Gorgan University of Agricultural Sciences and Natural Resources

Journal of Water and Soil Conservation

Print ISSN: 2322-2069
Online ISSN: 2322-2794

(OPEN ACCESS)

Laboratory investigation of the effect of wind speed on evaporation from dam reservoirs

Reza Shahbazi[1], Shahriar Kouravand[*2]

1. Ph.D. Student in Bio-System Mechanical Engineering, Renewable Energies, Technical Group, Abū Rayḥān University, University of Tehran, Tehran, Iran. E-mail: shahbazi.reza36@ut.ac.ir
2. Corresponding Author, Associate Prof., Technical Group, Abureyhan University, University of Tehran, Tehran, Iran. E-mail: skouravand@ut.ac.ir

Article Info

Article type:
Research Full Paper

Article history:
Received: 01.26.2025
Revised: 04.09.2025
Accepted: 05.03.2025

Keywords:
CFD,
Energy,
Evaporation,
Experimental,
Wind

ABSTRACT

Background and Objectives: Nowadays, freshwater management is critical due to the reduction of atmospheric precipitation. With the increase in global temperature and climate change, water evaporation occurs rapidly. Wind speed is one of the factors on evaporation. Winds have a 20 to 40 percent effect on the speed of water evaporation. Controlling the wind speed can help reduce water evaporation in reservoirs and dams. This study aimed to investigate the effect of wind speed at different air temperatures. Another aim of this study was to use the CFD (Ansys Fluent) method to determine the areas and percentage of wind impact on the reservoir surface so that the kinetic energy of wind applied on the water surface can be calculated. By investigating the effect of different wind speeds on the water surface at the two specified air temperatures, it was observed that water evaporation has a direct relationship with the volume of wind input to the water surface. Using the information obtained in this study, most water evaporation occurs at the beginning of the water reservoir in the direction. The use of CFD software (Ansys Fluent) allows for more accurate results. Using the mentioned software, it is possible to observe and analyze the airflow on the surface easily.
Novelty: This study is to investigate the amount of wind force applied to the surface of the water by the CFD method and the amount of water evaporation by measuring its weight at two temperatures of 40 and 30 degrees Celsius and several different wind speeds.

Materials and Methods: In this study, CFD and laboratory methods were used to investigate the effect of wind energy on water evaporation. In the CFD method, the effect of wind speed and its effect on different areas of a reservoir was applied to the surface of the reservoir using Ansys Fluent software and the amount of wind power to observe which area of the reservoir can have the most evaporation. For further investigation of the CFD method, first, the water reservoirs were drawn in 3D using SolidWorks design software to be analyzed in the workspace of Ansys Fluent software. In the reservoirs design, a 40 * 31.5 cm plate with 24 cm diameter air inlet ducts was used to control and measure the amount of air entering the reservoirs. The diameter of this plate facilitates precise

calculation of the volume of incoming air. In this study, to measure evaporation in the effect of wind speed and temperature, the weight of water was measured after applying wind speed at a specific temperature and time. Investigating how wind interacts with the water surface using the CFD method: Experimental, numerical, or turbulent wake models can usually be used to study airflow. In a laboratory study, a reservoir with a length of 63 cm, a width of 31.5 cm, and a height of 13 cm was constructed and used to determine the wind's effect on the evaporation rate. A wind generator was used to create the wind flow at the desired speed, a heater was placed behind the wind generator to increase the temperature, a temperature control module was used to adjust the temperature of the air entering the test environment, a wind meter was used to measure the wind speed and adjust the wind generator. A digital scale was used to investigate the changes in water weight. The weight of the water in the reservoirs was 16534 grams. The wind speed in this experiment is 3, 4, 5, and 6 m/s, respectively. The air temperature was set at 30 and 40 °C, respectively. To calculate the volume of air entering the water's surface, a wall with a height of 40 cm and a width of 31.5 cm and a 24 cm diameter vent in the center of this wall has been used for air intake.

Results: According to the output of CFD software, it can be understood that most of the air contact with the water surface takes place in the first 20% of the water level of the reservoir. The lowest wind speed is at the bottom of the reservoir, which includes about 25% of the total reservoir. The velocity changes along the path of the reservoir begin to decrease, resulting in a decrease in the amount of evaporation at the bottom of the reservoir compared to the beginning of the reservoir. Using the water evaporation data, it can be concluded that by creating a suitable windbreak, the wind speed can be further reduced to reduce water evaporation. The purpose of calculating the kinetic energy of the wind and the power generated by the wind when it hits the surface is to show that these two factors cause the water droplets to separate from their surface, which causes evaporation. The power exerted by the wind on the surface of the water creates waves and can increase the rate of evaporation when water comes into contact with the air. According to "According to the results of the laboratory analysis, the maximum wind power, the maximum wind power exerted on the surface of the water is 9 W/m2, which corresponds to a wind speed of 6 m/s. The maximum kinetic energy is 4.76 m^2/s. In this study, it was found that a wind speed of 6 m/s with an air temperature of 40 degrees Celsius caused water evaporation equivalent to 156 grams, which increased evaporation by 50% compared to the result of a temperature of 30 degrees Celsius. At wind speeds of 3, 4, and 5 m/s, the difference in water evaporation at temperatures of 40 and 30 °C is 36 g.

Conclusion: With the studies conducted on water evaporation using laboratory methods and Ansys Fluent software, it can be concluded that the impact of the wind flow on the water surface is greater at the beginning of the reservoirs. Wind speed and temperature are two very important factors in increasing the speed of water evaporation. The speed of water evaporation at a wind speed of 6 m/s at an air temperature of 40 ℃ can be 50 percent higher than the speed of water evaporation at the same wind speed at an air temperature of 30 ℃. At wind speeds of 3, 5, and 4 m/s, the evaporation of wind at a temperature of 40 ℃ is at least 30 percent higher than at the same wind speeds specified at a temperature of 30 ℃. Wind

temperature, velocity, and surface area of water are among the factors affecting water evaporation by increasing kinetic energy and creating a moisture difference between air and water, which causes water evaporation. At night, when the effect of solar radiation decreases, it can be said that the effect of wind on water evaporation is very high.

