IMPACT OF GIS IN WATER QUALITY MONITORING AND ASSESSMENT

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ABSTRACT

It is often known how important water quality is, and its significance increases when it is used for drinking. It has long been known that remote sensing and GIS are useful tools for managing and monitoring water resources. However, this research focuses on the use of GIS and remote sensing to monitor water quality parameters as turbidity, suspended matter, phytoplankton, and dissolved organic matter. Actually, this technology's capabilities provide excellent tools for operationalizing water quality monitoring and management in this nation. The idea of sustainable water resource management is promoted by identifying potential applications and management strategies. The application of several Geographic Information System (GIS) techniques to the evaluation of water quality is highlighted in this review study. Through the use of several models, including WQI models, export coefficient models, GIS-based spatial regression models, and GPZM groundwater pollution zone models, satellite images are utilized to trace the organic contamination in surface water. GIS-based pollution mapping techniques aid in determining the extent of pollution, and the source of pollution is highlighted by the overlaying of several thematic layers. We will talk about it in this paper. GIS's influence on water quality monitoring and evaluation.

Keywords: *Water Quality Monitoring; Assessment; Geographic Information System; Water Resources; Remote Sensing; Decision-Making; Flood Warning; Flood Reduction; Water Pollution*

INTRODUCTION

One of the most important needs for daily existence is water, which includes a large portion of the hydrosphere on Earth. There will be a catastrophe soon as a result of scientific studies on the deficiency of water resources, the rise in air pollution in water sources in a large portion of the world, and the expansion of human harmful activities that impact water resources. Water quality maintenance affects ecosystems, human health, and economic activity, making it crucial for environmental health. Even though they are accurate, traditional water quality monitoring techniques frequently give little spatial coverage and demand a large amount of work and effort. However, a revolutionary method of managing water quality on a wide scale has been proposed through the merging of remote sensing and Geographic Information Systems (GIS). [1]

Water is a precious natural resource that is necessary for both human survival and the well-being of ecosystems. Numerous uses for water are possible, including irrigated agriculture, mining operations, livestock, and home and industrial water supplies. However, the quality of the water has drastically declined due to the increase in anthropogenic activities and industrial development. River water quality can deteriorate due to home sewage, industrial effluents, and agricultural waste. Water's characteristics can be divided into three groups: chemical, biological, and physical. Water quality is currently assessed using in situ monitoring and water sample collection for further laboratory analysis. Although these measures are precise for a specific moment in time and location, they do not provide a temporal or geographical assessment of the quality of the water across a large area. As a result, remote sensing (RS) and geographic information system (GIS) monitoring programs are required to identify any contamination hazards and take appropriate action at all levels.

When it comes to monitoring water quality parameters in fresh water bodies (lakes, rivers, ground water, and reservoirs) and coastal levels, remote sensing and GIS techniques are more efficient, less expensive, and more valuable than in situ methods, which limit measurement to specific sampling locations. A technologically suitable approach for researching different aspects of water resources is provided by the synoptic view offered by satellite remote sensing and the analysis power offered by GIS. Because satellite remote sensing can cover a large region repeatedly at a very low cost, it is an obvious source of data for mapping and map updating. The next sections provide a brief overview of RS and GIS before moving on to applications of these two approaches in water quality research. [2]

GIS TECHNIQUES

GIS is a computer-based tool for managing digital geographic data. It is intended to collect, store, process, and analyze data that is dispersed geographically. It includes attribute data, which describes the characteristics of geometrical objects, as well as geometry data, which includes coordinates and topographical information. With a focus on maintaining and leveraging the intrinsic qualities of spatial data, GIS allows us to show results in both graphic and report format.

GIS provides instant insights into changes in water quality through real-time data processing and analysis. In order to facilitate decision-making and develop plans for future sustainability, stakeholders now possess a thorough, nuanced understanding of pollution levels, water flow patterns, and potential contamination sources. Additionally, data collecting can be customized to use AI and IoT devices, create unique reports, or modify queries with a high degree of integration and customization. Because of its adaptability, GIS may be used by any user to target their own particular needs and direct proactive intervention.

Application of GIS in water resource monitoring

The following data can be obtained using GIS in a variety of application fields:

- Flood mapping and monitoring.
- Hydrological modeling
- Rain water harvesting.

- Management of irrigation water system.
- Ground water exploration.
- Monitoring of drought.
- Monitoring water pollution activities.

