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Evaluation of Climate Water Balance of Nasiriya Meteorological station -Thi Qar Governorate-S. Iraq.

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ABSTRACT

The climatic parameters for the years (1960-2016) were collected from Nasiriya meteorological station and then were applied to evaluate the climatic conditions Nasiriya-Thi Qar Governorate-S. Iraq. The total annual rainfall is (128.4 mm), while the total annual evaporation is (3362 mm), the average monthly relative humidity is (46%), sunshine (8.9 h/day), temperature (25 C◦) and wind speed (4.0 m/sec). Climate of the study area is described as an arid according to many classifications. Mean monthly water surplus for the period (1960-2016) was recorded in the study area about (4.7mm) in November, (11.67 mm) in December, (20.56 mm) in January and (6.51mm)in February of the whole amount of Rainfall and equivalent to (119.65 mm).
Keyword: climatic condition, Classification of climate, Water balance, Nasiriya, Iraq.

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INTRODUCTION

Water resources have been a paramount importance in human life over all civilizations. With the development of the 21st century, the need has increased to seek additional resources to provide water from other sources besides rivers and rain falls. Climate change is one of the most important environmental issues to be studied and evaluated because of its significant impact in several sectors such as water, agriculture resources and others. Climate change may cause droughts intensity, increase flood risk, increase soil salinity, decrease groundwater level, etc. Lack of water security and water scarcity affect large parts of the developing world. The past century has seen a six fold increase in world water demand [1] . Climate is an important environmental component because it plays a major role in influencing other environmental components such as water quality, weathering and erosion activities, transportation, sedimentation, and the relationship between geochemical variables and then living organisms [2]. The climate is a vital factor affecting the quality of water resources and change of their quality. The increase in the amount of rainfall leads to develop the water resources quantity and quality, as well as the reduction of concentrations of some chemical elements in water, while increased summer temperatures lead to water evaporation and soil dryness, thereby reducing groundwater levels and increasing salts. Narrow groundwater in the intentional zone interacts with soil, vegetation, and climate through the capillary upsurge and root uptake from the water table, which are influenced land surface processes. Contrasting deep water table conditions, a shallow groundwater keeps elevated soil moist in the root zone by capillary flux [3], which depends on the properties of the hydraulic soil, the groundwater aquifer, and the distribution of possible matric soil through the unsaturated area [4] showed that the sensitivity of the hydrological response to climate change is strongly correlated with the interactions inherent between groundwater and surface processes.

Study Area

The studied area Nasiriya city is located on the Euphrates River in Thi Qar governorate in Iraq, between latitudes (31°00′ - 31°15′) and longitudes (46°00′ - 46°30′) with an approximate area of (3486km^2) Fig. 1. The highest ground level at the northwest of Al-Rifai city is about (17m) then decreases to about (5m) above sea level to the east of Nasiriya city (Fig. 1).

Geological Setting:

The study area extends along a part of Mesopotamia flood plain. Mesopotamia is a vast low land with a relatively flat surface sloping from 155 m (a.s.l.) north part to sea level at the head of the Arabian Gulf, about 300 km South of Nasiriya city. The Mesopotamian plan comprises a lake, marsh complex. The thickness of the Quaternary deposit exceeds 250 m. The upper part of the sequence (mostly of Holocene age) comprises fluviatile flood silts and Aeolian silts. The Quaternary sediments are unconsolidated and usually finer grained than the underlying formations [5]. This area lies in Euphrates sub zone of Mesopotamian zone from stable shelf of Arabian plate, in this location exist Mesopotamian flood plain deposits ,where alluvial fans (Pleistocene age). These deposits are covered by Holocene sediments which comprise fluvial and lacustrine deposits in addition to gypcrete on the surface of some fans [5]. The aim of the study is to determine climatic water balance by analyzing the climatic parameters of Nasiriya Meteorological Station for period (1960-2016).