Cite this article: Shahbazi, Reza, Kouravand, Shahriar. 2026. Laboratory investigation of the effect of wind speed on evaporation from dam reservoirs. *Journal of Water and Soil Conservation*, 32 (4), 195-212.

DOI: 10.22069/jwsc.2026.23246.3785
Publisher: Gorgan University of Agricultural Sciences and Natural Resources

Introduction

Global warming is a major threat to the quantity and quality of freshwater on Earth. The construction of dams overexploits underground reservoirs and rivers, and the lack of hydrological data and methods for assessing freshwater resources hamper global estimates of lake vulnerability to evaporation. Lakes contain about 87% of the world's freshwater. The evaporation of freshwater in the world is dependent on climate and environmental factors such as solar radiation, lake and watershed levels, wind speed, relative humidity, air temperature, and heat storage. Drought and water scarcity in Iran are a climatic reality, and given the increasing demand for water by various sectors, this problem will become more acute in the coming years. The long-term average rainfall in Iran is 243 mm (one-third of the global average), and the evaporation potential is about 2000 mm per year (three times the global average). The total volume of water resources from precipitation in Iran is 403 billion cubic meters, of which more than 70 percent is lost through evaporation. The volume of renewable water resources is about 100 billion cubic meters, of which more than 70 percent is consumed in the agricultural sector [1]. A significant part of the rain evaporates in areas with arid and semi-arid climates. Also, studies conducted in these areas show that the evaporation of water from the reservoirs can be 3200 mm in a year [2]. Wind increases the evaporation rate by moving moist air over the water's surface and replacing it with dry air during the day and night. Water salinity also reduces water evaporation in lakes and seas. Regarding the effect of water surface on the amount of evaporation, it can be said that the greater the contact surface of water with the ambient air, the greater the exchange of moisture with the ambient air and the increase in water evaporation. Of course, if the water surface is much larger, the water added to the air during the evaporation process will change the nature of the air, and over time, evaporation will decrease. By studying the atlas of the country's windy regions shown in Figure 1, it can be seen that in the provinces of Sistan and Baluchestan, Ilam, and Khuzestan, which have experienced a lot of water and environmental stress in recent years, wind speed plays a significant role. In addition to the high air temperature in these areas, the wind factor also increases the water stress in this region.

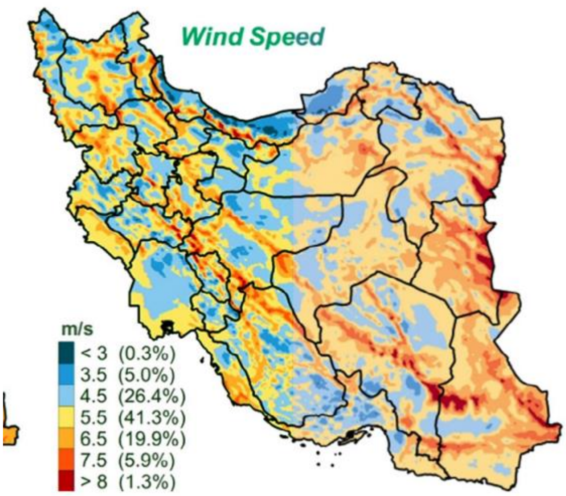

Figure 1. Wind speed display in different regions of Iran [3].

By studying the atlas of the country's windy regions shown in Figure 1, it can be seen that in the provinces of Sistan and Baluchestan, Ilam, and Khuzestan, which have experienced a lot of water and environmental stress in recent years, wind speed plays a significant role. In addition to the high air temperature in these areas, the wind factor also increases the water stress in this region. Figure 2 shows the zoning of total potential evapotranspiration at the level of the country's watersheds. Total potential evapotranspiration at the level of the country's watersheds in 2018 varied from less than 1000 mm in the northern, northeastern, northwestern, and small parts of the center and south of the country to about 2300 mm in parts of the Karun Bozorg, Karkheh, Marzi Gharb, Jarahi and Zohreh, Hille, Kol-Mehran, Mand, Koyirlot, Hamun Jazmorian, Hamun Meshkil and Hamun Hirmand basins [1]. In general, based on Figure 2, it can be said that in the provinces of Khuzestan and Ilam, which contain the largest freshwater resources of the country and various dams have been built on the rivers of these provinces, especially Khuzestan province, the southern regions of Iran have the highest evaporation and freshwater loss, which has caused environmental crises in recent years. In Sistan and Baluchestan province, due to annual evaporation, this province has been facing a biological challenge and population migration. Therefore, it is necessary to think about reducing the evaporation of water from dams in Khuzestan and Chah Nimeh of Sistan and Baluchestan, so that in addition to reducing the evaporation of water from reservoirs, we can be diligent in preserving the country's water resources.

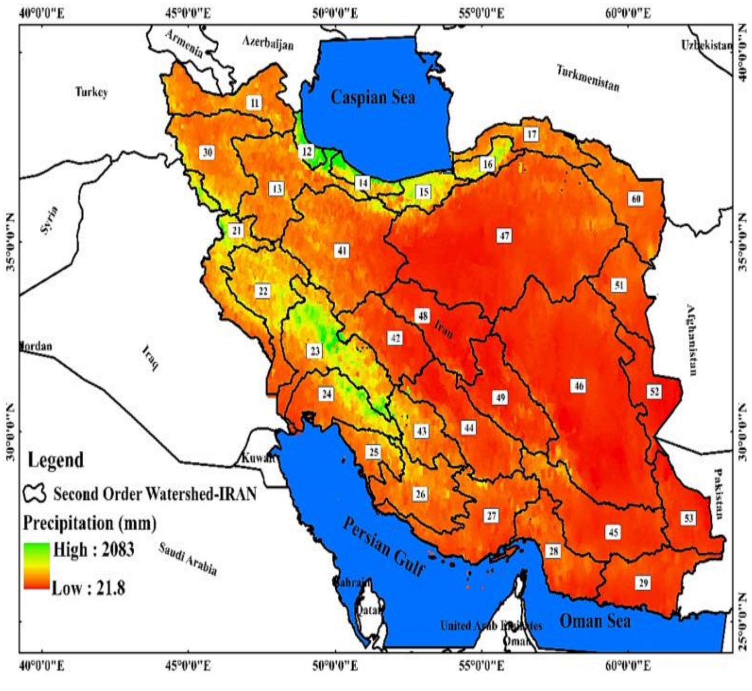

Figure 2. Figure 2, Zoning of total potential watersheds at the level of the country's watersheds in Iran [3].

