هیدروژئولوژی، سال ششم، شماره ۱، تابستان ۱۴۰۰
Hydrogeology, Volume 6, No. 1, Summer 2021

Application of Wavelet Neural Network Model in Prediction of Groundwater Resources (Case Study, Lorestan Province, Iran)

Document Type: Research Paper

Hassan Torabi Podeh[*1], Ali Heidar Nasrolahi[2], Reza Dehghani[3]

1- Associate Professor of Water Engineering, University of Lorestan, Khorramabad, Iran
2- Assistant Professor of Water Engineering, University of Lorestan, Khorramabad, Iran
3- Ph.D. Student of Water Structure, Faculty of Agric., University of Lorestan, Khorramabad, Iran
*corresponding author: torabi.ha@lu.ac.ir

Abstract

The phenomenon of the exploitation of groundwater recently has caused a sharp decline in groundwater levels, resulting in both subsidence and desertification caused by the groundwater withdrawal. Thus, reliable prediction of groundwater level has been an important component in sustainable water resources management. In this study, a data-driven prediction wavelet neural network model (WNN) was proposed for groundwater level in Azna-Aligodarz, Dourod-Brojerd, Delfan, Selseleh plain forecasting, and the results were compared with the artificial neural network. Parameters including precipitation, temperature, flow rate and water level balance during the period of the previous month were used as input of the model and level of the water table in each period as the output of the model through monthly scale (2002-2019) were selected. The criterion of the correlation coefficient, Root-Mean-Square-Error and average absolute error and coefficient of Nash Sutcliff for evaluating and the comparison of performance models were used. The results of the hydrograph analysis indicated that the increase of rainfall has an effect on groundwater resources, and also the findings evaluation of criteria showed that WNN has better performance and less error than the artificial neural network.

Keywords: Artificial neural network, Groundwater, Wavelet neural network.

Introduction

Given the increasing population growth and the need for optimal use of water resources, providing the greatest amount of groundwater possible to meet the needs of all human beings is of particular importance. Excessive exploitation of groundwater resources in recent years has disrupted its natural balance and groundwater levels in aquifers in many parts of the country have declined. In order to be aware of the status of these resources and their optimal management, precise predictions of groundwater level fluctuations need to be made. Most hydrologic time series, such as changes in groundwater level, always involve inhumane and complex processes that cannot be well described and modeled using conventional linear models. Therefore, nonlinear models should be used to model these hydrological phenomena. Today, intelligent systems are widely used to predict nonlinear phenomena.

In recent years, the use of smart methods in quantitative studies of groundwater has been of interest to researchers, including the following:

Thendiyath et al (2019) evaluated the hybrid artificial neural network model in Chicago, Japan. The results showed that the hybrid artificial neural network model has an acceptable performance compared to the artificial neural network model. Lee et al. (2019) analyzed groundwater level fluctuations to determine the performance of artificial neural networks. The results showed that the leading artificial neural network model has acceptable performance in predicting groundwater fluctuations. Overall, according to the researches conducted and also the importance of the study areas of Azna-Oligodarz, Dorood-Boroujerd, Dynasty and Delfan in terms of drinking and agriculture, the most important areas of Lorestan province are for agricultural production and the products of this plain for water development. Therefore, changes in water level are necessary for the prediction and management measures to improve its water supply. Therefore, the purpose of this study was to estimate the water level of Azna-Oligodarz, Doroud-Boroujerd, Selsan and Delfan Lorestan study areas using wavelet

neural network and artificial neural network based on the parameters of rainfall, temperature, flow rate and water table level. The time period of the previous month is as input parameters and the water level in the desired period is the output of the model on a monthly time scale.

Materials and Methods

Lorestan province covers an area of 28160 km2 in southwestern Iran and from north to Hamedan province to northeast to central province, northwest to Kermanshah province, east to Isfahan province, south to Khuzestan and southeast to Chaharmahal Bakhtiari province. It is confined to the southwest and west to Ilam. Lorestan province includes Karkheh and Karun basins. Lorestan's geography is due to its location in the Zagros Mountains and Four Seasons. This province is one of the western mountainous provinces of Iran that covers most of the Zagros Mountains. The climate of Lorestan province is varied and the climate varied from northeast to southwest. The most important study areas of Lorestan province are Boroujerd-Doroud, Azna-oligudarz, dynasty, Delphan which have alluvial aquifers and have relatively good surface and groundwater status.

Recently, the phenomenon of the exploitation of the groundwater has caused a sharp decline in groundwater levels, which has also led to groundwater-related subsidence and desertification. Therefore, reliable prediction of groundwater levels for managing these resources is of prime importance. In this research to predict groundwater level in Azna-Aligodarz, Dourod-Brojerd, Delfan, Selseleh plain of Lorestan Province, the wavelet neural networks were used and the results were compared with the artificial neural network. Parameters of precipitation, temperature, flow rate and water level within the time period of the previous month were used as input and the level of the water table in each period as output through monthly scale (2002-2019) were selected. The criterion of the correlation coefficient, root mean square error and coefficient of mean absolute error of Nash Sutcliff for evaluating the performance of models were used.

Wavenet called wavelet-based neural network which combined with wavelet theory and neural networks have been created. It also has supportive of the benefits and features of neural networks and charm and flexibility and strong mathematical foundations and analysis of multi-scale wavelets. a combination of wavelet theory with neural network concepts to the creation of wavelet neural network and feedforward neural shock can be a good alternative for estimating approximate nonlinear functions. Feedforward neural network with sigmoid activation function is in the hidden layer While at the nerve shocked wavelet, wavelet functions as activation function of hidden layer feedforward networks are considered, In both these networks and scale wavelet transformation parameters are optimized with their weight.

Results and Discussion

One of the most important steps in modeling is choosing the right combination of input variables. Therefore, the first correlation was calculated between the input and output variables and the input parameters to obtain the optimal model for estimating groundwater level of the study areas of Azna-Oligodarz, Doroud-Boroujerd, Dynasty and Delfan, each of which has a boundary. Piezometer well approved by Ministry of Energy and statistics obtained from Lorestan Regional Water Company. Due to the significant and significant correlation between input and output data, different combinations of input parameters were used to obtain the optimal model for estimating the water level. For this purpose, hydrometric station data in the study areas of Azna-Oligodarz, Dorood-Boroujerd, Dynasty and Delfan, which has 200 records recorded over a period of time (2002-2019), were used on a monthly time scale. Finally, 160 records for training during the years (2002-2015) and 40 records for the years (215-2019) were selected for validation of the studied methods.

The results showed that all two models have better results in structures Combined than other specified structures. In addition, according to the evaluation criteria, it was found between the models used, the Wavelet Neural Network model, as well as the results of evaluation criteria, showed that the wavelet neural network model has better performance and less error than an artificial neural network.

Conclusions

Performance of Wavelet Neural Network and Artificial Neural Network Models for Groundwater Modeling of Azna-Oligodarz, Doroud-Boroujerd, Selsan and Delfan Study Areas in Lorestan Province Using Precipitation, Temperature, Flow and Water Level Parameters During Period Statistical analysis (2002-2019) was performed. Groundwater levels observed with the estimated groundwater level of this model were evaluated using evaluation criteria. The results of the analysis of groundwater hydrographs showed that the increase of precipitation especially in the current water year had a significant effect on groundwater resources. The results of the evaluation criterion also showed that the wavelet neural network model has high accuracy and low error in estimating groundwater level and has high capability to estimate some minimum, maximum and intermediate values compared to the artificial neural network.

In sum, this study shows that the use of a wavelet neural network model can be effective in estimating groundwater levels. And it can also be useful in facilitating the development and implementation of groundwater management strategies. And it is a step in making management decisions to improve groundwater levels in watersheds.

Evaluation of the Relationship between Natural Factors and Subsidence in Ivanaki Plain Using Radar Imaging

Document Type: Technical note

Maesomeh Asadi[1]; Hamid Ganjaeian*[2]; Mahnaz Javedani[3]; Mahdyeh Ghaderi Hasab[4]

1- Faculty member, Department of Social Sciences (Geography), Payame Noor University, Tehran, Iran
2- Ph.D. in Geomorphology, Tehran University, Tehran, Iran
3- Ph.D. Studend of Geomorphologhy, Ferdosi University, Mashhad, Iran
4- M.Sc. Hydrogeomorphology, Yazd University, Yazd, Iran
*corresponding author: h.ganjaeian@ut.ac.ir

Abstract

Soil subsidence is one of the dangers facing many Iranian plains. In the meantime, the plains of Semnan province, including the Ivanaki plain, are at risk. Due to the importance of the subject, in this study, the rate of subsidence of Ivanaki plain and its effective factors are analyzed. In this research, the descriptive-analytical method was used. The survey data included radar and satellite imagery, statistical information, and a 30-m digital elevation model. The method is first to evaluate the geomorphology, land use and groundwater status of the Ivanaki Plain, and then, using Sentinel 1 radar image and SBAS time series method, the amount of subsidence is calculated. Surveys show that natural factors, including trends and trends in anomalies, have played a major role in shaping climate and water resource constraints, and restricting access to water causes the excessive use of groundwater and severe surface depletion. The results of calculating the groundwater level in the area show that the average of the study wells falls between 1372 and 1394 years between 0/85 to 2/01 cm per year. Also, the results of the assessment of the area's subsidence indicate that the range of studies over the 3-year period (from 2016/01/06 to 2018/12/21) decreased between -0.9 to -33.2 cm. Most of the subsidence has been in the center of the plain of Ivanaki, near the village of Cheshmeh Nadi.

Keywords: Groundwater, Ivanaki, SBAS, Subsidence.

Introduction

Earth subsidence is a slow, subtle phenomenon or sudden subsidence of the earth's surface due to the displacement of soil particles. This phenomenon can occur due to tectonic or anthropogenic factors and is a major cause of subsidence in arid and semi-arid regions, groundwater density and overexploitation. Subsidence is associated with many hazards, such as the creation of potholes, failure and abandonment of buildings, tilting of high altitudes, damage to agricultural installations, breakdown and demolition of bridges and roads and urban passages and networks. This phenomenon is present in most plains of the world along with its environmental consequences. In recent years, this phenomenon has been the subject of much attention in Iran due to the overuse of groundwater. One of the areas that have been experiencing a sharp drop in groundwater levels in recent years is the Ivanaki plain in western Semnan province. In fact, the low rainfall and the lack of sufficient surface waters in the area have led to the overuse of groundwater aquifers, leading to lower water levels in the Ivanaki Plateau and subsequent subsidence. Due to the importance of the subject, in this study, the rate of land subsidence in the Ivanaki Plain has been investigated from 2016/01/06 to 2018/12/21.

Materials and methods

In this study, in order to evaluate the sedimentation rate of the Ivanaki Plain and analyze the role of factors affecting it from statistical information (Information on the level of water drop; observation well in Ivanaki Plain), Radar images (Sentinel-1 radar images with VV polarization), Landsat 8 satellite images as well as the 30 m height model have been used, which has been performed in several steps

after providing the required information. The method of doing this is to study the geomorphology of the area first and then evaluate the impact of geomorphology and climatic factors on the type of land use. In addition, the impact of land use on groundwater levels has increased. After evaluating groundwater level status, using Sentinel -1 radar images and SBAS time series method, the rate of sedimentation of the Ivanaki plain was calculated from 2016/01/06 to 2018/12/21.

Discussion of results

The Ivanaki Plain is about 3 m high on the southern slopes of Alborz. The plains on the southern slopes of Alborz have caused much lower rainfall than the national average and in addition, the evaporation rate is high in the area, which has led to the expansion of evaporative soils and the fertility of the area. Depending on the geomorphological and climatic conditions of the area, its uses have been shaped. The northern and southern parts of the study area are devoid of vegetation due to the presence of moorland and sand dunes. Also, parts of the southern areas adjacent to the seasonal rivers of the region have poor and scattered vegetation. The limited water resources and fertile areas have led to the concentration of agricultural land in the central areas of the Ivanaki Plain, which has caused a severe drop in water levels. Based on the calculations, the average study wells fall between 1373 and 1394 years, between 0/85 to 2/01 cm per year. In line with the sharp drop in groundwater levels in the study area, the results of the assessments indicate that the study area over the 3-year period (from 2016/01/06 to 2018/12/21) ranged between 0/9 to -33/2 the centimetre has dropped.

Conclusions

Groundwater loss in different regions has been affected by various geological, climatic and geomorphological factors. Evaluation of the results indicates that tectonic, geomorphological and climatic factors have played an important role in the subsidence of the region. In fact, under the influence of tectonic factors, the trend and direction of the roughness of the region are formed. Trend and direction of unevenness in the climatic conditions and lack of rainfall has played a major role and the lack of precipitation and high evaporation has led to the development of evaporative and highland areas in the region. Due to the aforementioned natural factors, access to water and soil resources has been severely restricted and the scarcity of surface water resources has led to the overuse of groundwater. Given these factors, natural factors and agricultural land development, regardless of the region's potential, have caused groundwater levels to decline in recent years. The results of calculating the groundwater level in the area show that the average study wells fall between 1372 and 1394 years. It has been up to 0/85 to 2/01 cm/year which is a significant figure. Also, the results of the assessment of the area's subsidence indicate that the range of studies over the 2-year period (from 2016/01/06 to 2018/12/21) decreased between -0.9 to -33.2 cm. The survey of the region's subsidence map indicates that the highest amount of subsidence was in the center of the Ivanaki Plain near Cheshmeh Nadi village, and the marginal areas of the plain and altitudes had the lowest subsidence.

