Forecasting Trends in Relative Humidity in Iraq (Study in Climate Geography)

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ABSTRACT
The research aims to predict and determine the trend in relative humidity rates (%) in Iraq, for four months (October, January, April, July), as the percentage of water in the atmosphere does not exceed (0.01%) of the hydrosphere at any moment. Despite this, it is an important element in the weather and plays a major role in the formation of clouds, fog, and dew. He is responsible for all major weather events, such as hurricanes and other weather disturbances. To understand the nature of the behavior of relative humidity, its trend, fluctuations, and future changes in time and space, statistical models were designedm(SARIMA) based on the Box–Jenkins method in the time series forecasting method for the period (2023-2037), for the following stations (Kirkuk - Baghdad - Al-Hayy - Samawah - Nasiriyah - Basra) and relying on the base years from (1970 - 2022), and the research adopted the use of The algorithm drawn up by two researchers (BJ 1976), used the autoregressive model and the seasonal integration moving average, which is symbolized by the symbol (p, d, q) (P, D, Q) SARIMA, which is called the seasonal multiplier model.

1. Introduction

Relative humidity describes the amount of water vapor present in the air at a certain temperature relative to the maximum amount that the air can hold at the same temperature, and it is expressed as a percentage (Al-Samarrai, 2007:122-123), which represents one of the measures of atmospheric humidity and the most common expression. Therefore, the statistical method was used to analyze time series using Box Jenks models, and from these models this variable is simulated to reveal what its trend will be in the future. research importance:The importance of the research comes from knowing the direction and amount of change in relative humidity rates, its impact on the quality and quantity of precipitation, and its impact on the physiology of the organism's body, as it reflects the state of the atmosphere through an effect on the quality of the wind and the degree of air humidity and dryness. Research problem:The problem of low relative humidity rates is at the forefront of the problems that contribute to the expansion of desertification and drought due to lack of precipitation and dry air.

Research hypothesis: The trend and predictive values in relative humidity rates decrease between climate stations, and this decrease has a roleSignificant atmospheric transparency. research goal: The research aims to know the trend and predictive values of relative humidity rates (%) in Iraq for stations (Kirkuk - Baghdad - Al-Hayy - Samawah - Nasiriyah - Basra) for four months (October, January, April, July) and forecast for the period (2023-2037) and calculate The amount of change during that period. Research limits: The spatial boundaries of the research are limited to an area within the political borders of Iraq, which is located astronomically between two latitude circles (⁻29.5°_⁻ 23. °37(north and long arcs)⁻38.45°_⁻ 45. 48°Geographically, it is located in the southwestern part of the continent of Asia. Six main climate stations have been chosen: (Kirkuk - Baghdad - Al-Hayy - Samawah - Nasiriyah - Basra). As for the temporal dimension of the period (1970-2022) and the period of forecasting the trend of relative humidity rates for the year (2037-2023). Statistical method:The time series method was used following a systematic approachBox and Jenkins, the following model was used:

Autoregressive model and moving average seasonal integration, symbolized by:(p,d,q) (P,D,Q)m SARIMA, which is called the multiplicative seasonal model, is the most widely used Box-Jenkins model for its flexibility and suitability. for various types of data, which is expressed in the following formula: (**Mills T.C., 2014:15)**

$$\varphi_p (B)\varphi_P (B^m)\, \Delta_m^D \Delta^D\, X_t = \theta_q(B)\theta_Q(B^m) a_t \qquad (1-1)$$

2- The theoretical aspect:

Stages of building the appropriate model according to a methodology

Box – Jenkins

1.2- Model diagnosisIdentification: Diagnosing time series models is the most important step in building a time series model, and it is the first stage of the algorithm, which was established in 1976 by researchers.BOX-JenkinsIt must be preceded by the data initialization phase. If the data is stable by observing the original data plot and its autocorrelations and partial correlations, then the data is ready for diagnosis. If it is unstable in the mean and variance, the instability in the mean is dealt with by taking the first difference (1d=). If it is not stable, we take the second difference (d=2) and it often stabilizes after the first or second difference. As for instability in the variance, it is treated by performing the appropriate data transformation, and after achieving stability of the time series, the process of specifying the model begins, which means using data or information about how the time series is generated. The goal here is to obtain an idea of the values of (p, d, q) necessary for the general linear model ARIMA, which then obtains an initial estimate of the model parameters (1976:245, BJ).

