REMOTE SENSING AND MEASUREMENT OF WATER POLLUTION

[1] Dr. Osama Asanousi Lamma

[1]Department of Soil & water Faculty of Agricultural, Bani Waleed University, Libya.

Corresponding Author E-mail: osamalamma@bwu.edu.ly

Abstract : The devices used for remote-sensing of pollution are primarily working on the basis of imaging using a part of the electromagnetic radiation spectrum, which performs as a valuable tool for sensing and awareness of water pollution, to protect water resources. There is multilevel spectral reconnaissance, which provides information from various parts of the spectrum, interpreting the existing land and water conditions. They are specifically useful due to their interpretation of ways to identify the necessary features by the "tone signature." It provides a unique tone set, produced in multiple bands of images. These bands can involve radar and thermal infrared, giving very usual and useful photographic reach. Other remote sensing application of water pollution includes input electromagnetic waves, microwaves, gamma-ray spectrometry, airborne magnetism, fluorescent processes, and chemical vapor detection.

These methods supplement, but they do not replace the standard field systems. Monitoring and assessment of the environment involve a large study spectrum, that overlaps several disciplines, and all of them are independently operated. This review paper exemplifies the environmental constraints related to water pollution, numerous effects created due to atmospheric contamination, natural disasters, and strip mining. The Remote sensing devices can bestow complementary data and information to the existing ground-devised systems of environmental monitoring. Hence, remote sensing devices can be utilized to meet all the timely information requirements that can provide cross-boundary synoptic information with data. The Earth Observation Satellites (EOS) method for obtaining information can be utilized within the system of geographic information for comparison and overlay with various Geo-referenced information.

IndexTerms - Water pollution, measurement,Remote Sensing, atmospheric pollution, temperature detection, variation, natural hazards, strip mining.

I. INTRODUCTION

Environmental Assessment and Monitoring using Remote Sensing Approach

Human population growth and expansion have reached the epic proportion and brought several dimensions of environmental change throughout the globe. The driving forces have drastically affected the Earth's processes and systems. Considering the fundamental perspective point of view, the human-relevant historical actions have accompanied the civilization and technology development, and that has now been reached an impressive level due to the continually expanding human population (Leonard Hom, 2006).

Figure.1 : Remote sensing technology (Sidrah, Hafeez, et al., 2018).

The remote sensing technology allows the evaluation of chemical, physical, and biological conditions of the environment beyond the view, imagination and it is capable presently. Specifically, the data procured from high-tech electronic sensors mounted on the spacecraft can permit coverage of large areas to be viewed instantly, at any time, and repetitively, and they all depend on the overflight spacecraft frequency.

Our concern is to identify the water pollution level by the remote sensing method, using the electromagnetic spectrum method to cover a large wavelength range and identify the photon energies. Light used to observe an object should possess the same size wavelength or lesser size of the object. The system generates the ultraviolet light in the soft x-ray regions, that span the suitable wavelengths study atoms and molecules (Martinez, et al., 2007).

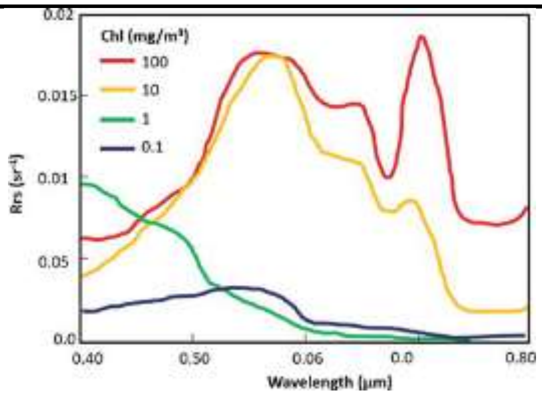

Figure.2 : Water spectral response having different chlorophyll levels of concentration (Sidrah, Hafeez, et al., 2018).