Evaluation of different options of inter-basin water transfer system using multivariate decision making method (Case study: Beheshtabad water transfer project)

Document Type: Research Paper

Efat Zamani*[1], Saeed Givechi[2]

1- Expert of Iran Water Resources Management Company, Tehran, Iran
2- Associated Professor, Environmental Management and Education Planning, Faculty of Environment, University of Tehran, Tehran, Iran
*Corresponding Author: efatzamani@gmail.com

Abstract

The increasing water resources demand various purposes, such as agriculture, drinking and industry, has faced many difficulties and limitations in achieving programmable water. In recent years, inter-basin water transfer is inevitable due to an increase in population cities and inappropriate spatial water resources distribution and is regarded as one of solving ways of water shortage issues. Regarding the complexity of the inter-basin water transfer projects caused by various factors of getting involved such as environmental issues, right of water and water balance, social cautions and immigration, the decision-making about water transfer and inter-basin water transfer effects is very important. Despite the existence of various multivariate decision-making approaches, still, these methods have not been applied in an appropriate way in national executive and infrastructure projects like inter-basin water transfer. One of the inter-basin water transfer infrastructure projects is water transfer from Charmahal_O-_Bakhtiari province to Iran's central plateau called the Beheshtabad project. In the present research, 3 recommended options of the Beheshtabad water transfer project considering 14 quantity and quality criteria using pairwise comparisons questionnaires, expert knowledge was ranked using analytical heretical process method that is a multivariate decision-making approach and the best option was identified for water transfer. Results showed that current and capital cost criteria were identified as the most important criteria and reservoir geological issues criteria were identified as the less important criterion. Also, the sensitivity analysis of the studied criteria was assessed using a change in the weight of each criterion. The results of this study could present a simple way to mythological usage of inter-basin water transfer projects especially in some cases where there is no clear vision of hazards and consequences.

Keywords: Integrate water resource management, Sustainable development, Water supply, Water transfer, Zayanderud.

Introduction

In recent years, inter-basin water transfer is inevitable due to an increase in population cities and inappropriate spatial water resources distribution and is regarded as one of solving ways of water shortage issues. Regarding the complexity of these projects caused by various factors of getting involved such as environmental issues, right of water and water balance, social cautions and immigration, the decision-making about the water transfer and inter-basin the water transfer effects is very important.

Inter-basin water transfer might extend regional and international debates on water crisis due to environmental, social and economic issues. Therefore, inter-basin water transfer could be effective in the balance between water supply and water consumption especially in arid and semiarid regions if the project is eco-friendly and cost-effective.

At the moment, there are many inter-basins the water transfer projects which are in progress or finished. In Iran, also there are many in progress or finished water transfer projects. The number of in

progress and finished projects in Iran demonstrated that water resources managers have special attention to inter-basin water transfer. Therefore, it could be concluded that water policy is based on meet water supply management while it is better to be based on water demand management.

Based on a literature review on various political, security, social, cultural, economic and environmental dimensions, the negative and positive effects of the water transfer in inter-basins could be assessed. Proponents and critics of the water transfer projects most focus on the negative consequences of environmental. From a social and political viewpoint, the inter-basin water transfer has positive outcomes that could be leading to an increase in social capital and avoid debates. Therefore, the water transfer could be the origin of many changes in origin and destination basins that should be assessed by different viewpoints and considering technical, economic and environmental aspects and emphasis on the social and political assumptions. Therefore, the water transfer project is feasible when technical ability and also environmental evaluation were confirmed.

The comprehensive water resources management needs to investigate the various options while in the Beheshtabad project just one option for the water transfer was considered and other options were not investigated. So, the only proposed option was constructing the reservoir Beheshtabad dam in the ShahreBagh Baharoran area. Based on a different study, the main criticism of Beheshtabad the water transfer project about the water transfer estimation is that upper estimate calculation occurred in the water transfer project. First, the 1100 million cubic meters was raised and the 746 million cubic meter.

Most research about the Beheshtabad water transfer project emphasis on the simulation or simulation-optimization models. Simulation models provide a comparison between different options while they cannot present the best option. Therefore, the application of multivariate decision-making methods like the analytical Hierarchical process in the present study is a helpful one. Hence, it seems that the evaluation of different options and also other potential proposed options could be considered for researchers, decision-makers and experts that is the main aim of the present study.

In the present study, after selecting effective criteria and appropriate with the aim of the research and then weighting them with water resources expert viewpoint, the value of every criterion in each scenario was identified and thereby multivariate decision-making matrix was formed. Finally, the analytical Hierarchical process method was used and the quality and quantity criterion was ranked to identify the best option for the water transfer.

Materials and methods

Despite the existence of various multivariate decision-making approaches, still, these methods have not been applied in an appropriate way in national executive and infrastructure projects like inter-basin water transfer. One of inter-basin the water transfer infrastructure projects is the water transfer from Charmahal_O-_Bakhtiari province to Iran central plateau called the Beheshtabad project.

Inter-basin water transfer is transferring physically water from a basin to another basin that one of them loses water and other one gains water. In the Beheshtabad water transfer project, Beheshtabad and Kohrang basins are the origin basin. The Beheshtabad basin is located in North-West of Charmahal_O-_Bakhtiari province and the total area is about 3880/9 square kilometres. The groundwater potential in Beheshtabad and Kohrang basin is about 893 and 636 million cubic meters in a year and about 433 and 2 million cubic meters come from wells, respectively. Also, 55.8 and 0/82 million cubic meters' extract from spring, respectively. Qanat's potential discharge is about 402 and 633 million cubic meters, respectively for Beheshtabad and Kohrang basins.

In this research, on the basis of the problem's nature, decision-making criteria were identified. The applied criteria in water resources researches return to benefit to cost ratio calculation. The employment factor is another key factor that could have an important role in the selection of the best project. Also, regrading to welcome people and their satisfaction from executing the project, this criterion was also very important. The main decision-making criteria were identified based on investigating different sources. 14 studied criteria were assessed independently in the decision-making matrix including:

Land acquisition; Induction earthquake; Migration; Water quality depletion and pollution of water resources; Springs and Wells; Dam Geology Problems; Reservoir Geology Problems; Transmission Line Problems; Current Costs; Capital Costs; Production Energy; Consumption Energy; Ease of Use; Duration of project implementation.

The decision matrix was formed by determining the values of each criterion for each option. In the second case, the sub-criteria were defined and each criterion was subdivided into several sub-criteria. Then, the model is developed by matrix along with the sub-criteria. The following criteria were defined as follows:

Social: Including 3 subgroups of land acquisition, earthquake induction and migration;

Environment: Includes 2 subgroups of water quality depletion and contamination of water resources and drying of wells and springs;

Geological and Executive Problems: Includes 3 subgroups of dam geology problems, reservoir geology problems, and transmission line implementation problems;

Economic: Includes 4 subcategories of the current cost, capital cost, energy consumption and produce energy;

Ease of operation;

Duration of project implementation.

Results and Discussion

In the present research, 3 recommended options of the Beheshtabad water transfer project considering 14 quantity and quality criteria using pairwise comparisons questionnaires, expert knowledge was ranked using analytical Hierarchical process method that is a multivariate decision-making approach and the best option was identified for the water transfer.

Given the theoretical basis of the hierarchical analysis method, the criteria based on the objective and the sub-criteria should be compared qualitatively or quantitatively with each other. Expert choice software is a multivariate decision-making tool based on the hierarchical analysis process that applies in a variety of ways including resource allocation, option selection, analytical planning, profit and cost analysis, performance management and production. Given its ability to design hierarchical graphs, decision making, and final weight calculation was used in the present study. The second state decision matrix was also formed by studying the options and determining the values of each criterion for each option. In this study, three water transfer options were investigated that provided information at the initial identification stage and estimated costs based on the same year interval.

First case

Results showed that options 1 and 7 ranked first and last, respectively. Model sensitivity analysis showed that the model is more sensitive (14.28%) to the reduction of the current cost criterion than other criteria and it had a sensitivity of 20% and 40% (14.28%) for reduced values. However, no sensitivity to incremental values was created in the ranking of options. The results also showed that in the applied model in this study only the middle, third and fourth ranks have changed but the first two and the last three have not changed.

Second Case

In general, social and economic criteria are the most sensitive criteria (28.5%) and then the criterion for sensitive geological problems. Increasing other criteria weight has no effect on ranking. It can also be identified that the criterion of ease of operation and detail execution time of the most sensitive criterion (28.5%) to decrease the weight of criteria and then the environmental benchmark is sensitive. Other weights decreasing of criteria do not change the ranking of options. Overall, it can be stated that the highest sensitivity (42.8%) was in the incremental and the decreasing values of 40% of the criteria weight.

Conclusions

Evaluation of national inter-basin the water transfer infrastructure projects effects regarding extensive and variety of hydrological, social and environmental criteria is very complex. In the present study, a multivariate decision-making method was used to evaluate different options of the water transfer from Charmahal_O-_Bakhtiari province to Iran's central plateau. Results showed that current and capital cost criteria were identified as the most important criteria and reservoir geological issues criteria were identified as the less important criterion. Also, the sensitivity analysis of the studied criteria was assessed using a change in the weight of each criterion. Overall, results demonstrated that the first option that transfers water via pipeline from Beheshtabad Tang to Saman Gardane and then adjoins to Zayanderud River was selected as the best option and also excavating a 65 kilometres tunnel called Beheshtabad tunnel was selected as the worst option because of the high depth of the tunnel, long tunnel path, and upper estimate assumptions in the water transfer calculation that are the faults of proposed option. Also, based on hydrogeological features of the study area, transfer water via tunnel act as drainage and consequently drying various spring and qanats in this region. The results of this study could present a simple way to mythological usage of inter-basin water transfer projects especially in some cases where there is no clear vision of hazards and consequences.

Grout curtain effect on downstream groundwater geochemistry at Daryan earth dam of Kermanshah

Document Type: Research Paper

Sara Ramazanpour[1], Mohammad Fathollahy[2*], Mehdi Kord[3], Kamal Ganjalipour[4]

1- M.Sc. of Hydrogeochemistry, Department of earth science, University of Kurdistan, Kurdistan, Iran
2- Assistant professor of Engineering geology, Department of earth science, University of Kurdistan, Kurdistan, Iran
3- Assistant professor of Hydrogeology, Department of earth science, University of Kurdistan, Kurdistan, Iran
4- Ph.D. of Engineering geology, Mahab Ghods Company, Tehran, Iran

* Corresponding Author: m.fathollahy@uok.ac.ir

Abstract

A grout curtain is constructed beneath the dam foundation to control water seepage. Cement is used to execute the grout curtain and to extend until it reaches impermeable bedrock. Grout curtain will mostly reach groundwater, too. The reaction between cement and water caused the cement compound to enter groundwater and changes its quality. The extent of change and its continuity is important so that it needs to be studied and investigated over time. In this research, the change of water quality has been studied by comparison of water test analysis during 4 years. For this purpose, four phases of water samples including site springs samples before any disturbance (first phase, 1392), after cement grout and before impoundment (second phase,1394), and also two phases samples after impoundment (third phase,1395 and fourth phase,1396) with one-year interval were examined. Samples of the second, third and fourth phases were taken from observation wells which are located downstream of the grout curtain. Therefore, it is expected to see the effects of cement entry in the groundwater flow through the curtain to the observation wells. In this study after categorizing the achieved data, using SURFER and GIS software, different parameters were interpolated in different periods and compared by the production of zoned maps, and the degree of variation of different elements was investigated. Diagrams and maps show that pH, SiO2, Na, K, Fe, CaCO3, SO4 and EC have been significantly changed which indicates that cement compounds have been entered into the groundwater and have decreased the water quality.

Keywords: Dam, Groundwater, Grout curtain, Hydrogeochemistry.

Introduction

A grout curtain is constructed beneath the dam foundation to control water seepage. Cement is used to construct the grout curtain which extended until reaches impermeable bedrock. Grout curtain will mostly reach groundwater, too. The reaction between grout cement and water caused the cement compound to enter groundwater and changes its quality. The extent of change and its continuity is important that needs to be studied and investigated over time. In this research, the change of water quality has been studied by comparison of water quality during 4 years.

Materials and Methods

For this purpose, four series of water samples including site springs samples before dam construction (first phase, 2013), after cement grout and before impoundment (second phase, 2015), and also two phases samples after impoundment (third phase, 2016 and fourth phase, 2017) with one-year interval were examined. Samples of the second, third and fourth phases were taken from observation wells which are located downstream of the grout curtain.

After categorizing the achieved data, using SURFER and GIS softwares, different parameters were interpolated in different periods and compared by the production of zoned maps and statistics analysis using SPSS software, and the degree of variation of different elements were investigated.

Diagrams and maps show that pH, SiO2, Na, K, Fe, CaCO3, SO4, Cl and TDS have been significantly changed due to the entry of cement compounds into groundwater. Some parameters such

as EC, pH and temperature have been measured in-situ and another parameter was obtained according to standard methods in the laboratory.

Discussion

With the addition of cement to water, the environment changes from neutral to alkaline. In the analyzed samples, pH values from 7.5 in the original sample to above 9 were observed in some boreholes. Increasing this parameter from the first to the third series shows an increasing trend. The rate of increase in pH in the fourth series in some cases shows a constant and decreasing state. The sampling interval between the third and fourth series samples is one year, and this indicates that the tendency of cement compounds to enter the water has decreased and is diluting and leaving the environment. Test results show the amount of SiO2 increases with the grout of cement slurry into the ground. This value is almost constant in stages two, three and four, although it shows some increase in the fourth series because of increasing the water level by ten meters. In the fourth series samples, low-level boreholes show less of this parameter, which means that the existing water flow, is removing SiO2 from the environment. Cement grout has increased sulfate. In the third and fourth series, with the dam water impoundment and more groundwater flow, the amount of sulfate shows a decreasing trend and moves away from the environment.

Test results indicate before the operation, due to low groundwater flow, the environment does not increase Na and K cation, but in the levels near the riverbed downstream due to the presence of water flow, its effect can be seen. In the fourth series after the operation, due to the increase in groundwater flow in the environment, this element has entered the environment and its amount has increased. Fe is also one of the elements that can be seen in the basic compositions of cement. This parameter is not measured in the original sample to be compared with the samples of subsequent series, but the generated maps show the effects of the presence of this element in relative terms. In the second series, the medium mainly has a small amount of iron and after operation by increasing the water flow in the third series, its amount in the diffusion medium and then the amount decreases and is leaving the environment.