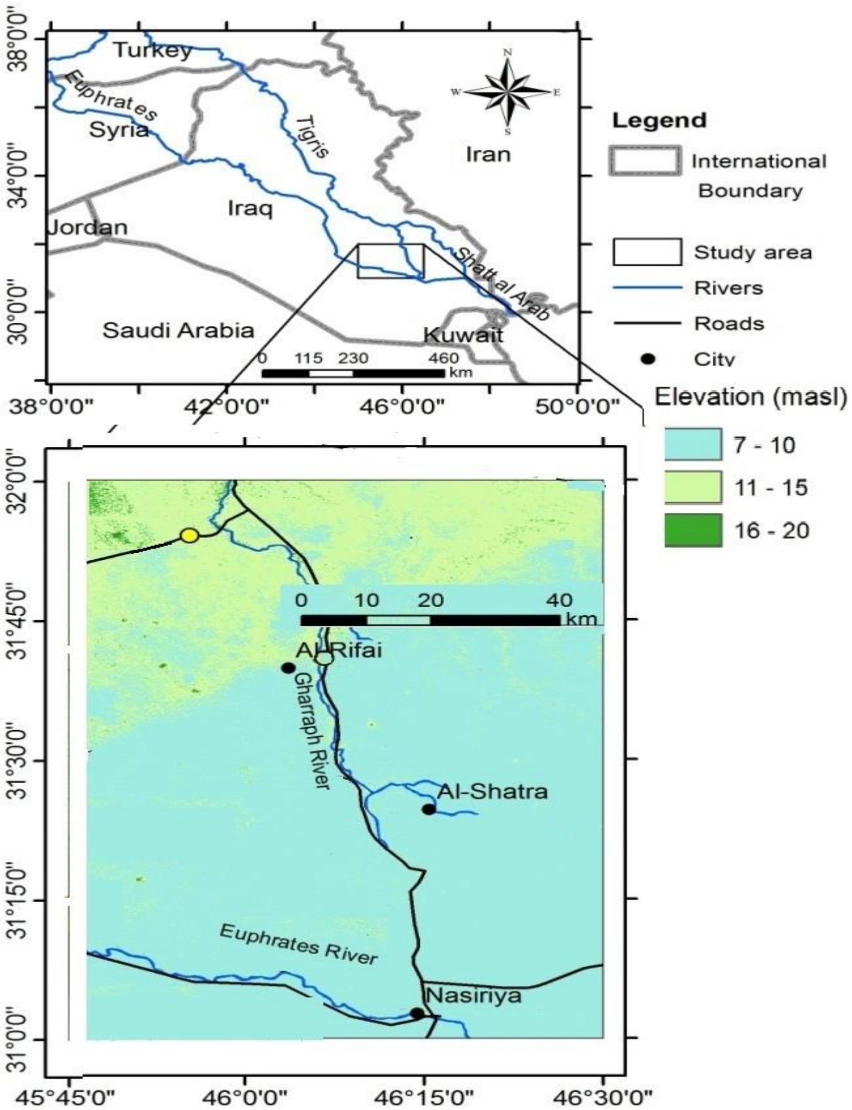

Figure 1: Map of studied area (Sissakian,et al.,2000)

MATERIALS AND METHODS

The climatic data from Nasiriya meteorological station was collected for the period (1960-2016) with calculation the mean monthly climatic parameters [6]. Values of potential evapotranspiration were determined by utilizing [7], equation. [8]. These methods were applied to computation water balance in the study area. Type of climate in the study area was determined according to four climate classifications, [9 - 12].

RESULTS AND DISCUSSION

The available data on the climatic conditions of Nasiriya city such as the Rainfall, relative humidity, temperature, wind speed, sunshine and evaporation were analyzed. The high amount of rainfall (R) and relative humidity in (mm) through the month (November, December, January, February, March and April) this month represented the wet period and the other months represented the dry period.

Rainfall

Rainfall is one of the most important climatic elements in hydrological studies, determines its abundance or decrease according to other elements and is the main source of flow or drought of rivers and the growth or lack of agriculture in some areas. The maximum mean monthly rainfall was (24.9 mm) in January and no rain in July and August (Table 1). The total annual rainfall was (127.3 mm) for the period (1960-2016).

Relative Humidity

Relative humidity is defined as the ratio between the amount of water vapor in the air and the amount of water vapor when the air is saturated at the same Temperature level. Relative humidity controls the rate of evaporation from water surfaces, soil and transpiration of plant leaves, where the greater the relative humidity, the less evaporation and transpiration. The maximum and minimum mean monthly relative humidity % are (72 %) and (25 %) in January and July respectively (Table 1), and the mean annual relative humidity % is (46 %).

Temperature

Temperature is an important factor in governing the evaporation and evapotranspiration, where increased temperature will heat the air. There is an important relationship between plant growth and temperature, where plants adapt to certain temperature limits through which the can perform its activities. In the study area the maximum and minimum mean monthly air temperature are (36.3 °C) and (10.3°C) in July and January respectively (Table 1), while the mean annual of temperature is (24.2 °C). In addition, mean maximum monthly air temperature are reflecting its maximum value is (44.8 °C) during July and minimum value as (17.5 °C) in January, while mean minimum monthly air temperature are reflecting its maximum value is (28.0 °C) during July and minimum value as (6.3 °C) in January.