The oceans perform like carbon dioxide, natural sink along with several different greenhouse gases. Anthropogenic activities have already polluted the marine environment severely in the last 10 years. The pollution sources include toxic industrial chemicals, oil, plastics, industrial and domestic sewage, radioactive waste and they have found in the river, sea, and ocean waters in a large quantity. The sewage discharge in the river waters along with excessive nutrients going into marine waters coming from pesticides and agricultural fertilizers and generated an adverse impact on marine ecosystems, affecting mangroves, coral reefs, and aquaculture. It is essential to map and record the flow of pollutants into ocean waters and monitor the sustainable marine water condition and ecosystem (Sidrah, Hafeez, et al., 2018).

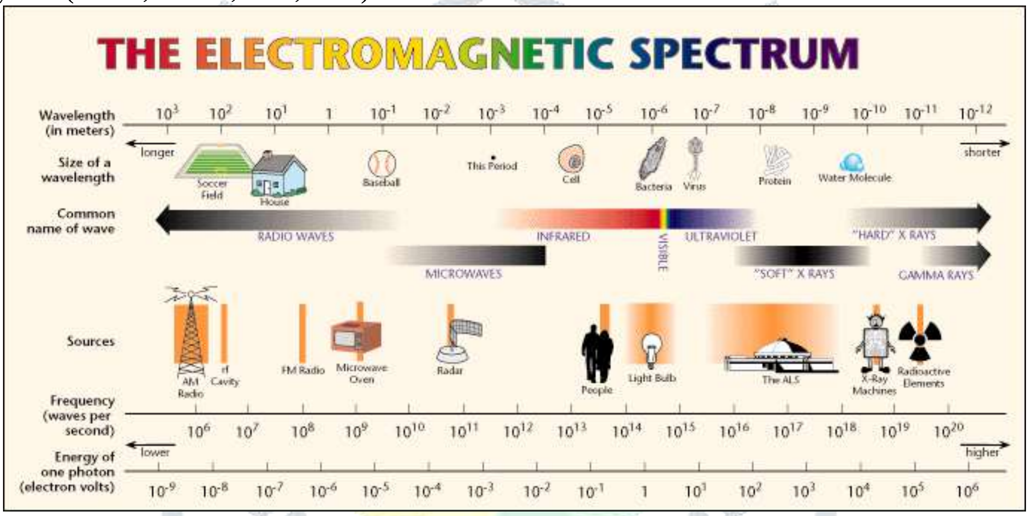

Figure.3 : The remote detection using electromagnetic radiation spectrum (Berkeley Lab, 2020).

Different water quality Spectra

Various water quality spectra can be compared by typically selecting the water pixels obtained from five different lakes, and by applying ROI- regions of interesting tools, and collecting a different water quality average spectrum from five lakes for further calculations and illustration, as shown in the below figure. The value of reflectance of band 2, band 1, and band 3 keep changing dramatically as per various water quality, which also indicates and relate to the pollutants in waters of different lakes (Maillard, & Santos, 2008).

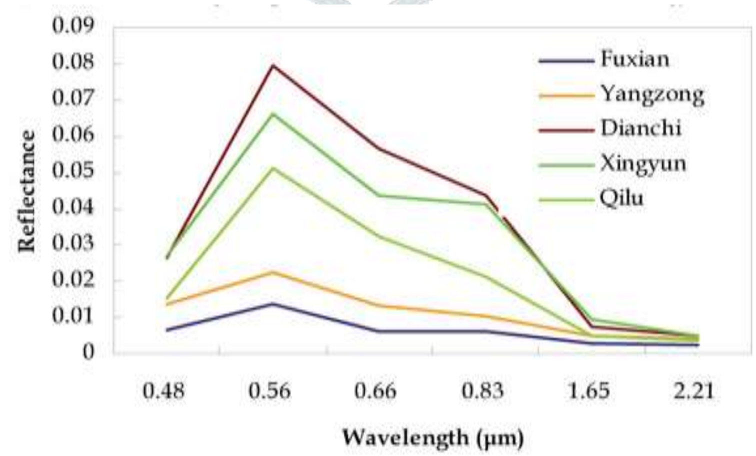

Figure.4 : The water quality spectra from different five lakes (Maillard, & Santos, 2008).

