

## Nomenclature

$m_w$  = Mass of water to be removed from fish

$m_i$  = Weight of fish in kg

$M_i$  = Initial moisture content in fish

$M_f$  = Final moisture content in fish

$\dot{m}_a$  = Mass flow rate of dry air in kg/sec

$C_p$  = Specific heat in kJ/kg-K

$T_1$  = Inlet temperature of collector

$T_2$  = Outlet temperature of collector

$L$  = Latent heat of vaporisation in kJ/kg-K

$\rho_a$  = Density of air in kg/m<sup>3</sup>

$A_c$  = Collector area in m<sup>2</sup>

$H_o$  = Monthly average daily global radiation on horizontal surface kJ/m<sup>2</sup>-day

$H_d$  = Daily diffuse radiation on a horizontal surface in kJ/m<sup>2</sup>-day

$H_g$  = Daily global radiation on a horizontal surface in kJ/m<sup>2</sup>-day

$n$  = Number of days of the year

$\delta$  = declination angle in degree

$\phi$  = Latitude angle of Bhubaneswar.

$w_s$  = Sunrise hour angle

$S_{max}$  = Day length

$E_L$  = Elevation from sea level

$a_1$  and  $b_1$  = Constants

$I_o$  = Monthly average of the hourly extra-terrestrial radiation on a horizontal surface (kJ/m<sup>2</sup>-h)

$I_g$  = Monthly average of the hourly global radiation on a horizontal surface (kJ/m<sup>2</sup>-h)

$w$  = Hour angle

LAT = Local apparent time

$I_d$  = Hourly diffuse radiation on a horizontal surface in kJ/m<sup>2</sup>-h

$\theta$  = Zenith angle

$r_b$  = Tilt factor for instantaneous/hourly beam radiation

$r_d$  = Tilt factor for instantaneous/hourly diffuse radiation

$I_t$  = Instantaneous/hourly flux incident of tilted surface.

$q_u$  = Rate of useful heat gain in Watt.

## AND IMPORTANT FINDINGS

$$m_i = 20 \text{ kg}$$

$$M_i = 71\%$$

$$M_f = 20\%$$

$$m_w = \frac{m_i (M_i - M_f)}{(1 - M_f)} = \frac{20(0.71 - 0.2)}{1 - 0.2} = 12.75 \text{ kg of water to be removed from 20 kg of wet fruits}$$

$$\dot{m}_a C_p (T_2 - T_1) = m_w L$$

$$\dot{m}_a = \frac{m_w L}{C_p (T_2 - T_1)} = \frac{12.75 \times 2260}{1.005(72 - 45)} = 1061.912 \text{ kg of dry air}$$

Assuming 24 hours to be dried

$$\frac{1061.912}{24 \times 3600} = 0.01229 \text{ Kg/sec of dry air}$$

$$\text{Volume flow rate} = \frac{\dot{m}_a}{\rho_a} = \frac{0.01229}{1.225} = 0.01003 \text{ m}^3/\text{sec}$$

Bhubaneswar latitude = 20.2961°N, 85.8245°E on 31<sup>st</sup> May

$$n = 31 + 28 + 31 + 30 + 31 = 151$$

$$\delta = \text{Declination} = 23.45 \sin \left[ \frac{360}{365} (284 + 151) \right] = 21.8984^\circ$$

$$w_s = \cos^{-1}(-\tan \phi \tan \delta) = \cos^{-1}[-\tan(20.2961) \tan(21.8984)] \\ = 98.5458 = \text{sunshine}$$

Hour angle = 1.719 radian

$$\text{Day length } S_{\max} = \frac{2}{15} (98.5458) = 13.139 \text{ hours}$$

$H_o$  = Monthly average daily global radiation

$$= \frac{24}{\pi} \times 1.367 \times 3600 \times \left( 1 + 0.033 \cos \left( \frac{360}{365} \times 151 \right) \right) \left\{ 1.42 \times \sin 20.2961 \times \sin 21.8984 + \cos 20.2961 \times \right. \\ \left. \cos 21.8984 \times \sin 98.5458 \right\} \\ = 37595.198 \times 5.982 \times (0.183 + 0.86) = 234694.72 \text{ kJ/m}^2\text{-day}$$

By taking  $E_L$  = Elevation from sea level = 45 m = 0.045 km

Average sunshine hours per day  $\Rightarrow \bar{S} = 11$  hours

$$a_1 = -0.309 + 0.539 \cos \phi - 0.0693 \times E_L + 0.29 \left( \frac{\bar{S}}{S_{\max}} \right)$$

$$= -0.309 + 0.539 \cos(20.2961) - 0.0693 \times 0.045 + 0.29 \left( \frac{11}{13.139} \right)$$

$$= 0.436$$

$$b_1 = 1.527 - 1.027 \cos\phi + 0.0926 E_L - 0.359 \left( \frac{\bar{S}}{S_{\max}} \right)$$

$$= 1.527 - 1.027 \cos(20.2961) + 0.0926 \times 0.045 - 0.359 \left( \frac{11}{13.139} \right)$$