Figure 2, Zoning of total potential watersheds at the level of the country's watersheds. The maximum water evaporation, according to Figure 2, is 2083 mm per year, and the minimum is 21.8 mm [4]. As shown in Figure 2, Iran is located in a low-rainfall zone, and the protection of water resources is very important. In the field of water evaporation and waste of water resources, various factors can be mentioned, including environmental pollution due to its improper use and population growth, which leads to environmental pollution. In addition to these issues, the demand for fresh water is increasing rapidly [5]. Evaporation from free surfaces can be realized using natural or powered convection [6]. Climate change has increased the rate of water evaporation in recent decades. Water evaporation due to climate change can reduce more than 40 percent of the volume of freshwater stored in existing dams in the world [1]. Researchers have conducted various studies to reduce water evaporation, one of which is the use of windbreaks. Physical and chemical methods have been used in the world to reduce water evaporation. In physical methods, floating coatings are used and can prevent water evaporation by 70 to 95 percent. In the chemical method, chemicals are widely used to reduce water evaporation, such as WaterSavr, and can prevent between 20 and 40% of water evaporation from reservoirs. Biological methods such as floating plants, plant windbreaks, etc. can significantly reduce the volume of water evaporation from reservoirs, but there are limitations in the use of biological methods, including water consumption by the plant itself and causing transpiration [7]. Behrouzi and Farshid (2017) conducted a study on the subject of evaluating evaporation estimation methods, a case study of Karaj Dam Lake. In this study, they studied the feasibility of different evaporation estimation methods to find a suitable method with a fair relationship between cost and accuracy. The optimal method may vary depending on the climate. They found the Penman, Monteith, and Unsworth (PMU) method as the optimal estimation method for Karaj Dam Lake (located northwest of Tehran, Iran), for Karaj Dam the PMU model provides consistent results with file measurements (error less than 2%). For example, from 2 to 15 August 2005, the PMU model predicts evaporation of 98.7 ± 0.83 mm/day, and the field measurement for the same period was 13.8 ± 0.01 mm/day [1]. In 2012, Karami et al. conducted a study on how evaporation from the free water surface will change under future climate conditions using the MLR-EPan model. They studied water evaporation for three time periods: 2021-2040, 2041-2060, and 2061-2080. They were able to predict the volume of evaporation over a 60-year period and under different scenarios as 1.4, 19.1, and 31.9 mm [8]. In 2013, Ghahraman and Rahimzadegan conducted a study on the efficiency of different methods for estimating evaporation using satellite data on the surface of saline water (case study: Lake Urmia). Their goal was to calculate evaporation from the surface of saline water using satellite images and estimate different methods for obtaining evaporation. The results of this study showed that evaporation on the saltwater surface of the lake is not uniformly distributed and that keeping the albedo and radiation inside the lake constant causes errors in calculating evaporation. It was also found that combined methods, due to considering all the parameters affecting evaporation, have less error than other methods and provide more reliable results [7]. In 2016, Maria Oros and her colleagues investigated the rate of evaporation from a warm-free surface. They developed a laboratory method for measuring evaporation rates that could control the humidity and temperature of the environment [6]. In 2012, Ebrahimi et al. conducted a case study of Khorramabad city on the subject of evaluating methods for reducing evaporation through combined methods of floating balls and monolayers in a class A basin. In the study conducted to reduce evaporation from class A evaporation basins, an attempt was made to examine for the first time the efficiency of three types of balls with a monolayer of hexadecanol as an evaporation-reducing coating. The balls used included three types of balls with two and six holes and without holes with a diameter of 7 cm made of propylene. To investigate the performance of these coatings in reducing evaporation, class A pans were tested for 2 months [9]. Shahi et al. "Simulating the effect of spatial wind changes on evaporation with CE-QUAL-W2 integrated model and Bowen's ratio" have conducted a study in 2024. They are a new solution. To investigate the effect of spatial changes of wind on the estimation of evaporation from the surface of reservoirs, they have been presented. Thus, The concept of the windshield index (Sx) and the ability of the 2W-QUAL-CE model to assign a separate value to Windshelter of different parts of the lake has been used by the WSC coefficient and it is possible to estimate evaporation from the lake under the influence of wind spatial variations, by combining the results of the W-QUAL-CE 2 model and the Bonn ratio energy budget method (BREB) [10]. Sharifi et al. have researched "Improving CE-QUAL-W2 calibration using a terrain-based wind sheltering coefficient tuning method" in 2025. They have conducted studies in the field of water quality simulation, including thermal stratification, selective harvesting, and eutrophication modeling using the CE-QUAL-W2 model. In their model, the wind shelter coefficient (WSC) plays an important role in calculating the wind-induced shear stress and, subsequently, the thermal gradient of the reservoir. In their study, they introduced the Windshelter Index (Sx) to the CE-QUAL-W2 model as a criterion for achieving the spatial distribution of the state of the wind shelter of water surface points and designed a more accurate and faster calibration method using Sx to determine WSC and estimate the thermal gradient in different parts [11]. In 2024 Salarijazi et al. have conducted a study on the subject of (More reliable determination of daily evaporation from the pan in cold regions by limited meteorological factors). They have examined, in two default and revised modes to determine the amount of evaporation in cold regions (a total of 14 equations) that the Emberg classification has been used. Performance index (PI) was used to analyze the efficiency of the equations and as an error criterion. Findings: They show that in the absence of suitable evaporation datasets for revision, the equations of Kohler et al. (evaporation from basins and lakes, U.S. Government Press, Washington, 1955) and Papadakis (Soil Science 93: 76, 1961) can be used as more appropriate options for determining evaporation in cold regions [12]. Mohammadi et al. conducted a study on (Improvement of daily pan-evaporation calculation in arid and semi-arid regions by limited climatic data) in 2024. They have concluded that for the analysis of evaporation pan data in arid and semi-arid regions, the Nordonson-Fox equation (K -N -F) (1955) is better for analysis than other equations related to a context [13].

