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Impact of Tropical Environmental Conditions on Mechanical Cooling Tower Performance: A Case Study at PT. XYZ

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ABSTRACT

Indonesia's tropical climate, characterized by high ambient temperatures, intense humidity, and frequent rainfall, presents significant challenges for industrial cooling systems. This research investigates how tropical climate conditions influence the operational performance of a mechanical cooling tower installed at PT. XYZ, located in Cileungsi, West Java, Indonesia. The research offers valuable insights into energy optimization and operational planning under varying weather scenarios. Data collection involved real-time measurements under nine combinations of weather and time conditions (sunny, cloudy, rainy; morning, noon, afternoon), using thermocouples, hygrometers, and an ESP32 microcontroller. Key variables observed include ambient temperature, incoming water temperature, outgoing water temperature, relative humidity, and wet bulb temperature. Multiple linear regression was employed for analysis, supported by correlation analysis, t-tests, and F-tests. The model achieved a high determination coefficient (R^2) of 80%, indicating strong predictive accuracy. Partial R^2 analysis revealed that the outgoing water temperature contributed 77% to the variation in cooling tower efficiency, followed by ambient temperature at 65%, incoming water temperature at 54%, and relative humidity at 36%. The highest efficiency, 67%, was recorded during sunny mornings, while the lowest, 42%, occurred at rainy noon. These findings confirm that tropical environmental factors have a significant and quantifiable impact on cooling tower performance. The results are expected to support the development of adaptive and efficient energy strategies in tropical industrial contexts.

KEYWORDS: *Cooling tower, Tropical environmental, Efficiency.*

NOMENCLATURE

T_{wb}	Wet bulb temperature
T_∞	Ambient Temperature
RH	Relative humidity
T_{inlet}	Inlet temperature
T_{outlet}	Outlet temperature
η	Cooling tower efficiency
Y	Dependent variable
x_1, x_2	Independent variable
α	Regression constant
β_1, β_2	Regression coefficients
r_{xy}	Correlation test
$\sum X$	Total sum of the x
$\sum Y$	Total sum of the y
$\sum XY$	Sum of the product of x and y
$\sum X^2$	Sum of the squares of the x value
$\sum Y^2$	Sum of the squares of the y value
R^2	Determination test
X_i	Predicted value of the regression model
Y_i	Actual observed efficiency value
$R^2(X_1\|X_2)$	Partial determination test
$R^2(X_1,X_2)$	Determination coefficient for all variables
$R^2(X_1)$	Determination coefficient for x1
$\bar{Y}$	Average of the actual efficiency values
$\hat{\beta}_j$	Estimated regression coefficient
$se(\hat{\beta}_j)$	Standard error of the estimated coefficient
F	Simultaneous test
K	Number of independent variables
n	Total number of samples

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1.0 INTRODUCTION

Indonesia is an archipelagic country located in the tropical region, precisely between 95°E - 141°E and 6°N to 11°S [1-2]. This region experiences a tropical climate characterized by high annual rainfall, warm air temperatures, and consistently high humidity levels throughout the year. The tropical climate typically consists of only two seasons [3]. The dry period typically extends from April through September, whereas the wet season generally takes place between October and March [4]. In tropical areas such as Indonesia, fluctuating environmental conditions throughout the year can affect the performance of various industrial equipment operating outdoors. One such system that is particularly vulnerable to environmental influences is the cooling tower, a heat rejection device that dissipates residual heat into the atmosphere through a heat exchange process between water and air [5]. This equipment is widely used in industrial cooling systems, power plants, and HVAC (Heating, Ventilation, and Air Conditioning) systems to maintain operational stability and improve energy efficiency [6]. Cooling towers are generally classified based on airflow method (natural draft, forced draft, or induced draft), heat transfer mechanism (wet or dry type), and design orientation [7].

Several previous studies have highlighted the influence of environmental conditions on cooling tower performance. Pontes et al [8] analyzed seasonal climatic variations and their effects on cooling tower efficiency, proposing strategies such as variable frequency drives (VFDs) and intermittent fan operation to reduce power consumption, with potential energy savings reaching 35.95% depending on the region. Viljoen et al [9] developed dynamic simulations of induced draft cooling towers incorporating pumps, water systems, and heat exchangers to enhance system optimization and reduce energy usage through predictive control. Chang et al [10] implemented a zone-based PI control strategy combined with rule-based fan operation in VFD-equipped towers, achieving 38% energy savings while minimizing fan cycling.

