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DRINKING WATER BY CONDENSATION OF ATMOSPHERIC WATER VAPOUR USING DIFFERENT MATERIALS

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ABSTRACT

According to WHO about 780 million people in the world is suffering from absence of a reliable source of drinking water. Nowadays most of the freshwater sources are contaminated or polluted by human activities. That creates more health issues day by day. Water vapour in the atmospheric air is an alternate fresh water source. This study was focussed on extract of water vapours by condensation technique.

In this experiment, condensation of dew drops using different materials like Plain glass(PG),Frosted glass(FG),Rexine sheet(RS),GI sheet(GI),Black glossy enamel paint coated GI sheet(BGI) and White glossy enamel paint coated GI sheet(WGI) were conducted. Also, the relation between the dew water volume with respect to relative humidity, ambient temperature and material temperature were analysed. Finally the dew water quality was analysed in the lab as per IS drinking water standards.

Generally in all the materials, condensation of dew drop occurs below 26°C and above 26°C condensation was nil effect. When relative humidity is above 85%, condensation occurs and below 85 % there is nil effect. It can be seen that Frosted glass (FG) and White glossy enamel paint coated GI sheet (GIW) gave better result. Water quality test of dew water collected was done in the lab, and the test results show that values are within the standard desirable limit . So it is potable to use in Kerala climatic condition.

KEYWORDS: Condensation, Relative humidity (RH), Ambient temperature, Dew water.

INTRODUCTION

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation.(MDG report, 2008) There is a clear correlation between access to safe water and gross domestic product per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability(Kulshreshtha,1998) .Approximately 70% of the freshwater used by humans goes to agriculture (Baroni et al, 2007).Nowadays water scarcity is the major problem of the world. For drinking purpose pure water is needed. But water availability for drinking purpose is decreasing and in some portions of the world pure water is not at all available. However, the atmosphere contains 14000km3 of water. If this water is extracted from the atmosphere it will be a viable solution for the water scarcity. Water is available in the atmosphere, but it is in the form of vapour (Oliver and Hidoref, 2003). Water is only substance that can exists as gas, liquid and solid at temperature found at earth surface .while changing from one form to another; it acts as an important vehicle for the transfer of energy in the atmosphere. The water in the earth is evaporated and it is condensed and recycled to earth by precipitation such as raining, fog formation etc .Hence the water molecule carry the energy. Some amount of water molecules will be present in the ambient air. The amount of water vapour the air can hold is said to be the humidity (Khurmi and Gupta, 2006).The maximum amount of water vapour present in the air depends on the temperature. Warm air can hold more moisture than cold air. The amount of moisture that is present in the air increases with

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temperature. The atmospheric air contains about 0.35% of water in the form of water vapour. Even then this small amount is the reservoir that provides the moisture for clouds and precipitation that occurs over the surface. Hence hot and humid places contain greater amount of water vapour (Lekouch et al, 2009) .

Dew water is widely used by plants and small animals and, in arid and semi-arid environment, it contributes essential moisture to organisms for survival(Sharan et al,2006).Dew comes from atmospheric humidity that is transformed into liquid water by (passive) radiative cooling. More recently, systematic investigations of high yield radiative materials with hydrophilic properties for drop recovery, and adapting the condensing architecture, were carried out with respect to local meteorological parameters such as ambient temperature, relative humidity, etc.

MATERIALS AND METHODS

Study area

The experimental set up was prepared at Pappanamcode. It is a locality of Thiruvananthapuram, the capital of Kerala, India. Co-ordinates are 8°28´13´´N and 76°59´27´´E.It is at 30 m height from MSL. City has a climate that borders between a tropical savanna climate and a tropical monsoon climate. As a result, it does not experience distinct seasons. The mean maximum temperature 34 °C and the mean minimum temperature is 21 °C.

