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Artificial Intelligence And Geospatial Technology For River Water Quality

Mrs. Pooja Deepak Pawar
Assistant Professor
Department of Civil Engineering
Bharati Vidyapeeth(Deemed to be University) College of Engineering Pune Maharashtra India

Dr. Vidula Sohoni
Principal
Bharati Vidyapeeth(Deemed to be University) College of Engineering Pune Maharashtra India

ABSTRACT

This review paper explores the current applications of Artificial Intelligence (AI) in conjunction with Remote Sensing (RS) and Geographic Information System (GIS) technology for river water management. It also discusses the potential future applications of AI in improving the accuracy of water quality predictions. While the literature on AI in the water domain is extensive, the ethical aspects of AI applications in water management receive limited attention. This paper emphasizes the need to consider ethical considerations alongside technological advancements. The integration of AI-GIS technology has shown promising results in predicting water quality parameters with greater accuracy.

Keywords:-AI, GIS, RS, DSS, GeoAI, predictive modelling, data integration, WQIs

ABBREVIATIONS

RS : Remote Sensing
GIS : Geographical Information System
AI : Artificial Intelligence
GIS : Geographic Information System
ANI : Artificial Narrow Intelligence
AGI : Artificial General Intelligence
ASI : Artificial Super Intelligence
IoT : Internet of Things
DSS : Decision Support System
ESRI : Environmental Systems Research Institute
GeoAI : Geospatial Artificial Intelligence
WQIs : Water Quality Index

Introduction

India is one of the major agricultural countries with nearly 52 per cent of the Population depending on it. Nearly three fourth of the cultivable land in India is dependent on monsoon, which is contributing approximately 42 per cent of the total production from agriculture. The productivity of any crop mainly depends on two natural resources like land and water in addition to management practices. Therefore, the conservation upgradation and utilization of these two natural resources on scientific principle is essential for sustainability of rain fed agriculture.

Water is the most important recourse in today's world. All the living organisms on this planet are dependent on water for their survival as like air and food. But not much attention is paid to it conservation. due to increasing population their basic need is also increasing. To fulfil their basic needs there a lot of increasing pressure on the natural resources. Human activities like deforestation, excessive use of fertilizers and pesticides and chemicals, extraction of ground water etc have become most common phenomena.

Water quality refers to its biological, chemical, physical characteristics. It is a measure of the condition of water to the biotic species requirements of or to any human need or purpose. It is used by reference to a set of standards where it can be assessed. The common standards to assess water quality relates to its ecosystems health, contact of human and drinking water.(1)

The water quality indices (WQIs) are used as tool to study the status of quality of water in rivers has been started since the 1960s. The WQI shows selected water quality parameters into a dimensionless number, as the changes in water quality of river for a specific time and period could be studied and shown in very easy manner. Many water quality parameters are developed but all methods are not accepted worldwide. Thus, there is a growing interest in developing perfect WQIs that is appropriate for a local or regional area.(2)

Assessment of surface water quality is a process which is complex as taking multiple parameters suitable of various stress causing on overall water quality. Very efficient and useful method for analysing the water quality id water quality index Water Quality Index is also a very useful technique for circulating the information on complete quality of water to the respectful citizens and policy makers. WQI concept is used to represent change in water quality was first proposed by Horten. The use of WQIs simplifies the presence of results of inspection of chemicals related to a water body, as it depicts in a single understanding simple value, the mutual effect of water quality parameters analyzed. (3)Multiple water quality indexes are maintained to assess quality of natural water features(4) . Thus, the indices not only interpreted the required information regarding the water quality, it also helps spatial and temporal comparisons. WQI shows water quality in terms of a decimal index numbers and also is useful in monitoring quality of water. To study water quality, different methods such as statistical analyses of individual parameter, multiple parameters water quality indices, etc., have been considered (5)

With advancement in science and technology there is an increasing use of computer applications and computing powers of computers are also increasing over recent decades. Over these years techniques in remote sensing have become powerful and are useful tools in achieving required goals. Techniques of Remote sensing are making it possible to observe and identify large scale areas and waterbodies that endure from qualitative

problems in a more efficient and effective manner. The collection of data which is remotely sensed appears in digital format and therefore is easily legible in computer processing. Remotely sensed techniques have been in use from the 70's and continue to be extensively used in water quality assessment in the contemporary world. (6,6–13)

