Derivation of An Equation to Measure The Sense of The Comfort (Study in Applied Climatology)

Abdul Zahra A. Al Jenaby
Geographic Department / College of Education for Human Sciences
University of Babylon / Babylon /Iraq
aa.aljenaby@yahoo.com

Abbas Fa. Al-Taie
Geographic Department /College of Arts / Al-Qadisiyah University/
Al Diwaniyah / Iraq
abbas2020altaie@gmail.com

ARTICLE INFO
Submission date:30 /7 /2019
Acceptance date: 3/11/2019
Publication date: 16/ 8/2020

Abstract

The subject of sensual heat is regarded as an important topic that comes into application in climatic studies and its impact on human comfort and health. in planning and architectural studies planners and engineers aim to provide an urban environment appropriate for-living and working under the prevailing climate elements. They also work to mitigate this effect as much as possible through various methods.

The research aims to find a mathematical formula by which to find out the amount of sensual temperature that affects the comfort of humans for each month of the year and for each country around the world. Researchers derived a mathematical equation in which three climate elements (temperature, relative humidity and wind speed) were inputted, and after applying the equation to the climate data of the Middle Euphrates Provinces of Iraq, accurate realistic and understandable results were obtained.

Key words: Sense, Comfort, Measuring, Influential temperature.

اشتقاق معادلة لقياس الشعور بالراحة (دراسة في علم المناخ التطبيقي)

عبد الزهرة علي ناجي الجنابي
كلية التربية للعلوم الإنسانية/ جامعة بابل

عباس فاضل عبيد الطائي
كلية الآداب / جامعة القادسية

المستخلص

يعد موضوع الحرارة الحسية من المواضيع المهمة التي تدخل حيز التطبيق في الدراسات المتعلقة بالمناخ وتأثيره على راحة الانسان وصحته، ففي الدراسات التخطيطية والمعمارية يسعى المخططون والمهندسون دائما لتوفير بيئة عمرانية ملائمة لعيش الانسان ومزاولة اعماله في ظل تأثير عناصر المناخ السائدة ، والعمل على تخفيف ذلك التأثير قدر المستطاع من خلال العديد من الوسائل .

يهدف البحث لإيجاد صيغة رياضية يمكن من خلالها معرفة مقدار درجة الحرارة الحسية المؤثرة في راحة الانسان لكل شهر من اشهر السنة ولأي بلد حول العالم ، ومن خلال الخوض في هذا الموضوع تمكن الباحثان من اشتقاق معادلة رياضية ادخل فيها ثلاثة عناصر للمناخ (درجة الحرارة والرطوبة النسبية وسرعة الرياح) ، وبعد تطبيق المعادلة على مناخ محافظات الفرات الاوسط من العراق فقد اعطت نتائج دقيقة وواقعية ومفهومة وبطريقة سهلة .

الكلمات الدالة: الشعور، الراحة، القياس، درجة الحرارة المؤثرة.

Introduction

Researchers in the various sciences trying to understand the movement of things: its regularity, system and sometimes, an understanding of all controlees which control this movement and then adjusting the cadence through a description which by law shall correspond with previous and subsequent facts.

Human records of achievements is filled with inventions and innovations. It was pioneered by pure science rather than human science, without defect, because of the relatively systematic repetition of natural phenomena, while the human phenomenal sciences are related with the human himself who is known to be changeable in behavior, approach and convictions. Achievements have been characterized by shortage in the field of law variation of the human phenomena, and the lack of existence of the achiever's number as well as temporal branching stages of achievement.

The history of human civilization stands us out at a basic fact that the accumulation of scientific knowledge is leading to recent achievements based on the contributions of the antecedents, and both this and that, the gratitude in what shall devolve upon the science of progress.

We do not claim priority in the subject of a sensual heat, as many sculpturesque scientists precede us in it, but we opened a new spotlight measurement. We claim that it is perfect, that by which mathematical law measures the human sense of temperature with its three measured interfere factors: temperature, relative humidity, and wind speed.

We hope for this achievement to obtain a good evaluation from specialists in applied climatology and those interested in the subject of research.

First: Sense of Comfort:

Whether man feels comfortable or not, as well as the relativity of this sense, is affected by a range of factors in the forefront of climatic factors: temperature, relative humidity, wind speed, and personal factors in later degree and which have a relationship with the type of activity of man, the psychology, health, the type of clothes, sex, age, other idioms, and other miscellaneous factors that interfere in the picture and have minor impact like the air freshness and noise (1,pp.105-108, 5,pp. 69, 7, pp. 77, 10, pp. 8).

If each of these factors had a specific effect on raising the level of sense of comfort, like reducing the temperature and increasing the wind speed and relative humidity, that does not appear unlimited at all. The appropriate temperature in which man is comfortable typically range from 20–26°C, and increase or shortage in it negatively affects the degree of sense of comfort and the other environmental factors .

On the other hand, these factors act individually or in isolation from each other once but interact with each other to affect each other, and therefore the result of this interaction affects the sense of comfort negatively or positively.