While these prior investigations offer meaningful perspectives on the influence of environmental variables and management approaches, most of them focus on generalities and emphasize equipment-level optimization. There remains a lack of empirical data concerning the specific influence of tropical environmental factors on cooling tower performance in real industrial settings. To address this gap, this study investigates the influence of tropical environmental conditions on the performance of a mechanical cooling tower at PT. XYZ, located in Cileungsi, West Java, Indonesia. The findings of this study are expected to serve as a foundation for developing operational strategies that are adaptive to tropical climates, to enhance energy efficiency and the reliability of industrial cooling systems.

2.0 METHODS

This study employed a descriptive quantitative approach by collecting data through direct observation of the cooling tower system installed at PT. XYZ, located in Cileungsi, West Java, Indonesia. The observed unit was a mechanically induced draft cooling tower of the Liang Chi brand, model LBC-40, with specifications including a height of 1.89 meters, a width of 1.76 meters, a fan diameter of 0.97 meters, and ±60 mm diameter inlet and outlet pipes, as depicted in Figure 1. Data were collected under various natural tropical climate conditions, specifically during sunny, overcast, and rainy weather. These weather classifications were determined based on direct visual observation in the field and were further verified using real-time weather forecasts provided by the official BMKG (Meteorological, Climatological, and Geophysical Agency) website. Observations were conducted across three time intervals, namely morning (07:30–08:30), midday (11:30–12:30), and afternoon (15:30–16:30). The independent variables in this study are ambient temperature, incoming water temperature, outgoing water temperature, and relative humidity. Meanwhile, the dependent variable analyzed was the cooling tower performance. During the observation period, the operational parameters were kept fixed, including the cooling water flow rate of about 200 L/min, the circulation pump pressure of 4 bars, and the heat load from the 20-unit injection molding machine that was on constantly.

In this study, a total of nine samples were obtained from the combination of weather conditions and observation times. Each sample consisted of ten measurements, recorded at 5-minute intervals, thereby resulting in a total of 90 data points. To represent the characteristics of each sample, the ten data points were averaged to obtain representative values for each variable, x and y. However, for the purpose of multiple linear regression analysis, all 90 individual data points were combined into a single dataset. This approach was chosen to enhance statistical accuracy and robustness, as performing regression on each sample individually would result in too few data points, thereby reducing the significance and reliability of the analysis.

Figure 1: Cooling tower in PT. XYZ

In the research process, the authors used a variety of measuring instruments to observe and record data from several key variables that affect cooling tower performance. These tools were used to measure incoming and outgoing water temperatures, relative humidity, and ambient temperature. Measurements are taken periodically to obtain accurate and consistent data. Table 1 outlines the measurement devices utilized in this study along with their respective technical specifications.

Table 1: Research measurement tools

Name	Information
Thermometer	Thermometer is used to calibrate the type k thermocouple and to measure the temperature of the wet bulb (-10 to 1260°C) ± 1°C
Type-k thermocouple	Type-k thermocouple is utilized to measure the temperature of both inlet and outlet water in the cooling tower. (-200 to 110°C) ± 1.5°C
Hygrometer	Hygrometer is employed to measure the ambient temperature and relative humidity surrounding the cooling tower. (0% to 100%) ± 5% (-50 to 70°C) ± 1°C
ESP32	The ESP32 is used to read the temperature data from the K-type thermocouple sensor and then send the data in real-time over a Wi-Fi network.

2.1 Research Parameters

2.1.1 Wet Bulb Temperature

In this study, several parameters were utilized to evaluate the cooling tower performance based on field measurement data. The first parameter examined is the wet bulb temperature, which represents the lowest temperature that water can reach through evaporative cooling. This parameter is essential in determining the approach value. Wet bulb temperature is influenced by ambient temperature and relative humidity. It was estimated to use an empirical equation as shown in Equation (1), adapted from the work of [11] and then validated using a psychrometric chart.

$$T_{wb} = T_{\infty} . \tan^{-1}\left(0{,}151977\sqrt{RH+8.313659}\right)+0{,}00391838\sqrt{RH^3} . \tan^{-1}(0{,}023101.RH)-\tan^{-1}(RH+1{,}676331) +\tan^{-1}(T_{\infty}+RH)-4{,}686035 \quad (1)$$

2.1.2 Range and Approach

Subsequently, the parameters assessed include range and approach. The range refers to the temperature gap between the incoming and outgoing water, whereas the approach reflects the difference between the outgoing water temperature and the wet bulb temperature. Cooling tower performance is considered optimal when the range is high and the approach is low. These two parameters were calculated using Equations (2) and (3), based on references [12] and [13].

$$\text{Range} = T_{inlet} - T_{outlet} \quad (2)$$

$$\text{Approach} = T_{outlet} - T_{wb} \quad (3)$$

2.1.3 Cooling Tower Efficiency

The final parameter is the cooling tower efficiency, which reflects the overall system performance. It is calculated using the previously obtained range and approach values, as shown in Equation (4), following the formulation provided in [14]. This efficiency value was further analyzed statistically to assess its relationship with various environmental variables.

$$\eta = \frac{\text{Range}}{\text{Range} + \text{Approach}} \times 100\% \quad (4)$$

2.2 Data Analysis Method

2.2.1 Multiple Linear Regression

After all parameters were determined, the data were analyzed statistically to investigate the relationship and influence of each input variable on the cooling tower efficiency. A multiple linear regression analysis was conducted using Microsoft Excel. The general regression model used is presented in Equation (5), as adapted from [15].