According to the initial composition of cement, calcium carbonate is one of the parameters that can enter the environment and increase the hardness of the water. Based on the available results, before operation calcium carbonate is relatively lower than in operation. In the third series of samples, the value of this parameter increases in the environment and in stage 4, its value shows a decreasing trend, with these results, we can expect its value to decrease over time.

Electrical conductivity is a function of factors such as solute concentration and temperature. As mentioned, over time, various parameters in piezometers have changed, so electrical conductivity is no exception. Based on the available results, the electrical conductivity before the operation is relatively less than the series after the operation. In the second series, which was analyzed immediately after cement grout, the electrical conductivity increased, indicating an increase in solutes in the boreholes. In subsequent series as the hydraulic gradient increases, the solutes in the medium is diluted.

Conclusions

Briefly, the results showed that by disturbing the natural environment of the site, the geochemical properties of the environment would change. In this study, hydrogeochemical properties were used to illustrate the trend of these changes. Changes occur depending on the type of material added to the environment, and groundwater flow. In the construction of grout curtains, the cement composition changes the quality of downstream groundwater. The following changes were achieved by examining:

- The pH ranges from 7.17 in the first phase to 8.49 (mean of the third phase). This indicates that the water has changed from neutral to alkaline and so that the groundwater downstream is non-drinkable.
- SiO_2 has changed from about zero in the first phase to an average of 15 mg/L in the fourth phase.

- SO_4 has changed from 3.4 in the first phase to an average of 35.34 mg/L in the second phase.
- K varied from 0.2 in the first phase to about 57 mg/L in the fourth phase.
- Na has varied from 0.6 in the first phase to about 43 mg/L in the fourth phase.
- The amount of iron in the first phase has not been measured, but it is different in the second, third and fourth phase samples due to its presence in cement compounds.
- Calcium carbonate varied from 108 in the first phase to 159 mg/L in the third phase.

Investigation of hydrogeochemical properties of spring water associated with travertines in Maku Area and determination of the source of water springs based on geochemistry and mineralogy of sediments and their surrounding deposits

Document Type: Research Paper

Nosrat Aghazadeh[*1], Yasser Golestan[2]

1- Assistant Professor, Department of Civil Engineering, Urmia Branch, Islamic Azad University, Urmia, Iran
2- M.Sc. in Geology, Department of Geology, Urmia Branch, Islamic Azad University, Urmia, Iran
*Corresponding Author: nosrataghazadeh@yahoo.com

Abstract

In the aquifers of hard rock, spring water is a good indicator for evaluating the interaction of rock water and water level changes. Maku area is located in West Azarbaijan province in northwestern Iran. Supplying part of the water needed for agriculture in the region through travertine-maker springs, the role of these springs in the travertine deposition process and the effect of the chemical composition of the waters on the travertine discoloration has made the study of hydrogeochemical properties of springs in the study area important. Thus, in this research, the assessment of hydrogeochemical characteristics, chemical composition and the water origin of springs were evaluated by water sampling, sediment deposits and rock units around the springs. The results of hydrogeochemical diagrams, ionic ratios and saturation index showed that the reservoir of the aquifer is impure limestone and the water of springs is saturated to supersaturated with respect to carbonate minerals and undersaturated for sulfate minerals and chemical type mainly is Ca- HCO_3. The high pressure of carbon dioxide and its removal from the water composition of the springs has caused the limestone springs of the region to have a high deposition ability and formation of Fissure-ridge and vein-type travertine with relatively high height and expansion. The results of geochemical analysis of the elements in the composition of sediments around the springs show that the correlation between CaO and Al_2O_3, SiO_2, TiO_2, Fe_2O_3 is negative, also the correlation between CaO and Ba and Sr is positive and also the correlation between SiO_2 and Fe_2O_3 and Al_2O_3, is positive, therefore, the water source of the spring can be considered mostly thermogenic.

Keywords: Geochemistry, Hydrogeochemical, Maku, Spring, Travertine.

Introduction

The water chemistry of the springs reflects the interaction of groundwater on the rocks of the infiltration and outflow of water from the aquifer. Mineral dissolution, water-rock interaction, residence time, temperature, evaporation and activity of microorganisms are the most important parameters affecting the hydrogeochemical properties of springs. The water origin of limestone springs white around travertine deposition is mainly meteogenic or thermogenic. In waters of meteogenic origin, the amount of TDS and the concentration of most ions are low and the main ions are bicarbonate and calcium. The source of thermogenic water is mainly atmospheric water that has penetrated deep and heated, but in addition to this source, connate water, magmatic water and metamorphic water can also be the source of thermogenic water.

The study area is located in West Azerbaijan province and northwestern Iran. In the study area, limestone springs with cold and sometimes hot water have an outlook along with extensive deposits of travertine. These springs are the result of the activity of recent active springs or older springs that have now dried up. These springs and travertine deposits are mainly located in the extended of faults with NW-SE and N-S trend. Supplying part of the water needed for agriculture in the region through travertine-maker springs, the role of these springs in the travertine deposition process and the effect of the chemical composition of the waters on the travertine discoloration has made the study of

hydrogeochemical properties of springs in the study area important. Thus, in this research, the assessment of hydrogeochemical characteristics, chemical composition and the water origin of springs were evaluated by water sampling, sediment deposits and rock units around the springs.

Materials and methods

In this study, in order to investigate the hydrogeochemical characteristics of springs, 14 samples from hot and cold springs were collected in August 2016. Temperature, EC and pH were measured on-site by the portable conductivity meter. The main cations and anions of water are analyzed by titration (for Ca, HCO3 and Cl), flame photometer (for Na and K), spectrophotometry (for SO4 and F) methods and calculation Mg and TDS based on other ions. To study the geochemistry of sediments and deposits around springs, 6 samples of sediment around springs were prepared and sent to the laboratory for analysis and determination of elements in their composition by the ICP-MS method. Also, to study the mineralogy and petrography of travertines around the springs, 23 stone samples were taken and a thin microscopic section was prepared from them.

Based on the results of sample analysis, the hydrogeochemical properties of spring water were evaluated by studying the concentration of ions and their changes, ion ratios, and the calculation of saturation index for different minerals. To evaluate hydrochemical characteristics and calculate mineral saturation indices, were used PHREEQC software. In order to investigate the solubility and aggressiveness of spring water, the partial pressure of carbon dioxide (PCO2) in spring water was calculated through Equation 1.

$$SI = CO2(eq) - CO2(free) \quad (1)$$

In this equation, SI is the index of water saturation relative to carbon dioxide in mg / L, CO2(eq) is equilibrium carbon dioxide in mg / L and CO2(free) is free carbon dioxide obtained from the Halopo-Duben diagram in mg / L. For SI values greater than zero, the spring has a travertine potential, less than zero, the spring has no travertine potential, and if the SI is zero, the spring water is considered chemically stable.

Results and Discussion

The temperature range of hot springs in the region is between 30 to 58 °C, cold water springs are between 11 to 20 °C. Based on the results of water sample analysis, calcium ion in the composition of spring water varies between 18 to 208 mg / l and in important limestone springs its amount is 200 mg / l. Magnesium concentrations vary between 7 and 169 mg / L.The molar ratio of Ca / Mg in the water composition of the springs varies between 0.1 to 4.5. Based on the values obtained from this ratio, the reservoir rock is limestone. In travertine springs in Shut, Margenler, Hindu and other areas, this ratio is less than 1, which indicates the release of free carbon dioxide from the solution and sedimentation process in water, which has led to the formation of calcite, aragonite or travertine.

The bicarbonate ion is the main anion in the water composition of springs in the study area, the amount of which varies between 195 to 2153 with an average of 878 mg / l. The amount of this ion in the water of springs in the Shutt and Margenler area is more than in other areas, which is due to the dissolution effect of carbonate units. The anionic and cationic frequencies of most springs are mainly as follows. r HCO3- >r Cl-> rSO4 , rCa >rMg> r Na >r K.

The source of water from limestone springs around which travertine sediments settle is mainly meteogenic (atmospheric) or thermogenic. Comparison of the results obtained in this study with the results of different types of travertine water in different parts of the world based on the parameters of T, pH, DIC, PCO2, Ca, Mg, Mg / Ca, shows that all the hot springs, as well as most of the cold water springs in the study area, are compatible with methogenic waters and in some samples with thermogenic waters.

The water-rock interaction and the effect of lithology on the hydrochemistry of springs water can be determined by calculating the saturation index(SI) of minerals. The results of calculating the saturation index for different minerals showed that the value of this index for calcite minerals varies

between 0.07 to 2.13, dolomite 0.02 to 4.2, and aragonite -0.7 to 1.99. Base on these results, the springs are saturated to supersaturate for carbonate minerals. The supersaturation of spring water concerning these minerals suggested diminution of Ca, Mg, K content due to the precipitation of their minerals in the groundwater system. The IS value of Gypsum and Halite, minerals is under zero. So that springs are undersaturated with respect to these minerals suggesting that their soluble component Na, Cl, and SO4 concentrations are not in mineral equilibrium. Hence, ion exchange, mineral precipitation and dissolution are important hydrochemical possess that control the spring water quality.

According to field studies, travertine deposits in the Mako region are mainly Fissure-Ridges type. Travertine ridges in the study area, like other regions in the northwest of the Iran have high elevation and relatively high expansion. Their high elevation indicates the intensity of the travertine deposition process and consequently the intensity of tectonic activity in the present. In travertine rocks around active or dried springs, can be seen structures such as hollow construction, pattern wave construction, strip construction, strip-wave construction.

In most travertines in the study area, the porosity is of the type controlled by the fabric. The most important of these porosities is between crystalline, phenstral and cavities. The results of microscopic thin sections prepared from travertines showed that the fabric was mainly micrite and in some places, sparite cement was grown in empty space.

The results of the chemical analysis of sediments around the springs show that most of the elements are present in the composition of travertines. Comparison of element values with the different types of travertines in the world (e.g. Pamokal in Turkey, Japanese misotomy and Thermis Giovanni in Italy, Northeast of Iran, Egypt, Northeast of Spain, West China and Northwest of Iran) shows that the amounts of elements in the composition of travertines in the region conformity with thermogenic travertines type. Studies show that there is almost a negative correlation between calcium oxide with aluminum, silica, titanium and iron oxides. There is a positive correlation between calcium oxide with barium and strontium.

The high amount of barium in the sediments around the springs indicates their relationship with igneous sources and groundwater associated with these sources. The high levels of copper and zinc confirm the possible thermogenic of travertine deposits.

Conclusions

The results of hydrogeochemical diagrams, ionic ratios and saturation index showed that the reservoir of the aquifer is impure limestone and the water of springs is saturated to supersaturated with respect to carbonate minerals and undersaturated with respect to sulfate minerals and chemical type mainly is Ca- HCO3. The high pressure of carbon dioxide and its removal from the water composition of the springs has caused the limestone springs of the region to have a high deposition ability and formation of Fissure-ridge and vein-type travertine with relatively high height and expansion. The results of geochemical analysis of the elements in the composition of sediments around the springs show that the correlation between CaO and Al2O3, SiO2, TiO2, Fe2O3 is negative, also the correlation between CaO and Ba and Sr is positive and also the correlation between SiO2 and Fe2O3 and Al2O3, is positive, therefore, the water source of the spring can be considered mostly thermogenic.

Estimation of Groundwater Variations using Optimized Gene Expression Programming model

Document Type: Research Paper

Ehsan Azizi[1], Ahmad Rajabi[2*], Behrouz Yaghoubi[3], Saeid Shabanlou[4]

1- Ph.D. Candidate, Department of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran.
2- Assistance Professor, Depatment of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
3- Assistance Professor, Depatment of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
4- Associate Professor, Department of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
*Corresponding Author: ahmad.rajabi1974@gmail.com

Abstract

Groundwater plays a vital role in supplying water demands for different consumptions in dry and semi-dry regions of earth. Iran is considered as an arid and semi-arid region and its groundwater resources have recently shown some significant changes. Owing to the reduction of groundwater resources and recent droughts, simulation of groundwater level variations has significant importance. In some areas of the country of Iran, groundwater levels have been dropped significantly. Therefore, the prediction and simulation of the groundwater level variation are crucially important. In this study, the Gene Expression Programming (GEP) model was combined with Wavelet Transform (WT) to estimate long-term variations of groundwater level (GWL) in the Sarab-Ghanbar observation well over a 13-years period. Firstly, observation data were divided into two sub-samples, 9 years for training and 4 years for testing. Then, the most effective input lags were identified using the autocorrelation function. Next, four different models for each GEP and WGEP method were developed using the lags. The superior model was identified by analyzing all GEP and WGEP models. The superior GEP model simulated the GWL with acceptable accuracy. For instance, the correlation coefficient and Nash-Sutcliffe efficiency coefficient for the model were calculated at 0.938 and 0.851, respectively. A comparison between the GEP and WGEP models showed that the wavelet transforms enhanced the performance of simulation significantly. For example, Variance Accounted For (VAF) index for the best WGEP model was 14 times more than the best GEP model. In addition, the sensitivity analysis indicated that (t-1), (t-2), (t-3) and (t-4) lags were the most influenced input lags.

Keywords: Effective lags, Groundwater aquifer, Simulation, Time series data, Wavelet transform.

Introduction

Groundwater plays a vital role in supplying water demands for different consumptions in dry and semi-dry regions of the earth. In addition, the country of Iran is considered as the arid and semi-arid region in the world where its groundwater resources have recently undergone some significant changes. Owing to the reduction of groundwater resources and recent droughts, simulation of groundwater level variations has significant importance. In some areas of the country of Iran, groundwater levels have been dropped significantly. Therefore, the prediction and simulation of the groundwater level variation are crucially important. Moreover, different numerical models such as artificial intelligence (AI) algorithms and soft computations (SC) techniques have been applied by numerous researchers to modeling this problem.

Materials and methods

In this study, the gene expression programming (GEP) model was combined with wavelet transform (WT) to estimate long-term variations of groundwater level (GWL) in the Sarab-Ghanbar observation well over a 13 years period.