B Apparatus

Passive dew collector

Passive dew collector set up consist 4- leg stand, bottle chamber and rectangular frame. Different sheet were placed in the rectangular frame with total dimension of 1.6 m X 1 m and are inclined at 35° to the horizontal level. It was placed at a height of 1m from the ground level. With respect to view factor and draining of water droplets is considered, 35° is considered as the best and is used for this experiment. The bottom surface of the collector is insulated to prevent the thermal radiation from the ground by thermocol sheet. The experiment is conducted on good weather condition. The data of rainy days are avoid

Fig 1 passive dew collector

Materials used as surface material for the experiment are listed below

1) Plain glass(PG) sheet
2) Frosted glass(FG) sheet
3) Rexine sheet(RS)
4) GI sheet(GI)
5) Black glossy enamel paint coated GI sheet(GIB)
6) White glossy enamel paint coated GI sheet(GIW)

All the sheets are cut into 0.2 m X 1 m size. Each sheet has 0.2 m2 surface area. These materials are placed on passive dew collector frame. Each sheet is connected to a flexible plastic tube and bottle. Bottles were kept inside a bottle cabin on a stand.

Weather measuring instrument (Testo 480)

This instrument is used to measure the material temperature, ambient temperature and relative humidity (RH). It has two probes, One is used to measure material temperature; it has a steel tip whichtouches the material. Then material temperatures will be recorded on display. Other probe is used to measure ambient temperature and relative humidity. It has a small sensor on its tip. The probe was placed in the ambient air and the ambient temperature and relative humidity (RH) can be measured.

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Fig 2.Testo 480

PROCEDURE OF EXPERIMENT

Methodology for passive condensation

Readings are taken at early morning. Dew water volume is measured with measuring graduated jar. At the same time, ambient temperature, material temperature and relative humidity is measured with Testo 480.The dew water collected is then taken for water quality analysis. Water quality test is done in the water quality testing lab. Conductivity, Total Dissolved Salts,Turbidity,pH,Total Alkainity,Total hardness,Sodium,Chloride,Potassium and Fluoride were tested.

RESULTS AND DISCUSSION

In this study, experiments were conducted for collecting field data by setting up suitable systems to harvest water from atmospheric humidity. To understand the effect of changes in relative humidity and ambient temperature on water collection from the atmosphere some analytical experiments were carried out.

Results of passive condensation

In order to study the scope of condensation in hot and humid climates, passive dew collector was designed as per the guidelines mentioned by G.Sharanet.al, 2007. The passive dew collector works on the principle of radiative cooling. The surface temperature of the passive condenser will be reduced due to radiative heat loss at night. This temperature drop in the surface causes, dew formation on it. In hot and humid climatic regions, the ambient temperature and relative humidity will be high. The experiment was conducted in January, February 2016.Comparatively low ambient temperature and high relative humidity results in dew formation. In early morning, relative humidity is around normally 85-95% and the ambient temperature reaches to 23-28°C respectively.

Data collection

Data collection was started on 12-01-2016.Fourteen set of readings was collected on January and seventeen set of readings was collected on February. Collected data are arraged into tables.1

Table 1 Ambient temperature (Ta), Relative Humidity (RH) and material temperature(Tm) of different materials