Integration with Geographic Information Systems (GIS)

By offering tools for mapping and spatial analysis, GIS improves remote sensing. It makes it possible to combine data from remote sensing with other datasets, such as historical records and measurements made on the ground. The development of comprehensive maps and models that identify problem regions, monitor changes over time, and forecast future trends in water quality is made easier by this integration. For example, estimating metrics such as Secchi disk depth, a stand-in for water transparency, requires the development of techniques to use Landsat satellite imagery to evaluate lake clarity. These applications show how satellite imagery and GIS may be used to monitor water quality over wide areas and provide information for water resource management plans. [3]

REVIEW OF LITERATURE

Water diversion from one reservoir to another has been hailed as a magnificent strategy since the 20th century for bettering freshwater resource planning and management as well as timely water reallocation. According to Moreno-Ostos et al. (2007), this emphasizes the significance of reservoirs that are built to store water through impoundment and release the impounded water at various volumes, demands, and times in order to meet one or more water quantity objectives (hydroelectric power generation, domestic water supply, agricultural demands, and industrial). The impact on water quality of the quantity-based goal of the water diversion system is only regarded as a secondary concern, or in certain cases, not addressed at all, because the dynamics of water diversion between reservoirs have up until now been centered on factors driven by economical prospects regarding its volume. [4]

Estimating the water quality in the study region and representing the water quality status thematically are the main goals of the current investigation. The difficulty to quickly grasp the current situation has been greatly aided by geo-informatics technology. Water is used extensively in the home, business, and agricultural sectors. It is crucial to analyze the water quality in a given location, which necessitates monitoring and evaluation in order to develop preventive measures against health risks. A location's physicochemical factors determine how the water quality varies there (Manual on Water Supply and Treatment, 1999). The Water Quality Index (WQI) is a single figure that represents the quality of the water at a certain place. Numerous water quality metrics that convey data on the general quality state of water from various sources are used to construct WQI (Kannel et al., 2007). [5]

The Export coefficient model (N.M. Mattikalli, 1996) defines suitable export coefficients for nitrogen and phosphorus in order to assess the nutrient loss from a watershed to surface water for all potential sources of these nutrients. To estimate solute losses, it makes use of data on the export coefficients and the area extents of different land use categories. It adds up the outputs from all possible sources to get the areal external nutrient load on a body of water. The model determines the solute load delivered at the watershed's outlet. Remote sensing was used to collect the data, and the GIS was used to carry out the export coefficient model calculations. A static index known as the Groundwater Pollution Zone Model has been established by the integration of several pollution risk-related variables in various thematic layers inside a GIS. [6]

Given the spatial and temporal variability of water parameters, a representative and trustworthy evaluation of water quality is essential as part of the water monitoring project. (2003) Simeonov et al. The comprehensive pollution index method, water quality grading method, and single-factor evaluation method are the traditional techniques for evaluating the quality of water bodies. These techniques actively contribute to the water quality assessment process. When there are several impairments, the single-factor assessment method is unable to adequately characterize the total water quality. It is challenging to evaluate the overall water quality conditions between sites when extreme conditions occur since the water quality grading technique ignores the influence of extreme contributing elements (maximum and minimum pollutant parameter values). [7]

Objectives

- The assessment can help implement water quality monitoring
- Assess the effectiveness of remote sensing and GIS
- Develop integrated monitoring frameworks

RESEARCH METHODOLOGY

In this study, the combined capabilities and benefits of GIS are examined in relation to water quality monitoring. Making use of these technologies facilitates better decision-making, more effective and efficient monitoring, and enhanced water resource preservation. Recent technical developments are used in the study to show how well these techniques work in a range of environmental conditions. The study is based on secondary data collected from reliable sources, including newspapers, textbooks, journals, and the internet. The research design of the study is mostly descriptive.

RESULT AND DISCUSSION

GIS in Water Resource Monitoring

Growing technological trends, such as GIS, make it easier to improve the nation's geographic data. The computer-based science technologies known as remote sensing and geographical information systems (GIS) were created to gather pertinent data for digital monitoring, management, and evaluation. To identify the watershed area, satellite pictures or aerial photographs are used. Topography, soil composition and texture, temperature, rainfall patterns, and crop cultivation in close proximity to water resources are all studied by systems. GIS functions both nationally and regionally. It is a database management system that keeps an eye on environmental management and controls water quality. Turbidity, phytoplankton, suspended particles, and dissolved organic particles in water are all highlighted by GIS. Actually, the monitoring, management, and promotion of sustainable use of water resources are the main goals of GIS technology. The information used to create the water management policy is provided by this technology. [8]

- **Flood Warning Programs**

The primary responsibility for monitoring water resources is flood warning, which necessitates extremely detailed and precise analysis. The occurrence of floods resulted in the loss of numerous lives and properties. Drought should also be closely watched because it typically has adverse effects as well. GIS technology is used to forecast the drought monitoring or flood reduction strategies. In order to initially avoid such warnings, GIS determines the range of hazard events, including magnitudes, frequencies, depths, and velocities. GIS pre-analysis is trustworthy and can lessen these kinds of disasters.

