IHJPAS. 36 (4) 2023

Ibn Al-Haitham Journal for Pure and Applied Sciences
Journal homepage: jih.uobaghdad.edu.iq

Estimation and Forecasting of Evaporation Losses for Lake Mosul Dam

Nadera A. Mohamed*
Agriculture Technical College,
Northern Technical University

Dr.Elham A. Hussain
Administration Technical College,
Northern Technical University

Ahmad . N.S. Al-Shallawi
Administration Technical College,
Northern Technical University

***Corresponding Author:** nadiarabas123@ntu.edu.iq

Article history: Received 23 October 2022, Accepted 30 November 2022, Published in October 2023

doi.org/10.30526/36.4.3086

Abstract

Evaporation from water bodies is important and considered a major problem in dry and semi-dry regions, in this research the evaporation has been analyzed from two approaches: engineeringly and statistically. The engineering approach deals with the calculation of evaporation rates of Mosul Dam Lake. Three methods were used: pan evaporation class A, the combined and the mass-transfer. It was found that the values obtained by pan evaporation class A method was the highest among the other, while the mass transfer method achieved the lowest results. The evaporation rates during the year ranged according to the first method (0.9–5.5) mm/day, second (0.7–11.5) mm/day and the last method (1.0039×10^6) m^3/year, which represents 9% of the highest storage in the Mosul Dam Lake.The statistical approach, the values of the evaporation occurring in Mosul Dam Lake were forecasted for the 2016-2017 rainy period, and 255 observations were used to find two forecasting models that were constructed using the simple exponential smoothing and Holt methods, then compare the results with the actual values of evaporation starting from (256 – 265) depending on MSE ,the Holt method gave less value to MSE than the simple exponential smoothing method, as its value was 0.421 versus 2.576. Matlab (14a) and R (3.2.1) were used in the statistical analysis.

Keywords: Class A pan evaporation, Combined method, Evaporation losses, , Mass-transfer ,Method, Forecasting.

1.Introduction

Evaporation is greater significance in arid & semi-arid regions, where water scarcities are already a common problem. Evaporation from lakes can be larg and be a huge part from the total water.Evaporative loss represents unproductive water losses unlike to productively used amounts of water in agricultural practices and storage can be reduced by feeding the land, as it seeps when it rains through soil and rock crumbs It filters through porous rocks to reach an area where groundwater collects. Evaporation is scarcely measured directly, even in small bodies of water. It is commonly estimated by association with evaporation measured from evaporation pans or calculated by water balance, energy balance, mass transfer or a combination of energy balance and aerodynamic techniques. The method chosen depends on the depth of the water body and the availability of weather data or meteorological equipment.

In Egypt [1] calculated the evaporation from Nasser Lake in the South of Egypt, using mass transfer method. The evaporated water range (10_16) billion m^3 every year, it represents a high percentage of the Nile water. The water loss from this lake is one of the national problems, because the lake is the water bank of Egypt.

In Turkey [2] studied the evaporation losses from 129 lakes and 223 reservoirs (total area 4,026.16 km for lakes and reservoirs respectively) have been estimated to be about 6.8 x 10^9 m^3 per year (using pan evaporation method and the modified Penman equation), 2.7 x 10^9 m^3 from lakes and 4.1 x 10^9 m^3 from reservoirs. This amount exceeds Turkey's total annual consumption of water, which is supplied from groundwater. The amount of fresh water for domestic use was (5.7 x 109 m3) and industrial use (4 x 109 m3) in 1999.

In Palestine [3] estimated the water evaporated from Lake Tiberias to be about 230 million m^3. Lake Tiberias is the largest reservoir in Palestine, and supplies the region with 30% of the national water consumption, and its annual operational volume is about 680 million m^3.

[4] calculated the evaporation of Lake Seminole in southwestern Georgia, average monthly estimates of evaporation was 5.6 inches for period April 2000 to September 2001.

Mosul dam considered the largest dam in Iraq, It is ranked as the fourth largest dam in the Middle East, but there are few studies about evaporation losses in the lake of Mosul dam, the best one was the study of [5]. They estimated the evaporation from Mosul reservoir using Morton model and compare the results with data measured by class A pan.

On the other hand, The forecasting process is one of the important topic that come after the planning process and cannot be dispensed with in any form of planning and decision-making [6], and this and this includes all areas of life, including water, which plays an important and vital role. As a result of population growth, in addition to global warming, the amount of evaporation from water bodies has increased, so there has been an increase in water-related studies and an increased focus on building mathematical models that can describe more than one phenomenon at a time.

