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A Novel Approach For Water Quality Detection Using Satellite By Implementing Clustering

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Abstract

For all living things, water is a crucial component. The colour of the water is a key factor in determining its quality. We are aware that lakes and areas up to 1 km2 are the only places where the water colour is currently determined but for a large scale there is no such identification.

We can utilise satellite images and the idea of forel-ule to assess the water quality and we can analyse various locations with bad water quality and mark those places. This will help us comprehend the colour of water bodies on a larger scale. Also, we may review and compare earlier data.

Keywords: Forel-Ule, Water Quality, Satellite Images..

Introduction

Even though satellite sensors for ocean colour can only detect optical radiation in a few restricted, narrow spectral bands, they are perfectly capable of determining the colour of natural waters.

The perception of photons with wavelengths between 380 and 720 nm leads to the impression of colour. There has been a significant lot of scientific research on how humans perceive colour since the turn of the 20th century. Since then, the prevalence of colour printing, colour displays (such as televisions, computer monitors, tablets), digital cameras, and smartphones has demonstrated the growing significance of colour in societal communication.

A part of the ESA Sentinel Application Platform (SNAP) programme, which is open-source and free. Ocean colour measurements taken from space are the best method for analysing water composition dynamics at various spatial scales. Global ocean composites can be created down to the lowest pixel level, which for

MERIS Full Resolution (FR) data is 300 m. The amount of chlorophyll-a (CHL) in phytoplankton is the main element influencing the colour of the open ocean.

The majority of EOW colour observations, however, are made near the shore, where additional factors, such as absorption by plant degradation products (Coloured Dissolved Organic Matter, or CDOM), Suspended Particulate Matter concentration (SPM), an indicator of turbidity, coastal erosion, riverine flux, and wind or current generated resuspension, also influence or dominate the colour of the water column.

Water bodies on Earth are under a lot of stress as a result of human activities and associated environmental changes and the close relationship between humans and water bodies. Therefore, in order to assist in managing and restoring the world's water supplies, there is an urgent need to increase knowledge about the quality of water bodies.

The results of the most recent national study indicate that 3% of the water on Earth is fresh water. Because it is highly contaminated, too deep to be extracted at a reasonable cost, or because it is trapped in glaciers, polar ice caps, the atmosphere, and soil, 2.5% of the fresh water on Earth is unavailable. Massive contamination of inland water sources has made the already severe fresh water deficit much worse.

Inadequate management of urban, industrial, and agricultural wastewater results in serious pollution or chemical poisoning of hundreds of millions of people's drinking water. Arsenic and fluoride are two examples of naturally occurring compounds that could have an effect on health. Drinking water may have higher concentrations of other chemicals like lead due to leaching from water-contact components of the water supply.

The cleanliness of the water was already assessed through thorough sampling and laboratory testing. However, this kind of in-situ measurement is not suitable for in-depth analysis because it requires a lot of time and effort. Satellite images are now a vital source of data for tracking various optical components in water as a result of the advancement of remote sensing technologies.

The absorption and dispersion of various water components influence the colour of the water as a result of interactions between sunlight and the compounds in the water. Water colour is another crucial indicator of water quality since it closely correlates with the amount of optically active elements in the water. The Forel-UIe index (FUI), which is calculated using the Forel-UIe colour scale, is the first quantitative approach for assessing water colour. Water is divided into 21 levels by the FUI, with colours ranging from dark blue to yellowish brown. The FUI can be easily calculated from optical satellite data using invariant approaches because it is an optical characteristic that can be used in any season or location. FUI can be used to monitor the quality of inland waterways on a broad scale.The amount of suspended particles and coloured dissolved organic matter, the Secchi depth (SD), and the chlorophyll-a concentration can all be identified from the spectral fingerprints of water that remote sensing devices can provide.

The techniques used to obtain these values, however, depend on the optical properties of inland water bodies because the bulk of these metrics are physical, biological, or chemical attributes.

The use of these methods for retrieving water quality is limited to particular far sensing sensors and circumstances since the optically active substances in inland water bodies are complicated and diversified.

As their methods are exclusively employed in China. However, we combine these techniques with our own all over the world.