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DATE, 2016	Ta (°C)	RH(%)	MATERIAL TEMPERATURE (Tm)(°C)						DEW WATER VOLUME (ml)					
			PG	FG	RS	GIB	GIW	GI	PG	FG	RS	GIB	GIW	GI
12-Jan	24.5	90	22.3	22.3					28	32				
13	24.4	87	22.3	22.3					8	6				
14	23.6	90	22.4	22.2					24	26				
15	22.4	87.5	21.4	21.2					24	22				
18	23.5	88.9	21.8	21.5					12	11				
19	23.1	92	21.8	21.7					25	30				
20	24	92	23.2	23					15	22				
21	24	92	23.2	23	24	24	23	26	10	22	15	18	22	0
22	22	90	20.7	20.5	22.5	23	21	23	20	25	22	25	30	0
25	24	94	23.2	23	24	24	23	26	10	24	18	18	22	0
26	23	90.5	22	21.7	23.2	23	22	23	16	21	15	25	25	5
27	25.5	88	24.2	23.9	25.1	24	24	25	10	15	12	8	9	0
28	24	88	22.1	22.6	24	23	22	25	21	23	18	21	22	6
29	23	91.2	22.4	22.1	23.5	23	22	25	18	23	20	28	23	4
01-Feb	24	90	23.3	22.1	24.2	24	23	24	19	20	19	22	20	3
2	23	88.6	22.4	22.2	23.3	23	23	24	22	24	19	24	21	4
5	23	89	22.1	21.8	23	23	23	24	25	30	15	18	30	4
6	26	87	24.7	24.5	25.4	26	25	27	0	0	0	0	0	0
9	25	88	24.2	24.4	24.8	25	25	25	15	13	10	14	12	3
10	26.4	88	25.7	25.2	25.4	27	25	27	0	0	0	0	0	0
11	26	84	24.7	24.5	24.5	26	25	27	0	0	0	0	0	0
12	27	85	25.9	25.5	25.6	27	26	28	0	0	0	0	0	0
15	25	85	24.2	24	24.8	25	24	26	11	14	11	10	13	0
16	26.5	83	24.9	25.4	26.2	26	25	27	0	0	0	0	0	0
17	26.5	83	25.4	25.8	26.3	27	25	27	0	0	0	0	0	0
18	26	80	25.2	25.1	25.5	25	25	27	0	0	0	0	0	0
19	28	78	26.8	26.9	28	25	27	29	0	0	0	0	0	0
23	25	85.4	24.2	24.3	24.7	25	24	25	12	10	10	11	13	0
24	24	88.1	22.8	22.1	24	25	24	27	22	24	18	16	12	5
25	25.6	85	25.3	25	26	27	25	25	15	15	10	12	10	0
26	25.9	90.5	24.8	25	26.5	26	27	28	13	14	10	14	12	5

Data analysis

Using the collected data, graphs were drawn between dew water volume of different material at same ambient temperature (fig 3) and between dew water volumes of different material at same relative humidity (fig4).

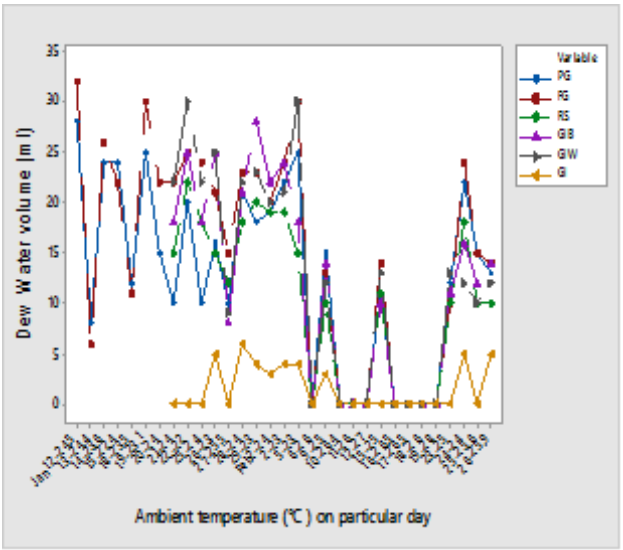

Fig 3 Dew water volume of different material at same ambient temperature

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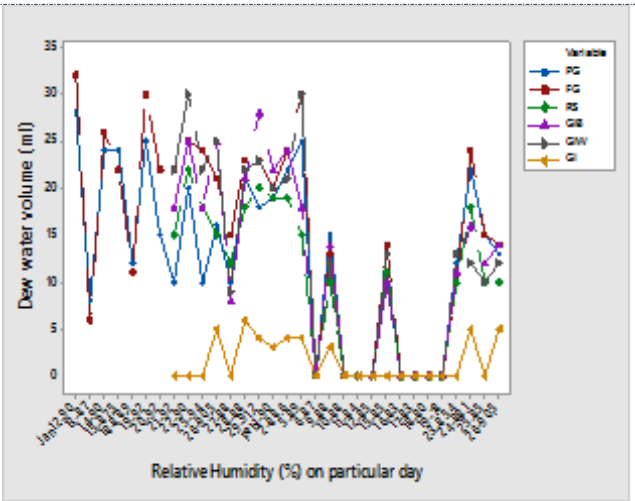

Fig 4 Dew water volume of different material at same relative humidity

From the above graphs we can see that generally in all the materials condensation of dew drop occurs below 26°C and above 26 °C condensation is nil effect. When relative humidity is above 85%, condensation occur and below 85 % there is nil effect. It can be seen that Frosted glass (FG) and White glossy enamel paint coated GI sheet (GIW) give better result. Plain glass (PG), Rexine sheet (RS) and Black glossy enamel paint coated GI sheet (GIB) give moderate result. GI sheet (GI) give least result.