Wind Speed

Prevailing winds generally in the study area are blows from the northwest to the south-east and are sometimes accompanied by dust storms, especially in the summer when the wind blows from the south and southwest. The mean monthly wind speed in the study area is ranged between (5.3 m/sec-2.9m/sec). The maximum mean monthly of wind speed was recorded in July while the minimum mean monthly was recorded in December (Table 1). The mean annual wind speed is (4.0 m/sec).

Sunshine

Sunshine is an important component of climatic elements as it influences relative humidity, evapotranspiration and temperature. The number of hour's brightness considered functions as solar influence on the temperature and relative humidity and then it is effects on the real evapotranspiration. The maximum mean monthly sunshine in study area is (12.2 h/day) in June and minimum mean monthly is (6.2 h/day) in December (Table 1), whereas the mean annual sunshine is (8.9 h/day).

Evaporation

Evaporation is influenced by several factors such as: Sunshine, air temperature, evaporation surface, saturation deficit, wind speed, atmospheric pressure, and surface evaporation nature.

Evaporation affects groundwater chemistry as extreme evaporation leads to deposition of minerals such as gypsum, calcite, and chloride salts in soils. The water then penetrates through these soils, thus enriching the water with these elements. Evaporation is an important climate factor that is closely related to many other factors such as temperature, soil, and land use and water resources in the region. Evaporation greatly affects the quality of water resources in any basin [13].The maximum mean monthly evaporation is (553 mm) in July but the minimum mean monthly is (68 mm) in January (Table 1), while the total annual evaporation is (3362 mm).

Table 1: Monthly Evaporation (mm) For Nasiriya meteorological station for the period (1960-2016) (I.M.O., 2017)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Mean Air Temp °C	25.1	17.2	11.8	10.3	12.8	19.0	24.0	30.6	34.3	36.3	36.0	33.1	24.2
Mean Max Temp °C	35.5	26.0	19.3	17.5	20.5	25.6	31.6	38.3	42.5	44.5	44.8	41.9	32
Mean Min Temp °C	19.1	12.6	7.8	6.3	8.4	12.5	18.2	23.5	26.4	28.0	27.4	24.0	18
Wind Speed m/s	3.1	3.0	2.9	3.1	3.5	3.9	4.1	4.2	5.2	5.3	4.7	3.7	4.0
Monthly Rainfall mm	7.4	20.3	18.5	24.9	16.8	18.6	15.4	4.9	0.2	0.0	0.0	0.3	127.3 Mm
Monthly Evaporation mm	231	113	76	68	99	179	257	365	476	553	475	353	3362 Mm
Monthly Sun shine hr/day	8.8	7.1	6.2	6.3	7.4	7.3	8.8	9.7	12.2	11.3	11.1	10.5	8.9
RH %	47	53	60	72	65	60	53	36	26	25	27	30	46

Evapotranspiration

Potential Evapotranspiration is a collection concept for both transpiration and evaporation and mean the aggregate lack of water from soil plants by transpiration and evaporation.

Thornthwaite 1948 define Evapotranspiration as the value of vapor-transpiration produced from soil that is covered with dense vegetation. The Thornthwaite in 1948 method was chosen from among different methods, because there is no daily monitoring of climatic factors and it is easy. Thornthwaite equations were based on the junction between evaporation capacity in any area, air temperature and shining hours between sun rises till sunset. PE was calculated in (mm) and was corrected by multiplying its value with (K) index (Table 2) K index value was calculated depending on the months and the location of the climate station from latitude coordination's.

Evapotranspiration was computed by [7], through making a number of experiments on different types of climate based on temperature only. Evapotranspiration is computed for each month in the year.

$$PE = 16\left(\frac{10t}{J}\right)^{a} \quad \text{................ 1}$$

$$J = \sum_{j-1}^{j=n} \quad \text{(for 12 months)} \quad \text{................ 2}$$

$$\mathbf{j = (\mathit{tn} / 5)^{1.514}} \quad \text{................ 3}$$

$$a = 0.016\, J + 0.5 \quad \text{................ 4}$$

$$PEc = PEx \; * \; DT / \mathbf{360} \quad \text{................ 5}$$

Where:

PEc: Corrected potential evapotranspiration (mm).
PEx: Actual potential evapotranspiration (mm).
D: the number of days in the month.
t = Monthly mean air temperature (°C).
n = Number of monthly measurement.
J = Annual heat index (°C).
j = Monthly temperature parameter (°C).
a = Constant.
Then: a = 0.016*130.67 + 0.5 = 2.59

Number of days during months and sunshine hours are affect potential evapotranspiration values, Table 2.