Constructing these models greatly assisted in managing and planning the various activities of water resources [7]. There are many ways to construct those mathematical models, some of which depend on current data, some of which depend on current and previous data, in which the data is in the form of a time series, and one of the methods of models that depend on constructing these models on current and previous data are exponential smoothing methods, where This method of construction depends on the state of the available data, as it is seasonal or non-seasonal, has a general trend, or does not have a general trend , etc.

The main aim of this research is to compute the evaporation losses from Lake, by using three methods (measurement in US Class A pan, combined Method and the mass transfer method techniques), then we will make a forecast to the evaporation losses as a statistical analysis.

2.Materials and Methods

1.2.Study Area:

The Mosul Dam is located on the Tigris River at a distance of 60 km northwest of the city of Mosul. Its coordinates are longitude (49°42’) and latitude (37°36’). It is an earthen dam with a mud core and contains graded filters on the upstream and downstream sides of the central core with sand filters. In addition to the lower outlets for the rapid unloading of the tank in the event of an emergency, as well as the presence of an electrical generating station with a generating capacity of 750 MW. The dam regulates the flow of the Tigris River through the lake that it created for the purpose of generating energy and achieving flood protection for the basin of the Tigris River below as well as to achieve the irrigation needs, the reservoir extends longitudinally on the course of the Tigris River, and its length is 45 km, while its width ranges from (2-14) km, and the surface area is (380) km^2 from the maximum operating level of (330) m above sea level. The left and 3 from the right. The highest flood level is 335 m, the lowest level for operation is 300 m, the maximum height of the dam is 113 m, the max width of the base is 650 m, and its length is 2.214km. The regulatory dam is located 8 km south of the main dam and works to reorganize the flow, as it detains the absolute high expenditures from the main dam and is released according to the irrigation needs. electrical generating of 60 MW. As for the generating station in storage and pumping, it works on storing energy when pumping it to the upper tank and then recovering the energy when it is re-launched to the bottom .

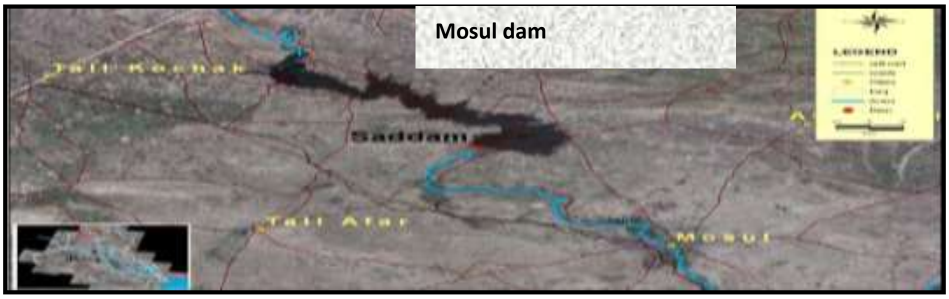

Figure 1. General Layout of Mosul Dam

The capacity of the emergency spillway is reported to be 4,000 cms. The power center is located at the front of the main dam on the right side of the river. The power plant includes four Francis turbines/generator units, each with a capacity of 187.5 MW, with a total rated capacity of 750 MW. The power plant is supplied with water through an intake structure and four separate tunnels. The minimum height of the operating basin is 300 m, and the maximum is 330 m (the flood height of the drainage channel is 317.5 m). The active storage area is about 8.1 billion cubic meters and the total storage at the maximum is 11.1 billion cubic meters.

Height 113 m and Length 3.4 km. The maximum discharge of the spillway is 12,400 m^3/s at maximum pool level. The fuse plug spillway on the left abutment is 400 m long and has a capacity of 4,000 m^3/s. The overflow of the fuse plug is 2 m below the dam crest. The powerhouse has a total designed capacity of 750 MW, though currently some 600 MW are being generated of the total 4,000 MW country requirement [8].

2.2.The Climate of Study Area:

The climate of the Mosul is mostly dry - hot in summer and humid –cold in winter. From November to April, rain falls in the Mosul Dam from the climatic point of view, and the rain is accompanied by snowfall in the mountainous areas The rainfall in the dam site does not exceed (450 mm) at a rate of (800 mm) annually over Rainfall during the summer is extremely rare .the entire region The annual average of rain in the city of Mosul is about (364 mm). The monthly averages of maximum temperatures range between (42.9°C) in July and (12.4°C) in January, while the monthly averages of minimum temperatures range between (24.2°C) in August and(2.2°C) in December. The maximum mean monthly temperature is28ºC in July and the minimum is 4.9ºC in January. The maximum evaporation in the month, starts to increase from March reaching a maximum (428 mm) July. wind speed recorded between (3-6 m per second) and its direction is from west to east in summer at a speed of (2-3 m per second), but in winter January and February it is at a rate of (5 m per second)and its direction is from east to west and is cold. The max. Sunshine duration is 14.37 hours in July & the min. is 9.39 in January [9]. The rainfall fluctuations in Mosul have been largely random over a city. Furthermore the spatial and temporal distribution of rainfall has become increasingly uncertain.