Literature Review

According to [1](R^2 = 0.90, P 0.001) The resulting FUI was found to be extremely comparable with FUI computed from in situ water surface reflectance. The in situ datasets for the Secchi depth and trophic level indexes shown significant levels of agreement (R^2 = 0.62, P 0.001) and consistency (R^2 = 0.90, P 0.001), respectively.

Due to cloud pollution and the return length of Landsat 8, the method proved inadequate for monitoring annual changes in water quality. In order to increase the quantity of trustworthy observations, more effort will be made in the future to analyse the use of data from various sources.The impact of the bottom reflectance may affect the observed color of water bodies, and this situation generally occurs in optical shallow waters.[1]

According to [2] they explored the potential of the hue angle derivation from multispectral imaging instruments with a higher spatial resolution but reduced spectral resolution:
the Multispectral Imager (MSI) on Sentinel-2 A and B from the European Space Agency (ESA), the Operational Land Imager (OLI) on NASA's Landsat-8 and its predecessor, the Enhanced Thematic Mapper Plus (ETM+) on Landsat-7.[2]

It may be possible to accurately replicate hue angles by using a limited number of narrow spectral bands, comparable to the band arrangement utilised by MERIS, MODIS, SeaWiFS, and OLCI. It is possible to determine hue colour, although not all hues can be calculated precisely. The band setting is mostly to fault for this, not the bands' width. With simulations that excluded the whole SRF and only included the mean wavelength of each band, somewhat equal results were obtained.[2]
According to [3] The apparent hue of natural streams is one element of our aquatic environment that is straightforward to see and acts as an additional visual water quality indicator. Here, we go over the research and the usefulness of the Forel-Ule colour index (FUI) scale as a stand-in for a number of attributes of natural waters. A FUI scale is used to discern between the apparent colours of various natural surface water bodies[3]

The FUI colour system is a trustworthy optical water quality proxy that may be used to monitor the marine environment since it is a low-cost and easy-to-use equipment, even if it is not yet apparent which CPAs are responsible for each colour index. To look at its possible applications, field study was done at sea and in estuary systems in mid- to high-latitude areas. Correlation and regression analysis were used to show the connection between FUI and a number of optical water quality parameters.I had a good relationship with a number of optical water quality factors.Precision-accuracy validation, which is crucial to studies of ocean colour, is made feasible by the acceptable accuracy of FUI data from the numerous sensors. Additionally, as monitoring devices generate massive amounts of data, there will always be a need to examine and confirm the data's correctness in related tasks[3].

According to [4] The average and variability of precipitation, as well as how it is transformed into useable water through surface water sources and aquifer recharge, all have a significant role in determining water availability. It also depends on our ability to manage reservoirs and aquifers responsibly and store water.The exponential growth of satellite-based information over the past ten years, as evidenced by the increased number of satellites deployed with continuously improving resolution and numerous derived products, has created unprecedented potential to support and enhance WRM in the LAC region and globally.[4]

There is still potential to engage more actively with the national stakeholders in order to build solutions and capacities for monitoring and early warning applications of natural hazards in support of effective disaster risk reduction strategies at the national level. This is especially true in areas with a lack of data. Knowledge networks linking governmental entities, academic institutions, and international development groups are essential for achieving this aim and staying current on this quickly changing issue.[4]

According to [5] Ocean surface partitioning strategies using Ocean Colour Remote Sensing: A Review. Progress in Oceanography, 155, 41-53. doi:10.1016/j.pocean.2017.05.013 The complexity of interplay between environmental forces and biological responses has resulted in distinct zones with distinct properties at the ocean's surface. The division of different functional units, each with distinctive, homogeneous traits and underlying ecological processes, is known as ocean surface partitioning. The main objectives and applications of ocean partitioning include the assessment of particular marine ecosystems, the development of more accurate satellite ocean colour products, the inclusion of data into biogeochemical and climatic models, and the development of ecosystem-based management practises.Partitioning the ocean to reveal this intricate spatial organisation advances our understanding of the mechanisms regulating phytoplankton dispersion, which in turn influences the structure and dynamics of the marine food web.For displaying environmental fluctuations, projecting small-scale, ship-based oceanographic discoveries locally over larger regions, and dividing the ocean surface into discrete, usable units putting in place balanced and inclusive sampling methods to avoid over- or undersampling of certain research regions; Using results from different ocean scientific domains and weighted estimates of biogeochemical fluxes at the regional, basin, and global scales[5]