The purpose of this study was to investigate the effect of wind speed on different air temperatures. Another purpose of this study is to use the CFD method to determine the area and percentage of wind impact on the reservoir surface in order to calculate the kinetic energy of the wind and the wind power applied to the water surface.

Novelty of this research is the use of the CFD (Ansys Fluent) method to determine the water level of the reservoir due to collision with different wind speeds. Also, the effect of wind speeds of 3, 4, 5, and 6 m/s at two temperatures of 30 and 40 °C has been investigated.

Materials and Methods

Water evaporation is one of the problems that humans are facing today. Evaporation statistics from the basin surface were used to estimate evaporation from free water surfaces. Based on the evaporation statistics from the basin, the amount of evaporation from the free water surface can be estimated from the following equation 1 [7].

$$E = \mathrm{k.Epan} \qquad (1)$$

E: Evaporation from the free surface of water in reservoirs or lakes. E_{pan}: Amount of evaporation from the pan. K: A constant coefficient whose value for a standard and class A evaporation pan is between 0.58 and 0.78 m^2.

The equations 2 are used practically and simply, including the equations stated that are used in hydrological works in water engineering:

$$E = 0.35(e_s - e_d)(0.5 + \frac{U_2}{100}) \qquad (2)$$

In equation number 2, the value es - ed, which represents the vapor pressure deficit, is the average daily temperature (T), the average relative humidity (RH), and U2 is the wind speed. Using equation number 3, the vapor pressure deficit can be obtained [14].

$$e_s - e_d = \left[\exp\left(\frac{16.78T - 116.9}{T + 273100}\right)\right](1 - \frac{RH}{100}) \qquad (3)$$

In equation 3, T is expressed in degrees Celsius, RH in percent, and es – ed in kilopascals. Equation 4 is also used to obtain water evaporation, in which the mass transfer method is used to calculate water evaporation from the surface of reservoirs or dam lakes [15].

$$\mathrm{E} = 0.291(\mathrm{A}^{-0.05})(\mathrm{U_2})(\mathrm{e_s} - \mathrm{e_d}) \qquad (4)$$

A is the surface area of a water reservoir or lake in square meters, (es – ed) The vapor pressure deficit depends on temperature and relative humidity. According to equations 2 and 4, it is observed that the evaporation of water in water storage areas is directly related to wind speed.

Investigating the effect of wind power on the water surface using the CFD (Ansys Fluent) method

In this study, the CFD and laboratory methods were used to investigate the effect of wind energy on the rate of water evaporation. In the CFD method, the effect of the passing wind speed and the amount of its impact on different areas of a reservoirs was studied using the Ansys Fluent software, and how much wind power was applied to which surface of the reservoirs to see which area of the reservoir could have the most evaporation. To further investigate the CFD method, the water reservoirs were first drawn in three dimensions using the SolidWorks design software to be analyzed in the Ansys Fluent software workspace. It is shown in Figure 3 along with its dimensions.

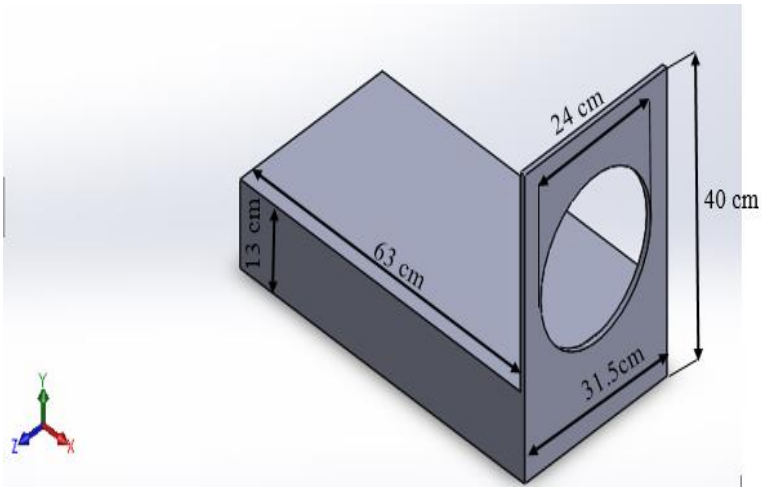

Figure 3. Designing the test environment with SolidWorks software.

In the reservoir design, a (40 * 31.5 cm) plate with 24 cm diameter air inlet ducts was used to control and measure the amount of air entering the reservoir. The diameter of this facilitates precise calculation of the volume of incoming air In this study, the method of water mass loss rate over time through evaporation (water weight changes) was used, thus, by applying wind speed at a specific temperature and at a specified time, the weight of water lost was calculated and the amount and effect of wind speed and temperature on the rate of water evaporation were calculated. The volumetric flow of incoming air can be obtained from the following equation:

$$Q = A\mathrm{V} \tag{5}$$

In equation number 5, it can be said that A is the cross-sectional area of the air inlet duct into the test chamber, in m^2, and V is the speed of the wind blown into the duct, in m/s. The amount of water evaporated by wind speed and at a given air temperature is calculated from equation number 6.

$$M = M1 - M2 \tag{6}$$

In equation 6, can say that M1 is the initial weight of water before the test and M2 is the weight of water after the test, the unit of which is grams or kilograms. In theory, the water evaporation rate can be obtained from equation 7:

$$ET = \frac{M1 - M2}{A\rho\ t} \tag{7}$$

In equation 7, it can be noted that ρ is the density of water equal to (gr/m^3) 1000, and t is the time in seconds [16]. To calculate wind speed at different altitudes can be obtained from the following equation:

$$V(h) = \frac{V}{K}\ln\left(\frac{h}{h_0}\right), h > 0 \tag{8}$$

In the above equation, V is the wind speed measured at a height of 10 m above the ground and K is the Karman coefficient, which is taken to be 0.41 for winds at a height of less than 100 m. h_0 is the height of 10 meters and h is the height of the study.

power and kinetic energy created by wind

The power produced by the wind is directly related to the surface area of impact. The larger the surface area of impact, the more power and energy can be applied to the surface. According to equation number 9, the power the wind generates when it hits a surface can be calculated. This power can create waves on the water's surface [17].

$$\mathrm{p} = 0.5\rho A V^3 \tag{9}$$

In the above equation, p is the wind density, A is the surface area of the object in contact with the wind, and V is the wind speed. According to the above equation, it can be said that the energy produced is directly related to the third power of the wind. From equation number 10, the kinetic energy created by the wind can be calculated. In equation 10, m is the mass of air entering the water surface, which can be extracted by equation 10 [18].