$$= 0.267$$

$$\frac{\bar{H}_g}{H_o} = a_1 + b_1 \left( \frac{\bar{S}}{S_{\max}} \right) = 0.436 + 0.267 \left( \frac{11}{13.139} \right)$$

$$= 0.659$$

$$\bar{H}_g = 154862.63 \text{ kJ/m}^2\text{-day}$$

$$\frac{\bar{H}_d}{H_g} = 1.411 - 1.696 \left( \frac{\bar{H}_g}{H_o} \right) = 1.411 - 1.696 \left( \frac{154862.63}{234694.72} \right)$$

$$= 0.292$$

$$\bar{H}_d = 0.292 \times 154862.63 = 45219.88 \text{ kJ/m}^2\text{-day}$$

Hour angle,  $w = 12 \text{ hours} - 4 \text{ (standard time longitude - longitude of location)}$

$$= 12 \text{ hours} - 4 (82.5 - 85.82)$$

$$= 12 \text{ hours} - 10.78 \text{ minutes}$$

$$= 11.49 \text{ minutes}$$

$$w = 11.49 \times \frac{15}{60} = 2.8725^\circ$$

$$a = 0.409 + 0.5016 \sin(w_s - 60)$$

$$= 0.409 + 0.5016 \sin(98.5458 - 60)$$

$$= 0.721$$

$$b = 0.6609 - 0.4767 \sin(w_s - 60)$$

$$= 0.6609 - 0.4767 \sin(98.5458 - 60)$$

$$= 0.3639$$

$$F_c = a + 0.5b \left[ \frac{\frac{\pi w_s}{180} - \sin(w_s) \cos(w_s)}{\sin(w_s) - \frac{\pi w_s}{180} \cos(w_s)} \right]$$

$$= 0.721 + 0.5 \times 0.3639b \left[ \frac{\pi \times 1.719 - \sin(98.5458) \cos(98.5458)}{\sin(98.5458) - \frac{\pi \times 1.719}{180} \cos(98.5458)} \right]$$

$$= 0.902 \left[ \frac{5.549}{0.988 - (-4.458 \times 10^{-3})} \right]$$

$$= 0.895$$

$$\begin{aligned}
I_o &= 1.367 \left[ 1 + 0.33 \times \cos\left(\frac{360}{365}\right) \times n \right] \times [\sin \phi \sin \delta + \cos \phi \cos \delta \cos w] \\
&= 1.367 \left[ 1 + 0.33 \times \cos\left(\frac{360}{365}\right) \times 151 \right] \times [\sin 20.2961 \sin 21.8984 + \cos 20.2961 \cos 21.8984 \cos 2.8785] \\
&= 532.765 \text{ kJ/m}^2\text{-h}
\end{aligned}$$

$$\frac{I_g}{H_g} = \frac{I_o}{H_o} (a + b \cos w) / F_c$$

$$\begin{aligned}
I_g &= 154862.63 \times \frac{532.765}{23469.72} \times (0.721 + 0.3639 \times \cos 2.8985) / 0.895 \\
&= 425.59 \text{ kJ/m}^2\text{-h}
\end{aligned}$$

$$\frac{I_d}{H_d} = \frac{I_o}{H_o}$$

$$I_d = \frac{532.7650}{234694.72} \times 45219.88$$

$$I_d = 102.65 \text{ kJ/m}^2\text{-h}$$

$$\text{Zenith angle} = \cos \theta = \sin \phi \sin \gamma + \cos \phi \cos \gamma \cos w$$

$$= \sin(20.2961) \sin(0) + \cos(20.2961) \cos(0) \cos(2.8725)$$

$$\theta = 20.495^\circ$$

$$\begin{aligned}
r_b &= \frac{0.936}{\sin \phi \sin \delta + \cos \phi \cos \delta \cos w} \\
&= 0.9378
\end{aligned}$$

$$r_d = \frac{1 + \cos \phi}{2} = \frac{1 + \cos(20.296)}{2} = 0.9689$$

$$\begin{aligned}
r_r &= \frac{0.2(1 - \cos \phi)}{2} = \frac{0.2(1 - \cos(20.296))}{2} \\
&= 6.20 \times 10^{-3}
\end{aligned}$$

$$\frac{I_T}{I_g} = \left(1 - \frac{I_d}{I_g}\right) r_b + \frac{I_d}{I_g} r_d + r_r = \left(1 - \frac{102.65}{425.59}\right) 0.9378 + \frac{102.65}{425.59} 0.9689 + 6.20 \times 10^{-3}$$

$$I_T = 404.94 \text{ W/m}^2$$

Assuming 50% instantaneous efficiency

$$\eta = \frac{\dot{m}_a C_p (T_2 - T_1)}{A_c \times I_T}$$

$$0.5 = \frac{0.01229 \times 1005(72 - 45)}{A_c \times 404.94}$$

$$0.5 = \frac{0.01229 \times 1005(72 - 45)}{A_c \times 404.94}$$

$$A_c = 1.647 \text{ m}^2$$

$$A_c = L \times B = 1.28 \times 1.28$$