Second: Measuring the Sense of Comfort:

Several research works using statistical equations measure the sense of comfort (8,pp.245),(11 ,pp.166). The most important of these equations was presented by Smith and is called "Presumption of the Wind Cooling"; it links between temperature and wind speed, according to the following formula:

K = $(\sqrt{100v} + 10.45 - v) \times (33 - Ta)$. (11 ,pp.166)

As:
K : Air force cooling kilo calorie / m / s
V : Surface wind speed m / s
Ta: Temperature: Celsius
33 : The temperature average of the human skin with Celsius degree
100, 10.45 : Constants reached by experience

Results of the analysis should be evaluated according to the rules presented in the (table 1).

Table (1):Presumption Evaluate of Cooling Wind

Values K Kilo /calorie / m / s	Sense
Less than zero	Very hot (uncomfortable)
0- 49	Hot (uncomfortable)
50- 99	Warm (uncomfortable)
100-199	Cute (comfortable)
200- 299	Trend to cool 50 %)
300- 399	Trend for more coldness (comfortable by 10 %)
400- 499	Cool (uncomfortable)
500- 599	Very cold (uncomfortable)
more than 600	Chilly cold (uncomfortable)

Source: Smith, K., Principles of Applied Climatology, John Wiley & Sons.,1975.pp.166.

In the same trend another equtation would depanded wich is:

$(Ta – Ts) V^{0.3}$. (4, pp.319)
As:
Ta : Air Temperature
Ts : Skin Temperature Dgree
V : Surface Wind Speed

As for the adoption of the degree of temperature + relative humidity, another equation had depended called "Presumption of Moisture – Temperature" (THI), according to the following mathematical formula:

THI = Td – (0.55- 0.55R.H) (Td -58) . (11, pp.167).
As:
THI : Heat Guide - Humidity (Comfort Guide)
Td : Dry Thermometer Temperature Degree (c.)
RH : Relative Humidity %
Results of the analysis should be evaluated according to the rules presented in table (2) .

Table (2):Heat Equation - Humidity and Corresponding From Human Feeling

THI	Sense
less than 11.9	Very cold (uncomfortable)
12-13.9	Prada less (inconvenient for the majority of the population)
14-14.9	Less cold (uncomfortable for fewer residents)
15-16	(10 % of the population feel comfortable)
16.1-18	(50 % of the population feel comfortable)
18-20	(The vast majority of the population feel comfortable)
20.1-23	(10 % of the population feel uncomfortable due to heat and humidity)
23.1-25	(50 % of the population feel uncomfortable due to heat and humidity)
more than 25	Most residents feel uncomfortable due to heat and humidity)

Source: Smith, K., Principles of Applied Climatology, John Wiley & Sons.,1975.

Scound equtation depaneded in measuring THI that:

THI = T – 0.55 (1- RH) (T – 14). (6, pp.41)
As:
T : Dry Thermometer Temperature Dgree (c.)
RH : Relative Humidity %

Third equtation depanded wich is:
THI = 0.55 td + 0.2 Tdp + 5.3 .(3,pp. 95)
As :
Td: Dry Thermometer Temperature Degree
Tdp: Dew Point Temperature Degree
Fourth equtation depanded which:
THI = 0.4 (TW + TD) + 4.8 . (2,pp.350)
As:
TW: Moist Tmperature Dgree
TD: Dry Tmperature Degree

Third: The new achievement:

It is clear that two equations were used for the purpose of measuring the sense of comfort on one hand; on the other hand every equation had taken up in isolation from the other, videlicet the dependent variables in the calculating of each equation (the first (temperature + wind speed, and the Scound temperature + relative humidity) get out a separate and isolated results for each equation, as if the variables do not associate with any connection, and it works individually, while an essential aspect of the subject remained absent from the account, which is that these variables' work is interdependent and interactive, and any one of them affects the other, so results obtained from these equations in spite of being mathematically correct do not give a rigorous and comprehensive scientific interpretation due to sense of comfort of subject.

It added to the subject's complexity that the elements of temperature and relative humidity are working in one direction generally but slightly, while the wind speed works at the opposite direction, as the speed of the winds alleviate the high

temperatures severity and the high relative humidity which causes the sensation of impatient and low sensory temperature levels.
A single equation was created in which all of the temperature, relative humidity and wind speed come into account. It is the following formula:

$$ET = t - w + \sqrt[3]{h}$$

As:
ET = Influential temperature (Celsius).
t = Dry air temperature (Celsius).
w = Wind speed m / s.
h = Relative humidity %.

The results of the analysis should be evaluated according to the rules presented in table (3).

Justification of the equation:

1- Since wind speed is working to reduse the temperature of the body, so negative signal was used to subtract value of wind speed from the temperature of dry air,
2- Posative signal were used in front of relative humidity because it works in direct proportion with the temperature, that is, it increases sense of discomfort, congestion, excess heat in summer and feel warm in winter.
3- The cube root was used for relative humidity because the following reasonse:

a- The relative humidity values are very high, and sometimes reach double of temperature during fall, spring and more than three times in winter.
b- Iit uses directly, results would be shaded and effect of relative humidity at level of comfort felt more than effect of dry air temperature , so this is untrue.
c- When humidity values are using directly, affecting temperature values during seasons will be enclosed, beasuse of wide range of relative humidity and there inverse relation with temperature, so this is un true also.
d- The impact of relative humidity in degree of cofort is limit coparing with temperature.
e- The wind speed values are low comparing with relative humidity numbers, while their inverse effect are proximate, there for, cube root of relative humidity was used to reduce difference in numbers, but not in degree of impact.