Table 2: Calculation of Actual and Corrected Potential Evapotranspiration (PEx-PEc) in Nasiriya area for period 1960-2016 according to [7] method.

Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Mean Air Temp°C	25.1	17.2	11.8	10.3	12.8	19.0	24.0	30.6	34.3	36.3	36.0	33.1	24.2
j = (tn /5)$^{1.514}$	11.4	6.1	3.55	3.2	4.07	7.5	11.36	15.76	19.03	20.46	20.43	17.48	
DT / 360	0.71	0.69	0.57	0.52	0.58	0.68	0.74	0.87	0.97	0.99	0.98	0.93	
PEx (mm)	85.1	30.2	11.48	7.7	14.6	31.6	71.6	130.3	178.4	214.5	206.3	150.6	1132.4
PEc (mm)	58.6	17.1	5.9	4.1	8.2	21.2	51.3	109.2	172.3	211.2	199.1	123.4	
Epan (mm)	231	113	76	68	99	179	257	365	476	553	475	353	3362 Mm

CALCULATION

The water surplus is mean increasing the values of rainfall up the values of corrected evapotransipiration through given months in the year (WS = P > PEc), whilst the Water Deficit is the decreasing of rainfall values related to the values of corrected evapotransipiration through the residual months in the same year (WS = P < PEc). Actual Potential Evapotranspiration (PEx) can be derived as follow [8]:

$$WS = P - PEc \qquad \text{………. 6}$$

PEc = PEX , when P more than PEc

$$WD = PEc - P \qquad \text{………. 7}$$

P = PEx, when P less than PEc

In the period of water surplus, rainfall values are more than the corrected evapotranspiration, thus the corrected evapotranspiration values are equal the values of actual evapotranspiration. Water surplus is mean recharge of groundwater plus surface runoff after saturation of the soil. Moisture of the soil was depleted either through plant or evaporation from soil. Thus it was taken in account missing portion of water which is potential evapotranspiration. In the period of water deficit, rainfall values are less than values of correct evapotranspiration; therefore rainfall values are equal actual evapotranspiration values (Table 3). As it shows that there is a water deficit from the beginning of March to the end of October, while the water surplus is from November to the end of February with an annual value of (45.2 mm). The maximum value of water deficit was in July (211.2mm), while the minimum water deficit was during November, December, January and February (Table 3).

Table 3: Calculation of water deficit and Water surplus in Nasiriya area for period (1960-2016) [8]

Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
P (mm)	7.4	20.3	18.5	24.9	16.8	18.6	15.4	4.9	0.2	0.0	0.0	0.3	127.3 mm
PEc (mm)	58.6	17.1	5.9	4.1	8.2	21.2	51.3	109.2	172.3	211.2	199.1	123.4	981.6
APE (mm)	7.4	17.1	5.9	4.1	8.2	18.6	15.4	4.9	0.2	0.0	0.0	0.3	82.1
WS (mm)	0	3.2	12.6	20.8	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2

WD (mm)	51.2	0.0	0.0	0.0	0.0	2.6	35.9	104.3	172.1	211.2	199.1	123.1	899.5

Where: WS: Water surplus (mm).; WD: Water deficit (mm).; PEx: Actual Evapotranspiration (mm).

Total value of annual water surplus equal (45.2 mm) from total value of the rainfall, it's confined between (February - November) due to rainfall is more than corrected evapotranspiration (PEc).

Annual rainfall and (WS) value used to calculate the ratio of water surplus as the equations:

$$WS\ \% = WS/\ P \times \mathbf{100} \quad \text{……….8}$$

WS % = 45.2 / 127.3 x 100 = 35.5 %

$$WD\ \% = 100 - WS\ \% \quad \text{……… 9}$$

WD % = 100 – 35.5 = 64.5 %

Classification of the Climate

Various methods are used for classification of climate including the difference elements of climate, and it is difficult to collect them in one classification of [10]. Four classifications are used to determine the type of climate in Nasiriya as follow:

Brown and Cocheme, 1973 [9] classification is based on humidity index (H.I) which indicate the ratio of rainfalls to corrected potential evapotranspiration (Table 4)

$$H.I.: = P\ /\ \mathbf{PEc} \quad \text{………. 10}$$

Where: H.I: Humidity index.; P: rainfall (mm).; PEc: Corrected potential evapotranspiration (mm).