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + e \quad (5)$$

2.2.2 Correlation Test

In addition to regression analysis, using the Pearson correlation coefficient, one also investigates the link between the output and input variables. This coefficient measures the extent to which changes in one variable are related to changes in another variable [16]. The correlation coefficient was calculated using Equation (6), based on a scientific journal [17].

$$r_{xy} = \frac{n(\sum XY)-(\sum X)(\sum Y)}{\sqrt{(n(\sum X^2)-(\sum X)^2)\times(n(\sum Y^2)-(\sum Y)^2)}} \quad (6)$$

2.2.3 Determination Test and Partial Determination Test

Following the correlation analysis, a determination test was conducted to measure the proportion of variance in the output variable explained by the regression model. This is presented in Equation (7), based on the reference [18]. To assess the unique contribution of each independent variable, a partial determination test was conducted. This test measures the increase in explained variance when a variable is added to a model that already includes the others. The calculation follows the formulation introduced by [19].

$$R^2 = 1 - \frac{(X_i - Y_i)^2}{(\bar{Y} - Y_i)^2} \quad (7)$$

$$R^2(X_1|X_2) = \frac{R^2(X_1, X_2) - R^2(X_1)}{1 - R^2(X_1)} \quad (8)$$

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2.2.4 Partial Test

Furthermore, a partial test (t-test) is conducted to assess the effect of each input variable on the output variable separately. This test is used in multiple linear regressions to determine whether each input variable has a significant effect on cooling tower performance. The t-test hypothesis is stated as follows [20]:

- H1 is accepted H0 is rejected, if |t count| > t table.
- H1 is rejected H0 is accepted, if |t count | < t table.

The t-value was calculated using Equation (9), as described by [21]. The calculated t-value will be evaluated against the t-table value to establish if the independent variable significantly impacts the cooling tower efficiency.

$$t = \frac{\hat{\beta}_j}{se(\hat{\beta}_j)} \quad (9)$$

2.2.5 F-test

Then, the impact of all independent factors on cooling tower efficiency was assessed collectively using the F-test (simultaneous test). This assessment is conducted to find out if the regression model holds significance. The hypothesis used in this F-test is:

- H1 is accepted H0 is rejected, if f count > f table.
- H1 is rejected H0 is accepted, if f count < f table.

The F-value was computed using Equation (10), as cited in [22].

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} \quad (10)$$

3.0 RESULTS AND DISCUSSION

Figure 2 illustrates the variation in cooling tower efficiency across different times of day and weather conditions based on field observations. The calculation results indicate that sunny mornings yielded the highest efficiency, reaching 67%, followed by overcast mornings at 64% and sunny afternoons at 62%. In contrast, the lowest efficiencies were recorded during rainy conditions at midday (42%), as well as overcast afternoons and rainy mornings, which reached only 43% and 47%, respectively. Sunny mornings appear to be the most optimal operational period due to relatively low ambient temperatures and moderate relative humidity. An increased thermal gradient between the heated water and the surrounding air significantly improves the efficiency of convective heat transfer, while moderate humidity allows the evaporative process to occur efficiently, resulting in higher cooling efficiency. Additionally, most industrial equipment begins operating in the morning, resulting in lower heat loads compared to later in the day. Conversely, during midday or afternoon in rainy or overcast weather, high humidity (approaching 100%) hinders the evaporative process, and elevated ambient temperatures reduce the temperature difference with the water. This combination makes air a less effective cooling medium, which contributes to reduced cooling tower efficiency under such conditions. However, Figure 2 also reveals a distinct trend in the overcast condition, which deviates from the patterns seen in sunny and rainy weather. While overcast mornings show relatively high efficiency, there is a notable drop in the afternoon. This unusual trend is likely attributed to the unstable nature of overcast weather conditions.

In the morning, temperatures are still relatively low, and humidity is not yet excessive, allowing effective cooling. In the afternoon, however, cloud cover may trap heat and raise humidity levels, thereby disrupting the evaporative mechanism. As a result, cooling tower performance under overcast conditions experiences a steeper efficiency decline compared to the other weather types. Figure 3 presents scatter plots depicting the relationship between cooling tower efficiency and each of the four independent variables. Each plot includes a linear regression line along with the partial coefficient of determination (R^2), which represents the individual contribution of each variable to the regression model after controlling for the effects of the other variables.