2- Determine the degree of the model

The appropriate model for the time series is diagnosed and the ranks are determined(q, p) by relying on some criteria, so that the model that corresponds to the lowest value of these criteria is adopted, and the most important of these criteria is: (Al-Kalabi, 2018:36)

Akaike Information Criterion (AIC)1- Akaike Information Criterion:

The Japanese scientist Ikeki suggested (Akaike) was established in 1973 as a criterion for determining the rank of the model and it was called the Akaike Information Criterion and its symbol is (AIC) and it is written in the following formula:

$$\mathrm{AIC} = \mathrm{n}\ \mathrm{Ln}\left(\hat{\sigma}_{\mathrm{a}}^{2}\right) + 2\mathrm{m} \qquad (1-2)$$

2- Schwartz criterion:Schwartz Bayesian Criterion (SBC)

In 1978, the researcher proposed (Schwartz) used a criterion similar to the Bayesian Criterion and called it (SBC). It is written in the following form:

$$\mathrm{SBC}_{(\mathrm{m})} = \mathrm{n}\ \mathrm{Ln}\left(\hat{\sigma}_{\mathrm{a}}^{2}\right) + \mathrm{m}\ \mathrm{Ln}(\mathrm{n}) \qquad (1-3)$$

3.2- Estimation stage Estimation:The process of estimating the model parameters is in the second stage of the study of time series analysis, and it comes after the process of diagnosing the appropriate model for the time series. In order for us to obtain a model that achieves the main goal of building it, which is prediction, we must ensure the quality of its estimation and its suitability for the time series. The most prominent methods for estimating the model parameters include: (Pirce, 1971:299-312)

1- The greatest potential methodMaximum likelihood Method

This method requires choosing the parameter matrix of the model to be estimated according to the principle of maximizing the potential function

2- Ordinary least squares methodOrdinary List Squares Method

The principle of this method is based on minimizing the sum of the squares of the estimation error and making it its minimum

Diagnostic Checking 4.2**- Examining the extent and suitability of the model**

The stage of examining the suitability of the model comes after determining the model parameters and whoThe tests used to verify the accuracy of the diagnostic model are: (Gujaratik2004:846-847)

1-Testing the naturalness of the remains

Kolmikrov-Smirnov goodness of fit test and drawing the shape of the natural probability of the residuals, to ensure that the residuals are normally distributed.

2- Testing the autocorrelation function of the residuals

The autocorrelation values of the residuals of the estimated model are calculated and determined whether they fall within the confidence limits of the plot

The autocorrelation function of the residuals. If it is within confidence limits, then the residuals have a symmetrical normal distribution.

3- Testing the autocorrelation function of the squares of the residuals

This test plots the autocorrelation values of the squares of the residuals in order to demonstrate the homogeneity of the error variances. If the autocorrelation coefficients all fall within the boundaries of the confidence interval, it indicates that the residuals have homogeneous variances.

5.2**- ForecastingForecasting**:

The last stage of the methodological stage (Box - Jenkins) is to predict the future value of the time series using the model that was arrived at during the previous stage, which represents the best representation of the time series. The better and more accurate the estimate, the smaller the error resulting from it and the less its variance. The first predicted future values are obtained through (). Setting the current and previous values of the variable () and the residuals as estimated values for the error term and the ARIMA model (p, q) and for the future period L then:$Z_{t+1}Z_t$**(Okla, 2017:44)**

3- The practical aspect:

The research adopted the use of the algorithm drawn up by two researchers (1976BJ) which is represented by the model. (SARIMA)m On relative humidity data (%) in Iraq for the period(1970-2022) for the following stations (Kirkuk - Baghdad - Al-Hay - Samawah - Nasiriyah - Basra) to know its future trends in the following months (October, January, April, July).

1- October:

The diagnostic models were chosen as the best model for the purpose of finding the predictive values for the month of October for the study stations are: Kirkuk Station 4(0.1.5)(2.1.2), Baghdad Station 4(0.1.0)(2.1.1), Hay Station 4(2.1.1)(2.1.2), Samawa Station 4(0.1.0) (1.1.2), Nasiriyah Station, Basra 4 (0.1.1)(1.1.2).