According [6] The demand for more effective environmental monitoring of the open and coastal oceans has led to recent significant advancements in satellite ocean colour technology and algorithm research. Earth observation is helpful for identifying, mapping, and tracking phytoplankton blooms because it provides a synoptic view of the ocean both geographically and temporally. Algal blooms are indicators of the health of the marine environment, hence monitoring them is crucial to the effective management of coastal and oceanic resources.We have shown that there are multiple operational ocean colour algorithms now available to help with phytoplankton bloom identification in the majority of ocean and coastal locations. For basic procedures, such as the exclusive use of the reflectance spectrum, it is recommended that understanding the study region and a more complete inspection of the pixels' reflectance spectra be taken into consideration to verify the validity of the algal bloom information gathered.[6]

According to [7] The demand for more effective environmental monitoring of the open and coastal oceans has led to recent significant advancements in satellite ocean colour technology and algorithm research. Earth observation provides a geographically and temporally comprehensive image of the ocean, hence information from satellite ocean colour sensors is commonly used for locating, identifying, and tracking phytoplankton blooms.[7]

While improving, ocean colour remote sensing still faces challenges when used in coastal waters to provide operational real-time monitoring of a phytoplankton bloom.

As a result, a global time series of satellite-derived data useful for algal bloom research is generated. The creation of biological baselines is made possible by these ocean colour databases, which can then be used to identify and anticipate changes in the dynamics of the ocean system.The biological and physical elements that initiated or terminated an algal event may also be determined using historical earth observation data[7].

According to [8] The current and expected status of the study, as well as any unanswered problems, are highlighted by the four fundamental elements of aquatic satellite remote sensing:mission capabilities, in situ observations, algorithm development, and operational capability.Discuss potential solutions, future strategies, and ideas that will have a direct bearing on the scientific investigations and social repercussions of upcoming missions that will be able to examine inland and coastal aquatic systems[8].

According to [9] It is now widely accepted that data on suspended particle matter, phytoplankton, and related processes in local waters may be collected using ocean colour remote sensing from sun-synchronous polar orbiting satellites. New data from optical remote sensors on geostationary satellites, which typically capture photographs more often during the day than at night, are now making a much greater temporal resolution available.[9]

The potential for resolving fast processes, such as tidal or diurnal changes in phytoplankton or suspended particulate matter, as well as for dramatically improving data availability during scattered cloud periods exists with this higher temporal resolution.

The spectral resolution of geostationary sensors may surely be improved in the future. It is important to consider how SSO and GEO ocean colour sensors should be coupled in the future for local applications including monitoring coastal water quality, spotting dangerous algal blooms, tracking sediment movement, and researching or keeping an eye on ecosystem health. This is due to the fact that GOCI now provides ocean colour data for the Korea, China, and Japan area with a spatial resolution of 500 m and a temporal resolution of hourly[9].

According to Satellite Ocean Colour: Current Status and Future Perspective Studying phytoplankton dynamics at seasonal and interannual scales is crucial for gaining a better understanding of the function of phytoplankton in marine biogeochemistry, the global carbon cycle, and how marine ecosystems react to climatic variability, change, and feedback mechanisms. These investigations depend on inferred chlorophyll content and spectrally resolved water-leaving radiances (ocean colour).[10]

This article examines the current state of the art and future directions for ocean colour research with a focus on large to medium resolution observations of oceans and coastal waterways.Aspects of the operational and state-of-the-art satellite ocean-color sensors for the present and the future are then examined after reviewing the user demands for products and uncertainty characteristics.[10]

Several factors make it necessary to maintain ocean-color observations in operational mode, improve ocean-color observations and the derived products (including data uncertainty characteristics) by improving the constituent retrieval algorithms, adhering strictly to international protocols, and thoroughly characterising the uncertainty of instrumentation for in-situ data collection (see section "Ocean Colour EO Sensors and in situ Observations"); and improve the methodology.Maintaining ocean-color observations in operational mode, improving ocean-color observations and the derived products (including data uncertainty characteristics) by improving the constituent retrieval algorithms, strictly following international protocols, and thoroughly characterising the uncertainty of instrumentation for in-situ data collection (see section "Ocean Colour EO Sensors and in situ Observations"); and improving methodological standards are all necessary due to a number of factors. There is a clear need for expanded training opportunities for both professionals and non-specialists in both developed and developing countries where worries about the consequences of climate change, food security, water availability, and biodiversity loss are particularly acute.[10]

Methodology

There are various Satellites which are hovering around us which are collecting continuous data .They have various types of sensors for different purposes.Here we are using the sensors which are dedicated to record the color changes of the water.

