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Estimating the amount of water loss due to evaporation in the Kalpoosh dam of Semnan province and investigating its reduction methods

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Abstract

In arid and semi-arid regions, the main cause of water loss is surface evaporation. It is an inevitable process, and depending on a country's location and weather conditions, it plays an important role in the loss of water resources. In this research, the rate of evaporation at the Kalpoosh Dam, located in Semnan Province, has been estimated, taking into account climate and weather conditions. The rate of evaporation was calculated using various methods, including experimental formulas and water balance measurements. The optimal method and the appropriate evaporation coefficient were then selected to estimate evaporation. According to the calculations, Ivanov's experimental method, which showed the smallest error, had the best agreement with the observed pan evaporation. The evaporation coefficient was examined across values between 0.6 and 0.9, and 0.85 was selected as the most accurate. The experimental formula of the American Society of Civil Engineers was ranked second. Other methods could not be applied to the Kalpoosh Dam because they require vapor pressure data, which is lacking, and could lead to significant calculation errors compared with actual values.

Keywords: Surface evaporation, Experimental formulas, Evaporation pan, Kalpoosh dam

1. Introduction

Surface evaporation is affected by factors such as solar radiation intensity, wind speed, air temperature, relative humidity, atmospheric flux, water depth, transparency, and concentration of salts in the water. Surface evaporation of water has long been one of the causes of water loss in water storage resources, and experts and researchers in this field have always sought ways to reduce the effects of this phenomenon.

Iran, as a country located in the arid and semi-arid regions of the world, has an average rainfall of about one-third of the annual rainfall of the world and an average evaporation of about three times the annual evaporation of the world. According to statistics, the average annual rainfall of the world is about 850 mm, and this amount in Iran is 250 mm, which is less than one-third of the average annual rainfall of the world. The average annual evaporation in the world is 700 mm, and in Iran it is 2,100 mm, and these statistics show that the annual evaporation in Iran is three times the average annual evaporation of the world, and it can be said that the limitation and shortage of water resources in Iran is much more serious than in other parts of the world. 70 percent of Iran's water resources are lost to evaporation in the plains, mountains, and behind dams. According to an annual estimate, nearly three to five billion cubic meters of lake water and water stored behind dams evaporates, and currently the country is facing the problem of severe water evaporation behind 600 dams built in it.

In this research, a case study has been conducted on the Kalpoosh Dam located in Semnan Province, which will be introduced in this section. The research shows that geographical location, climatic conditions, and atmospheric factors have a significant impact on the amount of water evaporation. The results of this research can be generalized to other dams in the country in different regions that have climatic conditions similar to the Kalpoosh region of Semnan Province. The northeast of the province (Miami Plain and Hosseinabad Kalpoosh) has a relatively cold and dry climate. In Semnan Province, precipitation is very low and mostly falls in the form of rain and rarely in the form of snow in the cold seasons. The province receives about 145 mm of rainfall annually. In this research, a case study has been conducted on the Kalpoosh Dam located in Semnan Province, which will be introduced in this section.

The Kalpoosh Dam and Drinking Water Network is located in Semnan Province, in Miami County, near the village of Hosseinabad, on a river of the same name. The distance from the dam site to the city of Shahroud is about 180 kilometers and is located at North latitude 37°07′ - 55°43′ East longitude. The

northeast of the province (Miami Plain and Hosseinabad Kalpoosh) has a relatively cold and dry climate. In Semnan Province, precipitation is very low and mostly falls in the form of rain and rarely in the form of snow in the cold seasons. The average annual rainfall of the province is measured to be about 145 mm. The technical specifications of the Kalpoosh Dam are briefly mentioned in the table below [2].