3.Meteorological Measurements:

Meteorological measurements for the period 1986-2008 were collected from Mosul weather station. The data collected are temperature (maximum, minimum), relative humidity (maximum, minimum), wind speed, solar radiation, sunshine hours, atmospheric pressure and Precipitation . An applied study on actual data on the evaporation of Mosul Dam Lake whose data are taken for the rainy year that begins in October of each year and ends in September of the following year, and the data period analyzed was October 2016 - September 2017, which amounts to 365 observations. Used for 355 observations, and the retention of ten observations were used to test the two models. Matlab 2014a and R (3.5.1) programs were used to obtain the results and construct the forecasting model of evaporation.

4.Methods of Determining Evaporation:

The estimation of evaporation from lakes and reservoirs is not easy as there are a number of factors which have affective to the evaporation rates, such as the climate and physiographic of the water body and its surroundings.

Clearly, evaporation depends on the supply of heat energy and vapor pressure gradient, which, in turn, depend on meteorological factors such as temperature, wind speed, atmospheric pressure, solar radiation, quality of water and the nature and shape of the evaporating surface [10].

Many methods exist for either measuring or estimating evaporative losses from lakes and reservoirs. We used this method to determine the evaporation losses in the lake of Mosul dam:

1. Pan Evaporation Class A.
2. The Combined Method.
3. The mass-transfer Method.

4.1.Pan Evaporation Class A:

Evaporation pans provide one of the simplest, inexpensive, and most widely used methods of estimating evaporative losses. Long-term pan records are available, providing a potential source of data for developing probabilities of net evaporation. It's the most commonly used method over two hundred years in U.S and the world but the measurements of pan evaporation may be be used directly because the differences between the pan and the water body in size and in upper air layers, which result in significant errors. So, the use of pan data must involve the application of a coefficient to measured pan readings to estimate evaporation from a large water body. the pan coefficients which varied between 0.47 and 1.18. The accepted standard coefficient for 1.22m (4') dia US Class A land pan is 0.70. as it is generally observed that a factor of 0.7 is accepted as the coefficient on an annual basis, the monthly variation has to be plus or minus the value of the annual coefficient. According to these considerations, the monthly coefficients can be adopted as 0.6 in cold dry winter months, 0.8 in hot summer months and 0.7 in the transition months between the winter and the summer [11].

Ep = pan evaporation× pan coefficient --(1)

Ep = Evaporation losses from the lake mm/month

pan coefficient= 0.6 in cold dry winter months, 0.8 in hot summer months and 0.7 in the transition months.

The evaporation losses from the reservoirs of Mosul dam using Equation (1) is shown in Figure2.

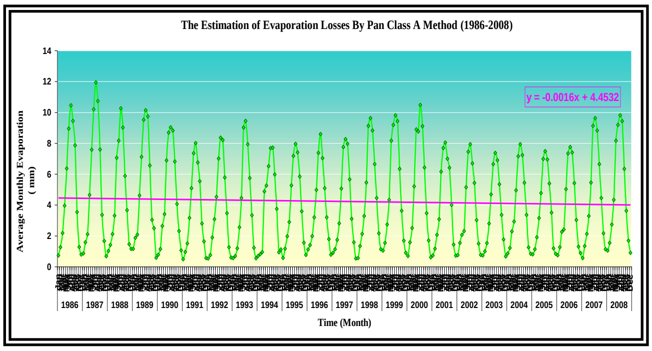

Figure.2. The evaporation losses from the reservoirs of Mosul dam using Pan Evaporation Class A

4.2.The Combined Method:

This method is a Combination of Mass Transfer (aerodynamic method) and Energy Budget method. It is not surprising that Evaporation has been estimated from meteorological parameters, because the primary source of energy for evaporation is solar radiation, the rate and time at which evaporation occurs is controlled by the difference in vapor pressure between the water surface and the atmosphere and the drying power of air is a function of wind run. Thus, the formulas which combination of energy balance and aerodynamic techniques type equations appear to be best at estimating evaporation (Evaporation is computed by two way , if the energy supply is not limited ,then aerodynamic method is used, when vapor transport is not limited then the energy balance method is used ,but ,normally both of them are limiting ,so the two are needed). Among the most useful methods for estimating evaporation is Penman-Monteith [12] now widely established and used.

$$Ep = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (es - ea)}{\Delta + \gamma(1 + 0.34U_2)} \quad \text{...(2)}$$

Ep=Evaporation losses from the lake mm/month.