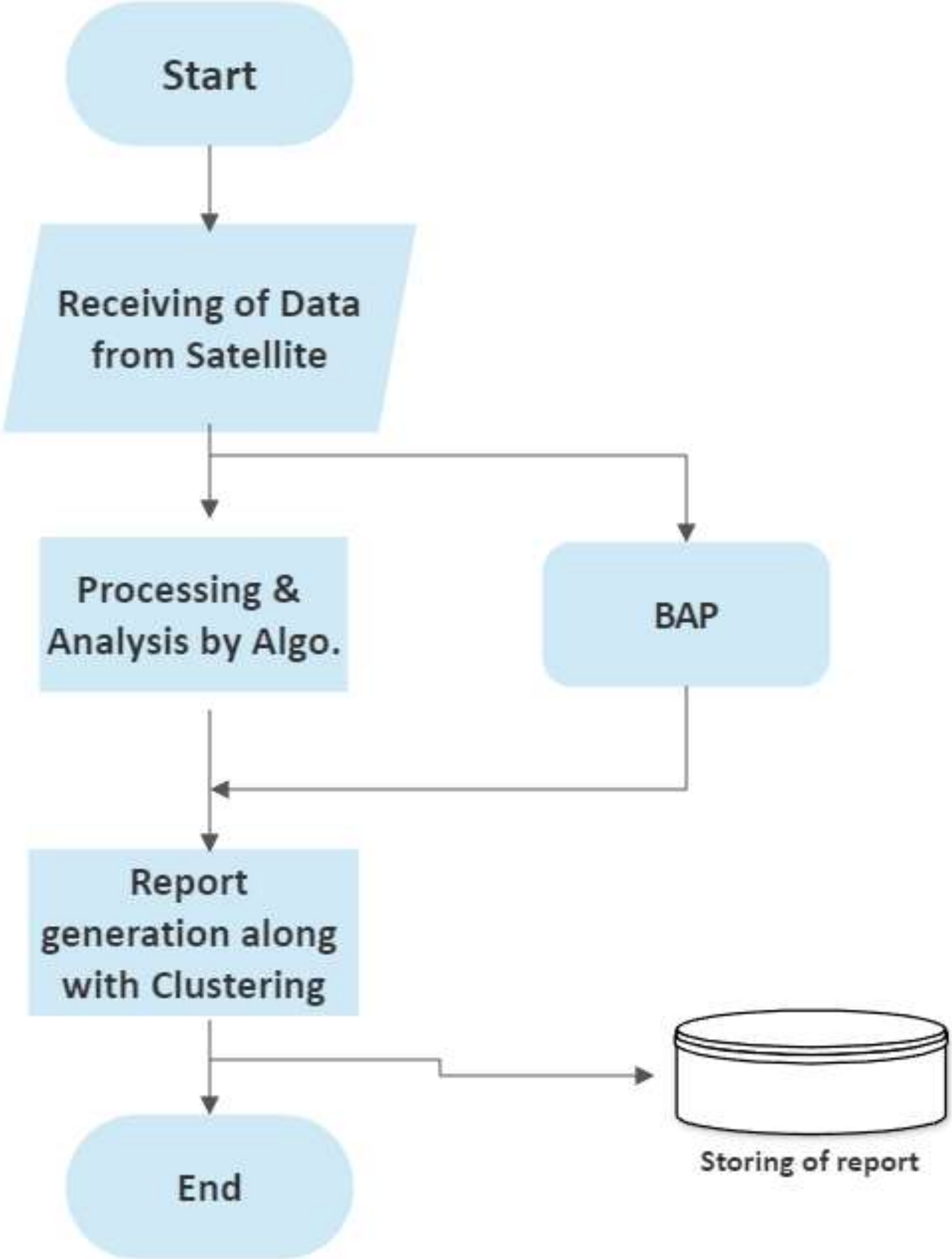

Fig 1: Flowchart

Firstly here we are using Earth Data API for getting the data from various satellites sensors and collect the data. We used the software development kit for the UI designing and the various functionality is also added. The data is then visualized in the map for various sections. The User can use various properties to search the required data. Various granularity is added to get the perfect data. The data can be sorted according to the date and time and also can also be used to see in a specific location or coordinates.