Kettaneh and Gangopadhyaya, 1974 [10] Classification that based on humidity index (H.I) which indicate the ratio of rainfalls to corrected potential evapotranspiration, (Tables- 4 and 5)

Table 4: Climate Classification according to [9, 10]

Climate type		**Range of HI**
Humid	Not humid	HI > 1
Moist		HI< 1< 2HI
Moist to Dry		2HI< 1< 4HI
Dry		4HI< 1< 10HI
V. Dry		10HI < 1

Table 5: Calculation of Humidity index (H.I) According to [9, 10] classifications for Nasiriya for period (1960-2016).

Months	P (mm)	PEc (mm)	H.I.	Climate type
Oct.	7.4	58.6	0.13	Dry
Nov.	20.3	17.1	1.19	Humid
Dec.	18.5	5.9	3.14	Humid
Jan.	24.9	4.1	6.1	Humid
Feb.	16.8	8.2	2.1	Humid
Mar.	18.6	21.2	0.88	Moist
Apr.	15.4	51.3	0.3	Between Moist and Dry
May	4.9	109.2	0.04	Very Dry
June	0.2	172.3	0.0	Very Dry
July	0.0	211.2	0.0	Very Dry

Aug.	0.0	199.1	0.0	Very Dry
Sept.	0.3	123.4	0.0	Very Dry

The second classification is for [11] were the climate type is based on the value of climate index to find three classes which related to the rainfall and evapotranspiration as in the following equation:

$$CI = [(P / PE) - 1] * \mathbf{100} \quad \text{......... } \mathbf{11}$$

Where: CI = Climate index; P = Rainfall ; PE = Potential evapotranspiration.

The positive value of the (CI) is indicating humid climate while Negative value indicates dry climate. This classification refer to that the climate type is arid in study area due to the climate index value (CI) = -88.76, as exhibited in (Table 6).

Table 6: Classification of the climate in the study area, according to [11] for Nasiriya for period (1960-2016)

Climate Type	Range of CI	CI in studied area
Dry-sub humid	0.0 to -33.3	-88.76
Semi-Arid	-33.3 to -66.7	
Arid	-66.7 to -100	

Classification proposed by [12] to define the type of the climate by applying the treatment of annual dryness which based on temperature and quantities of rainfall, as the following equations:

$$AI - 1 = 1.0 \times P / (11.525 \times t) \quad \text{...... } 12$$

$$AI - 2 = \sqrt{P} / t \quad \text{......} 13$$

Where: AI: Annual dryness index. P: Mean annual rainfall (mm).; t: Mean annual temperature (°C). The value of the (AI-1) characterizes the classification of the dominated climate, while (AI-2) characterizes a variation of the latter classification, as it is shown in (Table 7).

$AI - 1 = 1.0 \times 127.3 / (11.525 \times 24.2) = 0.456$
$AI - 2 = \sqrt{127.3} / 24.2 = 0.466$

According to this classification the values of (AI-1) and (AI-2) indicates that the type of climate is arid (Table-7).

Table 7: Classification of the climate according to [12] in Nasiriya area for period (1960-2016)

Type 1	Evaluation	Type 2	Evaluation
AI.1 > 1.0	Humid to Moist	AI.2 ≥ 4	Humid
		2.5 ≤AI.2 < 4	Humid to Moist
		1.85 ≤AI.2 < 2.5	Moist
		1.5 ≤AI.2 < 1.85	Moist to sub arid
AI.1 < 1.0	Sub arid to Arid	1.0 ≤AI.2 < 1.5	Sub arid
		AI.2 < 1.0	Arid

CONCLUSION

By conducting analyzes and calculating the annual averages of the climatic parameters it is shown that the total annual rainfall is (127.3 mm), evaporation is (3362 mm), while the mean monthly relative humidity % is (46%), sunshine (8.9 h/day), temperature (24.2 °C) and wind speed (4.0 m/sec). The climate

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water balance has been calculated. When analyzing the results, it was found that there was a large water deficit due to high temperature and thus increased evaporation rate.

There is water surplus in Nasiriya area of (3.2 mm), (12.6 mm), (20.8 mm), (8.6 mm) in November, December, January and February respectively.

Climate of study area is depicted as an arid according to climatic classification.

The global climate change is expected to change the hydro meteorological processes parameters, so that it was found according to the climate classifications the climate of Nasiriya area was continental and dry climates as well as the region has a great water deficit up to 95 % of the total rainfall values. The contribution of this research to knowledge is one of the most effective tools to provide feedback on the climate of the area and accordingly the quality of groundwater to the policy makers and environmentalists.

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