# Review of Ombrothermic Curve Graphs in the Interpretation of Drought (A Case study in Esfahan Province)

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**Abstract:** Drought is one of the most chronic natural disasters and is a gentle environmental phenomenon, so that it is more visible in the arid and semiarid regions. The intensity of dried periods in a 12-month scale was studied and analyzed and after obtaining precipitation and temperature statistics, Ombrothermic curves were drawn and studied using Excel software. Results of this study showed that in 2005, the duration of drought in majority of cities especially in Golpayegan was at least 2 months more than the long period. Therefore this article tires to study droughts in Esfahan in a 12-month scale for the statistic periods of 1992-2005 through the use of SPI "Standardize Precipitation Index".

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## 1. Introduction

Review of the history of human life on the Earth shows that man has always been exposed to natural disasters , part of which that is related to geological and tectonic features such as earthquakes , volcanoes , and so on , is referred to as geological disasters. Another part of natural disasters caused by climate changes and fluctuations such as flood, drought, storms, lightning, is called climatic and ecological disasters (Hare, F.K., 1983). Climatic and ecological disasters are very worrying but noticeable in Iran since it is located on a global dry belt. Sometimes, drought causes great damage to ecological environments. At the same time, even a rainfall during the drought may cause irreparable damage. Today, water supply management and rational analysis of existing conditions play a vital and undeniable role in determining less harmful and more useful ways of dealing with natural disasters such as floods and droughts and mitigating their harmful irreparable damage. Also due to the increasing development of human societies and the increasing demands and utilization of natural resources the need for careful review and adoption of a rational policy towards significant natural resources has been raised. Obviously, the logical analysis of natural phenomena, requires a relatively accurate estimation and as much actual simulation as possible of existing conditions. Given the random characteristics of natural events and their absolutely random behavior, any analysis of them would be quite uncertain. Therefore, prediction of any factors will be at various levels of probability.

### 1.1. Drought

Drought is a creeping environmental phenomenon that gently swallows a geographical area and may last several months to several years and causes a lot of damage. Climate change is the main cause of droughts in a global scale.

All regions of the world are temporarily, but irregularly suffering from repeated drought conditions, but this situation is more visible in the regions which are erratically affected by various weather patterns. The main consequence of drought is a long period of below-normal low rainfall. Reduction of soil moisture, surface water and underground water is the next consequence of low rainfall. Drought is a disaster that results from the lack of water (rainfall) and its absence means the destruction of life. This phenomenon is one of the main hazards associated with the weather. This natural Disaster will influence all aspects of our lives. There isn't a single Definition of drought at international level which is acceptable to all sides. Generally, drought occurs when water severely depletes in a special place and time. There are many definitions of the word 'drought' which are constantly changing specially with regard to its effect on natural and social environment. Drought is caused by numerous physical and spatial factors which can mainly be studied within the framework of general circulation of atmosphere and climate changes. Different studies represent researchers efforts to know drought more as a management tool since the far past. But the influence of various climate factors on drought has prevented a clear and comprehensive definition of it. Drought, is unusual dryness and continuous lack of rainfall in comparison to its long lasting average which, based on its severity and duration, might have different effects (Wihite,D. A. and Glants, M. H. 1985). To know the quantity of droughts, the use of indices developed based on precipitation has been considered by the researchers (Palmer,N. and K. J. Holmer. 1988). Lack of rainfall will have negative effects on underground waters, water supplies and resources, soil moisture and the flow of the rivers. Understanding this problem has led to conducting many researches and studies by different researchers (Correia, F. N, Santos, M. A, Rodrigues, R. R, 1991).

**2.1. Drought characteristics**

Each drought is known by three special features: intensity, duration, and the width of affected area. Quantitative measurement and expression of events are the requirements for knowing and comparing them. Therefore, to study and compare drought at different times, it must be monitored. According to Dracup , drought can be classified into 3 groups. In advanced stages of drought, water supplies and resources are facing severe shortages.