Δ = the slope of the saturation vapor pressure curve at temperature Ta in kPa

R_n = is net radioactive energy to the water body in MJ /m2 t.

G = MJ/ m2 d.

γ = the psychrometric constant in kPa /C

e_s= the saturation vapor pressure.

e_a = the vapor pressure.

T= air temperature.

U_2 = wind velocity at 2 m above from the surface in m/sec.

Using Equation (2) to estimate the evaporation losses from the reservoirs of Mosul dam as shown in figure 3.

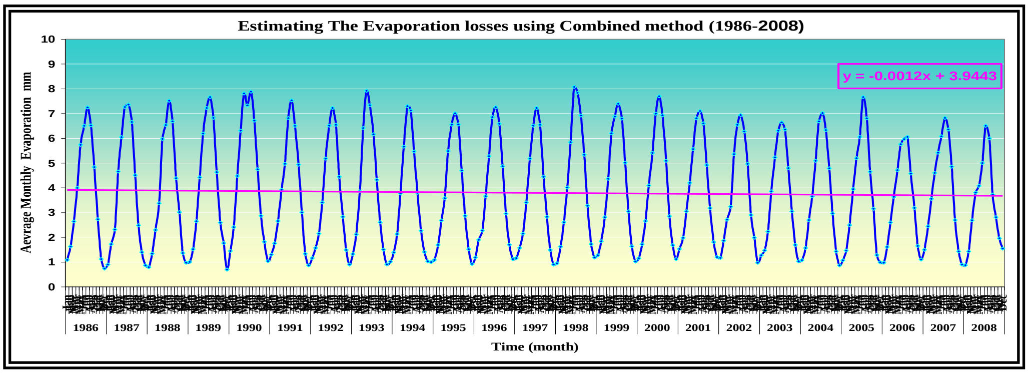

Figure.3. The evaporation losses from the reservoirs of Mosul dam using Combined Method

4.3.The mass-transfer Method:

The mass transfer method is one of the oldest and still an attractive method for estimating surface evaporation of water due to its reasonable simplicity and accuracy. Mass transfer methods depend on three main meteorological factors that are considered to influence evaporation: vapor pressure gradient, wind speed, and temperature. Air pressure, fluid density, and water surface height for a given location may not significantly affect the rate of evaporation.

The basic assumptions involved in this method are:

i) If a moisture gradient is present in the air, the water vapors will move towards the points with lower moisture content.

ii) The rate of movement of water vapor is increased by the intensity of the turbulence in the air.

The most used equation of this type is [13] :

E p = N* U_2 (es - ea) … (3)

E p= Evaporation losses from the lake cm/day then we changed to mm/month.

N= 0.1296

ea = vapor pressure of air [M L−1 T−2].

es = vapor pressure at the water surface [M L−1 T−2].

The evaporation losses from the reservoirs of Mosul dam using Equation (3) is shown in figure 4.

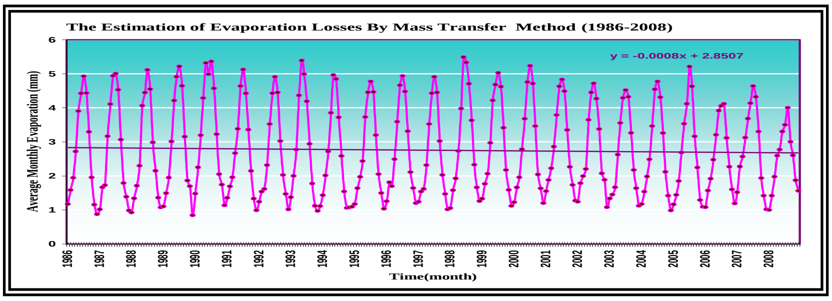

Figure.4. The evaporation losses from the reservoirs of Mosul dam using mass-transfer Method

5.Methods of Statistical Analysis for Forecasting Mosul Dam Lake

As a statistical analysis, exponential smoothing is used to represent the data, there are several methods of exponential smoothing:

1- Simple Exponential Smoothing
2- Double exponential smoothing.
3- Multiple exponential smoothing

In this research, the simple exponential smoothing, and double exponential smoothing methods were relied upon. The third method was excluded because the series was not seasonal.

The general formula for forecasting by simple exponential smoothing method is [14]:

$$\hat{y}_{t+1} = \alpha\, y_t + (1 - \alpha)\hat{y}_t \qquad \text{...(4)}$$

whereas:

y_t: represents the actual value at time t.

$\hat{y}_t$: represents the forecasting value at time t.

$\hat{y}_{t+1}$: represents the forecasting value at time t + 1.

α: represents the smoothing constant (smoothing) and its value is between $(0 \leq \alpha \leq 1)$.