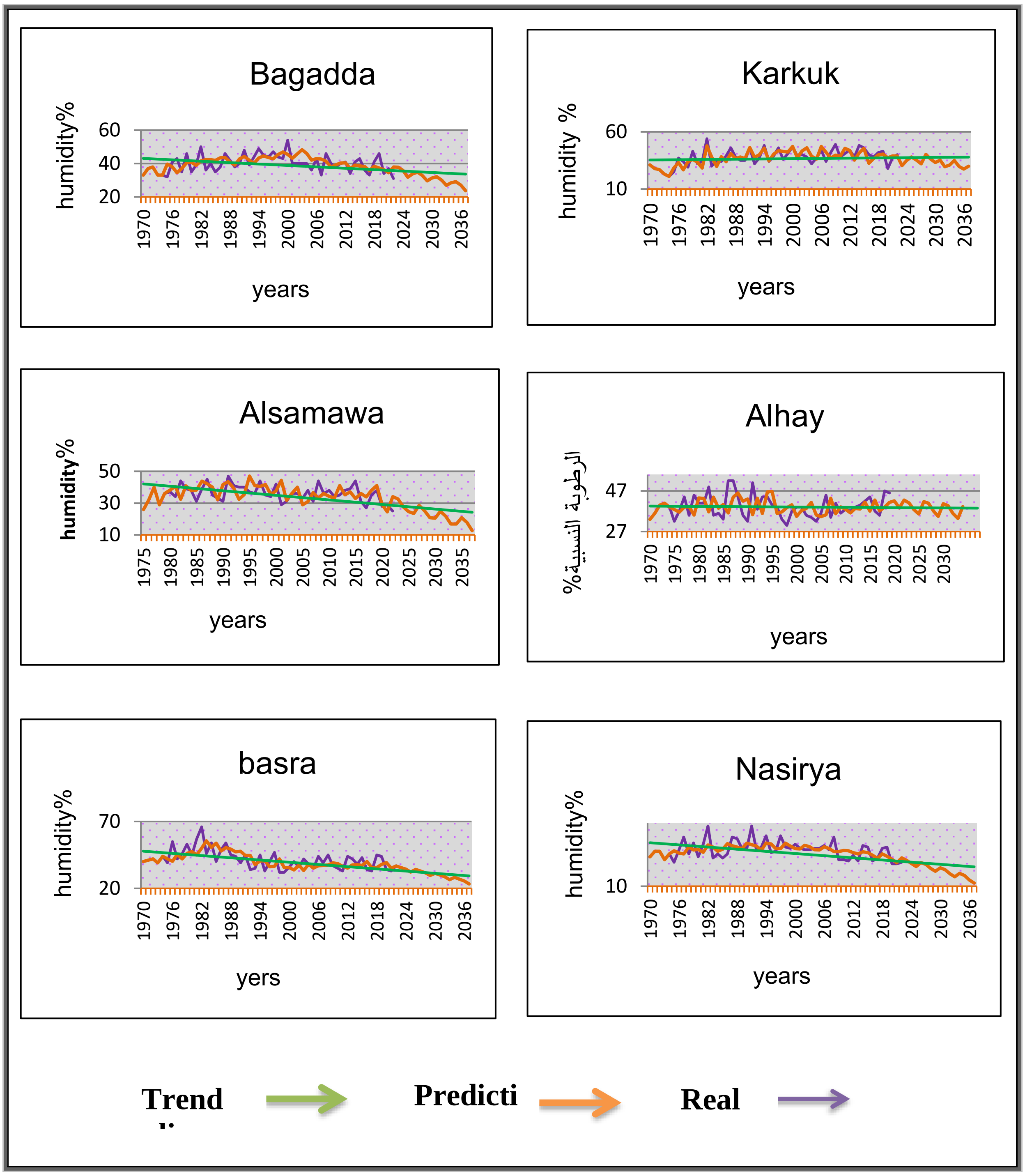
It was found that the predicted rates of relative humidity (%) were low in most of the climate stations included in the study, as the average values varied during the forecast period in October at the study stations between (42.5%) at the Al-Hay station and (12.3%) at the Nasiriyah station.

