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A Review on Forecasting of Water Quality Parameters for Irrigation Purpose Using Machine Learning Algorithms

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ABSTRACT:

Irrigation is the process of applying water to crops artificially to fulfil their water requirements. The agricultural sector in India which provide 54.6% of total employment to the growing population, alone consumes more than 90% of the total groundwater draft in irrigation. Over the years, groundwater has become a dominant source of irrigation due to its independent access and timely availability of water. Andhra Pradesh has one of the largest irrigated areas. For farmers, especially in developing nations, using traditional methods to assess irrigation water quality is typically costly and time-consuming. However, by predicting and assessing the irrigation water quality indexes of aquifer systems using physical factors as features, applications of artificial intelligence models can circumvent this problem. This study aims to predict water's suitability for irrigation purposes by reducing time, as well as cost. The developed models are useful for predicting the parameters governing the quality of irrigation water globally and could support farmers and decision-makers in handling irrigation water strategies. Through the use of physical parameters as input variables, the developed approaches in this research have shown promise in low-cost and real-time forecasting of groundwater quality.

INTRODUCTION:

To service the drinking, industrial, and agricultural domains, water supplies are crucial. The cost of water treatment is greatly reduced by the high quality of the available water resources. These are used to increase agricultural output and be used for drinking and industrial uses. Population increase, intensive agriculture, urbanization, and industrial activity all contribute to rising water demand. Since anthropogenic activities and natural pollution sources endanger water resources by endangering their ability to be used for industrial, agricultural, drinking, and other uses, To evaluate whether or not water is suitable for a particular use and, if not, what treatments or safety measures should be taken, water quality assessment and prediction are necessary. Therefore, it is vital to simulate groundwater levels to assess if the resources available to support human activities are sustainable. Automation in agriculture is increasingly built on AI. Simple and boring operations like acquiring field data, labelling and analyzing data, creating reports, and sending notifications are made easier with automation. In a short amount of time, the effects of these modest actions on agricultural practices will become apparent. Reduced human effort, a unified understanding of soil properties, reduced water use, improved long-term landscape health, and cost savings are all aspects of smart irrigation. Different kinds of water irrigation systems use AI systems heavily today to attain these benefits.

1) Power AI engines can process and analyse images from satellites, planes, or drones.
2) We can evaluate data from photos using machine learning, particularly deep learning algorithms, and find patterns that highlight irrigation problems.

LITERATURE REVIEW:

[1] Gonzalez Perea (2018), reported that, in Spain. Its purpose is to determine the field depth of the farm for different crops for irrigation purposes. Farm area (ha), Crop, Daily maximum temperature (°C), Daily maximum relative humidity (%), and Daily rainfall (mm) are the parameters. A hybrid methodology combining artificial neural networks, fuzzy logic and genetic algorithms, Fuzzy logic (FL), and Adaptive Neuro-fuzzy inference system (ANFIS). ANFIS, which is the combination of artificial neural networks (ANNs) and FL are the algorithm used. hybrid method (ANFIS) which is the combination of ANN and FL is the best method for this study. the accuracy of ANFIS for the prediction was 22.2 %, 9.8%, and 23.42% for rice, maize and tomato crops respectively [1].

[2] Youssef Brouziyne (2020), reported that in Iran. To ensure proper management of scarce water resources, simulate water levels for a scarcity war. input parameters: monthly groundwater level values, monthly precipitation in mm, temperature. The combination of GEP and M5 gives the Ensemble Empirical Mode Decomposition (EEMD) and the Complementary Ensemble Empirical Mode Decomposition (CEEMD). Hybrid models developed by GEP are better than other models. Regarding Multiple Linear Regression as the benchmark in the first data set, EEMD- GEP has improved its accuracy by 13.11%, and for the second data set it is improved by 103.23%, and for the third data set it is improved by 76%[2].

