CORRELATION OF WIND SPEED DATA OF SOME LOCATIONS IN EGYPT USING WEIBULL AND RAYLEIGH DISTRIBUTION FUNCTIONS

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ABSTRACT

The wind speed data for some locations in Egypt are represented using Weibull and Rayleigh distribution functions in comparison with climatological wind data. It is found that the measured wind speed data agrees well with Weibull function for locations with relative high mean wind speed. In locations with low wind speed, the Rayleigh distribution function gives good representation for wind speed data. The Weibull shape parameter k and Weibull scale parameter c are calculated for 10 locations in Egypt.

Keywords: Wind speed, Weibull distribution functions, Rayleigh distribution function.

Nomenclature

c Weibull scale parameter
f frequency
F_i yearly wind speed frequency in interval i
k Weibull shape parameter
s_n cumulative frequency for wind speed in interval n
v wind speed
$\bar{v}$ mean wind speed.
v_i average value of wind speed in interval i
zk number of wind speed intervals

1. INTRODUCTION

For predicting the energy output of a wind turbine in any location, wind speed frequency distribution appears as a very important parameter in this field. During the last two decades, comprehensive attention was paid toward the development of an adequate statistical model for describing wind speed frequency distribution. Special attention was given to the Weibull function and Rayleigh function [1], [2], [3], [4], [5]. They considered Weibull function as a good statistical model for wind speed data representation. They did not say about the limitations of using Weibull and Rayleigh distribution functions.

The aim of this work is to determine the limitations of these functions. To do that, it is important to compare Weibull function with Rayleigh function for wide range of mean wind speed. This comparison has been done for some locations in Egypt with different mean wind speed.

2. THE WEIBULL AND RAYLEIGH FUNCTIONS

The dominant parameters of the Weibull distribution function are; shape parameter k and scale parameter c. It is expressed mathematically as follows

$$f(v)=\frac{k}{c}\frac{v^{k-1}}{c}\exp-(\frac{v}{c})^k \quad (1)$$

where k is the shape parameter, c is the scale parameter and v is the wind speed. There are several methods available in the literature for the calculation of these two parameters [6]. In this study, the estimation of these parameters is carried out graphically using the special logarithmic Weibull sheets and the cumulative distribution function according to [7]. The cumulative distribution function can be obtained numerically from wind speed data as follows

$$s_n = \sum_{i=1}^{n} f_i \qquad (2)$$

where f_i is the relative frequency for wind speed in interval i and s_n is the cumulative frequency for wind speed in interval n.

The Rayleigh distribution function for describing the wind speed frequency distribution has the form [4]

$$f(v) = \frac{\pi}{2}\frac{v}{\bar{v}^2}\exp - \frac{\pi}{4}\left(\frac{v}{\bar{v}}\right)^2 \qquad (3)$$

where v is the wind speed and $\bar{v}$ is the mean wind speed.

3. DESCRIPTION OF OBSERVED WIND DATA

Ten locations in different regions in Egypt have been choosen for this study. Figure (1) shows the position of these locations.

Monthly wind speed frequency distribution has been obtained for these locations [8]. This data was measured for a long period of more than 20 years at 10 m level above ground surface. The wind speed was divided into 8 intervals and the wind speed frequency was measured for each interval.

The mean yearly wind speed $\bar{v}_y$ for each location can be obtained from the following equation

$$\bar{v}_y = \frac{\sum_{i=1}^{zk} v_i F_i}{\sum_{i=1}^{zk} F_i} \qquad (4)$$

where v_i is the average value of wind speed in interval i, F_i is the crospônding yearly wind speed frequency in this interval and zk is the number of wind speed intervals. The mean yearly wind speed for the 10 locations is given in Table (1). As noticed from the mean wind speed data, Hurghada has a maximum mean wind speed of 6.6 m/s, while a minimum mean wind speed of 2.61 is observed at El-Arish. The Weibull parameters k and c are determined by using the special logarithmic Weibull sheets and the cumulative distribution function. From equations (1) and (3) the Weibull distribution curves, as well as, Rayleigh distribution curves can be obtained.

Table 1. The mean yearly wind speed for some locations in Egypt.