Different sensors mounted on satellites and other platforms, such as aeroplanes, measure the amount of radiation at various wavelengths reflected from the water's surface. These reflections can be used directly or indirectly to detect different water quality indicators, such as total suspended solids (TSS), chlorophyll-*a* concentration, turbidity, salinity, total phosphorus (TP), Secchi disk depth (SDD), Temperature, pH, Dissolved Organic Carbon (DOC), etc. The characteristics of water and pollutants spectral in nature, are functions of the characteristics of hydrological, biological and chemical constitutes of water, etc., are necessary factors in the monitoring and assessment of water quality. The study thus introduces the widely employed spaceborne and airborne sensors in water quality investigations and discusses the utility of remotely sensed techniques in the qualitative assessment of waterbodies. spaceborne and airborne sensor's various properties (spectral, spatial and temporal, etc.) are marked to be used as a sensor selection guide. Finally, literature survey states that , the study puts forward a collection of the different sensors useful in the analysis of some measurable parameters of water quality, and looks over in a more precise water quality parameters based on the employed approaches to measuring their concentrations.(14,15). AI (Artificial Intelligence) and GIS (Geographic Information Systems) can be used together for water resources management to improve the efficiency and effectiveness of decision-making processes

Literature Review

Water quality indices

This paper tried to conduct a case study on how water quality indices is important tool for water quality assessment. The quality of water indices estimation endeavour single value which decrease the big quantity of parameters and represent data in a simple way. This review includes various water quality indices (WQI) used in the surface water quality assessment. (19)

Researchers tried to show quantification of quality parameters of inland and near shore waters by means of remote sensing. This paper comprehensively evaluates the quantification of four types of water quality parameters: inorganic sediment particles, phytoplankton pigments, coloured dissolved organic material and Secchi disk depth. It concentrates on quantification requirements, as well as the options in selecting the most appropriate sensor data for the purpose. This review reveals that the relationship between in situ samples and their corresponding remotely sensed data can be linear or nonlinear but are nearly always site-specific. The quantification has been attempted from terrestrial satellite data largely for suspended sediments and chlorophyll concentrations. The quantification has been implemented through integration of remotely sensed imagery data, in situ water samples and ancillary data in a geographic information system (GIS). The introduction of GIS makes the quantification feasible for more variables at an increasingly higher accuracy. Affected by the number and quality of in situ samples, accuracy of quantification has been reported in different ways and varies widely (20)

This study reveals the use of Remote Sensing and GIS in Monitoring Water Quality assessment. In this paper researcher discusses the application of remote sensing and GIS specifically in monitoring water quality parameter such as suspended matter, phytoplankton, turbidity, and dissolved organic matter. And proves that the capability of GIS technology offers great tools of how the water quality monitoring and managing can be operationalised. In conclusion remote sensing and GIS technologies coupled with computer modelling are useful tools in providing a solution for future water resources planning and management(21).

Human interventions and water quality

Water pollution was studied for the upper Ganga River basin for both urban and rural parts. Landsat 7 data was used for the study. Population was analysed statistically to study the demographics. LULC data was derived from the Landsat 7 satellite data. This study shows that the river pollution increased overtime in both the areas. A comparison was carried out. In rural areas it was majorly due to the agricultural activities and in urban areas it was due to human interventions and growing need of the people and industrial development. Multiple linear regression models developed for the Upper Ganga River basin could successfully predict status of the water quality.(3)

Relation between water quality and human population growth was studied this this paper Jinshui River basin of the South Qinling Mts., China. Water samples were collected on the 11 different parts of the rives. Various statistical analysis was carried out like regression analysis etc. to find the results. The results shows that variables of water quality and pollution for correlation analysis and stated 36.5–77.8 % of the total variances for regression analysis, indicating that human activities in relation to population growth are affecting the input and output of pollutants in river water. (22)

Remote sensing and water quality

This paper monitored Ground Water Quality in Thiruvannamalai district of Tamilnadu by using GIS based technology. This study shows that ground water is affected due to fertilizers, effluents run off from industries, chemical dumping sites and domestic sewage. For this study they collected the samples according to World Health Organization parameters like pH, Electrical Conductivity (EC), nitrates, fluorides, and chlorides. GIS is used for spatial and temporal domain for this study. The results are useful in efficient monitoring and assessment of ground water and for taking relevant measures to curb unrestrained exploitation. (23)