3.1.3 Analysis of each material with their ambient temperature (Ta) and material temperature (Tm)

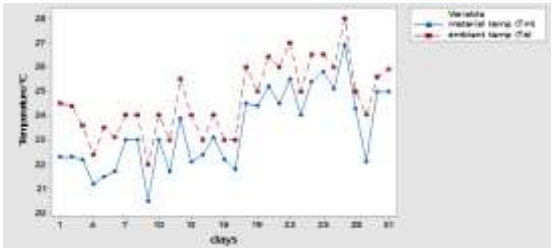

Fig 3.3 comparison of Ta and Tm of material FG

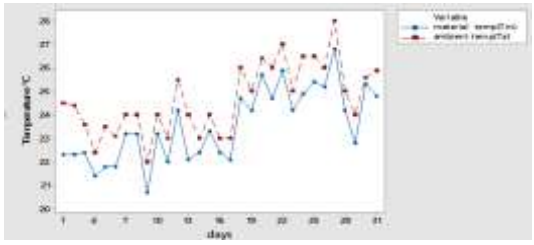

Fig 3.4 comparison of Ta and Tm of material PG

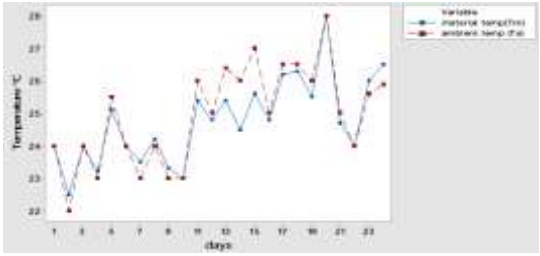

Fig 3.5 comparison of Ta and Tm of material RS

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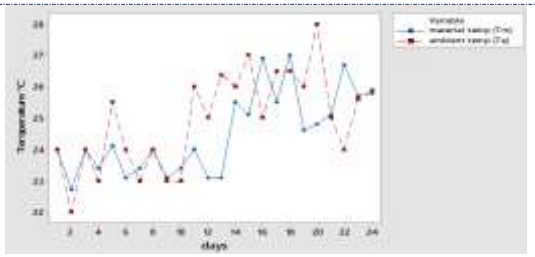

Fig 3.6 comparison of Ta and Tm of material GIB

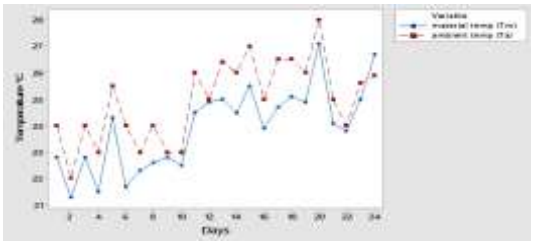

Fig 3.7 comparison of Ta and Tm of material GIW

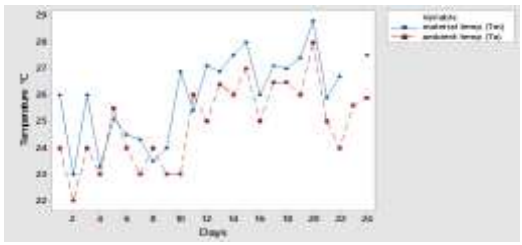

Fig 3.8 comparison of Ta and Tm of material GI

From the analysis of graph we can infer that, expcept GI sheet all other material has material temperature (Ta) below the ambient temperature. Rexine sheet has almost material temperature slightly below ambient temperature. So surface cooling of material is influence condensation of dew drops.