It became clear that the general trend of relative humidity rates (%) predicted for the month of October at the study stations tended to decrease, with the exception of Kirkuk station, and it tended to rise with a change amounting to Kirkuk (0.09), Baghdad (-0.35), and Al-Hayya (-0.03). Samawah(-0.80), Nasiriyah(-0.71), Basra(-0.66)(

It is clear from Figure No. (1) that there is a decrease in the predicted rates of relative humidity (%), as the Kirkuk station recorded the lowest rate (27.5%) in (2036) and the highest rate reached (40.3%) in (2028), as for the Baghdad station. It recorded its lowest rate (23.7%) in (2037) and the highest rate reached (37.8%) in (2023), while Al-Hay station recorded its lowest rate (33.4%) in (2033) and its highest rate (42.5%) in (2022), and the lowest rate was at Samawah station (12.7%) in (2037) and the highest rate was (32.6%) in (2023), then Nasiriyah station recorded its lowest rate (12.3%) in (2037) and the highest rate there (28.5). %) in (2023), and it became clear that the Basra station recorded the lowest rate (23.3%) in (2037) and the highest rate (35.4%) in (2023).

Figure No. (1). Actual and predictive values and trend line for relative humidity rates (%) for the month of October for the period

(1970-2037) for study stations



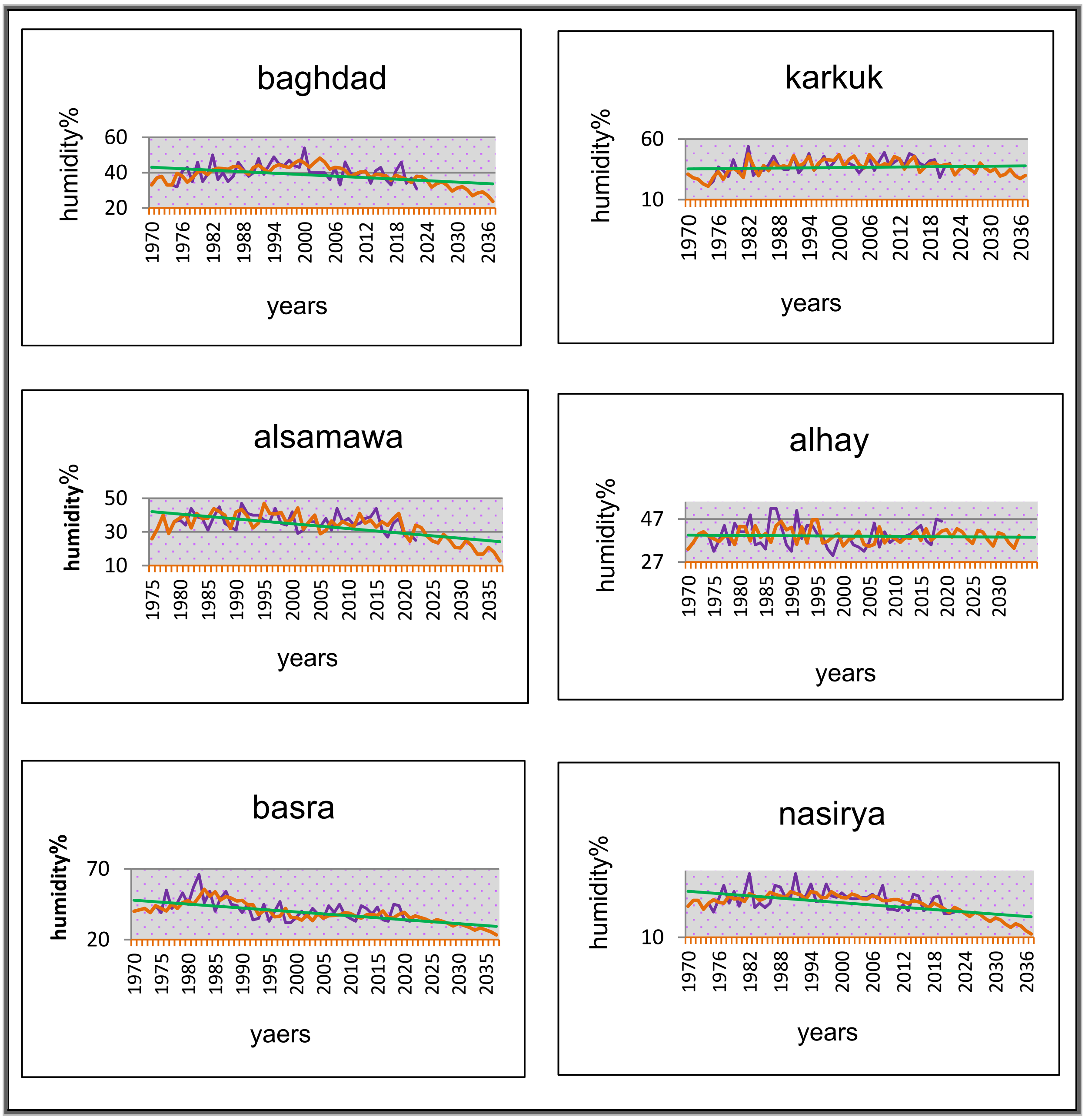
Source: The researcher's work based on Table (1) and data from the Iraqi General Authority for Meteorology and Seismic Monitoring. Climate Department. Baghdad. 2023 (unpublished data).