Researchers tried to carry out a study to monitor water quality parameters i.e. suspended sediments by using remote sensing techniques. They monitored turbidity, chlorophyll and temperature of the water by using remote sensing. For the study, they used remotely sensed data, GPS and GIS technologies which provide valuable tools for monitoring and assessing waterways. They used remotely sensed data to create a permanent geographically located database which provide a baseline for future comparisons. They also proves that, use of remotely sensed data, GPS, and GIS will enable consultants and natural resource managers to develop management plans.(24)

Researchers carried out a study of Monitoring water surface dynamics is essential for the management of lakes and reservoirs, especially those are intensively impacted by human exploitation and climatic variation by using Google Earth Engine. They reveals that the Google Earth Engine (GEE) platform provides a promising solution for this type of "big data" problems when it is

> combined with the automatic water extraction index (AWEI) to delineate multi-temporal water pixels from other forms of land use/land cover. The aim of this study is to assess the performance of a completely automatic water extraction framework by combining AWEI, GEE, and Landsat 8 OLI data over the period 2014–2018 in the case study of New Zealand. The result shows that the overall accuracy (OA) of 0.85 proved the good performance of this combination(25).

> This study is a case study of water quality monitoring over finger lake region using Sentinel-2 imagery on Google earth Engine. They show that surface water quality is degrading continuously both due to natural and anthropogenic causes. This study focuses on detecting and monitoring sediments through NDWI over the Finger Lakes region, New York. Time series analysis is performed using Sentinel 2 imagery on the Google Earth Engine (GEE) platform. The deteriorating water quality within the Finger Lake region has been reported based on ground sampling techniques. This study takes advantage of a cloud computing platform and medium resolution atmospherically corrected satellite imagery to detect and analyse water quality through sediment detection. The results demonstrate the amount of sediments is greater in the early spring and summer months compared to other seasons. This can be due to the agricultural runoff from the nearing areas as a result of high precipitation(26)

> This study shows regular quality monitoring of inland water bodies is vital for identifying the areas with deteriorating water quality/. In this paper satellite remote sensing has been used for obtaining long term trends that require the processing of many images. The computational load of processing many satellite imageries can be eased by utilizing the cloud computing

capabilities of Google earth Engine (GEE). The present study explores the possibility of using the GEE platform for mapping the Trophic State Index of an inland water body. The bottom of atmosphere reflectance retrieved by the SIAC algorithm id assessed for its accuracy. The capability of FGEE as a rapid water quality monitoring tool is demonstrated by displaying the temporal and spatial variations of water quality across Vembanad lake for the period of 2016-2021(27).

Researchers tried to study the present water quality using remote sensing in the Gulf of Finland, and focus on the spatial distribution of water quality information from satellite-based observations in support of water policy by a case study of nitrate concentrations in surface waters. Water quality monitoring using remote sensing has been studied in Finland for many years. But there are still few discussions on water quality monitoring using remote sensing technology in support of water policy and legislation in Finland under the WFD. The authors briefly describe instruments using a system of river basin districts (RBD), highlighting the importance of

integrated water resources and river-basin management in the WFD, and discuss the role of water quality monitoring using remote sensing in the implementation of water policy in Finland under the WFD(28).

CONCLUSION

Water Quality was predicted using various artificial neural network models. nonlinear autoregressive neural network (NARNET) and long short-term memory (LSTM) deep learning algorithm, have been developed. three machine learning algorithms, namely, support vector machine (SVM), -nearest neighbor (K-NN), and Naive Bayes, have been used for the WQC forecasting. Along with this various water quality parameters were used. Prediction results demonstrated that the NARNET model performed slightly better than the LSTM for the prediction of the WQI values and the SVM algorithm has achieved the highest accuracy (97.01%) for the WQC prediction. Furthermore, the NARNET and LSTM models have achieved similar accuracy for the testing phase with a slight difference in the regression coefficient (an). This kind of promising research can contribute significantly to water management.(29)