Dew water quality analysis

The minerals present in the dew water is shown in the table 5.4 .The amount of minerals are less when compared to water available from the fresh water resources. The dew contain sodium, potassium, calcium, magnesium, sulphate and fluoride ions. The presence of these ions in water determines the hardness of the water. In dew water, the total hardness is within the limit. Comparatively salt content is very less. The salt content in the dew water varies from place to place, since it is mostly mixed with airborne dust.

Table 3.4 Comparison of dew water and distilled water

Constituents/ parameters	Units	Standard permissible as per IS-10500, 2012	Dew Water	Distilled Water
Conductivity	µs/cm	2888	36.48	1
Total Dissolved Salts	mg/L	2000	13.4	0
Turbidity	NTU	5	1	0
pH		6.5 - 8.5	6.5	7
Total Alkainity	mg/L	600	110	0
Total hardness	mg/L	600	92	0
Sodium	mg/L	100	0.38	0
Chloride	mg/L	1000	0.81	0
Potassium	mg/L	10	0.27	0

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Sulphate	mg/L	400	3	0
Fluoride	mg/L	1.50	0.1	0

CONCLUSION

When dew point temperature is close to ambient temperature, dew condensation can occur without any external cooling. Any increase in ambient temperature will increase the dew point temperature, which eventually reduces the condensation process. Generally the quantity of water collected was greater at lesser ambient temperatures. But there were some variations. These variations were due to the variation in relative humidity. As relative humidity decreases, the dew formation decreases. Hence the amount of water collected decreases. The experiment was conducted in January and February .But in March the dew formed on the surface decreased, due to increase in temperature and decrease in RH. So better climatic condition of conducting experiment in Kerala on winter season.

Generally in all the materials, condensation of dew drop occurs below 26°C and above 26°C condensation was nil effect. When relative humidity is above 85%, condensation occurs and below 85 % there is nil effect. It can be seen that Frosted glass (FG) and White glossy enamel paint coated GI sheet (GIW) gave better result.

Water quality test of dew water collected was done in the lab on conductivity, total dissolved salts, turbidity, pH, total Alkalinity, total hardness, sodium, chloride, potassium and fluoride., and the test results show that values are within the standard desirable limit. So it is potable to use in Kerala climatic condition

REFERENCE

[1] Agama N. and Berliner P.R.(2005):` Dew formation and water vapor adsorption in semi-arid environments—A review', Journal of Arid Environments .(elsevier)65 ,pp. 572–590
[2] Anil K. Rajvanshi1(1981): 'Large Scale Dew Collection as a Source of Fresh Water Supply', Desalination, Vol. 36, No. 3, pp. 299-306
[3] Baixing YAN and Yingying XU(2010): ' Method Exploring on Dew Condensation Monitoring in Wetland Ecosystem', Procedia Environmental Sciences2 .pp 123–133
[4] Bhardwaj R.Kortenaar M.V. and Mudde R.F(2013): 'Influence of condensation surface on solar distillation', Desalination 326(elsevier) ,pp. 37–45
[5] Beysens D. and Milimouk I.(2000): 'The case for alternative fresh water sources', Sécheresse, Vol. 11, no 4,pp.1-17
[6] Beysens D.,Lekouch I.,Muselli M.,Mileta M.,Milimouk-Melnytchouk I. and Sojat V. (2010): 'Physical and chemical properties of dew and rain water in the Dalmatian coast, Croatia', 5th International Conference on Fog, Fog Collection and Dew Munster, Germany, 25–30 July
[7] Beysens D, Filippo Brogginib, Iryna Milimouk-Melnytchoukc,Jalil Ouazzanid, Nicolas Tixiere(2013): 'New Architectural Forms to Enhance Dew Collection', Chemical engineering transactions , VOL. 34,pp.79-84
[8] Brewster M Q(1992). Thermal Radiative Transfer and Properties. John Wiley & Sons. pp. 56.ISBN 9780471539827.
[9] Cetina J.G,Mongruel A.,Medici M.G.,Baquero E.,Parker A.R.,Milimouk-Melnytchuk I., Gonzalez-Vinas W. and Beysens D.(2014), 'Dew condensation on desert beetle skin', The European physical journal e, 37: 109,pp.1-6
[10] Gad H.E.,Hamed A.M.,El-SharkawyI.I. (2001):"Application of a solar desiccant/collector system for water recovery from atmospheric air", ,Renewable Energy 22 541–556
[11] Garrett R. And Grisham C.(January 5, 2012). Biochemistry. Cengage Learning. pp. 31–35.ISBN 978-1133106296
[12] Habeebullah B A.(2009) :'Potential use of evaporator coils for water extraction in hot and humid areas", Desalination 237,pp. 330–345
[13] Haida T. and Xiao-Hua L.(2014) :'Experimental study of dew formation on metal radiant panels', Energy and Buildings 85 5,pp.515–523
[14] Ikrime O and Husnu Y E(2013): 'Droplet condensation on polymer surfaces: a review, Turkish Journal of Chemistry. 37,pp. 643 – 674
[15] Kabeal A.E (2007) :'Water production from air using multi shelves solar glass pyramid system', Desalination 212 176–182