The general formula for forecasting by the double exponential smoothing method, which is also called the Holt Method, is [15]:

$$\hat{y}_{t+h} = s_t + h b_t \text{ ,h=1,2,…} \qquad \text{… (5)}$$

Whereas :

$$s_t = \alpha\, \hat{y}_t + (1-\alpha)(s_{t-1} + b_{t-1}) \qquad \text{… (6)}$$

$$b_t = \gamma(s_t - s_{t-1}) + (1-\gamma)b_{t-1}$$

s_t : the value of the phenomenon after smoothing.

$s_{(t-1)}$: the value of the previous phenomenon for the period t from the values of the smoothed phenomenon

α: smoothing constant.

b_t: the current value of the general trend.

$b_{(t-1)}$: the previous value for the period t of the trend values .

γ: the general trend constant.

h: number of periods to forecast.

$\hat{y}_t$: the estimated value in period t .

$\hat{y}_{t+h}$: the predictive value in the period t + h.

6. Mean Squares Error:

It is the sum of squares error divided by the number of observations -1. The general formula for this criterion is:

$$\mathrm{MSE} = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-1} \quad \dots (7)$$

This criterion was used to determine the best method to depend on it in forecasting.

7. Results &Discussion:

As shown in Fig. 5 below, the evaporation losses from class a pan provide higher values especially in summer than estimations given by the two other methods. This over estimation because evaporation from a Class A pan has an oasis effect, energy is transferred from the surrounding surface horizontally from the dry surface, and this will provide additional energy for evaporation of the water in the pan.

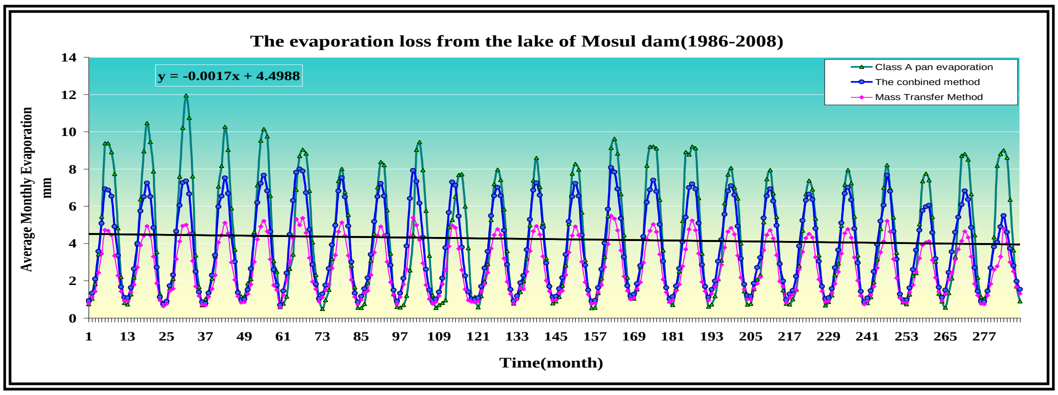

Figure 5. The evaporation losses from the reservoirs of Mosul dam using three methods

Class a pan contain some defects which that the sides exposes to the sun, which leads to increased evaporation compared to other pan. In times of hot weather, wildlife may use the pans as sources of drinking water.Despite their apparent simplicity, all pans must be carefully maintained. The water level should remain close to the specified level and regular cleaning and periodic repainting are necessary. The position of the pan can have a huge impact on the measurements[16].

The three methods have close values in cold months, also have similar tends. the values of mass-transfer method which are several times lower than the Combined method, especially in summer and it had the lowest results, variations in the evaporation rate winter are not strongly varied (0.9-5.5mm/day) but in the class A pan method they are (0.7-11.5mm/day).

Variations in the evaporation rate during the spring, autumn and winter are not strongly varied in the three methods. The maximum and mimimum average evaporation losses are (7.2-1 mm/day) in the three methods. In (2006,2007,2008) the water level of lake decrease(314-319m) during summer, the surface areas decrease and the evaporation losses decrease also.

The average monthly and annual volume of evaporation losses were calculated using eg(8),(9) [17]:

$$V = \sum_{1}^{12}(Em \times A \times n / 1000000) \quad \dots (8)$$

$$V = EP \times A \times 365 / 1000000 \quad \dots (9)$$

Em: evaporation rate mm/day

EP: evaporation rate mm/day

V: volume of annual evaporation losses × 10^6 m^3/year

A: area in Km^2

The changes in the average monthly volume of evaporation losses with water level relation as shown in Fig(6) which clearly shows that, the evaporation losses increases as the water depth increases were the surface area increase. The maximum water level of the lake (329-327m) was usually in June were the evaporation losses were maximum too.