The density of air is assumed to be 1.22.

$$m = \frac{2}{3}\ \rho A V_{in} \tag{10}$$

Investigating how wind interacts with the water surface using the CFD method: Experimental, numerical, or wake flow models can usually be used to study airflow. Today, one of the common numerical methods is the use of computational fluid dynamics (CFD), which is calculated based on the behavior of the fluid using the solution of the Navier-Stokes equations. Given the nonlinear nature of these equations, various methods have been introduced to facilitate the solution of those equations, one of which is the method that has high accuracy and can calculate the equations at high speed and help in presenting the results through the use of the mean Reynolds equations. These equations, by averaging the Navier-Stokes equations and reducing the effect of air velocity fluctuations in the equations, speed up the solution of the equations and provide acceptable results for calculating the amount of air velocity fluctuations and airflow turbulence on the blades of a wind turbine. Also, various turbulent flow models can be introduced, including two models that can be calculated based on the amount of kinetic energy of the turbulent flow k-ε and the rate of loss of this energy (k-ω) and the kinetic energy of the turbulent flow and the frequency of loss of this energy [7] ANSYS Fluent software is used to investigate the effect of wind speed on water evaporation using the CFD method. To analyze the water evaporation test space in ANSYS software, a laboratory environment with defined dimensions was first designed with SolidWorks software according to Figure 3. Figure 4 shows the design of the laboratory environment with SolidWorks software. The following table shows the boundary conditions specified for analyzing and investigating the effect of wind speed in the ANSYS software environment. It is written. Figure 5 shows the ANSYS space display and the designed test environment.

Table 1. Ansys Fluent environment boundary conditions (CFD).

Inlet area	8.58 m^2
Outlet area	8.58 m^2
Velocity inlet	6,5,4,3 m/s
The volume of the bounding box	51.48 m^3
Solution method	$k-\varepsilon$, Realizade
ρ air	1.22

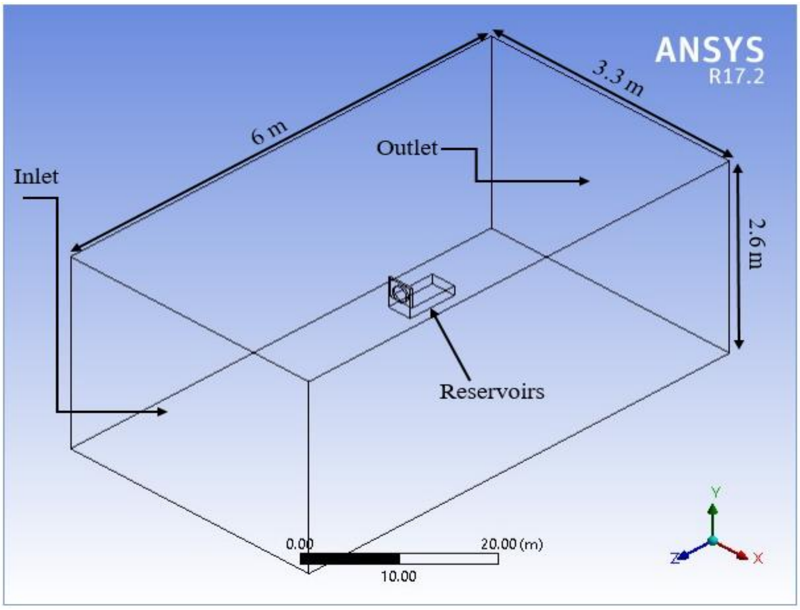

Figure 4. Display of the ANSYS Fluent environment.

Investigating the independence of the grid in AnasysFluent software analysis

Considering the possibility that the numerical solution results in AnsysFluent software may be dependent on the created network, to be sure of the results of software data, the independence of the results from the network is checked first. In this study has been used to analyze reservoir made of five mesh sizes. Number of grids are 63000, 80000, 105000, 120000, and 190000. According to the output of the results of the software analysis in determined meshes were the same, which indicates that the results are independent of the mesh size.

Investigating the effects of wind speed and temperature on water evaporation in the laboratory

In this study, a reservoir with a length of 63, a width of 31.5, and a height of 13 cm was constructed to determine the effect of wind on the evaporation rate on a laboratory scale. A wind generator was used to create a wind flow with the desired speeds, a heater was placed behind the wind generator to increase the temperature, a temperature control module was used to adjust the temperature of the air entering the test environment, an anemometer was used to measure the wind speed and adjust the wind generator, and a digital scale was used to check the changes in water weight. The water inside the reservoir weighed 16534 grams. The wind speeds in this experiment were 3, 4, 5, and 6 m/s, respectively. The air temperature was set to 30 and 40 ℃, respectively. To calculate the volume of air entering the water surface, a wall with a height of 40 cm and a width of 31.5 cm was used, and in the center of this wall, a valve with a diameter of 24 cm was used for air inlet, as shown in Figures 3 and 5. Figure 5 shows a demonstration of the experimental environment constructed to measure the rate of water evaporation due to wind power.