Location	$\bar{v}_y$ m/s
Hurghada	6.6
Mersa Matrouh	5.3
Sidi Barrani	5.19
Port Said	4.68
Suez	4.56
Aswan	4.4
Kharga	4.3
El-Mansoura	2.9
Rosetta	2.77
El-Arish	2.61

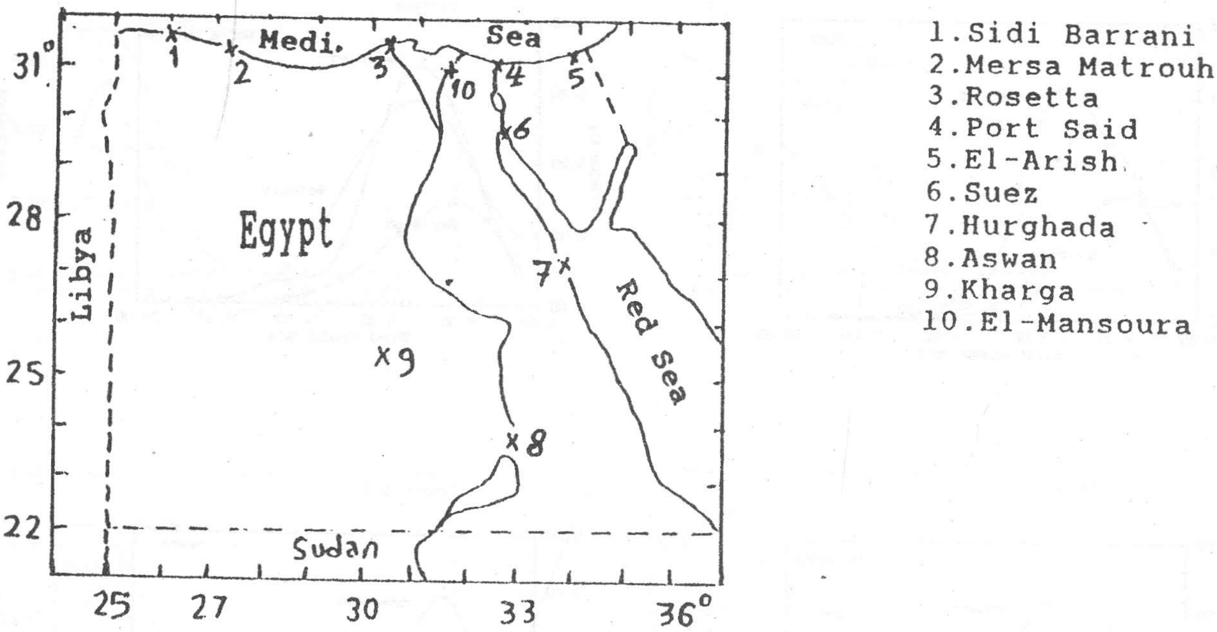

Fig.(1) The position of locations in Egypt

Figure 1. The position of locations in Egypt.

4. RESULTS AND DISCUSSION

Figure (2) shows the wind speed frequency distribution for Hurghada, Aswan, Mersa Matrouh and Suez. The Weibull curves obtained using the numerical values of k and c, as well as, the Rayleigh curves for these locations are also shown on this figure.

It is found that the Weibull distribution gives a good representation to the measured wind speed data for these locations.

Fig.(3) shows also good agreement between the Weibull distribution and the measured wind speed data for Sidi Barrani and Port Said.

Fig.(4) shows the wind speed frequency distribution for the remaining 4 locations. It is seen that the Weibull distribution gives good representation to the measured wind speed data for Kharga, while for Rosetta, El-Arish and El-Mansoura the Rayleigh distribution represents the measured wind speed data better than Weibull distribution.

It may be concluded from these figures that, it is useful to use Weibull distribution for locations with mean wind speed greater than 4 m/s and to use Rayleigh distribution for locations with mean wind speed lower than 4 m/s.

The Weibull parameters k and c for the 10 locations in Egypt are given in table (2). It is shown that the locations with relative high mean wind speed having greater values of k and c, while the locations with low mean wind speed show also lower values of shape and scale parameters k and c.

5. CONCLUSIONS

In the present work the Weibull and Rayleigh distribution functions were used for representation of wind speed data in some locations in Egypt. It is found that, the Weibull function gives a good representation to the measured wind speed data for locations with relative high mean wind speed. For locations with low mean wind speed, the Rayleigh distribution function represents the measured wind speed data better than Weibull function. The Weibull parameters for 10 locations in Egypt were calculated.