The maximum volume of evaporation losses was 1.0039× 10^6 m^3/year which represent 9% of the total storage at maximum pool is 11.1 billion cubic meters.

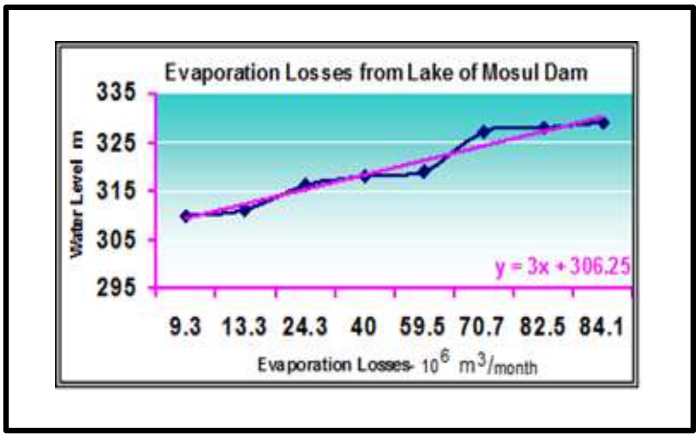

Figure 6.. The changes in the average monthly evaporation losses and the water levels of lake of Mosul dam

8.Reducing the evaporation losses from the Lake of Mosul dam:

There are a large number of ideas and techniques introduced by water resource management professionals to reduce the amount of water lost by evaporation from open water surfaces. It can be summarized as follows:

8.1. Ideas Proposed to Decrease Evaporation Losses:

Changing water levels upstream. Different administration methods can reduce evaporation and total evaporation too when you have more than one storage unit. For example by maintaining one complete dam instead of four part dams.

We can pump water between storages to reduce the surface area per unit size of water stored. Stores kept filled by cavities or overland flow will increase the overall volume without increasing the surface area. Water circulation can also reduce the water surface temperature and reduce the rate of evaporation

Water can be pumped between storages to minimise surface area per unit volume of water stored. Storages kept full by bores or overland flow will increase the total volume without significant increase in surface area. Water circulation could also reduce water surface temperature and decrease the rate of evaporation. Deep storage with a small surface area is more efficient in reducing evaporation losses. Windbreaks and local topography also affect evaporation losses.

Lakes should be surrounded by trees that grow in a humid environment, such as Salix or Populus, as the presence of such trees reduces radiation inputs, especially in early spring and late autumn when the solar elevation is low. Also, these trees will prevent the transmission of warm air from the heights and reduce the horizontal wind speed over the lake [18].

8.2. Techniques to Decrease Evaporation Losses:

- Use of floating sheets.

- Use of monomolec

Reduce evaporation from open water surfaces had some defects. For example, the application of the technique in which the entire surface of the water is covered, it is not possible because the complete coverage of the surfaces prevents the exchange between air and water, an issue that affects the oxygen demand that the aquatic environment needs.

Another defect is the use of cover sheets of irregular shapes that lead to the overlapping of the leaves when the wind speed becomes faster. Fortunately, these weaknesses were overcome while applying the proposed new techniques based on the concept that evaporation from the open water surface can be reduced by using floating cover plates. Coverage percentage, cover material type and control of wind effect on cover sheets were studied [19]**.**

9.Statistically Analysis

An applied study on actual data on the evaporation of Mosul Dam Lake whose data are represented for the rainy year that begins in October of each year and ends in September of the following year, the data period analyzed was from October 2016 - September 2017, which amounts to 365 observations. 355 observations are used to build the two models which are mention above , the rest of them (ten observations) were used to test these models.

Beginning, the behavior of the chain can be seen by drawing the evaporation data, which is illustrated in Figure 7 :

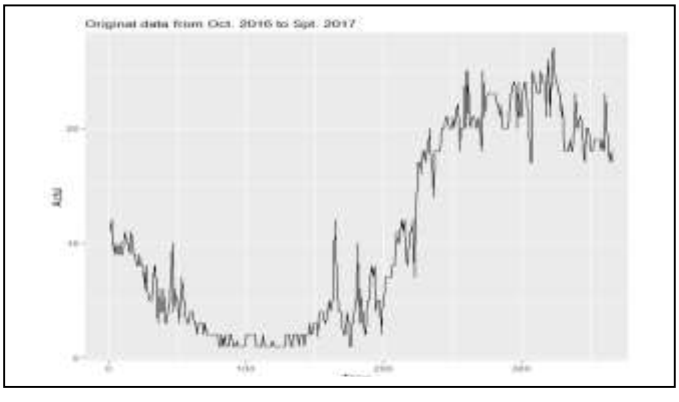

Figure7. Evaporation data, November 2016 - September 2017

From Figure 7 it is obvious that the series has a general trend, this means that the rain fluctuates between decreasing and increasing, as shown in the figure.