Figure 1: Water resource measurements for future GIS application (Source: https://uizentrum.de/)

- **GIS in Surface Water and Ground Water**

The use of GIS allows for the complete determination of surface water risk management. GIS uses the data gathered from databases to regulate water contamination. More spatial hydrological data can be displayed by the software. The weather condition can be determined by carefully going over the image. Surface water data provides information about precipitation and can be used to forecast when rainfall will occur. It gives information about the state of the watershed's land. [9]

Ground Water Management:

Applications of Geographic Information Systems (GIS) are significantly influencing groundwater management in a number of ways, including the mapping and monitoring of India's groundwater resources, including well locations, water quality, and rates of aquifer recharge and depletion. Although groundwater is a vital resource for industrial, drinking, and agricultural water, it is frequently misused in some areas. By creating detailed maps of groundwater resources and considering aquifer boundaries, water levels, and quality data derived from remotely sensed imagery and field-installed sensors, IGiS can be used to monitor and examine water resources. The platform uses a variety of image-processing methods to make it easier to identify possible groundwater zones. It also makes it possible to determine how groundwater levels will react to variations in rainfall, pumping rates, and other variables. Therefore, including GIS technology into the groundwater management system improves decision-making, encourages conservation, and makes it easier to use this essential resource sustainably. [10]

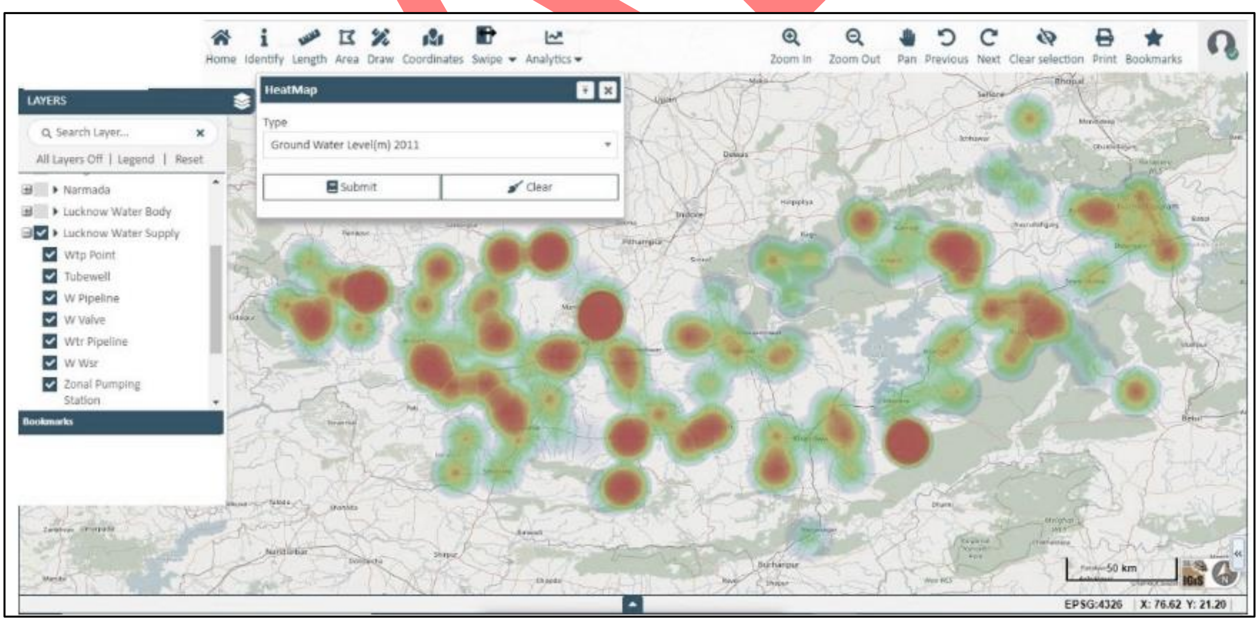

Figure 2: Ground Water Management (Source: www.sgligis.com)