By using the remote sensing imagery, we can obtain the potential link for remote sensing ability and functioning to evaluate and determine the onset timing variability and the duration of the Eutrophic condition (Kuhn et al. 2017).

Total phosphorus measure, remote, in-situ

Nitrogen and phosphorus in the nitrates, phosphates, and nitrate form are the prime cause to generate water pollution and that affects our drinking water quality, as they impact wildlife conservation, tourism, water sports, angling, and also human health.

Rivers and waterways, water pollution boards of management need a real-time monitoring method along with an intervention system using in-situ remote, monitoring schemes. Even though many remotely operated systems to monitor water pollution are available to identify the levels of nitrogen and Ortho-phosphates in water, the measure of phosphorus is not possible remotely, and it is the major pollutant to drive Eutrophication, an algal bloom in lakes, waterways, and river waters (Berkeley Lab, 2020).

High Q of Oxford university has developed a unique nutrient sensor in chemical sensing by using OMCA- Optical technology of Microcavity Analyser, that permits to measure of entire phosphorus in water, together with Orthophosphate, nitrites, and nitrates, to ensure that they are well within the legal prerequisites. These remotely deployed optical Microcavities assessments exist powered by the battery and solar power is capable of measuring the extremely tiny size of Microfluidics using small and compact sensors, with less cost (HighQ of Oxford university, 2020).

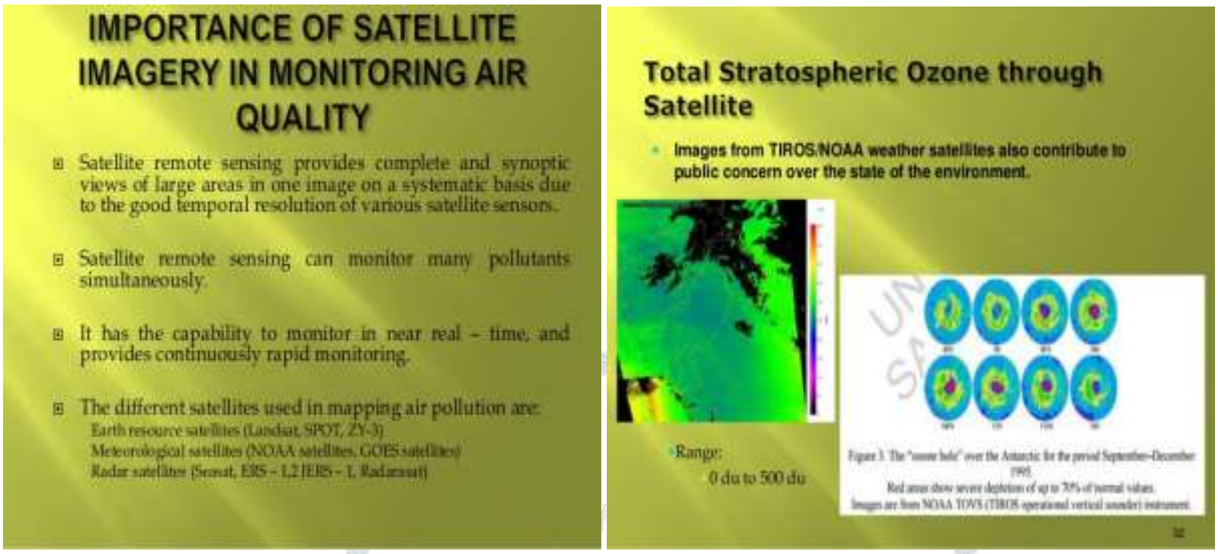

Figure.5 : Monitoring air quality through Satellite (Shivangi Somvanshi, 2016).