Gene expression programming (GEP) is an evolutionary artificial intelligence method. The basic difference between GEP, the genetic algorithm (GA) and genetic programming is in the nature of individuals. In GA, individuals are as strings with fixed length (chromosomes) and in the Genetic programming, individuals have different shapes and sizes (decomposition tree). However, in GEP, individuals are as linear strings with fixed lengths (chromosomes) which express non-linear nature and various sizes. In fact, GEP used the advantages of both GA and genetic programming simultaneously. GEP employs chromosomes and expression trees which are provided as programs. Chromosomes are usually a combination of genes of the same size and programs provide coded genetic data in chromosomes. GEP is a phenotype/genotype system whose genotype and phenotype are completely separate from each other. In this method, linear chromosomes and expression trees represent phenotype and genotype, respectively. The process of data decoding from chromosomes to expression trees which are known as "translation" consists of a set of rules. These rules are related to the organization of functions and terminals in expression trees and indicate the connection between different sub-expression trees (Sub-ETs). In order to create chromosomes and genes, the terminal set (TS) and the function set (FS) should be defined. FS consists of various signs such as FS={+, -, ×, /, √}. TS is composed of different components which represent different variables and fixed values (for example {a, b, c, 0, 1, 2}). Genes used in GEP contain two types of different information. The first type includes data which are used to provide the GEP model and are stored in the head, while the second type consists of terminals which are stored in the tail and employed for generating the next models.

FS should be determined for each non-linear problem. FS is the evolutionary nature in the GEP model so that allows unlimited changes in a gene or among different genes in a chromosome. Firstly, GEP creates a random distribution of functions and terminals in chromosomes genes regarding the interesting problem. Initial individuals generated randomly are called “parents”. These parents are produced to create offspring using genetic operators. In order to create new offspring adapted to the environment and more chances to survive, each individual benefits from its genetic information. In the evolutionary process of a function, the natural selection procedure is based on the fitness of relationships related to offspring producing less error. Hence, GEP benefits from an evolutionary process for reaching the best offspring without evolution stopping in the next generations.

The study area in this study is located in the Sarab-Qanbar area south of Kermanshah. Sarab-Qanbar has a warm and temperate climate. Sarab-Qanbar has a warm and moderate climate. The geographic coordinates of this area are 34.2870° N, 47.0547° E. In this study, the observational well located within the region is utilized for verifying the artificial intelligence models. Throughout the northern and eastern margin and part of the northwestern region of this plain is covered with Karstic limestone, which is mostly Karstic. The southern and southern parts of the East and in the northwestern part are restricted to altitudes that have different faces and include igneous sediments in the southeast, and siliciclastic and radiolarite in the south. Geologically, the study area is two parts of the Zagros zone and crushed zone. These two parts together with the Khuzestan Plain constitute the entire Zagros structure. The oldest unit of stone around the Miandarband plain belongs to the Jurassic. Due to this, the thickness, type and gravity of alluvium in this plain are different at different points. In this plain, groundwater is in alluvial with the thickness of 50-200 m, most of which are from silicate clay, fine and coarse sand, and rug. In general, the foothills and the plains are composed of large coarse aggregates causing good permeability in these areas. The bedrock Kermanshah plain is formed of radiolarite rocks. In the plain of Kermanshah, there are free and artesian aquifers and reservoirs of groundwater in this area are formed in alluvial deposits of the fourth period, which are the result of erosion of the marginal heights of the plain. The constituents of sediments are in the range of water table include cobblestone, gravel, sand, silt and clay. The main recharge source of the existing groundwater table, irrespective of the atmospheric precipitation on the plain, is a number of streams that originate from the range of adjacent heights and enter the area of the plain, as well as the presence of abundant springs, which are mainly karstic. Also, the transmissivity of groundwater table in different areas of the study area is different, so that in the margin of the table due to steep slope and low viscosity of alluvium is about 500 square

meters per day and even less, and in the central areas to a maximum of 10,000 square meters per day. The observational values were used monthly in a 13 year period from 2002 to 2015. The groundwater level variations in this region were evaluated for 13 water years and based on the results it was concluded that the groundwater level variations in the plain have a decreasing trend so that during these 13 years about 5.77m drawdowns has been measured in the aquifer. The mentioned drawdown is due to the recent droughts and also increasing withdrawal amount. The observational data were used in the form of the time-series data for 156 consecutive months. Firstly, observation data were divided into two sub-samples, 9 years for training and 4 years for testing.

Then, the most effective input lags were identified by means of the autocorrelation function (ACF). This means that after the classification of the data and determination of the training data, the influence of different time lags and their direction and correlation level with each other should be evaluated. Thus, different time lags are examined by the ACF. Next, four different models for each GEP and WGEP method were developed using the identified lags. After the determination of the samples used for training the model and also an examination of different input combinations, the type of the wavelet function and its decomposition level must be specified. The type of time series and nature of the interesting event (groundwater level) are the basic points in choosing the mother wavelet. In fact, the wavelet function must be chosen so that to be geometrically well-matched to the curve of the interesting time series to perform the mapping operation with higher ability. The wavelet functions used in this study are dmey, bior, coif, sym, haar and db.

In the current study, in order to evaluate the accuracy of the introduced numerical models, the correlation coefficient (R), variance account for (VAF), Root Mean Squared Error (RMSE), Scatter Index (SI), Mean Absolute Relative Error (MARE) and Nash-Sutcliffe efficiency coefficient (NSC) are used.

Results and Discussion

The superior model was identified by analyzing all GEP and WGEP models. The superior GEP model simulated the GWL with acceptable accuracy. For instance, the correlation coefficient and Nash-Sutcliffe efficiency coefficient for the model were calculated at 0.938 and 0.851, respectively. A comparison between the GEP and WGEP models showed that the wavelet transforms enhanced the performance of simulation significantly. For example, Variance Accounted For (VAF) for the best WGEP model was 14 times more than the best GEP model. In addition, the sensitivity analysis indicated that (t-1), (t-2), (t-3) and (t-4) lags were the most influenced input lags.

Conclusions

Due to the importance of groundwater resources as one of the main water supply sources, the estimation and simulation of groundwater level variations in dry and semi-dry regions of the earth like Iran are crucially important. In this research, long-term fluctuations of the groundwater level during a 13 year period within the Sarab-Qanbar observational well located in the city of Kermanshah were simulated by means of the GEP model as well as the WGEP hybrid method. To develop the hybrid model, the GEP model and the wavelet transform were combined. Furthermore, thorough the analysis of the modeling results, the mother wavelet dmey was selected as the most optimal member of the mother wavelets. The results of the simulations exhibited that the wavelet transform improves the accuracy of the GEP model.

Groundwater resources management of Mian-Ab Plain with emphasis on water requirement of agricultural crops using groundwater modeling

Document Type: Research Paper

Seyed Yahya Mirzaee Arjanaki[*1], Pooria Sheikhy Biglari[2], Manouchehr Chitsazan[3]

1- Assistant professor, Department of Geology, Faculty of Earth Science, Shahid Chamran University of Ahvaz, Iran
2- M.Sc. of Hydrogeology, Abatipajooh Consulting Engineering Company, Ahvaz, Iran
3- Professor, Department of Geology, Faculty of Earth Science, Shahid Chamran University of Ahvaz, Iran
*Corresponding Author: Yahyamirzaee@scu.ac.ir

Abstract

Mian- Ab is one of the most important plains in Khouzestan province and the most water demands in this plain is related to the irrigation for agriculture. In this research, the agricultural water requirement was first calculated using Penman- Monteith FAO method due to the necessity of water resources consumptions revision in agricultural field. Then, the numerical groundwater model of the study area was prepared to know about the water balance and consumed water. The model was calibrated from September 2016 to September 2017 in the unsteady state conditions with the 0.94 m of RMSE error. According to the calculations, the actual crop water requirement is 278.89 MCM per year. The model results show that 334.07 MCM of water is used though irrigation network and wells for agricultural purposes. Therefor, 55.27 MCM of water is used more than the actual water needs. Three scenarios were considered for excess consumed water including the transfer of all surplus water to southern lands through the development of irrigation network, decreasing the rate of well pumping and the integrated management of surface and groundwater resources. Applying the discussed scenarios to the numerical model showed that the fist scenario causes drawdown and water logging in the northern and southern parts of the aquifer, respectively. Applying the second scenario will cause a severe water logging in the northern parts of the study area. In the third scenario, the excess consumed water will be managed by decreasing the 8.5 percent of exploitation wells rate (equal to 25.27 MCM) and transferring the remaining water (30 MCM) to the southern lands of study area. Therefore, considering the hydrodynamic conditions of the aquifer and the model results, the third scenario is more desirable for the management of excess consumed water.

Keywords: Groundwater modeling, NETWAT, Water resources management, Water requirement.

Introduction

The water supply needed for crops cultivation is one of the most critical issues in the agricultural sector. In contrast, water resources and access are limited in arid and semi-arid areas. Water resources management in arid and semi-arid regions is critical. Iran is geographically located in the arid and semi-arid belt of the earth. The average annual rainfall in Iran is 250 mm, so the amount of rainfall in Iran is less than one-third of the rainfall in the world. Khouzestan province has an arid and semi-arid climate in most parts. On the other hand, the Khouzestan province has an essential role in agricultural production due to its fertile lands. In this regard, it is vital to determine the actual amount of water consumed in agricultural products to improve the water consumption pattern in agriculture. The exact amount of water consumed by crops is considered the crop's water requirement. By definition, the plant's water requirement refers to the depth of water required (in millimeters) to supply evapotranspiration (ETC) water consumed by a disease-free plant. Calculating the crop's water requirement shows the actual amount of water needed for agriculture and crop production in an area, so it can be used to manage the water resources of the study area. Groundwater modeling is a proper tool to study water resources because it is precise and saves time and cost. Therefore, mathematical modeling is one of the most suitable and cost-effective tools for studying and managing groundwater. Mian-Ab

is one of the most important plains in the Khouzestan. Groundwater and surface water resources are used simultaneously in this area, so the combined use of these resources requires integrated management of groundwater and surface water. In this study, first, the water requirement of the agricultural crops in the Mian-Ab plain was calculated. Then, the water resources management of the study area was investigated under three different scenarios using groundwater modeling.

Materials and Methods

Study area

Mian-Ab plain extends over about 640 km2 in the northern part of Khouzestan Province, SW Iran. From a geological point of view, the Mian-Ab plain is part of Zagros thrust and folded belt(Fig 1). The Mian-Ab aquifer is limited by a sandstone/siltstone formation (Aghajari Formation) in the east and southeast, the conglomerate and sandstone formation (Bakhtiary Formation) in the north and northwest, and the recent deposits of Ahou Dasht in the west. The recent alluvium deposits have covered all formations, except a small amount of Bakhtiary formation in the northwest of the study area.

Estimation of crop's water requirement

The Mian-Ab plain is very important in agricultural production in Khouzestan province. This plain's area is 64000 hectares, of which about 46000 hectares are under cultivation of various crops such as wheat, barley, rice, maize, sugar cane, and so on. The water requirement of agricultural crops in this area was estimated using the Penman-Monteith FAO method and Netwat software. Based on calculations, the water requirement of the crops cultivated in the study area equals 278.89 MCM during the plant growth and the water year. After calculating and estimating the water requirement of cultivated plants in the study area, the next step is to discover the amount of water consumed from underground and surface water resources using the water balance of the area.

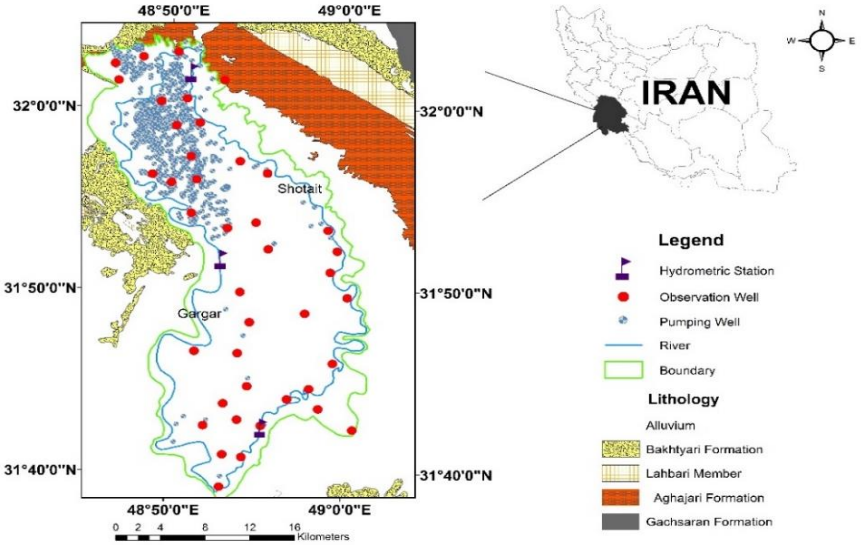

Figure 1: Location map of the study area and formation outcrops

Numerical model

Groundwater modeling is one of the most appropriate and cost-effective tools for water balance calculations and groundwater study. The groundwater flow model was performed in transient-state from September 2016 to September 2017 in 365 days in 12 stress periods, and each stress period was a time step (30days). The steady-state model was simulated and calibrated for a month period (September 2016).

Model calibration and verification

The calibration process started when the error occurred. Model calibration was performed for all observation wells with a one-meter interval function with the 0.94 m of RMSE error. After designing the model, execution, and calibration, it was performed to ensure the validity and accuracy of the model that it can predict correctly. The model was validated in six stress periods from September 2017 to February 2018 with 0.95 m of RMSE error.

Mian-Ab water balance

According to the volumetric water balance of the study area in 2015-2016, the amount of water consumed for agricultural purposes by irrigation networks and exploiting wells was 427.07 MCM. The amount of water needed to grow crops in this area is 278.89 MCM. Therefore, 148.18 MCM of water is consumed in surplus.