[3] H. Orouji (2017), To predict water suitability for irrigation, the so-called water management techniques using artificial intelligence, machine learning, linear regression, logistic regression, temperature sensors, Arduino, Random forest(RF), decision trees, support vector machine, nearest neighbour, support vector regression, artificial neural network, ada-boost(effective one), Genetic programming by generating output parameters like sodium adsorption ratio(SAR), Residual sodium carbonate index(RSC), boron content(>3 harmful), by using the input parameters like pH, Ca, Mg, Na to investigate the availability of water within that storage management, crop diseases, soil moisture, weather prediction, the ways to minimize the over wastage of water, the concentration of cations and anions and the percentage of sodium. Finally says that hybrid simulation gives quicker and better results than the conventional approaches [3].

[4] This paper is through the author Fatma Trabelsi. This research aims to evaluate the ability of machine learning (ML) models to predict the quality of groundwater for irrigation purposes in the downstream Medjerda River basin (DMB) in Tunisia. The random forest (RF), support vector regression (SVR), artificial neural networks (ANN), and adaptive boosting (AdaBoost) models were tested to predict the irrigation quality water parameters (IWQ): total dissolved solids (TDS), potential salinity (PS), sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), and magnesium adsorption ratio (MAR) through low-cost, in situ physicochemical parameters (T, pH, EC) as input variables. The performance of the ML models was evaluated according to Pearson's correlation coefficient (r), the root means square error (RMSE), and the relative bias (RBIAS). The results show that the AdaBoost model is the most appropriate model for predicting all parameters (**r** ranged between 0.88 and 0.89), while the random forest model is suitable for predicting only four parameters: - TDS, PS, SAR and ESP (r was with 0.65 to 0.87). Added to that, this study found out that the ANN and SVR models perform well in predicting three parameters (TDS, PS, SAR) and two parameters (PS, SAR), respectively, with the most optimal value of generalization ability (GA) close to unity (between 1 and 0.98) [4].

[5] Ali Mokhtar and Ahmed Elbeltagi (2021) have reported that in the place of Bahr El-Baqr, Egypt. This paper aims to predict the irrigation water quality index of Bahr El-Baqr, Egypt, based on nonexpensive approaches that require simple parameters. Artificial intelligence models are used: Support vector machine (SVM); Extreme gradient boosting (XGB); Random-Forest (RF). Regression models: Stepwise regression (SW); Principal components regression (PCR); Partial least square regression (PLS); Ordinary least square regression (OLS). Performance statistics of the root mean square error (RMSE) and the Scatter index (SI) are used as input parameters. stepwise regression emerged as the optimal regression model for predicting the IWQI. For the AI models Support vector machine was the best [5].

[6] J. I. Ubah, L. C. Orakwe et al (2022). This study was aimed at analyzing the water quality of Ele River Nnewi, Anambra State for irrigation purposes to predict a one-year water quality index using Artificial Neural Network (ANN). The methods used are Artificial Neural Network (Machine learning method) is used. Performance statistics such as Root mean square error (RMSE) are used. Considering the Food and agriculture organization (FAO) Irrigation water quality permissible standards, the river water quality analyses, modelling, and prediction were evaluated for Ele River Nnewi, Anambra State. Results declared that total dissolved solids (TDS), electrical conductivity (EC), and sodium (Na) were above the FAO permissible standard for irrigation during dry seasons while the pH was normal throughout the season. The R2 values obtained from the water quality index and prediction were very close to indicating a good model and prediction. Since this work is limited to irrigation water quality assessment, I recommend that future works on the water quality of Ele River can also determine the drinking and domestic water quality assessment using an Artificial Neural Network ANN [6].