When RS and GIS tools are used with other conventional techniques, they are seen as an effective way to use them for environmental planning and management. In practically every environmental subject, predictive models may be developed using RS and GIS. A predictive model is a tool for management and planning. A few instances of these models may be a map, a set of maps, a mathematical simulation model, or a mix of mathematical models and maps. [11, 12] One pertinent query would be: What are the benefits of incurring additional expenses, which are frequently significant, for obtaining RS imagery, image processing, GIS software, and GIS data processing? The increasing use of RS and GIS tools for real-world environmental issues like disease ecology, urban planning, watershed management, and many other environment-related fields is enough evidence that conventional methods can improve prediction accuracy to the point where the additional expense of using these tools may be easily justified. Information about a wide range of environmental factors, such as soil type, topography, vegetation cover type, density, slope, water/soil coverage, etc., can be obtained with the aid of RS and GIS technologies. A conceptual plan for an RS-based Water Quality Restoration and Planning Model (which integrates GIS/RS Tools with the Water Quality Model) is shown in Figure 3. [13]

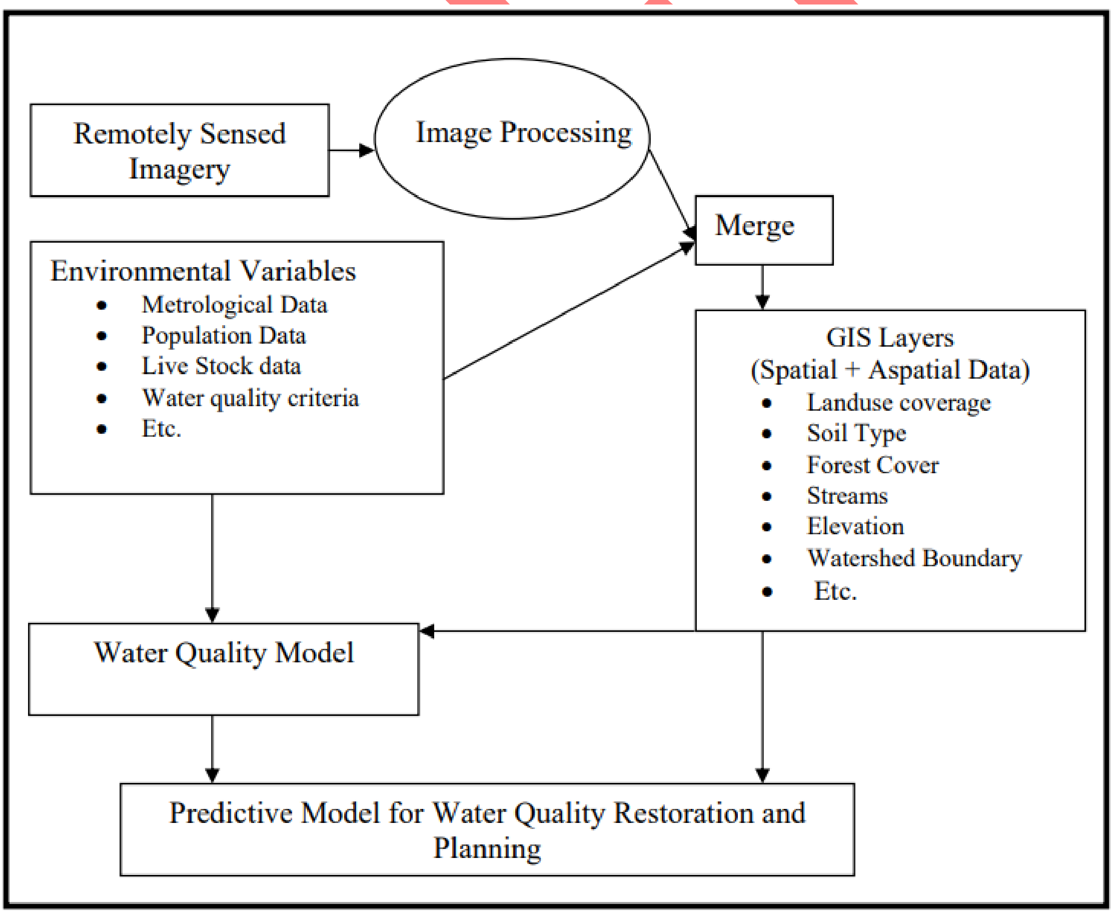

Figure 3: Conceptual scheme for a Generic Water Quality Restoration and Planning Model [14]

CONCLUSION

Water serves a number of purposes, including mining operations, irrigated farmland, livestock, and home and industrial water supplies. However, the quality of the water has drastically declined due to the increase in anthropogenic activities and industrial development. Therefore, in order to prevent pollution and to take effective action at all levels, monitoring programs that use remote sensing and GIS are required. When it comes to monitoring water quality parameters in freshwater bodies (lakes, rivers, ground water, and reservoirs) and coastal levels, remote sensing and GIS techniques are more efficient, less expensive, and more valuable than in situ methods, which limit measurement to specific sampling locations.

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