Water resources management in the study area

-Scenario One: Developing the irrigation and drainage network to transfer the surplus water

The irrigation and drainage network of the Mian-Ab Plain currently covers only the northern and middle parts of the plain. In southern lands, crop cultivation (often wheat and barley) is done rain-fed due to lack of development of the irrigation network. The groundwater can't be exploited in the southern parts of the study area due to the low quality and high salinity. With the development of the irrigation network, surplus water can be managed and transferred by canals to the southern parts of the area for agricultural development.

-Scenario Two: Optimization and decreasing exploiting wells rate

According to the water balance calculations, 94.24 MCM of the water consumed for agriculture has been supplied by pumping wells. Therefore, the groundwater provides a high percentage of water needed for agriculture. Another way to manage surplus water consumption is to deduct excess water only from the exploitation well-pumping rates. Even though about two-thirds of the excess water production is presented with a lack of groundwater abstraction, numerical modeling of the study area showed that the lack of groundwater abstraction caused an increase in the aquifer water table in areas where the density of wells is high.

-Scenario Three: Integrated management of surface and groundwater resources to manage surplus water

As mentioned earlier, irrigation networks and pumping wells have supplied the water needed for agricultural purposes. According to the hydrological and hydrogeological conditions of the study area, 35% of pumping rates was decreased to reduce 33 MCM of surplus consumed water. This scenario can prevent the drawdown in the aquifer. In the next step to manage the remaining amount of surplus water, it was decided to transfer 60 MCM of the water to the southern lands of the study area by developing the irrigation network. That way, the large amount of excess consumed water will be managed, and the water needed for agriculture in the southern part of the plain will be provided.

Results and Discussion

According to scenario one, in the case of transferring all volume of surplus water, there will be a high drawdown in northern parts of the aquifer due to the recharge decreasing by returned water of irrigation canals and high pumping there. The second scenario decided to reduce the pumping rate of exploiting wells to avoid excess water consumption. This scenario theoretically avoids the drawdown in the aquifer. It does not need to be costly to complete and develop the irrigation network, and the excess consumed water will be managed. The numerical model of the Mian-Ab plain showed that the last two scenarios caused some problems in the study area. So in the third scenario, integrated management of the surface and groundwater resources was decided to manage the surplus water.

Conclusion

According to the crops cultivated in the Mian-Ab plain, the actual amount of water needed for agriculture is 278.89 MCM. The amount of water consumed for agricultural purposes is 427.07 MCM. Therefore, 148.18 MCM of water is consumed more than the actual water demand for agriculture.

The numerical model of the study area showed that in the first scenario if the whole volume of surplus water will transfer to the southern part of the plain, we would also see a sharp rise in the water table in southern lands. This scenario causes different problems, such as marshy lands due to waterlogging.

Applying the second scenario in the numerical model showed that despite managing and prevention a large amount of excess water consumption, there would be severe waterlogging in the northern parts of the aquifer due to the decreasing pumping rate of the wells. On the other hand, the southern lands of the study area cannot access adequate surface water resources due to the lack of irrigation network development.

Surplus water management focused on surface and groundwater resources in the first and second scenarios. The model showed that each scenario had consequences and problems for the aquifer and agricultural lands. Therefore, we decided on an integrated approach for managing the surplus consumed water in the third scenario. Based on the discussion, the third scenario is hydrodynamically more stable than the first and second scenarios and has fewer consequences for the aquifer. Therefore, the third scenario is more desirable for managing excess water consumption due to the aquifer conditions.

Simulation of Water Level Fluctuations, Chlorine, Bicarbonate in groundwater using a Hybrid Learning Machine

Document Type: Research Paper

Ali Azizpour[1], Mohammad Ali Izadbakhsh[2*], Saeid Shabanlou[3], Fariborz Yosefvand[2], Ahmad Rajabi[2]

1- Ph.D. Candidate, Department of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
2- Assistance Professor, Depatment of Water Engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
3- Associated Professor, Depatment of Water Engineering, Kermanshah Branch, Islamic Azad University,

[*]Corresponding author: izadbakhsh.mohammad.ali@gmail.com

Abstract

Modeling qualitative and quantitative parameters of groundwater as one of the main water supply resources is crucially important. Due to recent climate changes in Iran, precipitation patterns have been dramatically altered leading to excess withdrawal. In this paper, two meta-heuristic artificial intelligence models are presented to simulate monthly time-series data of quantitative (groundwater level) and qualitative (chlorine and bicarbonate) parameters of groundwater within an observational well situated in the city of Kermanshah, Iran from 2005 to 2018. To define the hybrid artificial intelligence model, the extreme learning machine (ELM), differential evolutionary (DE) algorithms are combined with the wavelet transform and the Self-adaptive extreme learning machine (SAELM) and wavelet self-adaptive extreme learning machine (WSAELM) models are developed. It is worth mentioning that the autocorrelation function is utilized for detecting effective lags of the time-series data. Moreover, 70% of the observed data are used for training the artificial intelligence models and the remaining 30% for testing them. Then, using these influencing lags, different models are defined for the SAELM and WSAELM models. Also, different mother wavelets are assessed to choose the most optimal one for decomposing signals of the time-series data. After that, superior models for simulating GWL, Cl and HCO_3 are introduced by performing a sensitivity analysis. For instance, the values of the correlation coefficient (R), the variance accounted for (VAF) and Nash-Sutcliff efficiency Coefficient (NSC) for the superior WSAELM model are obtained to be 0.988, 97.450 and 0.973, respectively. It should be noted that for forecasting HCO_3 the lags (t-1), (t-2), (t-3) and (t-4) are identified as the most influencing lags of the time-series data. The utilization of an uncertainty analysis exhibited that the superior model has an underestimated performance in simulating Cl and HCO_3. Finally, three formulae are presented for computing GWL, Cl and HCO_3.

Keywords: Bicarbonate, Chlorine, Groundwater level, Self-adaptive extreme learning machine, Wavelet transform.

Introduction

Due to global warming and climate change, arid and semiarid regions have experienced serious difficulties in supplying freshwater. Iran situated in South-West Asia with a dry and semiarid climate has recently faced numerous issues and challenges related to supply drinking water. In other words, the vast majority of urban and agricultural water consumption in Iran is supplied from groundwater resources and excess withdrawal from them caused many crises such as water table drawdown, formation of sinkholes, and salinization of groundwater, drying up of surface water resources (rivers and lakes). Thus, the estimation and modeling of qualitative and quantitative parameters of groundwater are very important in Iran. Thanks to high accuracy and saving in time and costs, the use of artificial intelligence models is increasing every day. In recent years, various artificial intelligence algorithms have been employed for

forecasting different parameters of groundwater. In this paper, two meta-heuristic artificial intelligence models are presented to simulate monthly time-series data of quantitative (groundwater level) and qualitative (chlorine and bicarbonate) parameters of groundwater within an observational well situated in the city of Kermanshah, Iran from 2005 to 2018.

Materials and Methods

In this study, to validate the artificial intelligence models, the observed values of the Karnachi well located in Kermanshah, Iran is utilized. The observed values include the quantitative (groundwater level) and qualitative (chlorine and bicarbonate) parameters of groundwater in the Karnachi well from 2005 to 2018 which are used monthly. The well is situated in the northern part of Kermanshah with latitude and longitude of 34.3833 and 47.0753, respectively. Throughout the northern and eastern margins and part of the northwestern margin of this plain is covered by Cretaceous limestone, mostly karstic. The southern and southern parts of the northwest and the western part of the northwest are confined to different facies, including igneous sediments in the southeast and siliceous lime and radiolarite in the south. The study area is geologically part of two Zagros and crushed zone structures. These two parts together with the Khuzestan plain form the entire Zagros structure. The oldest rock unit around the Miandarband Plain belongs to the Jurassic. Due to this issue, the thickness, type and grain size of the alluvium in this plain vary from place to place. In this plain, Groundwater is available in alluviums with a thickness of 50–200 m that are mostly alternated with silty clay, fine sand and coarse sand. In general, foothills and margins of the plains consist of coarse-grained components giving good permeability in these areas. The bedrock of the Kermanshah plain is composed of radiolarian rocks. In the Kermanshah plain, there are free and confined artesian aquifers and groundwater resources of this area formed in alluvial sediments of the fourth period as a result of erosion of marginal elevations of the plain. Components of sediments in the aquifer domain include limestone, sand, sand, silt and clay. The main sources of groundwater aquifers, regardless of the rainfall in the plain, are numerous canals that originate from the slopes of the adjacent elevations and enter the plain, as well as the abundance of karstic springs feeding the aquifer. In addition, transmissivity varies in different regions of the area, varying in the margin of the aquifer due to the steep slope and low thickness of the alluviums is about 500 m 2 / day and even less and in central areas is about 10,000 m 2 / day. The observed data are used monthly in a 13 year period from 2005 to 2018. Variations of groundwater level and also monthly precipitation are studied in this region for 13 water years and it is concluded that the groundwater level is falling down so that a 5.77m drop has been measured during this period. Within three recent years, the acceleration of dropping has been reduced and the aquifer is reaching a relative balance. In this research, the measured values for 156 consecutive months are used in the time series format. Furthermore, 10 years of this period are used for training and the remaining 3 years for testing the artificial intelligence models.

To define the hybrid artificial intelligence model, the extreme learning machine (ELM), differential evolutionary (DE) algorithms are combined with the wavelet transform and the Self-adaptive extreme learning machine (SAELM) and wavelet self-adaptive extreme learning machine (WSAELM) models are developed. the ELM model randomly chooses the connection weight between the hidden layer and the input layer during the learning process. Given that the number of neurons in the hidden layer is crucially important in solving nonlinear problems, a new technique optimizing ELM using the self-adaptive mechanism is presented. This method is called "self-adaptive ELM (SAELM)". This approach tries to choose the best number of neurons for producing the most optimal network. Then, SAELM needs no parameters and chooses the most optimal solution. The hybrid method presented in this study is called "wavelet-SAELM (WSAELM)", which uses wavelet transform to decompose the original time series into approximation and detail time series, such that decomposed series are equal to the initial time series. In fact, in this study, using the combination of SAELM and Wavelet capabilities, a hybrid WSAELM method is developed. To develop

the SAELM presented in the present study, the type of the mother wavelet and decomposition level must initially be determined.

It is worth mentioning that the autocorrelation function is utilized for detecting effective lags of the time-series data. Moreover, 70% of the observed data are used for training the artificial intelligence models and the remaining 30% for testing them. In this study, for simplicity of modeling the value of the decomposition level is taken into account equal to one. Of course, allowable values of more than one have also been investigated, with no significant increase in modeling accuracy. After determining this parameter, the mother wavelet should be defined. In this paper, the influences of the mother wavelets Demeyer (dmey), Coiflets (coif), Daubechies (db) and Symlets (sym) are examined and the best one is selected. After determining these two parameters, the inputs of the model should be determined and presented as delays. In this research, the autocorrelation function (ACF) is utilized to detect effective lags (Figure1). Based on the presented ACF graphs, various inputs are presented for each of the parameters. In this paper, to examine the accuracy of the introduced numerical models, the correlation coefficient (R), the variance accounted for (VAF), root mean square error (RMSE), scatter index (SI), mean absolute error (MAE) and Nash-Sutcliffe coefficient (NSC) are employed.

Results and Discussion

After that, superior models for simulating GWL, Cl and HCO_3 are introduced by performing a sensitivity analysis. For instance, based on the GWL simulation results obtained by the SAELM and WSAELM models, the SAELM3 and WSAELM4 models are detected as the superior models. The SAELM3 model simulates the GWL values in terms of the lags (t-1), (t-2) and (t-3), whereas the WSAELM4 model forecasts the target function values in terms of the lags (t-1), (t-2), (t-3) and (t-4). It should be noted that the WSAELM4 model has higher accuracy than the SAELM3 model. Thus, for simulating GWL, the WSAELM4 model is introduced as the superior model. According to the simulation of Cl by the artificial intelligence models, the SAELM2 and WSAELM8 have the maximum accuracy and the minimum error. The SAELM2 model simulates the Cl values in terms of the lags (t-1) and (t-2), while the WSAELM8 model predicts the target function values by the lags (t-1), (t-2), (t-3), (t-4) and (t-12). Furthermore, the accuracy of the WSAELM8 model is dramatically higher than the SAELM2 model. Based on the HCO_3 simulation by different artificial intelligence models, the SAELM5 and WSAELM4 models are introduced as the superior models. These models simulate the target function values with the minimum error value and the maximum correlation with the observed data. The SAELM5 model simulates the HCO_3 values in terms of the lags (t-1) and (t-12), while the WSAELM4 model predicts the target function values in terms of the lags (t-1), (t-2), (t-3) and (t-4). According to the conducted uncertainty analysis results, the WSAELM4 model has an overestimated performance in simulating the GWL values, while this model has an underestimated performance in estimating the Cl and HCO_3 values. For simulating the GWL, Cl and HCO_3 values by this model, the WUB values are obtained equal to -0.081, -.023 and -0.035, respectively.

Conclusions

In this paper, two hybrid artificial intelligence models were employed for simulating the time-series data of the quantitative (groundwater level) and qualitative (Cl and HCO_3) parameters of groundwater in an observational well located in Kermanshah, Iran from 2005 to 2018 in monthly intervals. By combining the extreme learning machine (ELM), the wavelet transforms and the differential evolutionary (DE) algorithm, two hybrid models including the self-adaptive extreme learning machine (SAELM) and the wavelet self-adaptive extreme learning machine (WSAELM) were developed. It should be noted that 70% of the observed data were used for training the artificial intelligence model and the remaining 30% for testing them. First, using the autocorrelation function (ACF), the effective lags of the time series were

detected. Also, through the combination of the lags, four SAELM and WSAELM models were defined for simulating the GWL values. In addition, as a result of the mentioned combination, eight model were also developed for forecasting the Cl and HCO_3 values. It should be noted that different mother wavelets were examined and it was concluded that dmey was the best one. For instance, the values of R, VAF and NSC for simulating the GWL values by dmey were obtained equal to 0.988, 97.450 and 0.973, respectively. Moreover, the sensitivity analysis results revealed that the hybrid models simulated the quantitative and qualitative values with reasonable accuracy. For example, the RMSE, MAE and R statistical indices for simulating the HCO_3 values by the superior model were calculated to be 0.105, 0.091 and 0.979, respectively. Furthermore, the lags (t-1), (t-2), (t-3) and (t-12) are introduced as the most effective input lags of the time-series data for simulating the Cl values. It is worth mentioning that the superior artificial intelligence model predicted the GWL values with an overestimated performance, while its performance in predicting the Cl and HCO_3 values was underestimated. Finally, three relationships were proposed for approximating GWL, Cl and HCO_3.