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

[16] Lekouch I.,Kabbachi B.,Milimouk-Melnytchouk I.,Muselli M. and Beysens D.(2010) : 'Influence of temporal variations and climatic conditions on the physical and chemical characteristics of dew and rain in South-West Morocco', 5th International Conference on Fog, Fog Collection and Dew.
[17] Lekouch I.,Muselli M.,Kabbachi B.,Ouazzani J.,Melnytchouk-Milimouk and Beysens D. (2011): 'Dew, fog, and rain as supplementary sources of water in south-western Morocco', Energy 36 (elsevier) pp. 2257-2265
[18] Liddell H.G. & Scott R. (1940). A Greek-English Lexicon Oxford: Clarendon Press
[19] Lienhard J. H(2008). A Heat Transfer Textbook (3rd ed.). Cambridge, Massachusetts: Phlogiston Press. ISBN 978-0-9713835-3-1
[20] Luca Ferraris, Paolo Ferraris (2006) : 'Approach to the problem of water condensationby means of Photo Voltaic energy',IEEE journal1-4
[21] Mileta M.,Beysens D., Nikolayev V.I,MilimoukO. Clus and M. Muselli, "Fog and dew collection project in Coratia", Proc. International Conference on Water Observation and Information System for Decision Support (BALWOIS 2006), Ohrid, 2006, arXiv:0707.2931 [physics.flu-dyn
[22] Nelson R A.(2003). 'Air Wells, Fog Fences & Dew Ponds – Methods for Recovery of Atmospheric Humidity" Rex Research. Retrieved 10 September 2010. This article has been widely reproduced, including extracts in Sharan, 2006
[23] Sharan G.(2007):'Dew harvest to supplement drinking water sources in arid coastal villages of Gujarat', Indian Institute of Management Ahmedabad, India,
[24] Sharan G.,Beysens D.,Milimouk-Melnytchouk I.(2007), `A study of dew water yields on Galvanized iron roofs in Kothara (North-West India)', Journal of Arid Environments 69 (elsevier) ,pp.259–269
[25] Sharan G.,Clus O.,Singh S.,Muselli M. and D. Beysens(2011): 'A very large dew and rain ridge collector in the Kutch area (Gujarat, India)', Journal of Hydrology 405 ,pp.171–181
[26] Silverstein T P.(1998). "The Real Reason Why Oil and Water Don't Mix" (PDF). Journal of Chemical Education 75: 116–346.
[27] Trefil J. S (2003). The Nature of Science: An A-Z Guide to the Laws and Principles Governing Our Universe. Houghton Mifflin Harcourt. p. 377. ISBN 9780618319381.
[28] Vuollekoski H.,Vogt M.,Sinclair V.A.,Duplissy J.,Jarvinen H.,Kyro E.-M.,Makkonen R., Petaja T.,Prisle N. L.,Raisanen P.,Sipilab M.,Ylhaisi1 J. and Kulmala M.(2015): 'Estimates of global dew collection potential on artificial surfaces', Hydrology Earth System Science, 19, pp.601–613
[29] Welty J. R,Wicks C. E and Wilson R. E.(1976). Fundamentals of momentum, heat, and mass transfer (2 ed.). New York: Wiley. ISBN 978-0-471-93354-0.