Since the analysis by the simple exponential smoothing method requires that the data do not contain a general trend, so the first differences of the time series of the evaporation data are taken, Figure 8 shows the data after taking the first differences:

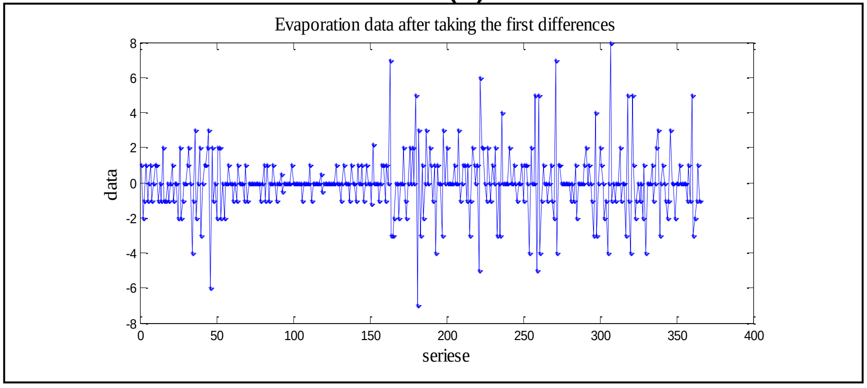

Figure8. Series of evaporation after taking their first differences

From Figure 8, It appears from the figure that the fluctuation has disappeared after taking the first differences of the series, in other words, the general trend was removed which was present in the series.

To construct the first models, we take many values to α,which are from 0.1 to 0.9 we exclude the values (0,1),because if the value is 1 it means that the smoothing values are ignored, and if the value is 0 means that the real values of the series are ignored, Therefore, the value of (α) affects the value of the mean squared error, and that is why it is necessary to choose a value (α) that makes the value of the mean error squares as small as possible[20]. we calculate MSE for each these values and choose a minimum value to use it in forecasting which is 0.5.

According to the simple exponential method, the model which represents the data, is as follows:

$$\hat{y}_{t+1} = 0.5\, y_t + 0.5\, \hat{y}_t \qquad \ldots (10)$$

The model represents the data according to the Holt method, is as follows:

$$\hat{y}_{t+h} = s_t + 10\, b_t \qquad \ldots (11)$$

$$s_t = 0.525\, \hat{y}_t + (1 - 0.525)(s_{t-1} + b_{t-1}) \qquad \ldots (12)$$

$$b_t = 0.0001(s_t - s_{t-1}) + (1 - 0.0001)b_{t-1} \qquad \ldots (13)$$

Based on equations (10), (11), (12) and (13), the forecasting values of the last 10 observations of the two methods, simple exponential smoothing and the Holt as in Table 1:

Table1: Actual and forecasting values according to simple and Holt methods

series	Actual	Forecasting by Simple Exponential Smoothing method	Forecasting by Holt method
356	19.0000	18.951	19.033
357	18.0000	18.9756	19.078
358	19.0000	18.4878	19.100
359	18.0000	18.7439	18.585
360	23.0000	18.3720	20.783
361	20.0000	20.6860	18.474
362	18.0000	20.3430	20.913
363	17.0000	19.1715	20.496
364	18.0000	18.0857	19.248
365	17.0000	18.0429	18.130

From Table No. 1 we demonstrate that the actual values are almost close to the forecasting values except the value whose sequence is 360, as the forecasting value according to the first estimation method, which are 18.3720, is somewhat far from the actual value of which is 23. but in a second method is 20.783.

It means that the models, which are constructing, represent the data in a good way.

The real and the forecasting values which are mentioned in table No. 1, can be represented as figure 9 :

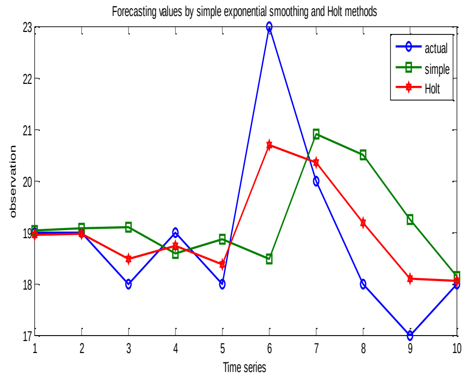

Figure 9. The forecasting values according to the simple exponential smoothing and the Holt methods

Figure 9 shows the forecasting values according to the data representation by the simple exponential smoothing and the Holt method. These values are sensible forecasts.