This means that groundwater reaction to droughts is too important. It should be noted that the impacts of low rainfall on soil moisture, water reservoirs, surface flow of rivers, and groundwater level will be shown at different time scales. However, for quantitative analysis of droughts, it's essential to have a definite index to determine dry and wet periods accurately (Silva. V. P. R. 2003). The review of determining indices of drought could be necessary to predict drought as the most important strategy to deal with it and to reduce its damage (Dracup J. A. Lee K. S and Paulson E. G. 1980). According to Tase Norio, years are divided to five categories of severely dry, dry, moderate, wet, and very wet. The performance of drought monitoring systems is seriously affected by the accuracy of index selection which is a description of subjective and objective conditions of drought. Each one of these indices is necessarily related to one kind of drought (agricultural, meteorological, hydrological, economic-social).

**Table 1:** Methods of studying drought

| Methods of studying drought | Indices of studying drought |
|---|---|
| Water balance | Torrent White |
| Flow analysis | Palmer |
| Groundwater analysis | Minimum flow |
| Determining threshold level | Surface water supply index(SWSI) |
| Synoptic analysis | |
| Remote evaluation | |
| Multivariate correlation | |
| Using geomorphologic and historical information | |

**3.1. Standardized Precipitation Index (SPI)**

Lack of rainfall, has different effects on groundwater, water resources, soil moisture and river flow. Understanding this issue has led to the conduction of various studies and researches by scientists and researchers. To determine the possibility of drought, the standardized precipitation index was developed. SPI has been designed to determine the lack of rainfall at different time scales. Standardized precipitation index can be calculated for any time and scale and at different time scales which depends on the rainfall probability (Mckee, T. B. ,N. J. Doesken, and J. Kleist,1993). Moreover, it can be an early warning about drought and a help to measure its severity. This method was presented by Mckee with regard to various effects of rainfall shortage on groundwater, surface water supplies and resources, soil moisture, and water flow. This index is use to quantify the lack of rainfall in a scale of several months and reflects the effects of drought on the rainfall anomalies in a relatively short time scale. However, it should be noted that the flow of groundwater and surface water reservoirs are reflecting the anomalies of long-term precipitation. That's why the standardized precipitation index (SPI) is basically calculated for 24, 12, 6, 3 and 48-month time scales. SPI is calculated by subtracting the amount of rainfall from the average in a certain time scale and then dividing it by standard deviation. SPI average in a time scale in a position equals zero and its standard deviation equals one. It's an important advantage of this index; since SPI has become normal. Therefore drier and more humid climates can be shown in the same way. In addition to drought periods, high rainfalls can also be studied by SPI. A drought happens when SPI is constantly negative and reaches to -1 or less. It ends when SPI becomes positive. Therefore each drought has a time period and will be defined by its beginning and end and its density is calculated for each month as long as it continues.

**4.1. The Understudy Area:**

The area which is studied in this research is Esfahan Province with an area of 106179 square kilometers. This province lies at latitude 30°42' - 34°30' north and at longitude 49°36' - 55°32' east in centaral part of Iran. This city has always been noticed by state managers due to its proper geographical position which is located in the heart of Iranian plateau. It is about 1580m above the sea level and is located in the east of Zagross Mountains. Esfahan is surrounded by dessert from north and east and its western and southern part is limited ro Zagross Mountains.

## 2. Material and methods

Since statistical period is needed to calculate SPI, synoptic stations which contained statistical periods were selected in the studied area. A 14-year period was chosen because of the lack of statistics. Then the statistics of rainfalls and temperature of Ardestan, Daran, East Isfahan, Golpayegan, Isfahan, KabootarAbad, Kashan, Khurbiabank, Nain, Natanz, and Shahreza stations were obtained from the meteorological office.

Then Ombrothermic curves were drawn separately for each station through Excel software and were finally used for analyzing data. After that, SPI was calculated for a12-month time scale.