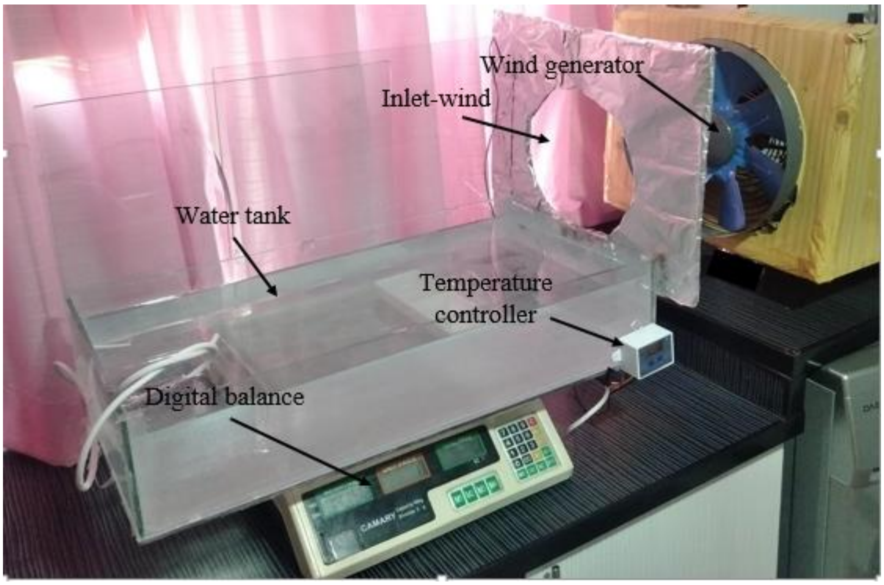

Figure 5. Experimental demonstration of the effect of wind speed, air temperature, and flow rate on water evaporation.

Figure 6 shows the wind speed meter. Using the wind speed meter, the inlet wind speed of the reservoir and the rotational speed of the blower are controlled. Figure 7 is an electric heater that can provide the inlet air temperature at two levels 30 and 40 °C.

Figure 6. Anemometer display.

Figure 7. Electric heater.

Results

The figure below shows the result of the analysis of the speed of air impact with the water surface, performed by Ansys Fluent Software.

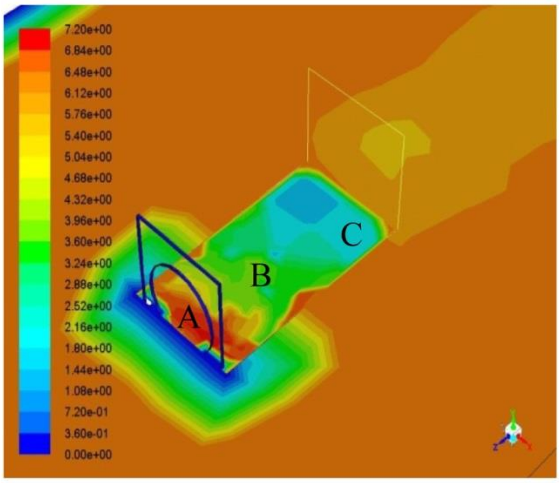

Figure 8. Wind hitting the water surface using an air speed of 6 m/s.

The total area of the reservoir is 1984.5 square centimeters. According to the output image from the CFD (Ansys Fluent) software shown in Figure 8, it can be understood that the greatest air impact with the water surface, which has a wind speed of 6 m, is about 20% of the first 396 square centimeters of the test water reservoir, which is indicated by the letter A. 55% of the reservoir surface is in contact with a wind speed of 3.9 meters per second, which is 823 square centimeters, which is indicated by the letter B. The end of the reservoir, which is about 25%, is in contact with a wind speed of 2.5 meters per second, which is 765.5 square centimeters, which is indicated by the letter C. The speed changes along the path begin to decrease, resulting in a decrease in the evaporation rate compared to the beginning of the reservoir. Using the water evaporation data in the diagram in Figure 4 and the air impact display in Figure 5, it can be concluded that by creating a suitable windbreak, the wind speed can be further reduced. The table below shows the amount of kinetic energy created and the power of the wind when it hits the water's surface. The reason why the highest wind speed is in the first 20% can be said that the greatest effect of water evaporation by air is at a low altitude of 10 meters, and at first, the wind hits the initial part of the reservoir with speed, and then its speed decreases and reaches other areas of the water surface. In general, it can be said that the reduction of wind speed is done in the first 20% of the reservoir.

Table 2. Calculation of kinetic energy and power exerted on the water surface by wind-flow.

Wind speed (m/s)	Kinetic energy (m^2/s)	power acting on the water surface (W/m^2)	Q (m^3)
6	7.765893	9.043134	0.271296
5	4.494151	5.233295	0.22608
4	2.301005	2.679447	0.180864
3	0.970737	1.130392	0.135648
2	0.287626	0.334931	0.090432

The purpose of calculating the kinetic energy of the wind and the power created by the wind when it hits the surface is to show that these two factors cause the separation of water droplets from its surface, which causes evaporation. The power applied by the wind to the water's surface creates waves and can increase the evaporation rate when water hits the air. According to Table 1, it is shown that the maximum power applied to the water surface is 9 W/m^2, which corresponds to a wind speed of 6 m/s. The maximum kinetic energy is 4.76 m^2/s.

Results of the experiment to investigate the evaporation of water due to wind power

The experiment was conducted to investigate the effect of wind speed and temperature on water evaporation for 30 minutes. The general results of the experiments conducted at two temperatures of 40 and 30 ℃ and defined wind speeds using relations 5 and 6 are written in Tables 3 and 4. In this experiment, the ambient air temperature is 29 ℃, and the initial water temperature is 22 ℃.

Table 3. Amount of water evaporation at speeds 3, 5, 5, 6 (m/s) at an air temperature of 40 ℃.

Wind speed (m/s)	Time	Initial weight of water (grams)	Inlet air volume (m^3/s)	Weight of water after testing (grams)	Amount of water evaporated (grams)
		16534	0.27	16378	156
6	30 min	16534	0.27	16378	156
		16534	0.27	16378	156
		16534	0.22	16402	132
5	30 min	16534	0.22	16402	132
		16534	0.22	16402	132
		16534	0.18	16413	121
4	30 min	16534	0.18	16413	121
		16534	0.18	16413	121
		16534	0.13	16420	114
3	30 min	16534	0.13	16420	114
		16534	0.13	16420	114

Table 4. Amount of water evaporation at speeds 3, 5, 5, 6 (m/s) an air temperature of 30 ℃.