The implementation of artificial intelligence (AI) leads to a flexible mathematical structure that has the capability to identify non-linear and complex relationships between input and output data. The different modelling approaches that have been implemented include: Adaptive Neuro-Fuzzy Inference System (ANFIS), Radial Basis Function Neural Networks (RBF-ANN), and Multi-Layer Perceptron Neural Networks (MLP-ANN). The first assessment process is dependent on the partitioning of the neural network connection weights that ascertains the significance of every input parameter in the network. On the other hand, the second and third assessment processes ascertain the most effectual input that has the potential to construct the models using a single and a combination of parameters, respectively. During these processes, two scenarios were introduced: Scenario 1 and Scenario 2. Scenario 1 constructs a prediction model

for water quality parameters at every station, while Scenario 2 develops a prediction model on the basis of the value of the same parameter at the previous station (upstream). Both the scenarios are based on the value of the twelve input parameters. The field data from 2009 to 2010 was used to validate WDT-ANFIS. The WDT-ANFIS model exhibited a significant improvement in predicting accuracy for all the water quality parameters and outperformed all the recommended models. Also, the performance of Scenario 2 was observed to be more adequate than Scenario 1, with substantial improvement in the range of 0.5% to 5% for all the water quality parameters at all stations. On validating the recommended model, it was found that the model satisfactorily predicted all the water quality parameters (R2 values equal or bigger than 0.9).(30)

References

1. Water Quality [Internet]. Available from: https://tethys.pnnl.gov/receptor/water-quality
2. Abbasi T, Abbasi SA. Water-Quality Indices. In: Water Quality Indices [Internet]. Elsevier; 2012 [cited 2023 May 14]. p. 353–6. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780444543042000166
3. Gholizadeh M, Melesse A, Reddi L. A Comprehensive Review on Water Quality Parameters Estimation Using Remote Sensing Techniques. Sensors. 2016 Aug 16;16(8):1298.
4. Sutadian AD, Muttil N, Yilmaz AG, Perera BJC. Development of river water quality indices—a review. Environ Monit Assess. 2016 Jan;188(1):58.
5. Venkatesharaju K, Ravikumar P, Somashekar R, Prakash K. Physico-Chemical and Bacteriological Investigation on the River Cauvery of Kollegal Stretch in Karnataka. Kathmandu University J of Sci, Engineering & Technol. 1970 Jan 1;6(1):50–9.
6. Gholizadeh M, Melesse A, Reddi L. A Comprehensive Review on Water Quality Parameters Estimation Using Remote Sensing Techniques. Sensors. 2016 Aug 16;16(8):1298.
7. Alparslan E, Aydöner C, Tufekci V, Tüfekci H. Water quality assessment at Ömerli Dam using remote sensing techniques. Environ Monit Assess. 2007 Nov 9;135(1–3):391–8.
8. Anding D, Kauth R. Estimation of Sea Surface Temperature from Space. Remote Sensing of Environment. 1970;
9. Brando VE, Dekker AG. Satellite hyperspectral remote sensing for estimating estuarine and coastal water quality. IEEE Trans Geosci Remote Sensing. 2003 Jun;41(6):1378–87.
10. Kondratyev KYa, Pozdnyakov DV, Pettersson LH. Water quality remote sensing in the visible spectrum. International Journal of Remote Sensing. 1998 Jan;19(5):957–79.
11. Maillard P, Pinheiro Santos NA. A spatial-statistical approach for modeling the effect of non-point source pollution on different water quality parameters in the Velhas river watershed – Brazil. Journal of Environmental Management. 2008 Jan;86(1):158–70.
12. Usali N, Ismail MH. Use of Remote Sensing and GIS in Monitoring Water Quality. JSD. 2010 Aug 19;3(3):p228.
13. Wang XJ, Ma T. Application of Remote Sensing Techniques in Monitoring and Assessing the Water Quality of Taihu Lake. Bull Environ Contam Toxicol. 2001 Dec;67(6):863–70.
14. Haji Gholizadeh M, Melesse AM, Reddi L. Spaceborne and airborne sensors in water quality assessment. International Journal of Remote Sensing. 2016 Jul 17;37(14):3143–80.
15. Bhutiani R, Khanna DR, Kulkarni DB, Ruhela M. Assessment of Ganga river ecosystem at Haridwar, Uttarakhand, India with reference to water quality indices. Appl Water Sci. 2016 Jun;6(2):107–13.
16. Vidya Sujitha.R, 2Patel Adityakumar Maheshbhai, 2Pawar Rahul Mothabhau, 2Guddu Sahani 2Shetty Shravan Ratnakar. A COMPREHENSIVE ASSESSMENT ON WATER QUALITY STATE OF PUNE CITY.
17. Pune has a surplus of water and sewage, polluting its rivers. Available from: https://www.cseindia.org/pune-has-a-surplus-of-water-and-sewage-polluting-its-rivers-4267

