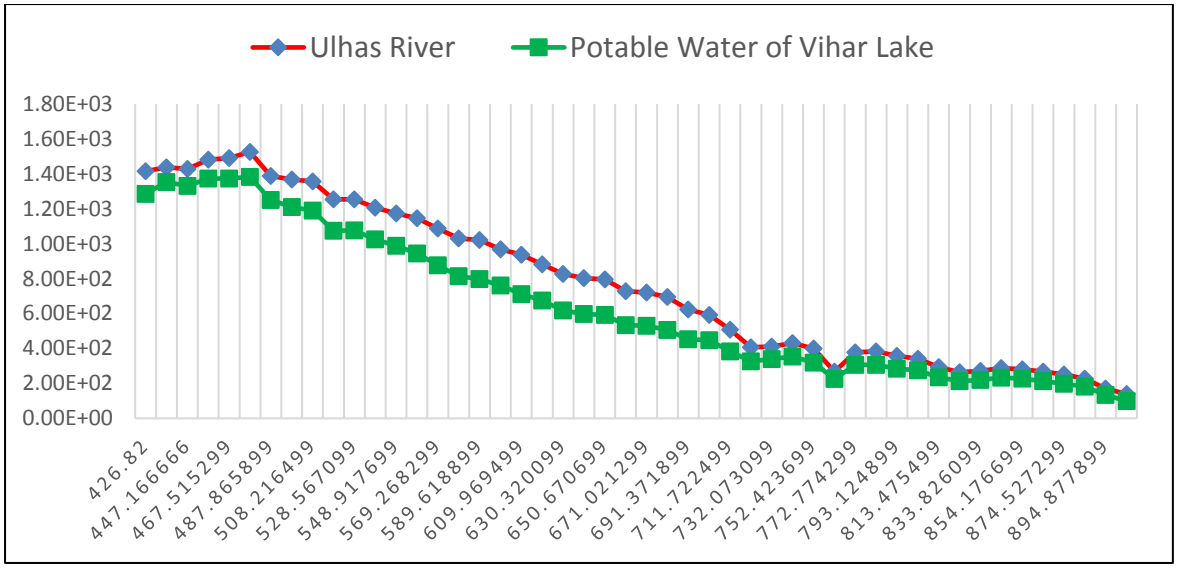

Fig 6: The graph representing the comparison spectral signature of Ulhas River with potable water.

The Ulhas river has the highest infrared radiation wavelength value 477.69 nm and the pixel value is 1.53E+03, which lies in blue colour.and the lowest infrared radiation wavelength value is 762.59 nm and the pixel value is 2.68E+02, which lies in red colour.

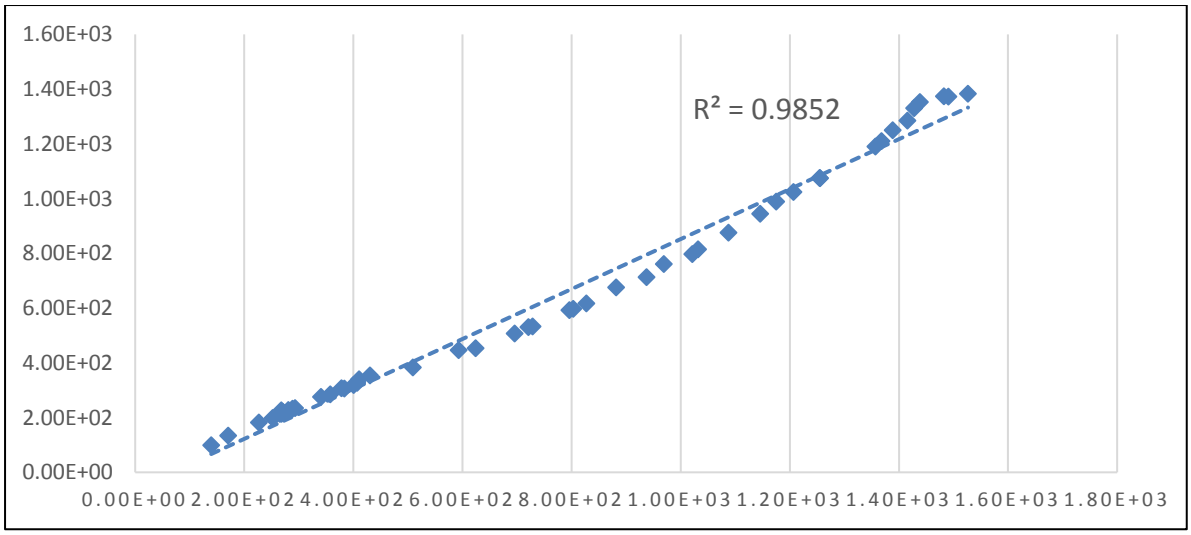

Fig 7: The graph representing the comparison spectral signature of Ulhas River with potable water. (The R^2 value of the Ulhas River is 0.9935 due to domestic pollution)

Water quality of Powai Lake

The water quality of the Powai River is compared with potable water as shown in the graph below.