2- January: The diagnostic models were chosen as the best model for the purpose of finding predictive values for the month of January for the study stations:

Kirkuk Station, Baghdad, Samawah 4(0.1.1)(1.1.1), Nasiriyah Station 4(0.1.0)(1.1.2), Basra Station 4(1 1 0)(1.1.2), Hay Station 4(0.1.0)(4.1.4). It is noted that the predictive values of relative humidity rates (%) are low, and their rates are close to each other, with a slight difference between the study stations, as the rates of the predicted values varied during the month of January in the study stations during the forecast period between the level of (78.4%) in the neighborhood station and (40.7%) %) Samawa station. The general trend of relative humidity rates (%) predicted for the month of January for the study stations tended to decrease with a change amounting to (-0.18) in Kirkuk. Baghdad (-0.43). Neighborhood(-0.24). Samawah (-0.63). Nasiriyah (-0.22). Basra (-0.67). Figure No. (2) shows a trend toward decline in the predictive rates of relative humidity (%), as Kirkuk station recorded its lowest rate (54.3%) in (2037) and the highest rate reached (68.0%) in (2024), as for Baghdad station. It recorded its lowest rate (50.1%) in (2037) and the highest rate reached (63.5%) in (2023), while Al-Hay station recorded its lowest rate (59.7%) in (2024) and its highest rate (78.4%) in (2020), and the lowest rate was at Samawah station (40.7%) in (2037) and the highest rate was (54.4%) in (2026), then Nasiriyah station recorded its lowest rate (50.9%) in (2025) and the highest rate there (69.5). %) in the year (2035), and it became clear that the Basra station recorded the lowest rate (47.7%) in (2037) and the highest rate (60.0%) in (2023).

Figure No. (2). Actual and forecast values and trend line for relative humidity rates (%) for the month of January for the period