Forel-Ule

The Forel-Ule scale is a tool for determining how coloured a body of water is. In limnology and oceanography, the scale is used to measure a body of water's transparency and categorise its biological activity, dissolved chemicals, and suspended sediments. It gives a visual estimation of the colour of the water.

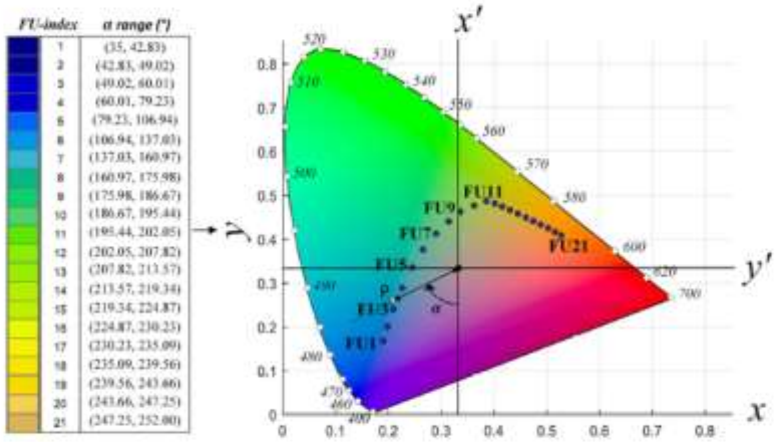

Fig 2: FUI [1]

Either a series of liquid vials[1] or a set of colour illumination filters in a white frame can be used to produce the colour scale, which has 21 different colours.

A collection of liquid vials in various colours is used in the traditional Forel-Ule Scale. Together, the liquid vials show a standardised colour palette that was made by mixing coloured water in various quantities of stable inorganic salts in a collection of tiny clear glass tubes. A standard colour scale is created in a set of numbered vials by combining various chemicals (distilled water, ammonia, copper sulphate, potassium chromate, and cobalt sulphate, among others) (1-21).

Clustering

The objective of clustering is to divide the population or set of data points into a number of groups so that the data points within each group are more similar to one another and different from the data points within the other groups. It is essentially a grouping of items based on how similar and unlike they are to one another.

We have used Opencv to mark the locations in these satellite pictures that we have obtained from the NASA official website Earth Data Ocean Colour. In essence, it draws the borders around the regions with various colour ranges. According to the Forel-Ule Index, the colour ranges are established. Following the creation of the contours, we use the polygon to mark the areas in the image where the contours will be drawn. The exact colour areas were designated with a green background, while the average colour areas were marked with various coloured borders.

