Modeling the Effect of Urban Trees on Relative Humidity in Khartoum State

*1Hisam M. M. Tahir, CNRES, University of Bahri
2Tawhida A. Yousif, Freelance Researcher

(Received July 1, 2013; Accepted September 16, 2013)

Abstract—This study was carried out at six sites in Khartoum State namely: Al Kadaru and Al Safia in Bahri town; Wad Nabawi and Al Salha in Omdurman town; and Sunt Reserved Forest and Al Riyadh in Khartoum town. The aim of the study was to determine the effect of urban trees on relative humidity in Khartoum State. Relative humidity was recorded throughout a calendar year. Spontaneous readings were made simultaneously in the bare land and under the trees at approximately 1.5 - 2 meters height which represents the environment in which humans live. Seven regression models were built to predict the relationship between relative humidity under the trees and that on the bare land; six regression models for the six sites and the seventh model, obtained from the pooled data, for Khartoum State. Each model depicts the relationship between the measurements under the trees as the dependent variable and that in the bare land as the independent one. All the models were linear according to the respective scatter plots and the respective most significant coefficients of determination ($R^2$). This study concluded that the quantification of the effect of urban trees on relative humidity could be obtained with an acceptable level of accuracy using empirical regression models. The increase in relative humidity under the trees ranged from 0.2% to 0.9% at all sites.

Index Terms—relative humidity, modeling, urban trees.

I. INTRODUCTION

Relative humidity is an indicator of precipitation, dew or fog; and it is used in weather forecasts and reports. When the temperature is high and the relative humidity is low, evaporation of water is rapid; but when the temperature is high and the relative humidity is high, evaporation of water is slow; and when the relative humidity approaches 100 percent, condensation can occur on surfaces, leading to problems of moulds, corrosion, decay, and other moisture-related deterioration [1].

Trees and vegetation cool the air by evapotranspiration. In this process, the radiant energy is converted to latent energy which reduces sensible heat and then cools the air adjacent to trees rapidly and would be removed quickly and dispersed by even a gentle breeze. Hence, trees are an important tool for the modification of relative humidity and temperature [2] [3] [4]. Federer [5] found that an urban tree well supplied with water may transpire at a rate sufficient to provide cooling equal to the effect of five room air conditioners. Kramer and Kozlowski [6] demonstrated that a tree can evaporate up to 100 gallons of water a day; he also found that a mature tree with a 30 - foot crown can transpire approximately 40 gallons of water per day. Moreover, Evapotranspiration alone can result in peak summer temperature reductions of 1° - 5°C. It was found that the evaporation from a single large tree can produce the cooling effect of 10 room size air conditioners operating 24 hours/day [7].

II. MATERIALS AND METHODS

Relative humidity data (%) were collected from six sites in Khartoum State: namely, Al Kadaru and Al Safia in Bahri town; Wad Nabawi and Al Salha in Omdurman town; and Sunt Reserved Forest and Al Riyadh in Khartoum town. The tree species with the highest relative abundance in each of the six sites were as follows: Conocarpus lancifolius in Al Kadaru, Ficus binjamina in Al Riyadh, Azadirachta indica in Wad Nabawi, Peltophorum pterocarpum in Al Safia, Albizia lebbeck in Al Salha and Acacia nilotica in the Sunt Reserved Forest. RH Anemometer Pen-Model 850021 was used in data logging. Spontaneous relative humidity readings were taken on three days every month during a full calendar year from December 2010 to November 2011. Relative humidity
readings were taken simultaneously on the bare land and below assumption that this is the height at which human beings live [8]. The readings were made at intervals of two hours during the period from 8.00 am to 6.00 pm in each of the three days. Six readings were taken daily. The simultaneous readings taken during the period of the study were 162 for the Sunt Forest and 216 for each of the other five sites. Measurements were not conducted in Sunt Forest during the months of August, September and October because the forest was completely flooded. The collected data were analyzed using the computer packages SPSS 15.0 for Windows and Microsoft Excel version 7. Scatter plots and trend graphs were fitted.

III. RESULTS AND DISCUSSION
In all the relative humidity line graphs (Figures 1.1, 2.1, 3.1, 4.1, 5.1 and 6.1), the two lines followed the same trend throughout the year at all sites. It is apparent that the relative humidity in the bare land (RH_{BL}) is lower than relative humidity under the trees (RH_{UT}). All the results showed linear relationships between relative humidity under the trees (RH_{UT}) and relative humidity in bare land (RH_{BL}) with significant coefficients of determination (R^2).

![Fig.1.1. Trend graph for relative humidity (%) under the trees (RH_{UT}) and in bare land (RH_{BL}) at Al Kadaru](image)

![Fig.2.1. Trend graph for relative humidity (%) under the trees (RH_{UT}) and in bare land (RH_{BL}) at Al Safia](image)

![Fig.1.2. Relationship between relative humidity (%) under trees (RH_{UT}) and in bare land (RH_{BL}) at Al Kadaru](image)

![Fig.2.2. Relationship between relative humidity (%) under trees (RH_{UT}) and in bare land (RH_{BL}) at Al Safia](image)
Fig. 3.1. Trend for relative humidity (%) under the trees ($RH_{UT}$) and in bare land ($RH_{BL}$) at Wad Nubawi

Fig. 3.2. Relationship between relative humidity (%) under the trees ($RH_{UT}$) and in bare land ($RH_{BL}$) at Wad Nubawi

Fig. 4.1. Trend for relative humidity (%) under the trees ($RH_{UT}$) and in bare land ($RH_{BL}$) at Al Salha

Fig. 4.2. Relationship between relative humidity (%) under the trees ($RH_{UT}$) and in bare land ($RH_{BL}$) at Al Salha
Fig. 5.1. Trend for relative humidity (%) under the trees (RH<sub>UT</sub>) and in bare (RH<sub>BL</sub>) at Sunt Forest

Fig. 5.2. Relationship between relative humidity (%) under the trees (RH<sub>UT</sub>) and in bare land (RH<sub>BL</sub>) at Sunt Forest

Fig. 6.1. Trend for relative humidity (%) under the trees (RH<sub>UT</sub>) and in bare land (RH<sub>BL</sub>) at Al Riyadh

Fig. 6.2. Relationship between relative humidity (%) under the trees and in (RH<sub>UT</sub>) bare land (RH<sub>BL</sub>) at Al Riyadh
In all the foregoing results which were obtained for relative humidity under the trees and on the bare land at all sites, it is clear that relative humidity was higher under the trees throughout the study period. The results of this study showed that an average increase in the relative humidity which might be attributed to trees ranged from 8 to 19% in the six sites. These results are consistent with studies of others [5] [6] who concluded that relative humidity under the tree was higher than that in the bare land due to the shade and transpiration by trees. As a matter of comparison, relative humidity measurements showed a little variation in the average increase among different sites in Khartoum State during the study period. This variation might be due to the differences in transpiration which is affected by many factors such as leaf area, leaf orientation, leaf size and the shape of different tree species found at different sites, as well as extra humidity added to the atmosphere by watering of trees.

IV. CONCLUSION

The main finding of this study is that quantification of the effect of urban trees on relative humidity could be obtained with an acceptable level of accuracy using empirical regression models.

RECOMMENDATIONS

Further research work on the effect of urban trees on relative humidity is needed, giving consideration to other factors in the study area. These factors include:

- Tree species, spacing, density, crown spread and leaf area index
- Microclimate, buildings and other constructions.

Acknowledgement

The authors acknowledge with gratitude the assistance rendered to them by Mr. El Mughiera M. Ibrahim (CNRES) during data logging.

REFERENCES