[7] Exploring Machine learning models, Groundwater quality indices (2022) reported that the main aim of this work exploring machine learning models in predicting irrigation groundwater quality indices for effective decision-making in the Medjerda river basin in Tunisia. Input variables (Temperature, Ph, Electrical Conductivity) Parameters are Total dissolved solids (TDS), Potential salinity (PS), Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), Magnesium Absorption Ratio (MAR), and Percentage of Sodium (%N). Machine learning models are developed namely Random Forest (RF), Support Vector Regression (SVR), Artificial Neural Network (ANN), and Adaptive Boosting (Ada Boost). r=0.88-0.89(Ada Boost), RF=0.65-0.87, (SVR) in these 3 parameters (TDS, PS, SAR) in which Generalization ability (GA)=1-0.98. In which the Ada Boost predicts accurate values (0.88 and 0.89). Input data Ph=0.5, Temperature =88. Physio-Chemical parameters-Cations (Na+, NH4+, K+, Mg2+, and Ca2+) &Anions (Cl−, NO3−, SO42−, F−, Br−). Salinity Hazard Class1=0-25, Class2=25-75, Class3=75-225, Class4=225-500 in which Class1 is suitable for irrigation. Sodium Hazard S1=0-10, S2=10-18, S3=18-26, S4=>6.[7]

[8] Yazid Tikhamarine, Anurag Malik, Anil Kumar, Doudja Souag-Gamane&Ozgur Kisi (2019): Estimation of monthly reference evapotranspiration using novel hybrid machine learning approach's main objective of the work is to review the application of a big data-based decision support system framework for sustainable water irrigation management using intelligent learning approaches. The algorithms used are Artificial neural network (ANN), ANFIS, support vector machine (SVM), and GEP. In the domain of agriculture, big data analytic technologies have offered newly predictive models for ETo estimation, e.g. generalized neuro-fuzzy models, artificial neural networks (ANN), adaptive neuro-fuzzy inference systems, multi-layer Perceptrons neural network (MLPNN) and least square support vector regression (LSSVM), GRNN, ELM, WNN, and GANN. Regarding the conclusions to estimate crop water modelling on general manifolds, we have different approaches available in literature moreover, the water balance is a well-entrenched approach for estimating irrigation amount and time (i.e., irrigation frequency) in irrigation scheduling. This approach is simple to use, inexpensive, and very effective by estimating the reference evapotranspiration (ETo), and crop evapotranspiration(Etc). The major objective is to adopt several approaches to develop a flexible system that supports irrigation water requirement systems, which may fit into diverse fields of operational activities (weather information, field data collection, crop coefficients, etc.). This study provides an overview of irrigation water scheduling. It also presented the concept of reference evapotranspiration and crop evapotranspiration for crop water modelling. It also presents the various methods of irrigation scheduling. It also addresses the need for a decision support system and its various approaches that lead to irrigation water management.[8]

[9] Ali EiBilai (2020), reported a place in Morocco in the breached aquifer. The main aim of this work is groundwater quality forecasting using machine learning algorithms for irrigation purposes. Input parameters are Temperature (T), Electrical Conductivity (EC), and PH, are output parameters are Total

Dissolved Solids (TDS), Sodium Absorption Ratio (SAR), Potential Salinity (PS), Magnesium Sodium Absorption (MSA), Exchangeable Sodium Percentage (ESP), and Residual Sodium Carbonate (RSC). There are 4 machine learning models developed namely Artificial Neural Network (ANN), Adaptive Boosting (AdaBoost), Random Forest (RF), and Support Vector Regression (SVR). In this simulation process, 476 data samples were used. 300 samples were used in training testing and the remaining 176 samples were used for validation. Overall prediction performance of AdaBoost and RF given higher than the ANN and SVR. Electrical Conductivity (EC) has the strongest correlation factor (R) with TDS(r=0.96), PS (r=0.95), SAR (r=0.78), and RSC (r=0.79) and moderate correlation factor ESP (r=0.50) and MAR (0.41) PH is weak r values. Except for the SVR RBIAS values less than 5%in the RSC parameters [9].