Table (3):Affecting Temperature and Sense in

Affecting temperature	Sense
- 5	Chilly cold (uncomfortable)
5.1-10	Very cold (uncomfortable)
10,1 -15	Cold (uncomfortable)
15,1-20	Moderate (comfortable)
20.1- 25	Relatively mild (relatively comfortable)
25.1- 30	Hot (uncomfortable)
30.1 and more	Very hot (uncomfortable)

Source: of the work of the researchers.

Fourth: Implementation of the achievement:

This equation has been applied at a realistic state of the Middle Euphrates Schematic Region of Iraq, which includes five provinces (Babil, Karbala, Najaf, Qadisiyah and Muthanna), and the results of the analysis have emerged as presented by table (4).

Table (4): The Temperature Affecting the Middle Euphrates Region of Iraq for the Period (1982 - 2014)

Months	Temperature (M) (1)	Wind Speed (M / s)(1)	Relative Humidity % (1)	Cube Root of Relative Humidity (2)	Affecting Temperature (M) (2)
January	10.97	2.00	69.72	4.11	13.08
February	13.54	2.46	60.02	3.91	14.99
March	18.13	2.78	50.93	3.7	19.05
April	24.02	2.84	42.3 0	3.48	24.66
May	30.03	2.78	31.93	3.17	30.42
June	33.77	3.28	26.23	2.97	33.46
July	36.01	3.46	25.55	2.94	35.49
August	35.57	2.84	27.83	3.03	35.76
September	32.22	2.10	31.35	3.15	33.27
October	26.29	1.86	40.91	3.44	27.87
November	18.02	1.78	57.14	3.85	18.79
December	12.84	1.78	68.88	4.09	14.35
the average	24.28	2.49	44.59	3.54	23.34

Source: (1) Ministry of Sciences and Technology , Common Society For Climate & Seismic Observation, Climate Section, 2015.

(2) ET: Results of applying the new equation achievement

Results:

1 - The generally accepted formula to measure the sensory temperature was composed of two separate mathematical equations, and so are their findings, thus they are not leading to total full-precision results scientifically.

2 - The previous mathematical formulas are measuring the interaction between each two factors separately: temperature + relative humidity, temperature + wind speed, and overlook the interaction and reverse correlation between the temperature and humidity on one hand, between temperature and wind speed on the other hand and between the wind speed and humidity on a third direction.

3 - The new equation which the researcher achieved for the measurement takes into account the factors involved in the effect all together once in one hand, and they interfere and interact together on the other hand, thus it is regarded as more comprehensive and scientifically accurate.

4 - The equation applied at its actual case study and the results were realistic, scientifically accurate, and mathematically correct.

5 - The New Equation Achievement ($ET = t - w + \sqrt[3]{h}$) and supplement Affecting Temperature and Sense (table 3), distinct from the previous ones in fewness of the number of categories, the simplicity of significance, distance from the

relativity, and their results are small numbers, making it easier for the researcher to understand and derive their significance.

CONFLICT OF INTERESTS

There are no conflicts of interest

References

(1) Al Jenaby, Abdul Zahrah A., & Al Biermany Deyaa, 2015, Towards Building a Scientific Study on The Calendar According to The Climatic Characteristics in Iraq, Geographical Research Journal, College of Education for Girls - University of Kufa, No. 20, pp. 105 - 108.(In Arabic)
(2) Critchfild H. J., General Climatogogy, 3rd. ed., Printic Hall , Inc., New Jersey , 1974.
(3). Gases David M., Man And His Environment, Climet , Harper & Row Pub., New York , 1972.
(4) Griffiths John F. & Discall& Dennis M., Survey of Climatology , Charles E. Merrill, Pub. Com., Columbus , Ohaio, 1982.
(5) John E. Hobbs, Applied Climetalogy, A Study of Atmorosphic Resources, University of New England, K. J. Gogrry , 1980.
(6) Lutgens Fredrick K. & Tarbuk Edward J., The Atmosphere, An Inntroduction to Meterology, Prentic Hall Inc., Englwood Cliffes , New Jersey, 1979.
(7) Martin Evan , Housing Climate and Cofort , The Architecture Press, London 1980.
(8) Mather John R., Climetology : Fundmentals Applications , Mc Grow- Hill Book Com. New York , 1974.
(9) Ministry of Sciences and Technology , Common Society For Climate & Seismic Observation, Climate Section ,2015.
(10) Obasi P., Weather, Climate And Health , Wmo- Bulletin, Vol.48, No. 1,1999.
(11) Smith, K., Principles of Applied Climatology, John Wiley & Sons.,1975.