(1970-2037) for study stations



Trend **Predicti** **Real**

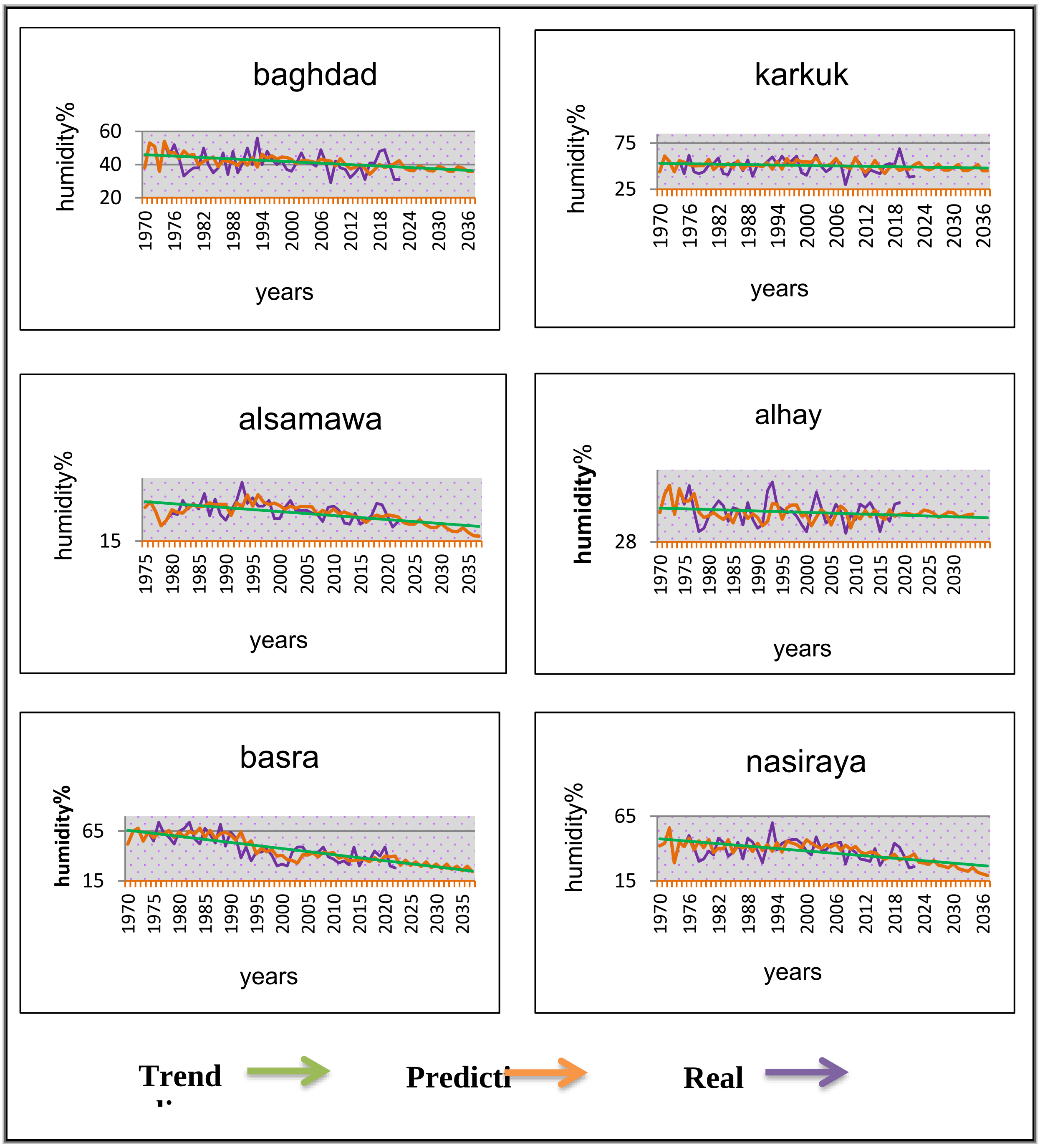
Source: The researcher's work based on Table (2) and data from the Iraqi General Authority for Meteorology and Seismic Monitoring. Climate Department. Baghdad. 2023 (unpublished data).

3- April: The diagnostic models were chosen as the best model for the purpose of finding predictive values for the month of April for the study stations: Kirkuk Station 4(0.1.1)(2.1.1), Al-Hayya Station 4(0.1.1)(3.1.3), Nasiriyah Station 4(1.1.1)(1.1.1), Baghdad Station, Samawah, Basra 4(0.1.1)(1.1.1). It is evident that the predictive values of relative humidity rates (%) decreased, as their rates varied during the month of April at the study stations between (54.1%) in Kirkuk station and (18.6%) in Samawah station. The general trend of relative humidity rates (%) predicted in the month of April for the study stations tended to decrease with a change amounting to (-0.15) in Kirkuk. Baghdad (-0.34). Neighborhood(-0.18). Samawa (-0.77). Nasiriyah (-0.79). Basra (-0.25).

It is clear from Figure No. (3) that in most of the studied stations, the relative humidity rates (%) predicted a clear trend towards a decrease, and the Kirkuk station witnessed a slight decrease, as the Kirkuk station recorded its lowest rate (45.1%) in the year (2036.2037) and the highest rate reached (2036.2037). 54.1% in the year (2023), while the Baghdad station recorded the lowest rate (35.8%) in the year (2037) and the highest rate reached (39.1%) in the year (2026), while the Hay station recorded the lowest rate in it (42.3%) in the year (2027) and the highest rate was (46.6%) in (2024), and the lowest rate was at Samawa station (18.6%) in (2037) and the highest rate was (30.2%) in (2026), then Nasiriyah station recorded the lowest rate (19.2). %) in (2037) and the highest rate (30.8%) in (2026), and it became clear that the Basra station recorded the lowest rate (24.2%) in (2037) and the highest rate (35.9%) in (2024).