Wind speed (m/s)	Time	Initial weight of water (grams)	Inlet air volume (m^3/s)	Weight of water after testing (grams)	Amount of water evaporated (grams)
		16534	0.27	16430	104
6	30 min	16534	0.27	16430	104
		16534	0.27	16430	104
		16534	0.22	16438	96
5	30 min	16534	0.22	16438	96
		16534	0.22	16438	96
		16534	0.18	16449	85
4	30 min	16534	0.18	16449	85
		16534	0.18	16449	85
		16534	0.13	16456	78
3	30 min	16534	0.13	16456	78
		16534	0.13	16456	78

According to Tables 3 and 4, it has been determined that wind speed 6 (m/s) with an air temperature of 40 ℃ produces water evaporation equal to 156 grams, which, when compared with the result of temperature 30 ℃, has an increased evaporation of 50%. At wind speeds 3, 4, and 5 (m/s), the difference in water evaporation in temperatures 40 and 30 ℃ is 36 grams. By examining the difference in water evaporation at wind speed 6 (m/s) with wind speeds 3, 4, and 5 (m/s), it can be understood that increasing wind speed along with the temperature of the air entering the test chamber increases the evaporation rate sharply. In water evaporation, wind speed 6 (m/s) at a temperature of 40 ℃ caused a difference of

24 grams compared to wind speed 5 (m/s) at the same temperature, which indicates the effect of wind speed higher than 5(m/s) at temperature 40 ℃ on water evaporation. By comparing the results of this study, it can be seen that in the southern regions of Iran, especially in Khuzestan province, where many dams have been built and the air temperature is often high, wind speed can play a decisive role in reducing the water volume of dams. However, to examine this evaporation more accurately, airflow rate should be used instead of wind speed. Considering the airflow rate entering the experimental environment, it can be concluded that by increasing the contact area of water with wind, the evaporation rate in this experiment can change.

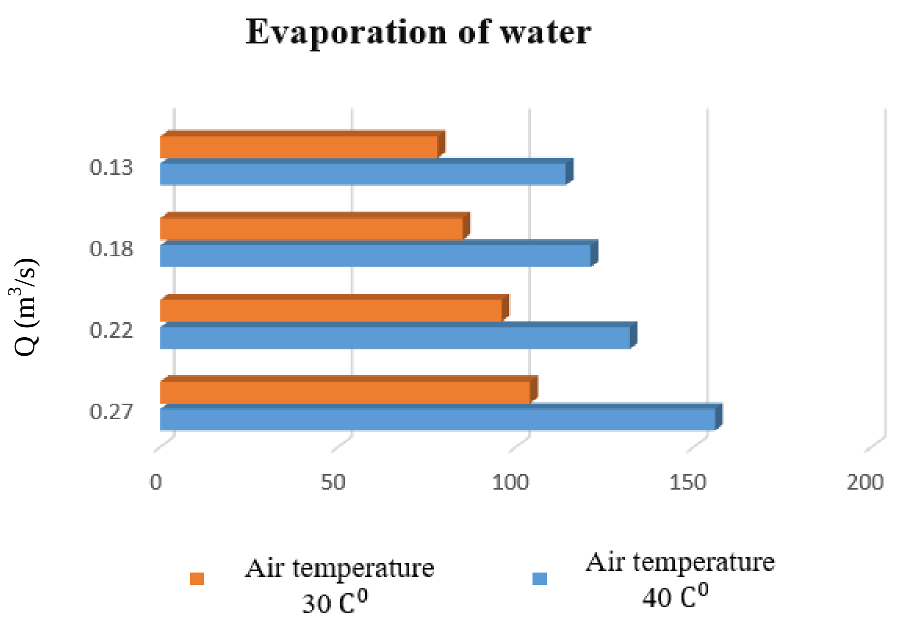

Figure 9. Showing the effect of air speed and temperature on the rate of water evaporation.

According to the diagram in Figure 9, it is clearly shown that water evaporation has a direct dependence on the inlet air flow rate, which determines the surface area of wind contact with water, and also shows the effect of air temperature 40 and 30℃, which creates a difference of nearly 50% in wind speed 6 (m/s). At wind speeds 3, 4, and 5 (m/s), the air temperature has a more significant effect, at least 30% between the temperatures 40 and 30 ℃, on the rate of water evaporation at a constant inlet air flow rate. According to the results obtained in the discussion of the experiment and the CFD method, the wind speed must be controlled to protect water evaporation and reduce the rate of evaporation. In windy areas, windbreaks or chemical and physical methods can prevent sunlight and wind from hitting the surface of the water.

Conclusion

Novelty in this study is to investigate the amount of wind force applied to the surface of the water by the CFD method and the amount of water evaporation by measuring its weight at two temperatures of 40 and 30 degrees Celsius and several different wind speeds.With the studies conducted on water evaporation using laboratory methods and Ansys Fluent software, it can be concluded that the impact of the wind flow on the water surface is greater at the beginning of the reservoirs. Wind speed and temperature are two very important factors in increasing the speed of water evaporation. The speed of water evaporation in a wind with a speed of 6(m/s) at an air temperature of 40 ℃ can be 50 percent higher than the speed of water evaporation at the same wind speed at an air temperature of 30 °C. At wind speeds of 3, 5, and 4 (m/s), the evaporation of wind at a temperature of 40 °C is at least 30 percent higher than at the same wind speeds specified at a temperature of 30 °C. By studying the air inlet flow rate in this study, it is possible to observe the effect of the water surface and air impact in addition to air temperature and wind speed. Wind temperature, speed, and water surface area are factors affecting water evaporation by increasing kinetic energy and creating a difference in humidity between air and water, causing water evaporation. At night, when the effect of solar radiation is reduced, it can be said that the effect of wind on water evaporation is very high. Using the results obtained, it is possible to have an acceptable effect on water evaporation by making changes in the wind speed discharge, such as using windbreaks. Water evaporation can also be prevented by using water surface covers such as black balls or canopies, etc. In the southern provinces, especially Sistan Baluchestan and Khuzestan, various windbreaks should be used to reduce evaporation from constructed dams and manage water resources. The findings of this study help to reduce the wind speed and its kinetic energy due to collision with the surface of the water by using items such as windbreaks and with the correct proportion to the wind, in order to prevent the evaporation of water in the reservoirs. Analyzing this study at two different temperatures and with varying wind speeds can give us complete guidance on how to store water in reservoirs in different climatic zones to better conserve water resources. Today, by studying the wind speed of the region, especially in areas with good wind potential, using wind turbines and their appropriate arrangement, it is possible to reduce the wind speed on water reservoirs and use the wind turbine as a windbreak, so that in addition to producing energy, it reduces the rate of water evaporation from reservoirs.