The measurement after detecting the gas concentration in the water using the optical absorption characteristic of the gas species is crucial to understand and monitor several phenomena, starting from industrial activities to environmental influences. There are many gas detection in water techniques, that includes spectrophotometry, non-dispersed infrared, Photoacoustic spectroscopy, tunable laser diode spectroscopy, and so on. Every testing technique has a diverse method and performance limitation. The technology uses light sources and gas cells to support this field and draw conclusions.

There are several intriguing optical Microcavity detections in the chemical sensing realm, with many sensing modalities possible, for instance, optical tracking, nanoparticle trapping, optical absorption and measurement, and sensing refractive index. They detect extremely small volume mode within any optical microcavity, permitting extremely small molecules to be detected, to the level of around 10^5 to 10^2 molecules (Claire Vallance, *et al.*, 2016).

Purpose

Environmental monitoring is explained as the scientific and systematic monitoring methods to obtain samples of biota, soil, air, and water, in order to study and observe the condition of the environment, the level of pollution and to identify the pollutants, and to derive complete knowledge of this procedure.

Recently, scientists and researchers have shown interest to detect volatile and gaseous substances like VSC- sulfur compounds in the environment and in our breath. They were provided the biological relevance of potential pathological conditions. Specifically, by using laser-derived spectroscopic sensors they could conduct precise breath diagnostics when tested in clinical settings. The VSC status of volatile sulfur compounds was sensed by laser spectroscopy absorption in the pathological conditions, like Carbonyl sulfide, Hydrogen sulfide, Dimethyl sulfide, Carbon Disulfide, and Methanethiol (Natalia Drabińska, *et al* (2021).

Figure. 6 : Air quality monitoring programs (Shivangi Somvanshi, 2016).

Aim

To apply remote sensing methods and systems to identify and measurement of water pollution.

Objectives

1. To gain information regarding the harmful or potentially harmful pollutants discharged in the water bodies and the environment;
2. Living creatures likely to be affected by such pollutants;
3. Monitoring to assess pollutant effects of human being and the environment;
4. The water, climate change due to pollutants;
5. Pollutant interactions and patterns;
6. Legislative control, and compliance with emission standards (Shivangi Somvanshi, 2016).