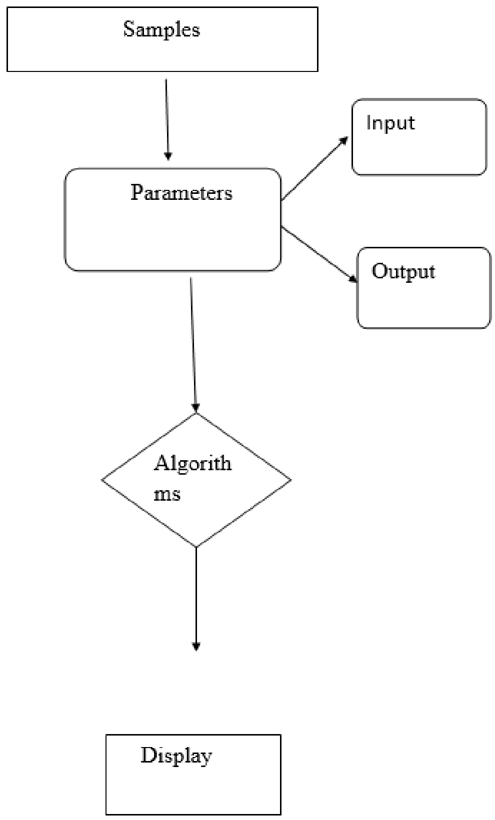
[10] Sudhakar Singha (2021) reported that the Raipur district in India. The main aim of this work prediction of groundwater quality using efficient machine learning techniques. Input parameters PH, Total Dissolved Solids (TDS), and Biological Oxygen Demand (BOD). Machine learning models have developed namely the Deep Learning predictive model when compared to other models Random Forest (RF), Extreme Gradient Boosting (xgboost), and Artificial Neural Networks (ANN). DL is the highest accuracy prediction model.e.(R^2 =0.996) against the RF (R^2=0.886), XGBOOST (R^2=0.0927), and ANN (R^2=0.917). DL prediction of RMSE=1.254, water quality and removal of major pollutants Fluoride, Nitrate, Potential Toxic trace elements (PTEs) Removal Magnesium (Mn), Lead (Pb), cadmium (Cd), Arsenic (As) for both surface and sub-surface [10].

METHODOLGY:

A place was selected for predicting water quality parameters. Water samples were collected at different locations. for those samples parameters (PH, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Residual Sodium Carbonates etc..) will be taken. Those parameters were classified into 2 types