Appreciation and thanks: In this way, the authors of this article are responsible they appreciate all the hard work of the editor-in-chief and the referees Courtesy of the Journal of Water and Soil Protection Research Detailed review and constructive feedback, thank you.

Show appreciation data, information, and access: The data in this article belongs to a doctoral thesis - access to the data and information is available by contacting the corresponding author.

Conflict of interest in this article: there is no conflict of interest, and all the authors confirm this issue.

Authors' Contribution: The contribution of the authors is equal throughout all stages of the research.

Ethical principles: All authors confirm that they adhered to ethical principles in executing and publishing this scientific work.

Financial Support: This research was conducted at the authors' personal expense.

Reference

1. Yousefi, H., Kasaeian, A., Ranjbaran, P., & Katouli, M. H. (2017). A Review of the Criteria for Locating of Solar Power Plants in Iran. *GEJ*. 8 (2), 25-38, **URL: http://gej.issgeac.ir/article-1-212-fa.html.**
2. Neverman, H., Aminzade, M., Madani, K., & Shokri, N. (2024). Uantifying water evaporation from large reservoirs: Implications for water management in water-stressed regions. 262, 119860, **https:// doi.org/ 10.1016/ j.envres. 2024. 119860.**

3.Razmjoo, A., et al. (2019). Stand-alone hybrid energy systems for remote area power generation. *Energy Reports*, 5, 231-241, **https://doi.org/10.1016/j.egyr.2019.01.010.**

4.Sadeghi, S. H., et al. (2023). Watershed health and ecological security zoning throughout Iran. *Science of The Total Environment*, 905, 167123, **http://dx.doi.org/10.1016/j.scitotenv.2023.167123.**

5.Shahbazi, R., Kouravand, S., & Hassan-Beygi, R. (2019). Analysis of wind turbine usage in greenhouses: wind resource assessment, distributed generation of electricity and environmental protection. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, p. 1-21. **http://dx.doi.org/10.1080/15567036.2019.1677810.**

6.Örvös, M., Szabó, V., & Poós, T. (2016). Rate of evaporation from the free surface of a heated liquid. *Journal of Applied Mechanics and Technical Physics*, 57, 1108-1117, **http://dx.doi.org/10.1134/S0021894416060195.**

7.Mehdi, N. D., & Hossein, E. (2017). Comparison of experimental methods for estimating evaporation from the free surface of water (Case study: Doz Regulating Dam). *Bi-Quarterly Journal of Water Engineering*, 4, 2. **https://sanad.iau.ir/en/Journal/jwe/Article/1024343.**

8.Nadi, A., Nabatian, N., Hashemi Tari, P. & Asgari Marnani, S. (2021). Aerdyanmic Assessment and Wake Analysis of a Small Horizonatal Axis Multi-Rotor Wind Turbine. *Modares Mechanical Engineering*, 21(8), 551-561. **URL: http://mme.modares.ac.ir/article-15-38819-fa.html.**

9.Raminm, Gh., & Majid, R. Z. (2024). Investigating the efficiency of different evaporation estimation methods using satellite data on saline water levels (Case study: Lake Urmia), *Iran's water resources research*, 19(2), 1-13. **https://www.iwrr.ir/.**

10.Shahi, Z., Shirifi, M., & Zakermoshfegh, M. (2024). Simulating the effect of spatial wind changes on evaporation with CE-QUAL-W2 integrated model and Bowen ratio, *Water and Soil Conservation Research*, 31, 133-152. **DOI: https://doi.org/10.22069/jwsc.2024.22049.3704.**

11.Shahi, Z., Shirifi, M., & Zakermoshfegh, M. (2025). Improving CE-QUAL-W2 Calibration Using a Terrain-Based Wind Sheltering Coefficient Tuning Method, *Iranian Journal of Science and Technology, Transactions of Civil Engineering*, 49 (2), **DOI: https://doi.org/10.21203/rs.3.rs-3713867/v1.**

12.Mohamadi, M., Salarijazi, M., Ghorbani, Kh., & Dehghani, A. (2024). More reliable determination of daily evaporation from the pan in cold regions by limited meteorological factors, *Applied water science*, 14. **https://doi.org/10.1007/s13201-024-02100-x.**

13.Mohamadi, M., Salarijazi, M., Ghorbani, Kh., & Dehghani, A. (2024). Improvement of daily pan-evaporation calculation in arid and semi-arid regions by limited climatic data, *Journal of Water and Climate Change*, 15(2), 305-324. **https://doi.org/10.2166/wcc.2023.459.**

14.Mehdi, N. D., & Hossein, E. (2017). Comparison of experimental methods for estimating evaporation from the free surface of water (Case study: Doz Regulating Dam). *Bi-Quarterly Journal of Water Engineering*, 4, 2. **https:// sanad.iau.ir/ en/ Journal/ jwe/ Article/1024343.**

15.Emamdoust, S., Shahnazari, A., & Taghavi, J. (2019). Determination of Evaporation from Free Surface Water in Mazandaran Plain (Dazmirkandeh Abbandan) and Compared with Seven Experimental Methods. *J Watershed Manage Res*. 9(18), 241-249. **doi:10.29252/ jwmr.9.18.241 URL: http://jwmr.sanru.ac.ir/article-1-730-fa.html.**

16.S. M. B. Mirafzali, A. H. (2023). Investigating the energy absorption quality of the porous Schwarz P structure made by 3D printing method, *Iranian Journal of Engineering*, 9(2), 13-20,

https:// www.doi.org/10.22034/IJME. 2023.383269.174. [In Persian]

17. Aghbashlo, M., et al. (2018). Performance assessment of a wind power plant using standard exergy and extended exergy accounting (EEA) approaches. *Journal of Cleaner Production*, 171, 127-136. **https://doi.org/10.1016/j.jclepro.2017. 09.263.**

18. Ehyaei, M., Ahmadi, A., & Rosen, M. A. (2019). Energy, exergy, economic and advanced and extended exergy analyses of a wind turbine. *Energy conversion and management,* 183, 369-381. **https://doi.org/10.1016/ j.enconman.2019.01.008 https://doi.org/ 10.1016/j.enconman.2019.01.008.**