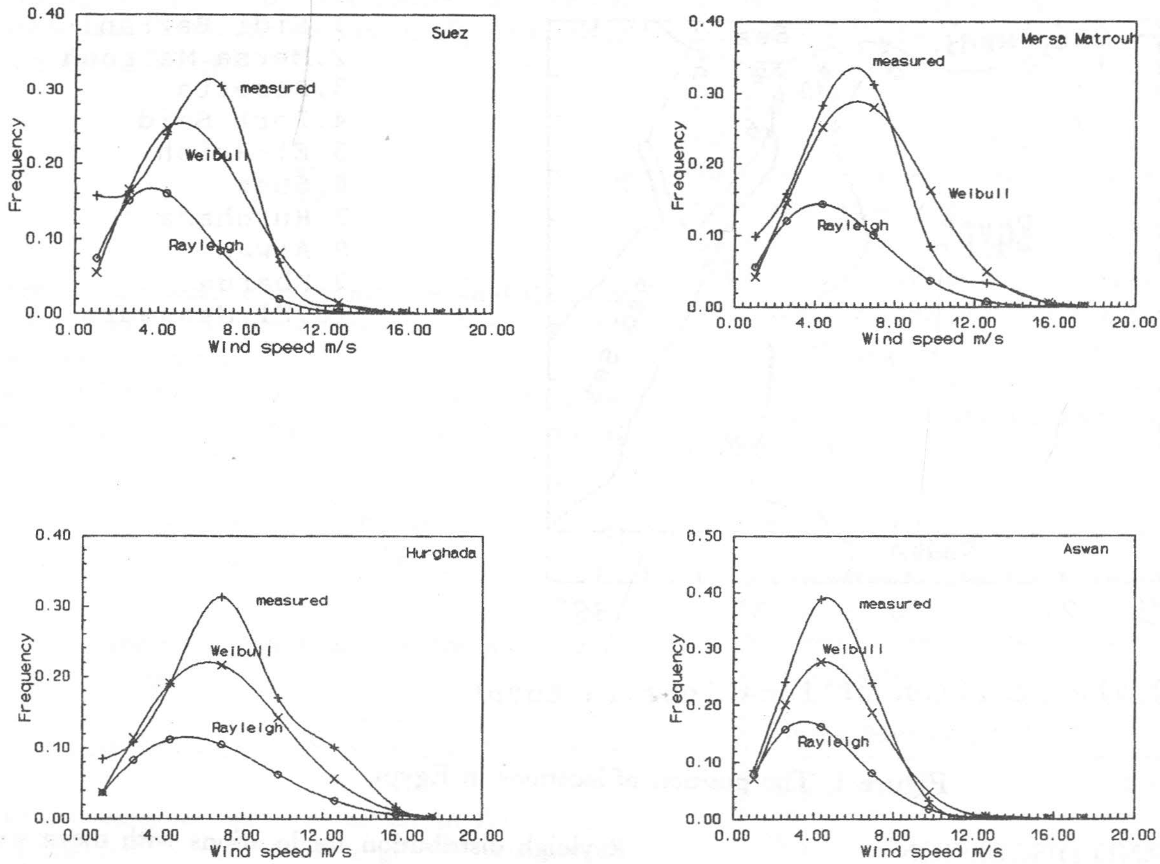

Figure 2. Wind speed frequency distribution for Hurghada, Aswan, Mersa Matrouh and Suez.

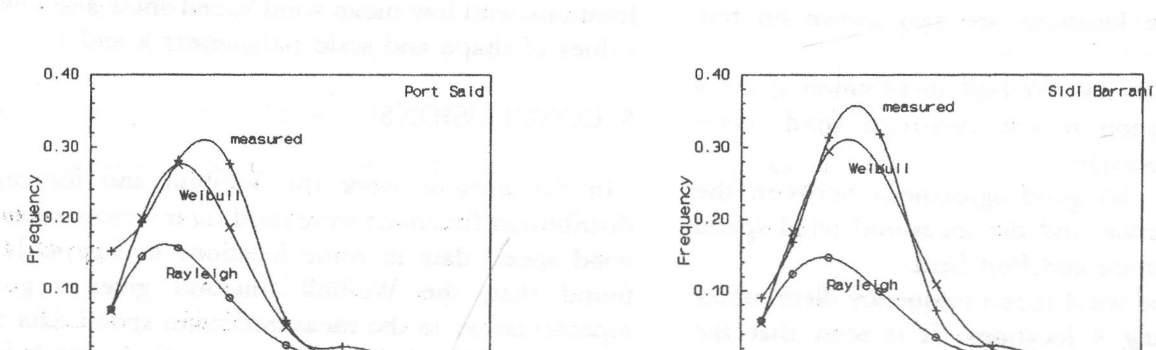

Figure 3. Wind speed frequency distribution for Sidi Barrani and Port Said.