When comparing MSE values which are computed according to the methods, simple exponential smoothing and the Holt method, we find that the difference is clear between them, as in Table 2:

Table 2 : MSE value according to the two methods

Criterion	Simple exponential smoothing	Holt
MSE	2.5765	0.421

From Table No. 2 it is evident that MSE value when using the Holt method is less than using the simple exponential smoothing method in forecasting, which indicates that the representation of data using Holt method is better than its representation according to the simple exponential smoothing.

10. Conclusion

1.Data has a general trend.

2.When selecting multiple values for alpha . Alpha 0.5 achieved the lowest value for MSE in simple exponential smoothing approach.

3. Depending on the MSE value of the two methods, it appears that the Holt method is better than the simple exponential smoothing method in representing the data and using it in the prediction.

References

1. Shaltout, M. A. M., & El Housry, T. **1997**. Estimating the evaporation over Nasser Lake in the upper Egypt from Meteosat observations. Advances in Space Research, *19(3), 515–518.*
2. Gökbulak, F., & Özhan, S. **2006**. Water loss through evaporation from water surfaces of lakes and reservoirs in Turkey. Official Publication of the European Water Association, EWA.
3. Rimmer, A., Givati, A., Samuels, R., & Alpert, P. **2011**. Using ensemble of climate models to evaluate future water and solutes budgets in Lake Kinneret, Israel. *Journal of Hydrology, 410(3–4), 248–259.*
4. Mosner, M. S., & Aulenbach, B. T. **2003**. Comparison of methods used to estimate lake evaporation for a water budget of Lake Seminole, southwestern Georgia and northwestern Florida.
5. Hasan, I. F., & others. **2013**. Evaluation of a Simplified Method to Estimate Evaporation Losses From Mosul Dam Reservoir. *Al-Rafidain Engineering Journal (AREJ)*, *21*(5), *53–62*.
6. Yaffee, R. A., & McGee, M. **2000**. *An introduction to time series analysis and forecasting: with applications of SAS®and SPSS®*. Elsevier.
7. Izquierdo, J., Pérez, R., & Iglesias, P. L**. 2004**. Mathematical models and methods in the water industry. *Mathematical and Computer Modelling*, *39*(*11–12), 1353–1374*.
8. Adamo, N., & Al-Ansari, N. **2016**. Mosul dam full story: Safety evaluations of mosul dam. *Journal of Earth Sciences and Geotechnical Engineering*, *6*(3), *185–212.*
9. Al-Najmawi, Sari Muhammad, **2001**. Climate of the Governorate.Nineveh, unpublished master's thesis, geographical section,College of Arts, University of Mosul.
10. Singh, V. P., & Xu, C.-Y. **1997**. Evaluation and generalization of 13 mass-transfer equations for determining free water evaporation. *Hydrological Processes, 11(3), 311–323.*
11. Hounam, C. E. **1973**. Comparison between pan and lake evaporation. *WMO Technical Note*, *126*, 1–52.
12. Allen, R. G., Pereira, L. S., Raes, D., Smith, M., & others. **1998**. Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper *56. Fao, Rome, 300(9), D05109.*
13. Omar, M. H., & El-Bakry, M. M. **1970**. Estimation of evaporation from Lake Nasser. *Meteorological Research Bulletin, 2, 1–27*.
14. Ostertagová, E., & Ostertag, O. **2011**. The simple exponential smoothing model. *The 4th International Conference on Modelling of Mechanical and Mechatronic Systems, Technical University of Košice, Slovak Republic, Proceedings of Conference, 380–384.*
15. Hyndman, R. J., & Athanasopoulos, G. **2018**. *Forecasting: principles and practice*. OTexts.
16. Jensen, M. E. **2010**. Estimating evaporation from water surfaces. *CSU/ARS Evapotranspiration Workshop, Fort Collins, CO*, 1–27.
17. Myers, L. E., & Frasier, G. W. **1970**. Evaporation reduction with floating granular materials. *Journal of the Irrigation and Drainage Division*, *96*(4), 425–436.
18. Reda, M.A., Nasr, T.H. Nader, M.S. **2007**. Evaporation reduction from Lake Naser using new environmentally safe techniques. Eleventh International Water Technology Conference, IWTC11 **2007** Sharm El-Sheikh, Egypt-*185*.
19. Al. Saud, M.I. **2010**. Reduction of evaporation from water surfacees preliminary assessment for Riyadh region, *Kingdom of Saudi Arabia.research journal of soil and water management.1(1):5-9,2010*
20. Akyuz, A Okay and Uysal, Mitat and Bulbul, Berna Atak and Uysal, M Ozan.**2017**. Ensemble approach for time series analysis in demand forecasting: Ensemble learning. EEE *International Conference on INnovations in Intelligent SysTems and Applications (INISTA).*