Figure No. (3). Actual and forecast values and trend line for relative humidity rates (%) for the month of April for the period

(1970-2037) for study stations



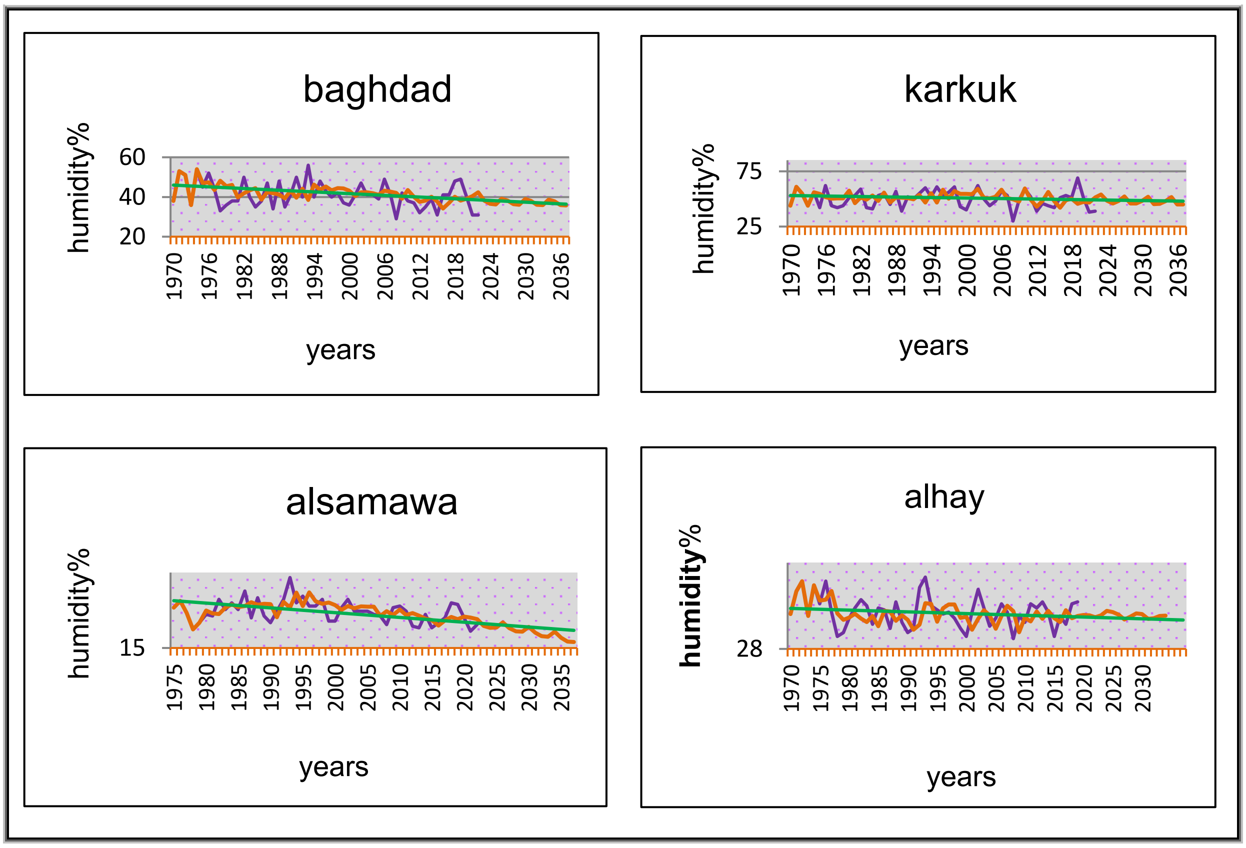
Source: The researcher's work based on Table (3) and data from the Iraqi General Authority for Meteorology and Seismic Monitoring. Climate Department. Baghdad. 2023 (unpublished data).