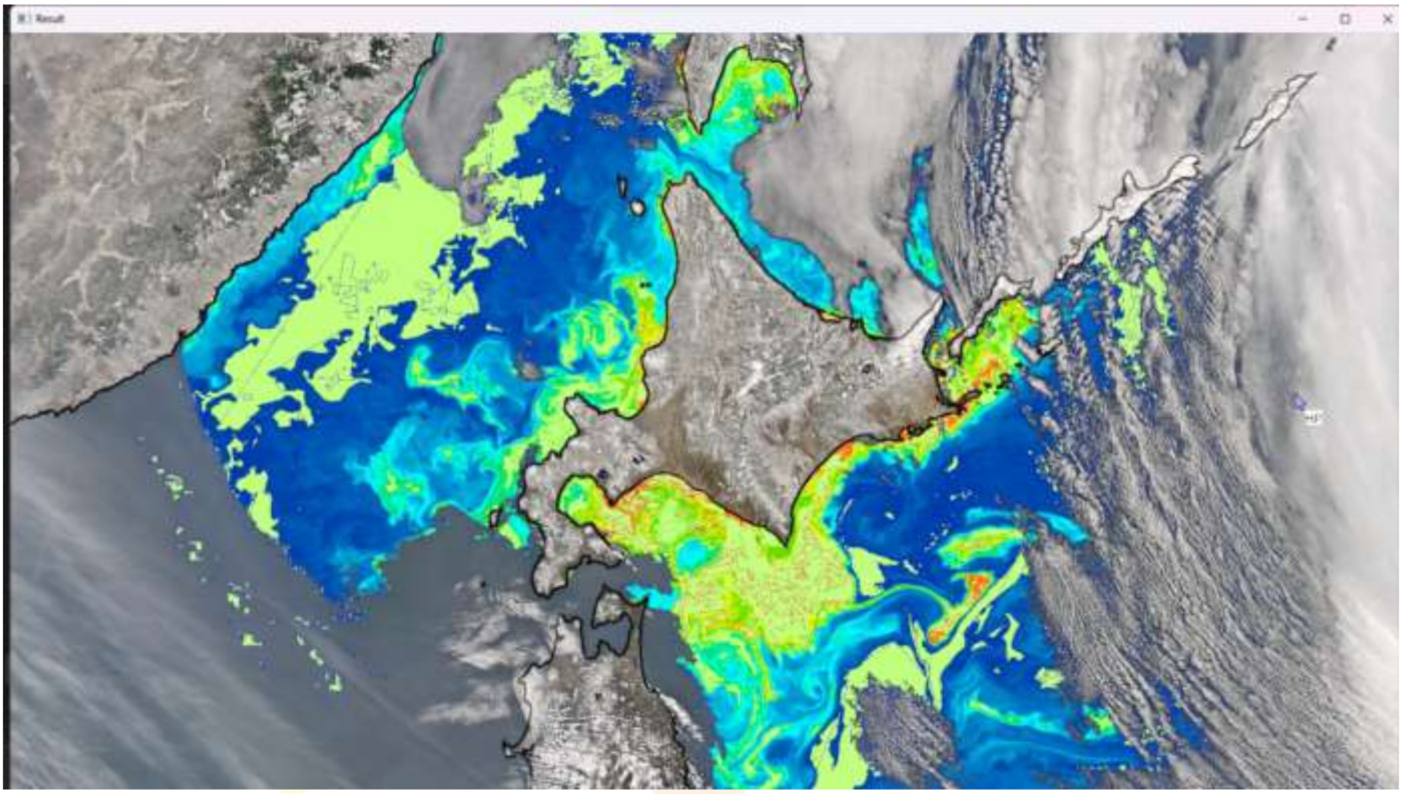

Fig 3: Marked Areas

Results

Here we have segregated the result obtained into 3 different categories. These categories represent different types of water quality in different locations. One of them shows all the defective areas and mark them with green colour and to indicate the average areas of that it marks with Red colored border. The second one shows the areas with good water quality and marks with green color and the average is marked with Blue colored border. And the last one shows both these areas marked in green colored separated the areas with Blue color border for good areas and red color border for defective areas

The defective areas are the main concern here, as we can see in the Fig. 4 the areas which are found defective are marked in green color areas. These are the exact markings of the areas. And the average of the areas is denoted with Red colored borders.