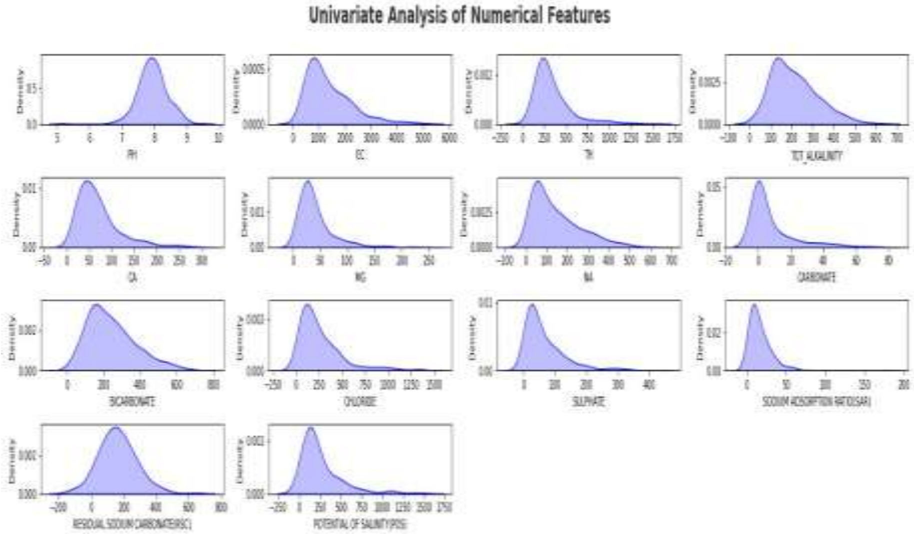
1) Input
2) Output

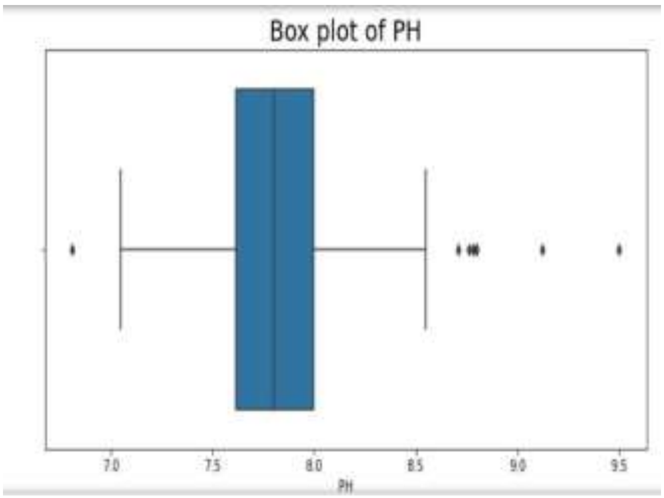
Then the algorithms will be chosen for simulating the parameters. Some of them are AdaBoost, Artificial Neural Network (ANN), Random Forest (RF), and Support Vector Machine (SVM). Each algorithm divides the sample data into testing, training and validation sets. For this flowing equations will be used.

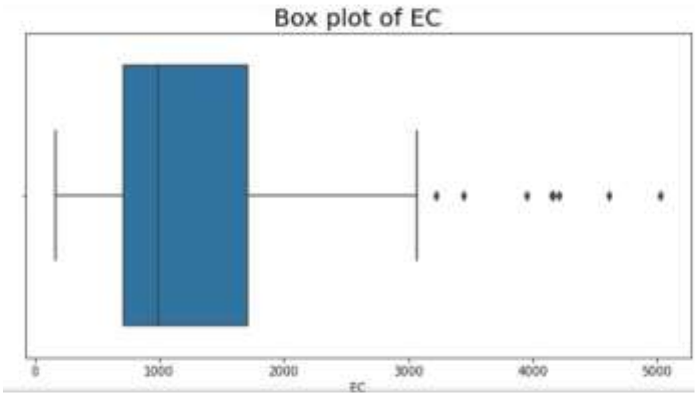


RESULTS AND DISCUSSIONS:

For the simulated data the error will find out. Based on the error accuracy will be determined. The parameters can also be displayed in box plots co-relation matrices etc.







CONCLUSION:

The main aim of this study is to determine whether ML models are valuable tools to forecast water quality parameters using physical parameters**.** The primary goals of this study were to determine whether ML models are useful tools for forecasting IWQ parameters using physical parameters as features and to investigate their sensitivity to input variables. As a result, the adaptive boosting, Random Forest, ANN, and SVR models were created and tested for predicting the TDS, PS, SAR, ESP, MAR, and RSC parameters using physical parameters as features.The Adaboost model is best suited for forecasting all parameters, while the RF model is best suited for forecasting five parameters (except the MAR parameter). The ANN and SVR models perform well in forecasting four (TDS, PS, SAR, and RSC parameters) and three (PS, SAR, and RSC parameters) of six parameters, respectively.The SVR and ANN models outscored the Adaboost and RF models in terms of a sweeping statement. Overall, the sensitivity analysis reveals that the developed models are just faintly susceptible to the input variables that will use when compared to the range of each forecast parameter.ML models with physical parameters as features are efficient tools and should be recommended for forecasting IWQ parameters to manage saline water. They will improve groundwater quality monitoring for irrigation purposes in real-time at a low cost.From the above result, we got 92% accuracy which is more than 80%. So this water is fit for irrigation purposes.

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