2. Material and Methods

Table 1. Technical Specification of the Kalpoosh Dam[1]

Specifications	Comment
Manufactured	2008
Water intake year	2014
Geographical area	Kalpoosh- Mayamey-Semnan North latitude 37^0-7' East Longitude 55^0-43'
Type of dam	Soil with a clay core
Height of the dam from the riverbed	40 m
The size of the lake	140 Hectare
Tank volume at normal level	16.5 Million cubic meters
Dam crest length	273 m
Annual adjustable water volume	10 Million cubic meters

In general, the methods used to estimate evaporation from the water surface could be divide into three categories:

- ✓ Measurement with an evaporation pan
- ✓ Water balance method
- ✓ Energy balance method

Data related to temperature, wind speed, humidity, and the daily evaporation rate are based on the readings of equipment whose specifications are listed in Table 2.

Table2. Meteorological equipment specifications [1]

Name	Model	Measurement range	Accuracy
Wind speed and direction measuring device	WSP101	0-50 m/s 0-360º	2.8
Thermometer	TMF101 RTD PT100	30-70 Cent.	0.2
Relative humidity meter	HMF101	% 0-100	3
Evaporation pan(10 in Height and 48 in Diameter)	Class A stand. WMO	0-250 mm	0.1 mm

In this study, the data recorded at the Kalpoosh Dam meteorological station during the days of the year 2021 were used. This information includes evaporation from the pan, average daily temperature, relative humidity, and wind speed.

By reviewing these data, it was determined that, considering the climatic conditions of the Kalpoosh region, the average relative humidity of the air is 78 percent and the average wind speed is 4.8 meters per second, which can be effective in selecting the equation appropriate for the Kalpoosh Dam. The air temperature in this region was recorded with a minimum of minus 6 and a maximum of 27 degrees Celsius on January 21 and July 5, respectively.

3. Results and Discussion

The amount of evaporation from the free surface of the water was calculated using empirical relationships and compared with the amount of evaporation from the basin. As mentioned, a model with a higher coefficient of determination (R2) and a lower root mean square error (RMSE) is a more desirable model. Based on this and the information in Table 6, the US Civil Engineering Organization relationship with the lowest error rate (RMSE = 1.66) compared to the data from the basin and also the highest coefficient of determination of 0.73 has a higher accuracy in estimating the amount of water evaporation in the Kalpoosh Dam compared to other empirical relationships.

Table3. Results from empirical relationships

Model	RMSE	R^2	Pearson Correlation Coeff.
USBR	1.66	0.73	0.89
Mayer	2.18	0.45	0.67
Marciano	2.48	0.24	0.49
Shahtin	2.58	0.28	0.53
Hefner	2.49	0.24	0.49
Ivanov	1.96	0.49	0.7
Tichomirov	2.4	0.39	0.62