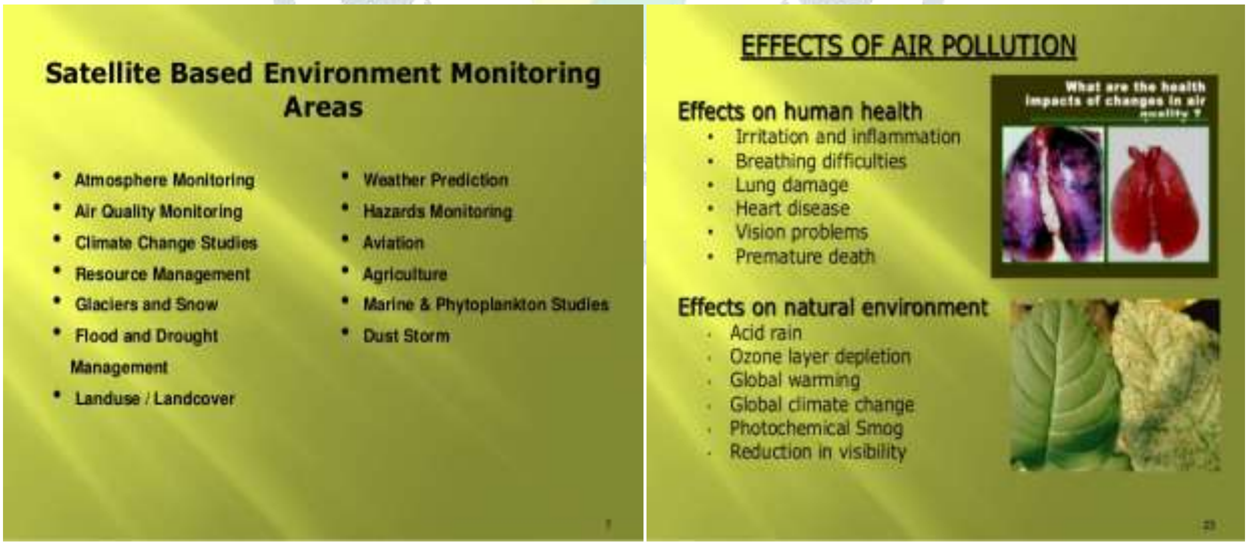

Figure.7 : Environmental monitoring areas, and air pollution effects (Shivangi Somvanshi, 2016).

Environmental Conditions

Environmental cycles are responsible for the overall blending, transportation, physical ,and chemical compound changes in the atmosphere to poison. The breeze speed and bearing select how rapidly the toxins will be scattered in the air and what will be the course of effect. The upward temperature profile of the environment chooses the upward blending and disturbance in the atmosphere.

To assess contamination in the atmosphere, monitoring might be done to evaluate contamination consequences for man and his current circumstance to distinguish any conceivable circumstances and logical results connection between toxin concentration and impacts on human wellbeing, climatic changes, and so on. Monitoring of the climate might be necessary for various reasons. By and large, observing is done to acquire data about the current degrees of unsafe or possibly harmful toxins released in the atmosphere, to affect the climate, or in living animals that might be influenced by these contaminations (Hadjimitsis & Clayton, 2009).