Table 2: The following table briefly shows the results of Ombrothermic curves in 2005

| | Ardestan | Daran | East of Isfahan | Golpayegan | Isfahan | Kabootarabad | Kashan | Khorbiyabanak | Naein | Natanz | Shahreza |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drought months** | 11 | 7 | 10 | Station9 | 10 | 10 | 9 | 12 | 10 | 8 | 10 |
| **Jan** | | | | | | | | * | | | |
| **Feb** | * | * | * | | * | * | | * | | | * |
| **March** | * | | * | * | * | * | * | * | * | * | * |
| **April** | * | | * | | * | * | * | * | * | * | * |
| **May** | * | * | * | * | * | * | * | * | * | * | * |
| **June** | * | * | * | * | * | * | * | * | * | * | * |
| **July** | * | * | * | * | * | * | * | * | * | * | * |
| **August** | * | * | * | * | * | * | * | * | * | * | * |
| **September** | * | * | * | * | * | * | * | * | * | * | * |
| **October** | * | * | * | * | * | * | * | * | * | * | * |
| **November** | * | | * | * | * | * | * | * | * | | * |
| **December** | * | | | * | | | | * | * | | |

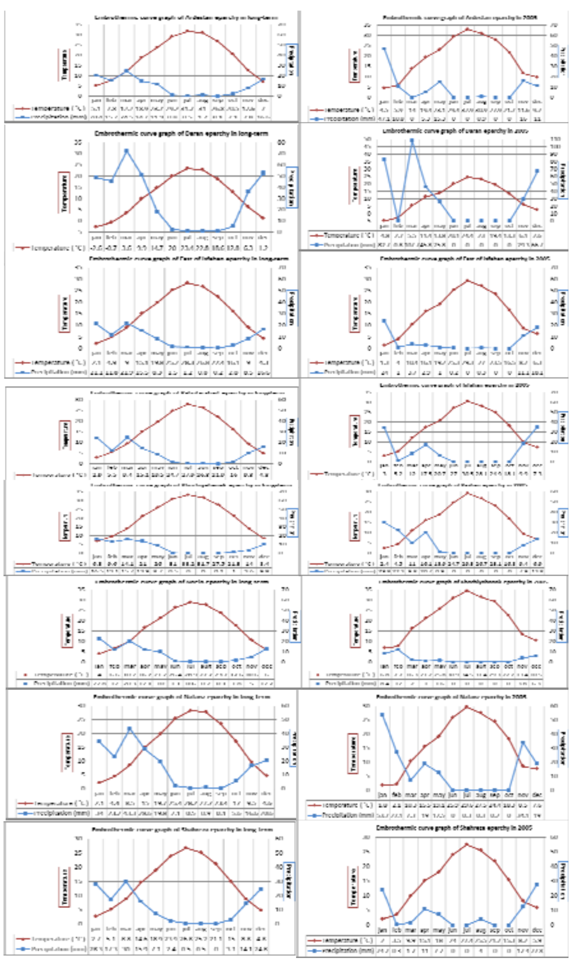

Figure 1


Figure 2.

Table 3: The results of Ombrothermic curves for a long period of time:

| Station | Ardestan | Daran | East of Isfahan | Golpayegan | Isfahan | Kabootarabad | Kashan | Khorbiyabanak | Naein | Natanz | Shahreza |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drought months** | 9 | 6 | 8 | 6 | 8 | 8 | 8 | 11 | 9 | 8 | 8 |
| **Jan** | | | | | | | | | | | |
| **Feb** | * | | | | | | | * | * | | |
| **March** | | | | | | | | * | | * | |
| **April** | * | | * | | * | * | * | * | * | * | * |
| **May** | * | * | * | | * | * | * | * | * | * | * |
| **June** | * | * | * | * | * | * | * | * | * | * | * |
| **July** | * | * | * | * | * | * | * | * | * | * | * |
| **August** | * | * | * | * | * | * | * | * | * | * | * |
| **September** | * | * | * | * | * | * | * | * | * | * | * |
| **October** | * | * | * | * | * | * | * | * | * | * | * |
| **November** | * | | * | * | * | * | * | * | * | | * |
| **December** | | | | | | | | * | | | |