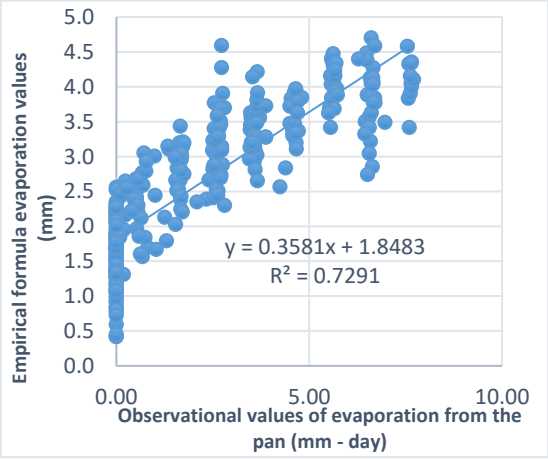

Figure 1. Comparing pan evaporation values with the US

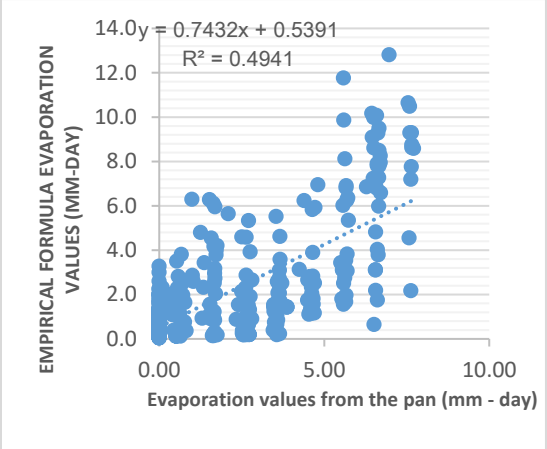

Figure2. Comparison of pan evaporation values by the Ivanov method

In this study, the evaporation rate in Kalpoosh Dam was investigated. First, the evaporation rate was calculated using an evaporation pan. Then, using meteorological parameters including relative humidity, temperature, wind speed and direction and using seven experimental methods, an estimate of the daily evaporation rate of the dam was made. In the continuation of this study, each of these methods was compared with the evaporation from the pan using statistical methods, and among them, the Ivanov experimental method was selected with the lowest error and most appropriate correlation coefficient, considering the evaporation pan coefficient.

4. Conclusions

In evaporation basins, coefficients are considered to increase accuracy and reduce its error. Different evaporation coefficients were calculated for the basin and each of these calculations was compared with the Ivanov method to select the optimal coefficient with the least error and the best overlap, which included the coefficient of 0.85. The evaporation rate in Kalposh Dam was calculated during the months of the year 1400 and was calculated to be 807 mm in total. Using the lake surface volume diagram, this evaporation rate is equivalent to 706 thousand cubic meters, which can also be applied to the evaporation coefficient of 0.85 to cover the error resulting from the basin. The evaporation rate with this recalculation is 600 thousand cubic meters, equivalent to six percent of the total reservoir water in that year.
In order to manage water consumption and prevent evaporation in the agricultural allocation of dam water, this issue can be helped by choosing an appropriate cultivation pattern and modern irrigation methods. Considering that beet cultivation is a common crop in the lands around the dam and its high water consumption and traditional irrigation, it is suggested that by creating a culture and encouraging farmers to cultivate crops with less water consumption and changing irrigation methods, it will play an effective role in water resource management. Another method of reducing evaporation and water loss from the surface of dams is planting trees and plants around the dam. Planting trees around dams can be used as a sustainable and cost-effective method of water consumption, in addition to creating shade and preventing wind. Trees can reduce the surface area exposed to evaporation by absorbing water and having high leaf density. Also, by creating shade around the dam, the rate of water evaporation from the dam surface is reduced, which will result in an increase in water discharge and water retention in the dams. In addition, planting trees around dams can be considered as a sustainable and natural way to preserve the ecosystem of the region. One of the suitable trees, considering the climatic conditions of Kalpoosh, in order to reduce evaporation in the dam is the walnut tree. Walnut trees are among the trees planted in the Kalpoosh region. Walnut trees have a strong stem, large leaves, and hard bark that can withstand drought and adverse weather conditions. Also, walnut trees have a lower water consumption rate than some other trees and can be used as a sustainable solution to reduce evaporation from the surface of Kalpoosh Dam and preserve water resources in this region. Also, products such as walnuts produced from this tree can be used as a source of income for the people of the region and related economic products.

5. References

[1] Ab Niroo Consulting Engineers. Publication No. 272-*Management and Planning Organization*: "Guidelines for studies on the exploitation of dam reservoirs - Instructions for the exploitation and maintenance of Kalpoosh Dam and related components" (2012)

[2] Mazaheri, Mehdi. (June 1402). General Survey of the Water Balance in the Country: Status and Challenges. Tehran, Iran: *Research Center of the Islamic Consultative Assembly*.

[3] Najafond Derikondi, M. Eslami, H. (2016). "Comparison of experimental methods for estimating evaporation from the free surface of water (Case study: Dez Dam)" *Quarterly Journal of Water Engineering*, Article 7, Volume 4, Number 2, October 2016, Pages 65-73