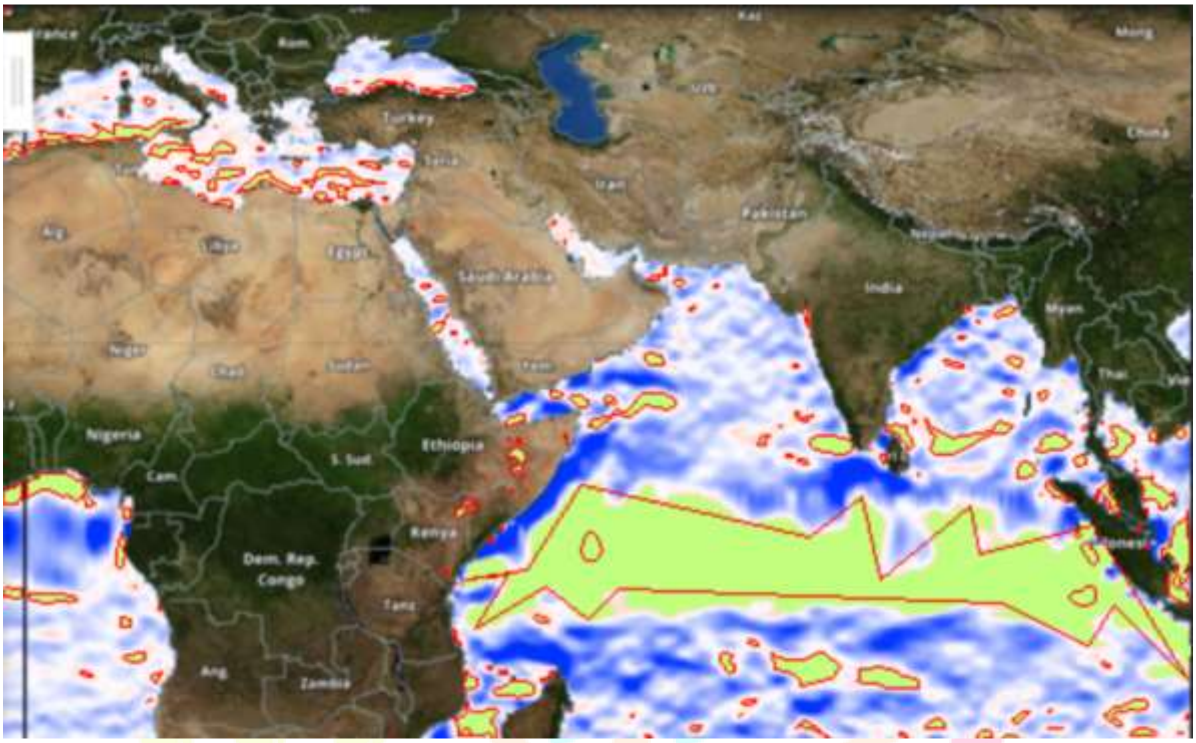

Fig 4: Defective Areas marked

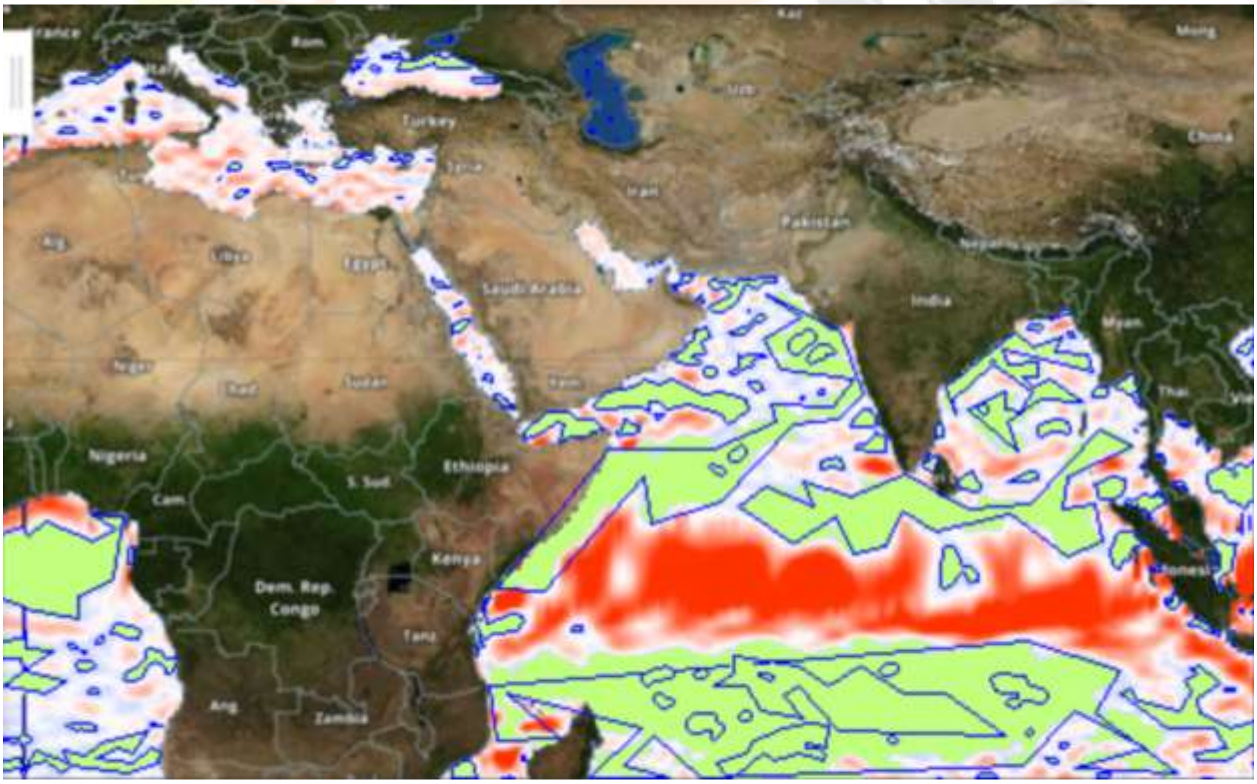

Fig. 5: Areas in good condition

Now for the areas which are in good condition, as we can see in the Fig. 5 the areas which are found are marked in green color areas. These are the exact markings of the areas. And the average of the areas is denoted with Blue colored borders.