Table 4: SPI tables are as following:

| Eparchy / Year | Ardestan | Daran | East Of Isfahan | Golpayegan | Isfahan |
|---|---|---|---|---|---|
| 1992 | Moderately wet | Near normal | Near normal | Near normal | Near normal |
| 1993 | Near normal | Very wet | Extremely wet | Very wet | Very wet |
| 1994 | Severely dry | Moderately wet | Near normal | Near normal | Severely dry |
| 1995 | Near normal | Severely dry | Near normal | Moderately dry | Near normal |
| 1996 | Extremely wet | Near normal | Near normal | Near normal | Near normal |
| 1997 | Moderately dry | Near normal | Near normal | Near normal | Near normal |
| 1998 | Near normal | Near normal | Near normal | Near normal | Near normal |
| 1999 | Near normal | Moderately dry | Near normal | Near normal | Near normal |

Table 5

| Eparchy / Year | Kabotarabad | Kashan | Khorbiyaban | Naein | Natanz | Shahreza |
|---|---|---|---|---|---|---|
| 1992 | Near normal | Very wet | Near normal | Very wet | Moderately wet | Severely dry |
| 1993 | Very wet | Near normal | Near normal | Near normal | Near normal | Near normal |
| 1994 | Near normal | Near normal | Near normal | Near normal | Near normal | Near normal |
| 1995 | Near normal | Moderately dry | Near normal | Near normal | Near normal | Moderately wet |
| 1996 | Near normal | Very wet | Very wet | Moderately wet | Very wet | Near normal |
| 1997 | Near normal | Moderately dry | Moderately dry | Near normal | Moderately dry | Near normal |
| 1998 | Near normal | Near normal | Near normal | Near normal | Near normal | Near normal |
| 1999 | Near normal | Near normal | Moderately wet | Very wet | Near normal | Near normal |
| 2000 | Severely dry | Near normal | Near normal | Near normal | Near normal | Moderately dry |
| 2001 | Severely dry | Moderately dry | Near normal | Moderately dry | Extremely dry | Near normal |
| 2002 | Near normal | Moderately wet | Near normal | Near normal | Moderately wet | Near normal |
| 2003 | Near normal | Near normal | Near normal | Moderately dry | Near normal | Near normal |
| 2004 | Very wet | Near normal | Moderately wet | Near normal | Near normal | Extremely wet |
| 2005 | Near normal | Near normal | Severely dry | Moderately dry | Near normal | Moderately dry |

Table 6

| Station | Ardestan | Daran | East of Isfahan | Golpayegan | Isfahan | Kabootarabad | Kashan | Khorbiyabanak | Naein | Natanz | Shahreza |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drought months in 2005 | 11 | 7 | 10 | 9 | 10 | 10 | 9 | 12 | 10 | 8 | 10 |
| SPI | Near normal | Near normal | Severly dry | Near normal | Near normal | Near normal | Near normal | Severly dry | Moderately dry | Near normal | Moderately dry |

## 3. Discussions

The results obtained from Ombrothermic curves in 2005 indicate that the number of drought months is as the following for different cities respectively:

Khurbiabanak 12, Ardestan 11 , East of Isfahan, Isfahan, Kabootarabad, Nain and shahreza 10, Golpayegan and Kashan 9, Matanz 8, Daran 7 and for a long period of time are respectively as the following:

Khurbiabanak 11, Ardestan 9, East of Isfahan, Isfahan , Kabootarabad, Kashan, Nain, Natanz and Shahreza 8, Golpayegan and Daran 6. Therefore, the results show that drought duration in 2005 in most cities specially in Golpayegan is at least two months more than the long term duration.

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