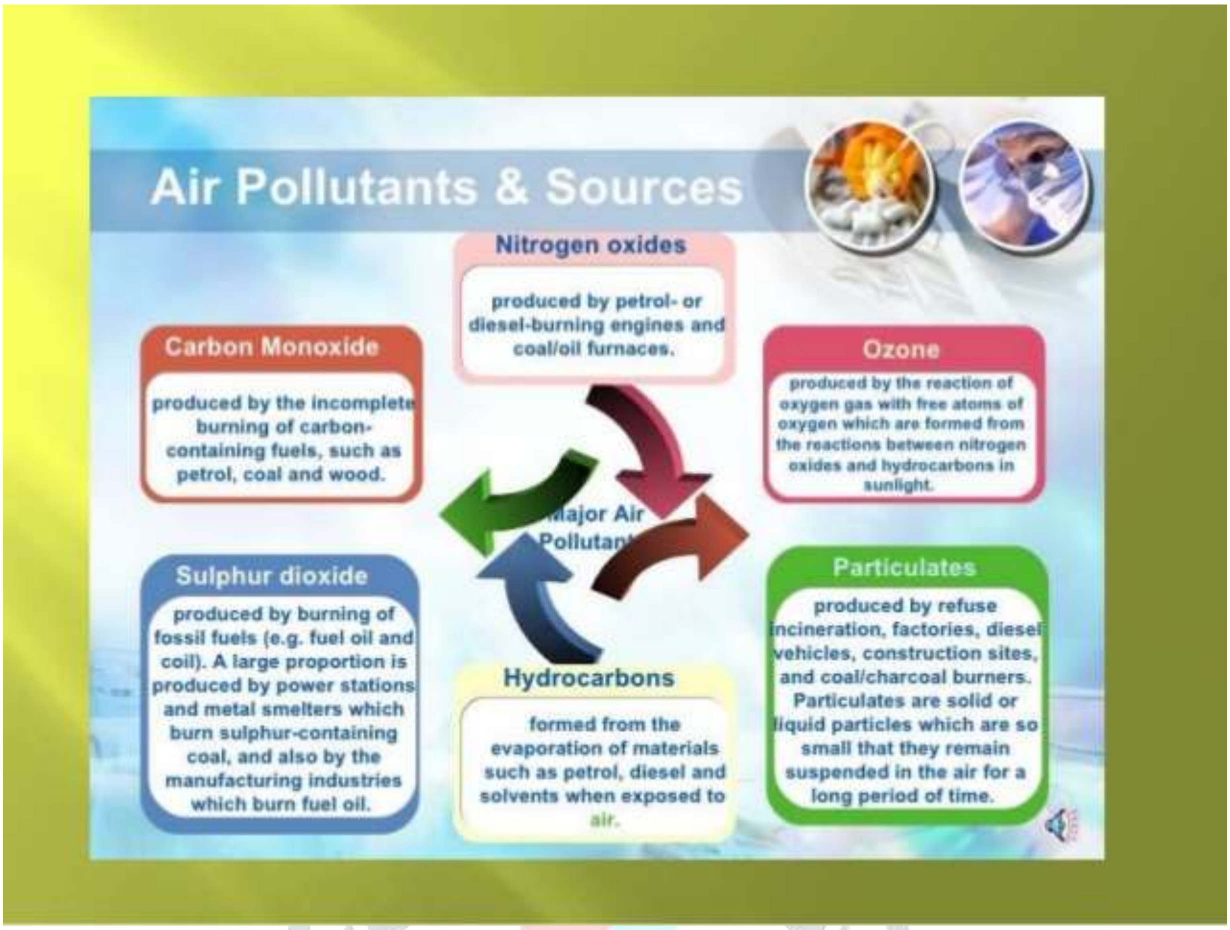

Figure.8 : Sources of Pollution (Shivangi Somvanshi, 2016).

Environment and Air Pollution monitoring

The ambient environment and air pollution monitoring include the entire environmental monitoring to be carried out for several reasons:

- The concentration mapping of the environmental pollutants;
- Identification and assessment of pollution sensitive areas and zones;
- Possible site identification for the environmental scrutinizing and monitoring stations;
- Finding the tracking progress, whether implemented as per the National Quality Standards to attain emission reductions;
- Serving the basic model to predict pollutant concentrations in the atmosphere and ambient air;
- Provide an accurate human health input for risk assessment studies;
- To identify the level of air pollution, knowing particulate matters, gases, chemicals, or biological materials in the air, water, soil that has potential to cause discomfort or harm to human beings and other living organisms, and also the damages that can be caused to the natural environment (Sidrah, et al., 2018).

A monitoring system to evaluate the water quality is done by the Remote Sensing method and is the procedure to ascertain the physical, chemical, and biological features of water bodies. It is also to identify the possible pollution source, if any, or water contamination, which can cause water quality degradation. The indicators are categorized as (i) Physical: turbidity temperature, clarity, salinity, color, dissolved solids, suspended solids, (ii) Biological: algae, bacteria, (iii) Chemical: dissolved oxygen, pH, nutrients, biological demand of oxygen, (inclusive of phosphorus and nitrogen), inorganic and organic compounds (inclusive of toxic materials), and (iv) water Aesthetic like color, taints, odors, and suspended floating matters. Several research studies have been stated several results on remote sensing's usefulness as effective tools to monitor water quality (D.O.E. 2007). The process of Remote Sensing is a scientific method, an art of collecting the data and information regarding the area, object, or a phenomenon by the data analysis acquired by a specific device operated remotely without any contact with the area, object, or phenomena to be investigated (Thomas et al., 2004). The monitoring is done with remote sensing to assess the water quality and it was initiated in early 1970 by Ritchie et al., (1976), who developed the preliminary empirical approach to determine water suspended matter and sediments using the general equation:

$Y=ABX$ or $Y=A+BX$

While, Y is the measure of remote sensing, which uses reflectance, radiance, energy, and X= the parameter of water quality, like turbidity and suspended sediment. Empirically derived, A and B are the value factors gained through statistical connection, which determines the value of spectral reflectance between the water quality parameters in situ. The spectral reflectance gives enough information regarding the wavelength and band suitable for parameters of water quality.