Now we can see in the Fig. 6 all the areas which are found defective as well as in good condition are marked in green color areas. These are the exact markings of the areas. And the average of the areas is denoted with Red colored borders for Defective areas and with Blue colored borders for areas in good condition.

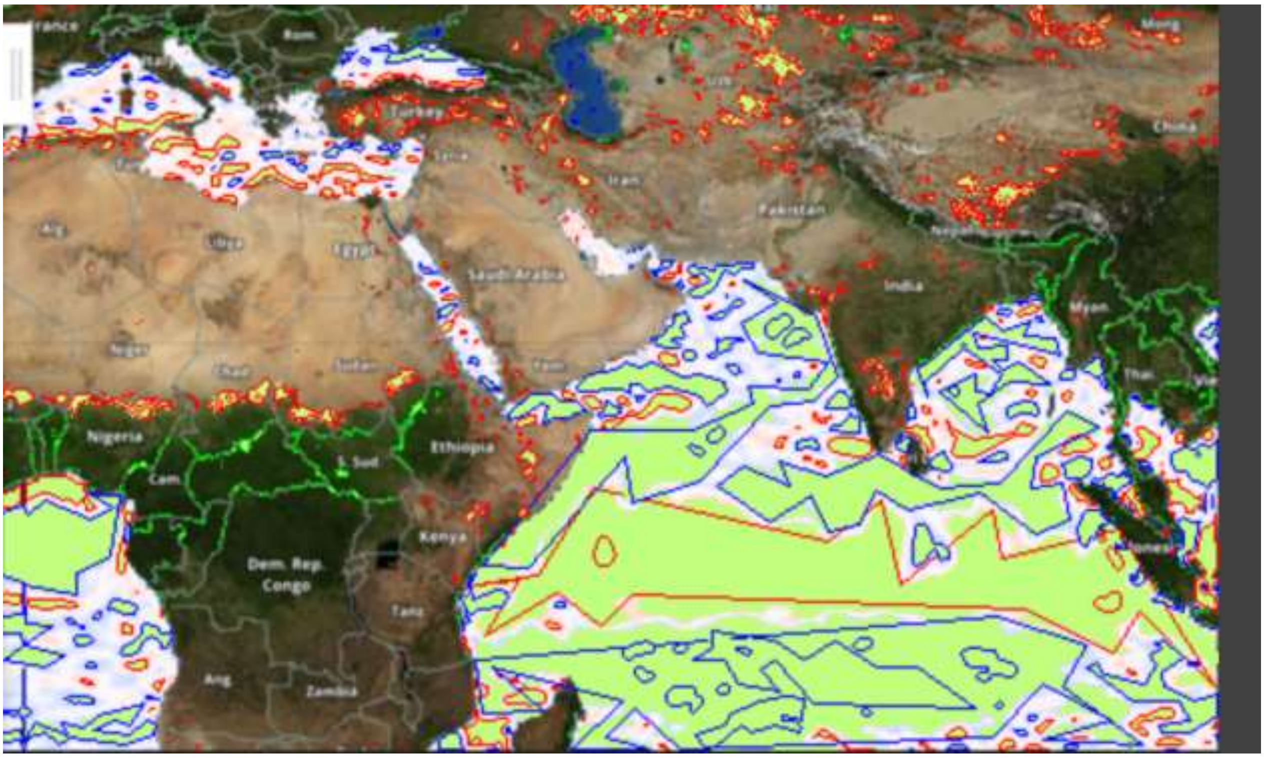

Fig. 6: All the Areas detected

This can also be used for live images which can be taken from any smartphone or the google images which are available online and test the water quality of them. This is not that accurate as of now but in the future we will improve this to be more accurate. Here we have showcased some of the applications of this technique. The below figures show the water images which are marked with according to their quality.

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