18. Hindustan Times P. Rivers from Pune carry most polluted water: MPCB. Available from: https://www.hindustantimes.com/pune-news/rivers-from-pune-carry-most-polluted-water-mpcb/story-P9xHpGaTvXmznMo4OkBSiJ.html
19. Poonam T, Tanushree B, Sukalyan C. WATER QUALITY INDICES- IMPORTANT TOOLS FOR WATER QUALITY ASSESSMENT: A REVIEW. International Journal of Advances in Chemistry. 2013
20. Liu Y, Islam MA, Gao J. Quantification of shallow water quality parameters by means of remote sensing. Progress in Physical Geography: Earth and Environment. 2003 Mar;27(1):24–43
21. Hajigholizadeh M. Water Quality Modelling Using Multivariate Statistical Analysis and Remote Sensing in South Florida [Internet] [Doctor of Philosophy Civil Engineering]. Florida International University; 2016 [cited 2023 May 14]. Available from: https://digitalcommons.fiu.edu/etd/2992
22. Bu H, Liu W, Song X, Zhang Q. Quantitative impacts of population on river water quality in the Jinshui River basin of the South Qinling Mts., China. Environ Earth Sci. 2016 Feb;75(4):292.
23. Kaviarasan M, Geetha P, Soman KP. GIS-Based Ground Water Quality Monitoring in Thiruvannamalai District, Tamil Nadu, India. In: Suresh LP, Panigrahi BK, editors. Proceedings of the International Conference on Soft Computing Systems [Internet]. New Delhi: Springer India; 2016 [cited 2023 May 14]. p. 685–700. Available from: http://link.springer.com/10.1007/978-81-322-2671-0_65
24. Ritchie JC, Zimba PV, Everitt JH. Remote Sensing Techniques to Assess Water Quality. photogramm eng remote sensing. 2003 Jun 1;69(6):695–704.
25. Nguyen UNT, Pham LTH, Dang TD. An automatic water detection approach using Landsat 8 OLI and Google Earth Engine cloud computing to map lakes and reservoirs in New Zealand. Environ Monit Assess. 2019 Apr;191(4):235.
26. Khan RM, Salehi B, Mahdianpari M, Mohammadimanesh F. WATER QUALITY MONITORING OVER FINGER LAKES REGION USING SENTINEL-2 IMAGERY ON GOOGLE EARTH ENGINE CLOUD COMPUTING PLATFORM. ISPRS Ann Photogramm Remote Sens Spatial Inf Sci. 2021 Jun 17;V-3–2021:279–83.
27. Sherjah PY, Sajikumar N, Nowshaja PT. Quality monitoring of inland water bodies using Google Earth Engine. Journal of Hydroinformatics. 2023 Mar 1;25(2):432–50.
28. Chen Q, Zhang Y, Hallikainen M. Water quality monitoring using remote sensing in support of the EU water framework directive (WFD): A case study in the Gulf of Finland. Environmonit Assess. 2007 Jan 5;124(1–3):157–66.
29. Aldhyani THH, Al-Yaari M, Alkahtani H, Maashi M. Water Quality Prediction Using Artificial Intelligence Algorithms. Algalil FA, editor. Applied Bionics and Biomechanics. 2020 Dec 29;2020:1–12.
30. Najah Ahmed A, Binti Othman F, Abdulmohsin Afan H, Khaleel Ibrahim R, Ming Fai C, Shabbir Hossain M, et al. Machine learning methods for better water quality prediction. Journal of Hydrology. 2019 Nov;578:124084.
31. Jaybhaye RG, Mundhe NN. Hybrid Image Classiication Technique for Spatio-temporal Analysis.
32. Bhaskar P. URBANIZATION AND CHANGING GREEN SPACES IN INDIAN CITIES (CASE STUDY – CITY OF PUNE). International Journal of Geology. 2012;2.

33. Wise T. DISTRICT CENSUS HANDBOOK.
34. Lakshmi N. Kantakumar a * 1, Shamita Kumar a, Karl Schneider. Spatiotemporal urban expansion in Pune metropolis, India using remote sensing.