Effect of geological formations on the quality and geochemical characteristics of groundwater Shiyan plain aquifer, Kermanshah

Document Type: Research Paper

Hadi Habibinia[1], Mehdi Kord[2,*], Kamal Taheri[3]

1- MSc in Geochemistry, Faculty of Science, University of Kurdistan, Kurdistan, Iran
2- Assistant Professor of Hydrogeology, Faculty of Science, University of Kurdistan, Kurdistan, Iran
3- Karst expert and research committee secretary, Kermanshah Regional Water Authority, Kermanshah, Iran
*Corresponding author: m.kord@uok.ac.ir

Abstract

The plain of Shiyan, with an area of 207 km^2,is one of the most important plains of the Kermanshah province, Iran. However, the framework of hydrogeochemistry of this plain has not been studied yet. This study investigated the hydrogeochemical characteristics of this aquifer through groundwater sampling, geological survey while considering the direction of groundwater flow. Hence, the geological map of the study area was prepared through aerial photographs and field investigation, and then a sampling of groundwater was carried out. After the chemical analysis of the samples, the dominant hydrogeochemical processes in the groundwater system were studied and interpreted according to the geological environment. According to the results, the most abundant process in the aquifer is ion exchange and the groundwater evolves hydrogeochemical as it flows from north-west to east and south-east. The electrical conductivity of the samples taken from the input and output borders of the plain is higher than that of its central zones due to the presence of the Amiran and Kashkan marly formations and maybe the elimination of dolomite from the broke-down zones. The results of the Piper, Stiff, Durov diagrams are consistent and indicate that the dominant water type in this aquifer is the bicarbonate with high magnesium. The Shahbazan Formation has the most influence of terrigenous agents on groundwater quality. Meanwhile, the Amiran and Kashkan formations are responsible for the high concentration of the chemicals found in the groundwater of the east and north of the Shiyan plain. Also, since the plain is entirely under irrigated cultivation and application of chemical fertilizers for increasing agricultural productivity is common in this region, the high level of nitrate in the aquifer should have a human-made origin.

Keywords: Groundwater, Hydrogeochemistry, Shiyan plain, water quality.

Introduction

The qualitative features of water and groundwater are evaluated for different purposes. However, the most considerable purposes include water quality analysis for various applications, assessing the effect of geological formations on water quality, defining water interaction, understanding flow systems and developing conceptual models .As aforementioned, several studies have attempted to understand groundwater systems by analyzing their hydrogeochemical characteristics. Such analysis can help to understand the natural and human-made processes of the system, in addition to playing an important role in water resource management. In this respect, this study investigated the groundwater quality of the Shiyan plain. This plain has about 207 km2 area and is one of the biggest agricultural centers in the Kermanshah province, Iran. Furthermore, according to the reports of the local authorities, the Shiyan plain is one of the fertilized plains that has conserved a noticeable and sufficient level of water despite overexploitation of its water resources over the last decade and the decrease of its hydrostatic level. Most agricultural lands of this plain are irrigated using groundwater resources. Consequently, utilization of its water resources and the

application of chemical fertilizers have affected the quality of its groundwater, negatively. Since no study has considered the Shiyan plain, which is one of the most important plains of the Kermanshah region, and improved management of this aquifer requires some basic knowledge of its properties, this research determines the geochemical characteristics of this plain from a hydrogeochemical perspective.

Materials and methods

The Shiyan plain lies between 3772089 and 3763326 m north altitude and between 668035 and 654547 m east longitude in UTM zone 38S .

In the first stage of this study, the basic map of the region was prepared by defining the borders of the plain according to satellite images and topographic and geologic maps. After that, a field study was conducted and lithology of the geologic formations was studied.

To analyze the hydrogeological features of the area, some specific points were selected for sampling prior to the field study.

The hydrogeochemical study was designed to analyze the major ions of the groundwater samples including sodium, magnesium, calcium, sulfate, bicarbonate, carbonate and chloride. Due to the fact that agriculture is the main contributor to the use of the exploited water, the samples' levels of nitrate, iron and manganese were measured, in addition to the major ions .

The determined qualitative parameters of the water samples were interpreted using the Piper, Expanded Durov and Stiff diagrams .

Studying the water table, flow direction and boundary conditions, along with qualitative analysis, is highly effective in the understanding of the hydrogeochemical aspects of the studied plain. In this respect, the hydraulic head of the piezometers that were established in the Shiyan plain was recorded to determine the direction of groundwater flow in this plain. It should be added that a total of eight piezometers have been installed in this plain for hydrostatic level measurements.

Results and Discussion

The lithology, formations and geologic structures of the study area were defined using the geologic map of the region, photogeologic studies and field trips. The corresponding results are summarized in the large-scale map of Fig. 1 and The distribution of the major ions at the sampling points is shown in Fig. 2.

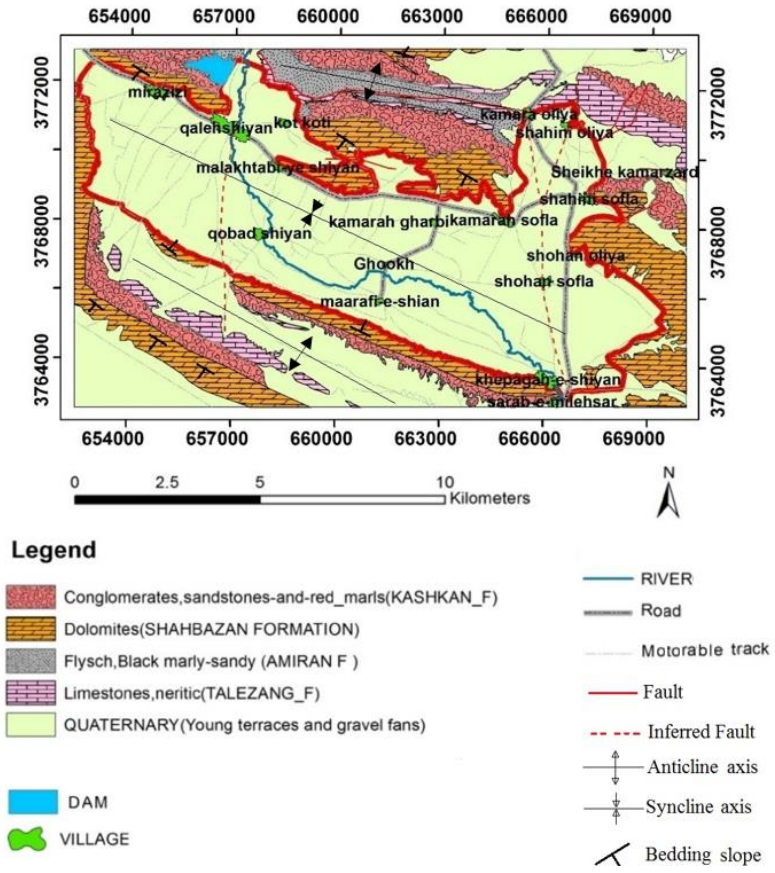

Fig. 1. Geological map of the study area

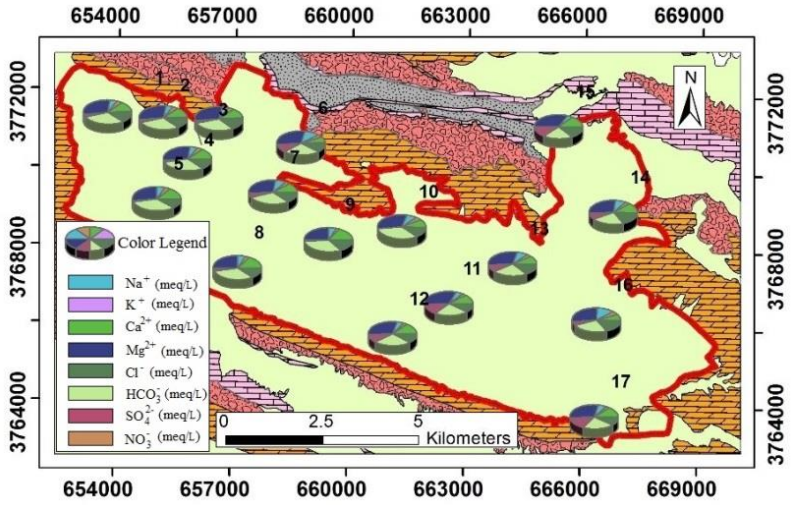

Fig. 2. Distribution of major ions in the groundwater of the Shiyan plain aquifer

In this paper, the geological environment and the hydrogeochemical features of the Shiyan plain aquifer were studied. Based on the obtained results, the aquifer is located in the alluvium deposited in the direction of the syncline axis with a bedrock of dolomitic Shahbazan formation. The faults with north-south trends in the two districts of the plain have caused hydraulic interconnection of the Shiyan plain aquifer with the adjacent plains that are located in the north and south of the plain. A fault around the Kot Koti and Ghaleh

Shiyan villages trends towards the south, where geological formations are intersected. This fault collects the flow of the groundwater from the Hassan-Abad plain towards the recharge point of the Shiyan plain aquifer in the northwest. Another fault that has a major effect on the groundwater system follows a north-south trend and continues within the Shiyan plain from the Kamareh-Bala village towards the Khapegeh village. The existence of this fault results in groundwater inflow from the Hassan-Abad plain and the upward lands and its outflow in the adjacency of the Khapgeh village. Also, at the intersection of this fault's zone with a fault with an east-west trend, two springs appear in the location of the Kamareh Bala and Shahini villages. The total hardness of the samples varies from 234 to 319 mg L-1 and is related to the presence of calcium and magnesium ions. There is a great possibility that the origin of these ions is terrigenous and corresponds to the dolomitic formation of Shahbazan, which has surrounded the plain. Also, since the plain is entirely under irrigated cultivation and application of chemical fertilizers for increasing agricultural productivity is common in this region, the high level of nitrate in the aquifer should have a human-made origin. The electrical conductivity of the samples taken from the input and output borders of the plain is higher than that of its central zones due to the presence of the Amiran and Kashkan marly formations and maybe the elimination of dolomite from the broke-down zones.

Conclusions

The dominant process in the aquifer is ion exchange and the hydrogeochemical context of the groundwater evolves along its flow direction from north-west to east and south-east. According to the Piper, Stiff and Expanded Durov diagrams, the dominant type of water in this aquifer is bicarbonate. An out-of-bed dam is constructed on the waters that flow from the north of Ghaleh-Shiyan village that is located on the anticline axis of the Amiran formation. With respect to the field evidence and the satellite images, the body of the dam is parallel with the fault that has a north-south trend. Further research should be conducted to study water leakage from this aquifer as this event can increase pore pressure and trigger some faults around the Ghaleh-Shiyan and Mir-Azizi villages that are located close to the downstream of the dam. Also, due to the importance of the studied region, the groundwater of this district should be analyzed to evaluate their potential pollutants and their quality for drinking.

Performance Six Intelligent Combined Methods in Groundwater quality modeling, Case study: Bafgh Plain

Document Type: Research Paper

Amir Mohamad Rokhshad[*1]; Ali Shahidi [2]

1- PhD student, Department of Water Science and Engineering, Faculty of Agriculture, University of Birjand, South Khorasan, Iran
2- Associate Professor, Department of Water Science and Engineering, University of Birjand, South Khorasan, Iran
*Corresponding Author: amir9329@yahoo.com

Abstract

Assessment and controlling groundwater quality have an important role in planning and developing water resources. Therefore, the use of an efficient method can greatly increase accuracy and reduce costs in this field. In this study, 6 optimization algorithms Consist of Particle swarm optimization (PSO), Genetic algorithm (GA), Imperialist competitive algorithm (ICA), Fireflies algorithm(FA), Cultural algorithm(CA) and covariance matrix adaptation evolution strategy- Evolution strategies (CMA-ES) were used to train and optimize the parameters of the neural-fuzzy inference system model (ANFIS) to model the groundwater quality of Bafgh plain in Yazd province. At first, to select the best combination of input for an estimate of the electrical conductivity (EC), sodium adsorption (SAR) and total hardness (TH), Pearson and Spearman's methods were used to analyze the sensitivity and correlation of other parameters. then qualitative modeling is done with hybrid methods and the performance of the models was measured by correlation coefficients (R2), root mean square error (RMSE), and Nash-Sutcliffe Efficiency (NSE). The results showed that all six combined methods showed a very good performance in modeling groundwater parameters. Also, the ANFIS-FA model was one of the best models in all three modeling parts. So that the value of R2, RMSE and NSE for the test part in TH was, 0.99, 0.41, 0.99, for SAR, 0.98, 1.11,0.95 and for EC 0.99, 305.7 and 0.99. Other methods have also succeeded in modeling and predicting the desired parameters with proper precision. According to the accuracy of the calculations, these methods are suitable alternatives for the prediction of groundwater quality variables.

Keywords: Algorithm, Anfis, EC, Groundwater, SAR.

Introduction

Water is the most important natural resource, and factors such as population growth, agricultural development, and an arid climate have contributed to reducing its supply and creating a serious crisis in the region.. Also, this limitation has been associated with a rapid increase in freshwater quality depletion due to salinity and contaminant processes.

Groundwater is one of the main sources of drinking and agricultural water. Groundwater quality modeling is necessary to develop better strategies for water resource planning and management. Among the various parameters that may be important in groundwater, measure and specify of three parameters consist of electrical conductivity (EC), sodium absorption ratio (SAR) and total hardness (TH) are very important.