This empirical equation can be used to find the parameters of water quality in areas under investigation (Liza, et al. 2007).

Adequate knowledge regarding the quantity of phytoplankton gives a vital implication, proposing the carbon cycle model for the primary production to monitor the water body condition. There is an uncertainty gap concerning the chlorophyll amount that occurred at the time of cyanobacterial blooms. A large scale quantitative mapping, the detection was gained after using remote airborne sensing technique (Hadjimitsis & Clayton, 2009).

Water Quality Remote Sensing and Monitoring Advantage

The remote sensing observation has an advantage over traditional monitoring of water quality measurements because it provides temporal and spatial information regarding the surface water features elaborating their entire characteristics. The prevailing advanced technology of satellite sensors provides extensive water quality information regarding suspended sediment, chlorophyll-a, turbidity, yellow substances, wave height, color index, Secchi disk depth. Hence, the water surface temperature can be found on a regular basis (Ferdi, et al., 2007). Besides that, remote Sensing technology is largely applied to find the water quality in inland lakes and in coastal regions (Koponen et al., 2002). The remotely operated and sensed data develop the potential to give the entire knowledge of a large scale alteration, with a link between near-shore and offshore waters, along with the facility to get a near-daily and long-term view of the area of interest for interannual and seasonal variability (Louheng, & Karen,2005).

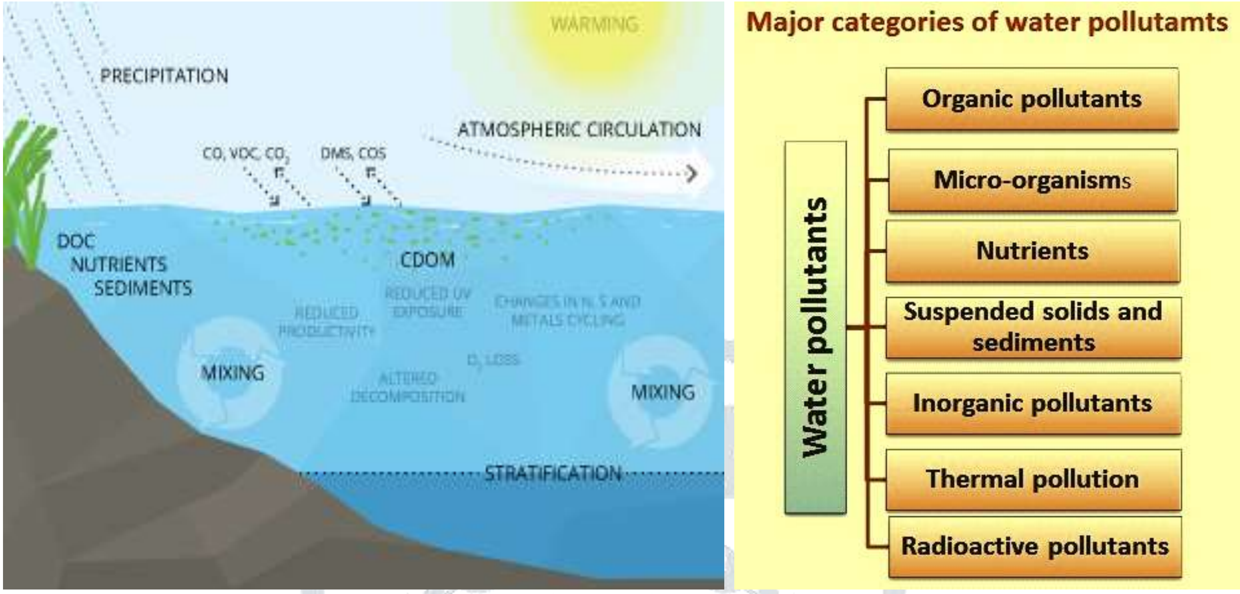

Figure: Water Pollutants and they are composed of Organic Pollutants, Inorganic Pollutants, Point Source, Nutrients, Suspended Solid, Radioactive Pollutants, Thermal Pollution, Water Pollution, Water Pollutiants (Satyendra, 2019).