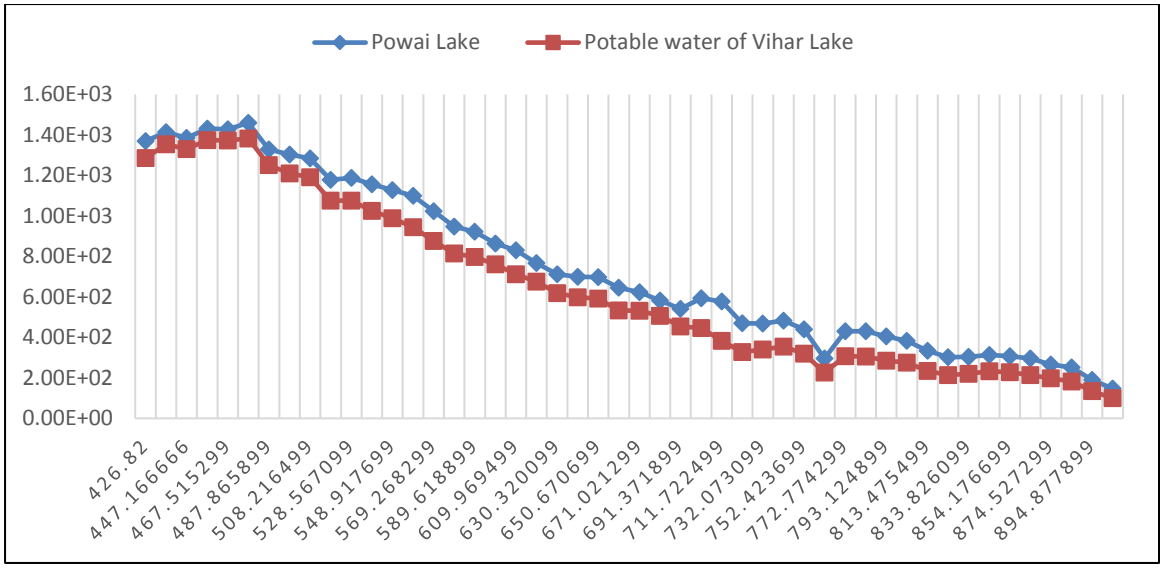

Fig 8: The graph representing the comparison spectral signature of Powai Lake with potable water.

The Mithi river has the highest infrared radiation wavelength value 477.69 nm and the pixel value is 1.46E+03, which lies in blue colour.and the lowest infrared radiation wavelength value is 762.59 nm and the pixel value is 2.97E+02, which lies in red colour.

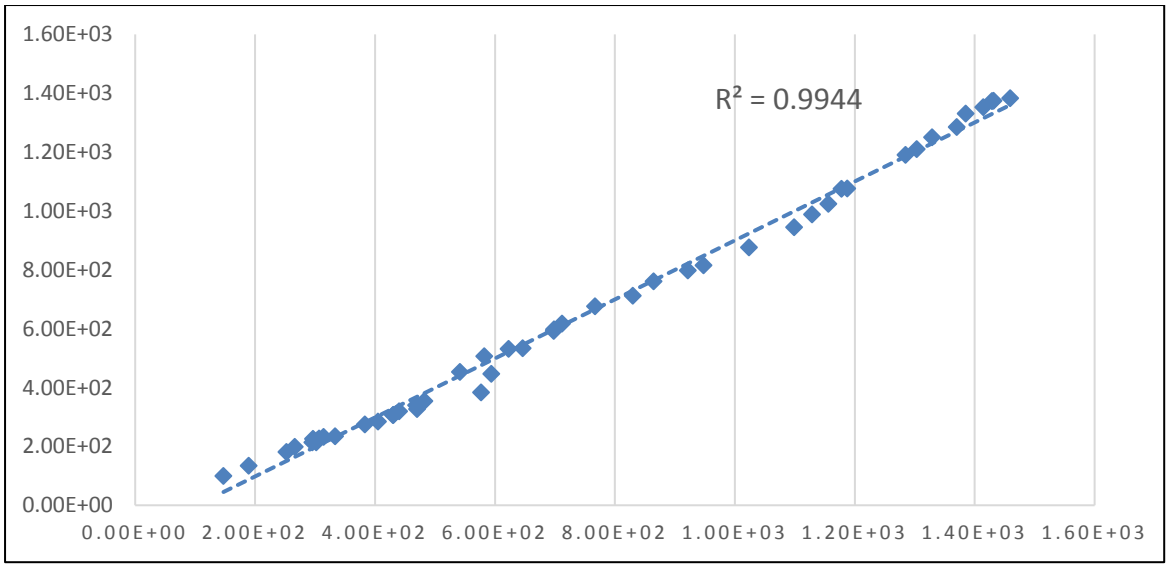

Fig 9: The graph representing the comparison spectral signature of Powai Lake with potable water.

The R^2 value of the Mithi River is 0.9944 which shows the low content of water pollutants. Comparing the Spectral Signatures of Mithi River, Ulhas River and Powai Lake with potable water. The Mithi River is least correlated to the Spectral Signature of potable water and Powai lake is highly correlated with the Spectral Signature of potable water. Ulhas River shows different results than potable water.

4. Conclusions and Recommendations

The remote sensing method for identifying the quality of water can be useful for the water resources whose quality assessment is difficult because of its dynamic nature. The combined observation with the filed data can be an important framework to identify the quality precisely. The R2 value of potable water properties and Powai Lake water is 0.9944 which shows the low content of water pollutants. The Mithi River is the least correlated to the spectral signature of potable water and possibly polluted by heavy metal due to its proximity to different industries. The R2 value of the Mithi River is lowest among other inland water bodies of about 0.98 due to heavy water pollution. The reflectance of the Ulhas River also shows different results than potable water due to its heavy domestic pollution. The R2 value of 0.9935 is observed for the Ulhas River. This study is important because of over 3 million residents are depending on the Ulhas river from a suburban area of Mumbai and the Mithi River flows through the heart of Mumbai and is important to maintain the city's hygiene. The regular monitoring of water quality will require the sample collection and big investment to develop the testing laboratories but the combination of remote sensing and in situ observations of water pollutants will help to monitor the water quality efficiently over the Mumbai region.

Acknowledgement

I would like to thank faculty of Civil Engineering department of Dilkap Research Institute of Engineering and Management studies for providing the lab facilities and guidance. I would also mention Prof. D. G. Regulwar form Government College of Engineering, Aurangabad for the valuable guidance.

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