The old groundwater quality analysis methods, such as time series and statistics and probabilities, are essentially mathematical modeling that usually assumes a linear relationship between the dependent and independent variables. Therefore, they aren't accurate enough. For this reason, the use of new methods and artificial intelligence has been proposed as an alternative and numerous researches have been conducted on this basis. One of the most current methods of modeling water quality along with the neural network method is the ANFIS model. The meta-heuristic algorithms have been used in numerous water resources research. Due to some of the weaknesses in artificial intelligence methods and their

increased accuracy, hybrid methods have been suggested that in addition to increasing accuracy, it also increases the computation speed.

The purpose of this study was to evaluate the performance of six metaheuristic algorithms consisting of GA, PSO, FA, CA, ICA, and CMA-ES in improving the ability of the ANFIS model to model groundwater quality parameters in a dry area.

Materials and Methods

The study area

Bafq is one of the cities of Yazd province, that located in the center of Iran, 5 km from Yazd. The geographical coordinates of Bafq are '21 55˚ to '25 '55 east longitude and '34˚31 to '38˚31 north latitude. The elevation of the city is 27 meters and has a warm and dry climate. Bafq area is 15298 square kilometres. In this study, 16 years of data between years 2002 to 2017 were used in the Bafq plain and 31 deep wells and aqueducts were obtained from the Regional Water Authority, and after removing missing data, 675 data per parameter were used in the modeling.

Fuzzy Neuro-Inference System (ANFIS)

The fuzzy system proposed by Zadeh (1965), and it is a mapping of the input-to-output space and is implemented using membership functions and fuzzy rules. in the following, Zhang used the artificial neural network algorithm and the if-then fuzzy rules in the form of combined membership functions to analyze the phenomena. The ANFIS model uses an artificial neural network structure and is known as a neural-fuzzy inference system, which has the capability of learning neural networks, fuzzy inference power, and mapping of nonlinear models together. ANFIS is a five-layer network that the first layer is the inputs. The second layer contains nodes for the rules and operators are used to calculate the degree of participation. The third layer contains the normalized nodes, which calculate the ratio of the degree of participation of each rule to the sum of the degree of participation of all the rules. In the fourth layer, using the result parameters, the output of each node is calculated and the fifth layer is the output node that calculates the final output value with the sum of the outputs of the previous layer nodes.

Genetic Algorithm (GA)

The genetic algorithm was presented by John Holland in the year 1967. Goldberg later completed this method in the year 1989, and because of its good capability, it is well-positioned among other methods. First, the fittest individuals are selected from a population. Then they produce offspring that inherit the characteristics of the parents and will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance of surviving. This process keeps on iterating and in the end, a generation with the fittest individuals will be found. This notion can be applied to a search problem. We consider a set of solutions for a problem and select the set of best ones out of them. The five phases of the genetic algorithm are: Initial population, Fitness function, Selection, Crossover, and Mutation. After trying and error to achieve higher accuracy, Crossover Percentage and Mutation Percentage numbers were selected as 0.7 and 0.4 respectively for this study.

Particle Swarm Algorithm (PSO)

The PSO algorithm was introduced in 1995. This algorithm is inspired by the mass movement of birds looking for food. This algorithm emulates the interaction between members to share information. Particle swarm optimization has been applied to numerous areas in optimization and in combination with other existing algorithms. This method performs the search of the optimal solution through agents, referred to as particles, whose trajectories are adjusted by a stochastic and a deterministic component. Each particle is influenced by its ‘best’ achieved position and the group ‘best’ position, but tends to move randomly. One of the advantages of particle swarm optimization over other derivative-free methods is the reduced number of parameters to tune and constraints acceptance. The particle's best

position, Pbest, and the group's best position, Gbest, influence the velocity of the particle at the next iteration. Nevertheless, the stochastic properties of the algorithm allow for solution variability to guarantee solution space exploitation.

Cultural Algorithm (CA)

This algorithm is one of the newest meta-heuristic algorithms that works based on the thoughts and beliefs of a community. The different parts of this algorithm are Taxonomy, Inspiration, Metaphor, and Strategy. The steps of the algorithm are: 1-Initialize population space (choose initial population). 2-Initialize belief space (e.g. set domain-specific knowledge and normative value ranges). 3-Perform actions of the individuals in population space. 4- Evaluate each individual by using the fitness function. 5- Select the parents to reproduce a new generation of offspring. 6- Let the belief space alter the genome of the offspring by using the influence function. 7- Update the belief space by using the accept function (this is done by letting the best individuals affect the belief space). In this study, the acceptance ratio was 0.3 and alpha and beta values were 0.3 and 0.5, respectively.

Imperialist Competition Algorithm (ICA)

This algorithm was first introduced by Atashpaz Gargari (2008), which was inspired by a social-political phenomenon rather than nature. This algorithm starts by generating a set of candidate random solutions in the search space of the optimization problem. The generated random points are called the initial Countries. The cost function of the optimization problem determines the power of each country. Based on their power, some of the best initial countries (the countries with the least cost function value), become Imperialists and start taking control of other countries (called colonies) and form the initial Empires. The two main operators of this algorithm are Assimilation and Revolution. Assimilation makes the colonies of each empire get closer to the imperialist state in the space of socio-political characteristics (optimization search space). Revolution brings about sudden random changes in the position of some of the countries in the search space. During assimilation and revolution, a colony might reach a better position and has the chance to take control of the entire empire and replace the current imperialist state of the empire. All the empires try to win this game and take possession of colonies of other empires. The algorithm continues with the mentioned steps (Assimilation, Revolution, Competition) until a stop condition is satisfied. The parameters of revolution rate, absorption multiplier, gamma and zeta were set as 0.4, 0.5, 0.5, and 0.08, respectively.

Firefly Algorithm (FA)

This algorithm is inspired by the behavior of fireflies that live together in large collections and is one of the most efficient algorithms for solving hybrid optimization problems, that proposed by Xin-She Yang. In essence, FA uses the three idealized rules: 1-Fireflies are unisexual so that one firefly will be attracted to other fireflies regardless of their sex. 2-The attractiveness is proportional to the brightness and they both decrease as their distance increases. Thus, for any two flashing fireflies, the less bright one will move toward the brighter one. If there is no brighter one than a particular firefly, it will move randomly. 3-The brightness of a firefly is determined by the landscape of the objective function. So, in this procedure, the firefly algorithm is executed by three parameters which are attractiveness, randomization, and absorption. The attractiveness parameter is based on light intensity between two fireflies and defined with exponential functions. When this parameter is set to zero, then it happens to the random walk corresponding to the randomization parameter which is determined by the Gaussian distribution principle as generating the number from the [0,1] interval. On the other hand, absorption parameters affect the value of attractiveness parameters as changing from zero to infinity. And, for the case of converging to infinity, the move of fireflies appears as a random walk.

In this study, water quality variables were modeled on three important parameters including electrical conductivity (EC, μmhoCm-1), sodium absorption ratio (SAR) and total hardness (TH). To select the input data for estimating each of the three variables, a correlation between Ca, Mg, pH, Cation,

Anion, TDS, K, Na, So4, Cl and Hco_3 with that parameter in SPSS software with Pearson and Spearman methods were analyzed and parameters with a correlation above 95 in one of the two methods were selected with each output. These parameters are: sulfate (SO4, mg L^{-1}), chloride (Cl, mg L^{-1}), bicarbonate (HCO3, mg L^{-1}), potassium (K, mg L^{-1}), sodium (Na, mg) L^{-1}), magnesium (Mg, L^{-1} mg), calcium (Ca, L^{-1} mg), anion (meq L^{-1}, Anion) and cation (meq L^{-1}, Cation). That only bicarbonate and potassium were excluded because they were in poor correlation with intended output parameters. Therefore, for TH, Ca, Mg, Cation and Anion inputs, for SAR, Cl and Na inputs and for EC, Cl, So4, Na, Cation, and Anion inputs were used.

To perform this study, each of the mentioned algorithms was combined with the ANFIS model, so that the task of these algorithms is optimization the weight of the nodes based on the introduced indexes to increase the accuracy of the modeling for the same conditions of all modeling, the initial population in all algorithms was 100 and the number of iterations was 500. Also, at each step, 75% of the data were used as training data and 25% as test data. The indices used in this study to evaluate the performance of the models are correlation coefficient (R2), mean square root error (RMSE), and Nash-Sutcliffe coefficient (NSE).

Results and Discussion

In modeling total hardness (TH), which is mainly due to the presence of calcium and magnesium, anion, cation, magnesium, and calcium data were used to model the inputs for TH modeling. According to the result, in the training section, all models except ANFIS-FA and ANFIS-ICA have R2 = 1 values, indicating a good correlation between the computational and observational data. However, this value was not obtained 1 only for ANFIS-GA and ANFIS-FA models in the test section. Given the same NSE values for all models, the RMSE index could be a better criterion for selecting a better model, so ANFIS-GA and ANFIS-FA models in the training section, and the ANFIS-PSO model in the test section with the lowest RMSE have the most appropriate values. Overall, although all models showed high capability in TH modeling, the ANFIS-PSO model may be more appropriate in this section.

To calculate SAR, Na and Cl parameters were selected as inputs with a high correlation of 95%. Although some other parameters such as magnesium and calcium are also effective on SAR, due to their not very high correlation, they were excluded in this section. Therefore According to the calculated values, the ANFIS-GA model was the strongest model in the training part with R2 = 0.97, RMSE = 1.11 and NSE = 0.97. Subsequently, there were ANFIS-GA and ANFIS-CMA-ES models. In the test section, the ANFIS-FA model performed the best. Overall, the ANFIS-ICA model is presented as the best model of this section for SAR modeling.

In the EC modeling section, five parameters of anion, cation, sodium, chloride, and sulfate were used. The unit of data used for EC is µmho Cm-1, so the unit of calculated RMSE is also expressed in the same unit. According to the R2 and NSE equivalents obtained for all models, the ANFIS-FA model with RMSE = 258.2 was selected as the top model in the training section and the ANFIS-PSO and ANFIS-CMA-ES models ranked next. In the test section, the ANFIS-CA model was the best model with RMSE = 2667.2. Overall, this section cannot be introduced any model as a preferred model, because neither had a significant advantage over the others.

Conclusions

The results showed that the ANFIS-FA model was the best model in all three model categories, and R2, RMSE and NSE values for TH are 0.99, 0.41, and 0.99 respectively, for SAR is 0.98, 1.11 and 0.95 respectively and for EC is 0.99, 305.7 and 0.99 respectively. Although the model's run speed was much slower than the other models. In general, it can be concluded that the hybrid models of different algorithms with the ANFIS model can be used as an effective tool for calculating and predicting groundwater quality variables.

Evaluating the Effect of Recent Droughts on Changes in Groundwater Resources Level (Case Study: Bandar Abbas Plains)

Document Type: Research Paper

Maryam Heydarzadeh*[1], Amir Salari[2]

1- Assistant Professor, Water engineering department, Minab higher Education Center, University of Hormozgan, Hormozgan, Iran
2- Assistant Professor, Water engineering department, Minab higher Education Center, University of Hormozgan, Hormozgan, Iran
*Corresponding Author: M.heydarzade88@yahoo.com

Abstract

Introduction: By definition, drought is a period of dryness especially when prolonged that causes extensive damage to crops or prevents their successful growth and has a negative impact on water resources (groundwater resources). The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. The SPI can be related to groundwater and reservoir storage. For this purpose, the SPI index was evaluated at 3, 6, 9, 12, 18 and 24 months scales in relation to groundwater level changes in Bandar Abbas plains Hormozgan Province. Materials and Methods: The Bandar Abbas plains, including the Isin, Shamil-Takht, Gnu, Choch Dehno, and Sarakhoon plains play an important role in agricultural production and development in the region. In order to investigate the impact of recent droughts on groundwater levels of the above-mentioned plains, meteorological data were obtained from Bandar Abbas Synoptic Station during the period 2001-2005. Results: The results showed that in all the plains during the years studied, the SPI index is getting worse, that is, the drought is expanding and intensifying. Concomitant to this situation, groundwater levels are also falling. The average water level drop for the whole region was 3.35 m. Changes in the groundwater level were more consistent with the long-term effects of drought so that the highest correlation with changes in groundwater level occurred in the 24-month series. Conclusion: Drought has a great effect on the groundwater level drop and changes in the groundwater level were more consistent with the long-term effects of drought.

Keywords: Bandar Abbas, Drought, Groundwater, SPI Index.

Introduction

Groundwater is one of the most important and valuable water resources on Earth and in arid regions such as Iran as one of the most important water resources needed by agriculture, drinking and Industry is very important. The occurrence of successive droughts increases harvesting and creates serious challenges in the quantity and quality of groundwater, especially in arid and semi-arid regions. Paying attention to proper management practices and reducing the consequences of drought, requires planning and implementation of preventive measures against the phenomenon of drought, which itself requires the use of sufficient knowledge in drought forecasting. Research on the effects of drought on groundwater resources indicates the importance of identifying the relationship between drought and groundwater level. Various indicators are used to identify the occurrence of drought and to determine its degree and severity, one of these indicators is the standardized precipitation index (SPI). The standardized precipitation index has been developed to define and monitor drought and determines precipitation deficit for time scales of three, six, nine, 12, 18 and 24 months. The diversity of SPI applications makes it possible to monitor the impact of drought on both short-term scales (such as the effect of drought on soil moisture) and long-term scales (such as the effect of drought on surface and groundwater). Appeared. Due to the normalization of this index in terms of time and place, the spatial

and temporal distribution of drought is covered in the analysis of this index. Among the other advantages of SPI can be the usability of this index in different time scales and presenting the risk of drought and their evaluation, as well as its simplicity compared to other indicators and the possibility of comparing rainfall variables from He pointed out the way of normalizing rainfall values in different places and therefore its application in different areas with different rainfalls. Numerous studies have shown that the SPI index is superior to other drought indices, and the US National Center for Drought Adjustment uses the standardized rainfall index to monitor drought and soil moisture storage conditions. This study used this index. One of the most important applications of drought and its severity is to assess its impact on surface and groundwater resources, and the results show that the occurrence of climatic droughts causes a decrease in groundwater levels.