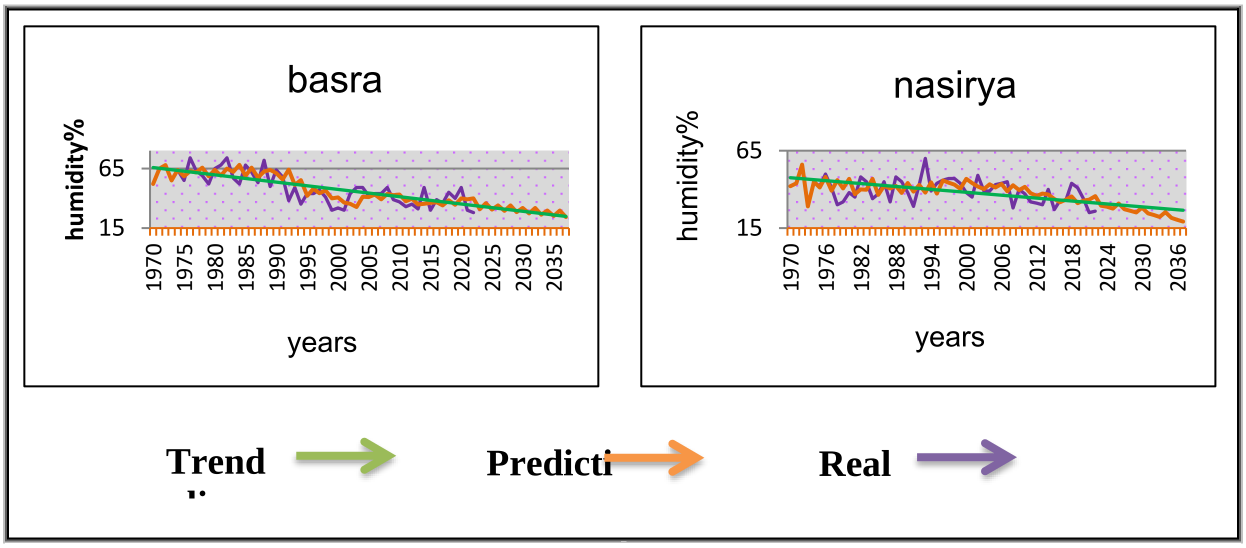
4- July: The personalized models were chosen as the best model for the purpose of finding predictive values for the month of July for the study stations: Kirkuk Station 4(0.1.1)(1.1.1), Baghdad Station 4(0.1.0)(2.1.1), Al Haya Station 4(0.1.1)(3.1.1), Samawah Station 4(0.1.0) (2.1.2), Nasiriyah Station 4(1.1.1)(1.1.2), Basra Station 4(0.1.1)(2.1.1). The forecast values for relative humidity rates (%) decreased according to what was shown in the analysis, except for the Kirkuk station. The values recorded a slight increase, as the forecast relative humidity rates (%) varied during the month of July at the study stations during the forecast period between the level of (24.7%) at Kirkuk station and (8.5%) at Samawa station.

The trend in relative humidity rates (%) predicted for the month of July at the study stations tended to decrease, with the exception of Kirkuk station. It tended to increase with a change amounting to Kirkuk (0.27), Baghdad (-0.43), Al-Hayy (-0.18), and Samawah (-0.83). , Nasiriyah (-0.83), Basra (-0.25). Figure No. (4) shows a trend in the forecast relative humidity rates (%) towards decline, except for the Kirkuk station, which witnessed a slight increase, as the Kirkuk station recorded its lowest rate (19.9%) in (2037) and the highest rate reached (24.7%) in (2037). 2023), while Baghdad station recorded the lowest rate (14.6%) in (2034) and the highest rate reached (21.1%) in (2023), while Al-Hay station recorded the lowest rate (20.2%) in (2032) and the highest rate. The lowest rate was (24.3%) in the year (2021), and the lowest rate was in the Samawa station (8.5%) in the year (2037) and the highest rate was (17.4%) in the year (2023), then the Nasiriyah station recorded the lowest rate in it (12.6%) in the year (2037).) and the highest rate was (16.4%) in (2024), and it became clear that the Basra station recorded the lowest rate (19.7%) in (2034) and the highest rate (22.5%) in (2024).

Figure No. (4). Actual and forecast values and trend line for relative humidity rates (%) for the month of July for the period

(1970-2037) for study stations





Source: The researcher's work based on Table (4) and data from the Iraqi General Authority for Meteorology and Seismic Monitoring. Climate Department. Baghdad. 2023 (unpublished data).

2. Conclusion and future scope

The general trend of the predicted relative humidity rates (%) tended toward a decrease in most stations, with the exception of the Kirkuk station. It will witness a variation in the general trend between a decrease and an increase during the forecast period, as the predictive values tended toward a decrease in Iraq but remained below the rate of 79%. The most stations that will witness a noticeable decrease in the predicted relative humidity rates are the Samawah and Nasiriyah stations due to the lack of sources of air humidity and high temperatures. Most of the stations witnessed a slight decrease in the predictive values of relative humidity rates, Kirkuk station, due to the increase in precipitation amounts and the decrease in temperature.

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