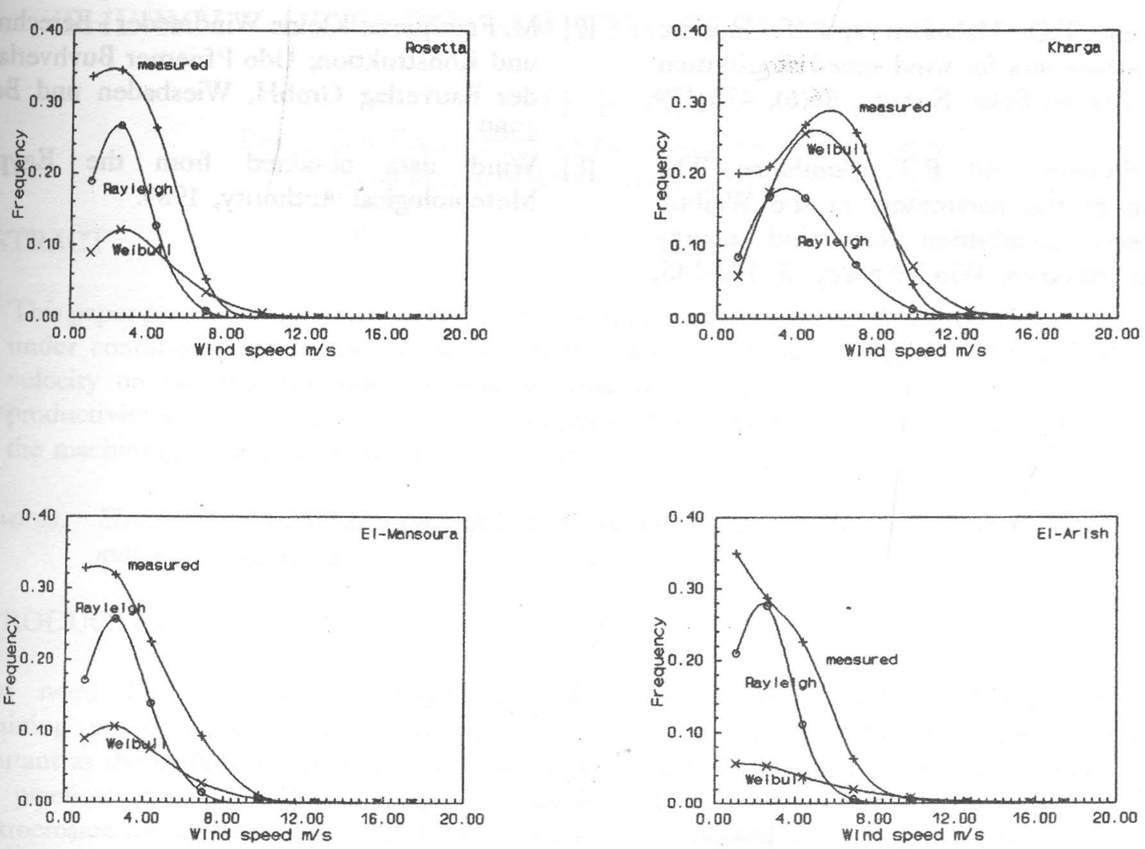

Figure 4. Wind speed frequency distribution for Kharga, Rosetta, El-Arish and El-Mansoura.

Location	k	c
Hurghada	2.3	8.0
Mersa Matrouh	2.4	7.6
Aswan	2.3	5.8
Kharga	2.3	6.3
El-Mansoura	1.6	4.0
Port Said	2.3	5.8
El-Arish	1.3	4.5
Suez	2.3	6.5
Sidi Barrani	2.3	6.7
Rosetta	1.7	4.2

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