The water suspended Matters comprise inorganic and organic substances, and they play a major role to assess the water quality and its management. This relates to the entire primary production of micro-pollutants, heavy metal fluxes. The suspended matters form the major pollutants found on the water surface. The suspended sediments amplify the surface water radiance in the near-infrared and visible range of its electromagnetic spectrum (Maillard, et al., 2008). Laboratory tests and in situ measurement have indicated that the radiance of surface water is influenced by sediments' sun angles, color, texture, type, sensor views, and water depth (Louheng & Karen, 2005). The techniques of remote sensing can estimate the mapping of the suspended matter concentration in an inland water body, which provides temporal and spatial information. Using various satellite platforms, remote sensing activities can be applied using CZCS- Coastal Zone Color Scanner, IRS, SPOT, Landsat, and SeaWiFS- Wide Field Sea-viewing with View Sensor. The suspended matters, reflectance, and radiance from a single band or collective method of certain satellite bands or airborne platforms are also applied. The surveys have found that the wavelength of about 750 nm was a highly effective and useful range to determine surface water suspended matter. The radiance absorption by suspended sediment is normally small like chlorophyll, but its scattering is very high. In the case of optical wavelength, the terrestrial remote sensing is large as compared with the water body remote sensing, which is of a narrow range. Hence, Therefore, the specific range of 650 nm is utilized to estimate the parameters of water quality. Many investigators have observed TM4 (Landsat images) contain a better connection with TSM, to properly estimate the suspended matter (Dekker et al., 2002).

Conclusion

Chronological data mismatch: Harmonizing water quality, timing, and sampling of inland waters using remote sensing process are cumbersome due to frequent changes in the quality of water, which are extremely variable over time, and space. They often vary with the rivers change, tides, the streamflow, changes in lakes with wind events, and precipitation. Spatial data mismatch of inland waters is very small to be noticed using the technology of remote sensing. It needs a strong national program by calibrating the data of remote sensing with the ground-level facts regarding the data, which includes standardized terms and methods. There has to be a link between the water quality and remote sensing that requires formulating between water quality laboratory methods, which rely on absorbing tendency, in situ sensors depending on fluorescence, and remote sensing techniques derived reflectance (Crawford, et al., 2016). The floating and water mixed particles also have an effect on the needs of light attenuation, which should be accounted for in this field with deployable sensors to measure water quality optical properties. A standard atmospheric correction method can be applied to apply for satellites. By deriving the data of remote sensing for data on water quality for inland waters, surrogate models can be developed to relate water quality optically active components with interest, as several vital water quality attributes are not detectable simply by remote sensings, like a metal contaminant in water. Proper communication and link between the remote sensing and water quality communities can be used to identify potentially hazardous and anomalous water quality matters to improve the routine water quality monitoring and spatial coverage (Foster, et al., 2017).

Discussion

Water remote sensing provides several purposes and water supply sources for industrial and domestic purposes, livestock, irrigated agriculture, and mining activities. However, due to excessive anthropogenic activity and related industrial development, the water quality has reduced dramatically. Hence, remote sensing use of the monitoring programs and GIS are required to find the water contaminants, water quality parameter monitoring, in reservoirs, lakes, groundwater, and rivers (Verma, et al., 2008). It has been proved that the remote sensing techniques and GIS are more cheaper and effective and provides valuable tools in freshwater bodies and coastal levels compared to in situ, when measuring facilities are restricted to chosen sampling areas. Also, the parameter of water quality can be assessed by using an algorithm map or various satellite platforms. Each parameter of water quality like turbidity suspended matter, dissolved organic matter, phytoplankton concentration, has its own reflectance estimation in the range of 650 µm. Hence, in the future the water quality assessment and solution to various issues can be sorted out quickly by applying these sustainable water resource technologies (Liza, 2007).

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