Materials and Methods

The Bandar Abbas plains, including the Isin, Shamil-Takht, Gnu, Choch Dehno, and Sarakhoon plains play an important role in agricultural production and development in the region. In order to investigate the impact of recent droughts on groundwater levels of the above-mentioned plains, meteorological data were obtained from Bandar Abbas Synoptic Station during the period 2001-2005. MATLAB and Excel software were used to perform SPI method calculations.

Discussion of Results

The overall results show that in all plains during the years under study, the SPI index is becoming negative, in other words, the drought is expanding and intensifying. Approximately with this situation, the level of groundwater aquifers is also decreasing. Despite this same trend, the amount of change varies. The results also showed that changes in groundwater aquifers with a time delay follow the SPI index. The interesting point is the small changes and stability of the groundwater aquifer level in the Chouchehdehno plain, despite the significant changes in the SPI index, whose aquifer height is between 12 and 13 meters. Apart from the general decline of the groundwater level of the Chouchehdehno plain, the decreasing trend is such that from the beginning of the surveys (1991) to 1996, after an almost continuous drop of groundwater level every three years, the following year It has happened relatively well and the water level has returned to its original level, but after this date, the feedings have not been able to meet the annual discharge and fall of the groundwater level, and therefore the groundwater level has been constantly falling and falling.

The general trend of changes in the groundwater level of the Isin plain is also decreasing, with the difference compared to the Chouchehdehno plain, where the changes of the Isin plain are relatively less and much more gradual, while the SPI changes are still strong and intense and towards It tends to be more negative. In other words, in the Isin plain, changes in SPI have not had much effect on the decline of groundwater aquifers. One of the reasons for this phenomenon is the higher altitude and depth of groundwater level in the Isin plain and its lower impact compared to the Chouchehdehno plain, which has shallower and shallower groundwater. The Gno plain has had an almost continuous decline with a steeper slope than the Chuchedno and Isin plains. This plain, with the exception of 1994 in other years, has always faced a decrease in surface and a decrease in the height of the groundwater aquifer. Although the water table depth of this plain is much higher than other plains of Chouchehdehno and Isin, the high density of the number of wells drilled in this area has caused a more severe decline. The high impact of this plain from droughts is one of its important features. Sarkhon plain, like Chouchehdehno and Gnu plains, was strongly affected by the severity of the droughts and many feedings and discharge fluctuations were observed in this plain. These fluctuations had a certain average until 1999, but after This date, with the intensification of droughts, the amount of nutrition did not respond to high and continuous evacuation and has caused a continuous and severe drop in the groundwater level of the region. In the water level drop of Shamil plain, no large and significant fluctuations have been observed and the gradual continuation of the water level drop of this plain is one of its prominent characteristics.

Intensification of drought intensity and its continuity and the effect on water table drop in this plain was quite clear and with increasing SPI period, the relationship between this method and water table drop is better observed, in other words, water table drop have been with time delay. Changes in the water level of wells were more consistent with the long-term effects of drought so that the highest correlation with changes in groundwater level occurred in the 24-month series. This highlights the need for a long-term study of the phenomenon of drought and its effects in an area because it turns out that the longer the study period, the results show the reality of the phenomenon well. In general, with increasing the scale from 3 months to 24 months, the correlation coefficient has an increasing rate. The highest correlation coefficient was obtained for Shamil plain on an 18-month scale. The results showed that short-term time scales fluctuated more than long-term scales, so they reacted quickly to the slightest change in monthly rainfall.

In recent years, Hormozgan province, including the mentioned plains, has witnessed continuous droughts. According to the multi-month chart of the studied plains, the drought index in recent years shows a downward and negative trend. On the other hand, the effects and results of this drought have been shown to decrease the level of groundwater resources in recent years. According to the obtained results, the SPI index, coinciding with the year of occurrence of minimum rainfall during the statistical period, shows the occurrence of drought in selected plains, which has a good performance in showing drought. According to the quarterly chart of the plains, the amount of quarterly changes in this index with absolute changes in water level had many fluctuations that these fluctuations were adjusted significantly in the periods of 12, 18 and 24 months. Increasing and decreasing the amount of SPI index with time delay is effective in the fluctuations of groundwater level of the plains so that the 24-month chart of SPI due to less affected by transient climatic changes well shows that with increasing severity of drought in the climatic conditions of the region, the SPI index has become more negative and this increase in drought has led to a significant decrease in the level of groundwater resources in the region.

Among the studied plains, the most severe drop in water level was related to Gno plain. Since this plain has agricultural uses with high dependence on groundwater resources, this decline seems quite reasonable. With the occurrence of drought and lack of groundwater nutrition by the region's rainfall and on the other hand the decrease of humidity in the areas where agriculture has been done, the use of groundwater has increased and naturally the aquifer area decreases more than before. On the other hand, due to the role of geology and topography of the studied plains, GNU plain has a higher slope than other plains, which indicates the slope of groundwater. Therefore, the steeper the slope, the less groundwater is trapped. The location of the region's lands on the marl massifs, which strongly affects the water quality and thus the production of agricultural products, with the intensification of the effects of drought and lack of consideration for the potential of the region, complicate the situation and the issue of lack of Emphasizes land use appropriateness and emphasizes the importance of comprehensive planning and management for sustainable development for provincial and national managers, policymakers and planners. The overall results showed that in all the plains during the years studied, the SPI index is getting worse, that is, the drought is expanding and intensifying. Concomitant to this situation, groundwater levels are also falling. The average water level drop for the whole region was 3.35 m. Changes in the groundwater level were more consistent with the long-term effects of drought so that the highest correlation with changes in groundwater level occurred in the 24-month series.

Conclusions

Drought has a great effect on the groundwater level drop and changes in the groundwater level were more consistent with the long-term effects of drought.

Predicting Inlet Flow to Jamishan Dam Using Time Series Models

Document Type: Research Paper

Mahdi Sarai Tabrizi[1*], MohammadNabi Jalali[2], Hossein Yousefi Sahzabi[3]

1- Assistant Professor, Department of Water Engineering and Sciences, Faculty of Agricultural Sciences and Food Industries, Science and Research Branch, Islamic Azad University, Tehran, Iran
2- M.Sc. of Water Resources, Department of Water Engineering and Sciences, Faculty of Agricultural Sciences and Food Industries, Science and Research Branch, Islamic Azad University, Tehran, Iran
3- Associate Professor, Department of Renewable Energies and Environment, Faculty of New Sciences and Technologies, University of Tehran, Tehran, Iran
Corresponding Author: m.sarai@srbiau.ac.ir

Abstract

As aquifer feeder and influential parameter in water balance equations and groundwater resources balance, accurate prediction of dams and rivers discharge plays an important role in planning managing and operating optimal and sustainable water resources. In this research, in order to organize the Jamishan catchment area. In order to predict the future natural hazards of the basin, the monthly discharge of this basin is predicted by time series analysis methods. In this regard Was used from monthly discharge data of entrance to jamishan dam in sonqor city of kermanshah province during the period (1360-1389). Initial analysis of data included a review of definitive series semantics (period, trend, jump) done on the time series and after assurance remove these semantics, data was normal and the data stagnation was made. By examining the correlation and partial correlation functions for fifty percent of the data, the self-correlated model (AR) and the moving average model (MA) were fitted for the calibration period to the time series and with the non-correlation test of Port-Manto and the normalization of the remainder, a number of models that did not have these conditions were eliminated, and the best models were identified among the remaining models with Akayek's test. In the verification stage, using the best model during the calibration period, for the fifty-second percent of the data, the prediction verification step was performed. And error validation values were evaluated using white nose, Barlett-Test (Cumulative Rotational), mean of remaining significance, and after the success of the model in the verification prototypes, it was used to predict the monthly discharge of the next 15 years. It can be concluded that the more the model is more static, the analysis of the series is easier and the model with less acacia gives a better answer.

Keywords: ARIMA, Jamishan dam, Stochastic, Time series.

Introduction

As a feeder of aquifers and an effective parameter in equations and water balance reports, forecasting the discharge of dams and rivers has a significant role in the planning, management and optimal and sustainable use of groundwater resources. In this study, in order to organize the Jamishan catchment, the monthly discharge of this basin was predicted using time series analysis methods. For this purpose, the monthly data of the inflow to Jamishan Dam in Sanghez city of Kermanshah province in the period (1365-1395) were used. Preliminary data analysis including definite series term (frequency, trend and jump) was performed using Mann-Kendall test in MINITAB software and after ensuring the removal of these terms, the data were normal and static data were determined.

Then, according to the autocorrelation and partial autocorrelation functions, an attempt was made to fit the time series models suitable for the calibration period to the desired data and to eliminate a number of models that lacked these conditions by the test of portanto correlation and normality of residuals.

The results show that among the remaining models with Akaik test (AIC), ARIMA time series model (1,1,1) with akaik value of -11.76 and error variance of 0.92 was identified as the best model, in the validation stage. Also, using the best model in the calibration period, predictions were made and the results related to the lack of autocorrelation between the residues resulting from the fit of the selected model of the values of the errors of the validation period were evaluated by Barlett test.

The results of the permutant statistic indicate that the p-value in all delays is greater than 0.05, which confirms the independence of the residues. Barlett test results also show the high accuracy of the model. After the success of the model in validation tests, the model now has the ability to enter the prediction stage. The model gives better results and the model with less Akaike and variance remaining is a better model.

Materials and Methods

Jamishan Dam in Songor city of Kermanshah province, Songhar city leads to Gavroud catchment area from the north, Khorramroud catchment area from the east, Maryam Negar river catchment area from the south and Siah and Gavroud sub-basins from the west.

This dam with a normal volume of 62.8 million cubic meters was constructed with the aim of supplying agricultural water to the region and controlling floods.

In this study, the monthly data of the inflow to Jamishan Dam in Songor city of Kermanshah province in the period (1363-1392) are used. The data must be deleted before the static test, which is achieved by standardizing the data.

The initial analysis included examining the definite terms of the series (frequency, trend and jump) on the time series using Minitab software, and after ensuring the removal of these terms, the data were normalized and the static data was determined. In this study, Box Cox transform was used to investigate the static variance, which is done before differentiation.

Also, in this study, the Mann-Kendall test was used to investigate the trend. After ensuring the elimination of the definite terms of the series, the stasis of the series was checked by correlation drawing (ACF). At this stage, by dividing the data into two periods of calibration and validation, the order of the model suitable for fitting for the calibration period was determined.

In time series, it tries to identify the possible pattern of data generator by examining the status of data series in the past and comment on the future behavior of the series based on this pattern.

To model the time series of the data, the value of the variable in the existing step is considered either as a linear combination of the values of the variable in the previous steps (self-correlated model) or as a linear combination of the error values of the model in the previous steps (moving average model). Both self-correlated and moving average models are obtained. The self-correlated, moving average model is obtained.

A static condition must be met to use these models. Among the selected models that have normal and independent residues, the Akaike test is performed and the model with the lowest value (AIC) enters the validation stage as the superior model. A general model that is able to represent a wide group of unstable time series, so in this study, this test was used to compare different ARIMA models (p, d, q) that in fact, the lower the variance of the error, the model The fitted is a better model, so a model with a lower AIC is chosen as the superior model.

After selecting the model at this stage, the model validation was examined on the second 50% of the data. In this study, the Manto port test was used to show no correlation in the residues. The Barlett test is also used to assess whether periodic semesters are well removed from time series information. Finally, to measure the accuracy of different forecasting methods, the squared index of mean squares error and correlation coefficient are used.

Results and Discussion

In the verification stage, using the best model during the calibration period, for the fifty-second percent of the data, the prediction verification step was performed. And Validation Error Validation Values were evaluated using White Nose, Barlett Test (Cumulative Rotational), mean of Remaining Significance, and after the success of the model in the verification prototypes, it was used to predict the monthly discharge of the next 15 years. it can be concluded that the more the model is more static, the analysis of the series is easier and the model with less acacia gives a better answer. The use of time series models due to the incidental and uncertain nature of water engineering and water resources management issues is one of the recommended methods in predicting the parameters. In the present study, the monthly data of the inflow to Jamishan Dam in Songhor city of Kermanshah province in the period (1363-1392) are used. The data must be processed before performing the static test, which is achieved by standardizing the data. The initial analysis included examining the definite terms of the series (frequency, trend and jump) on the time series using Minitab software, and after ensuring the removal of these terms, the data were normalized and the static data was determined. After ensuring the elimination of the definite terms of the series, the stasis of the series was checked by correlation drawing (ACF).

Conclusions

The results of data analysis are given in data and variables, which according to the box method, the number of lags for data less than 240 is N / 4 and for data more than 240 is 45. After plotting the autocorrelation diagram, it shows that the time series was intermittent and was unstable on average. Which is followed by a time series with one time difference in static mean. Therefore, a periodic table of the differentiated series was drawn, where the points with omega values are 0.5236, 1.047 and 1.5708, which should be removed from the series. After removing these sentences from the time series, the values of Statistics I were calculated and compared with Fisher test. It can be seen that the statistic obtained from these series is much larger than F, so the time series is still alternating.

In the following, standardization has been used to eliminate rotation. After standardization and elimination of periodicity, as can be seen, the values of Statistical I are compared again with the values of Fisher test and show that all values of I are less than F and the periodicity is lost. Now, the various fitted models with coefficients and variance of the residuals were investigated.

Therefore, ARIMA model (1,1,1) with AKAIKE 11/76- error variance of 0.92, in addition to the small amount of akaik variance has a lower error and a correlation coefficient of 0.88 and has been selected as the best model.

After selecting the superior model, the results related to the lack of autocorrelation between the residues resulting from the fit of the selected model on the second 50% of the data were examined according to Pert_Manto statistics. The results indicate that the residues are independent. Also, the residual normality test and the residual time independence test (residual correlation) obtained from the fitting of the selected model show that the residuals are also in the safe and normal range, so the fitted model seems to be a suitable model.