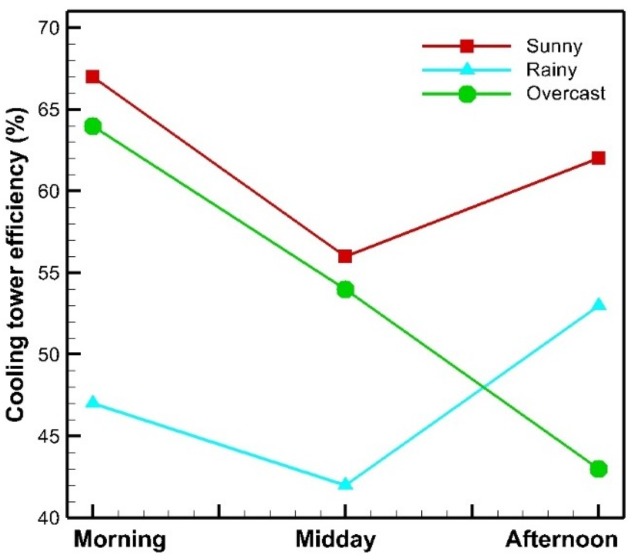

Figure 2: Relationship between environmental conditions and cooling tower efficiency

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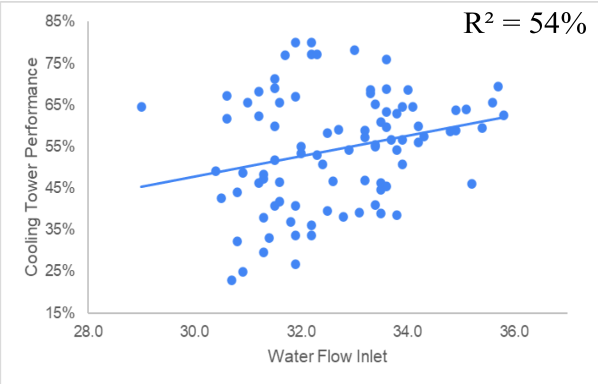
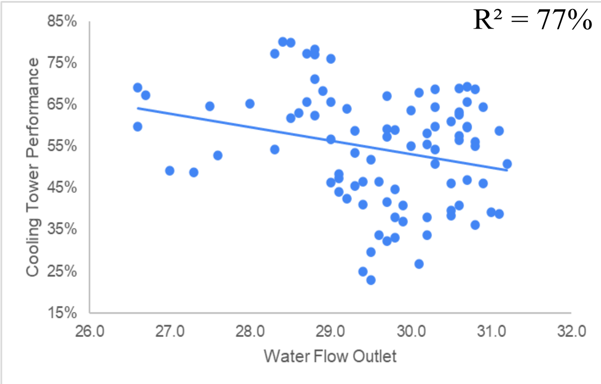
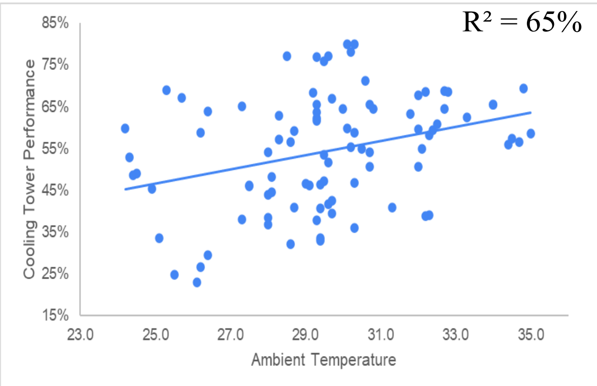
The inlet water temperature exhibits a positive relationship with cooling tower efficiency, as indicated by the upward slope of the regression line. The partial R^2 value of 54% suggests a moderate contribution to explaining the variance in efficiency. This positive association may be attributed to the increased temperature gradient between the hot water and the surrounding air, which enhances the rate of heat transfer. Similarly, ambient air temperature also shows a positive correlation with efficiency, with a partial R^2 value of approximately 65%. Despite the visually looser data distribution, its higher partial contribution indicates a relatively significant influence after controlling for other variables. Higher air temperatures may improve the air's capacity to carry water vapor, thereby supporting the evaporative cooling process, although this effect can be diminished under high humidity conditions. On the other hand, outlet water temperature demonstrates a negative correlation with cooling tower efficiency, as shown by the downward slope of its regression line. With a partial R^2 value of 77%, it stands as one of the most influential predictors in the model. Theoretically, a lower outlet water temperature signifies better heat rejection performance by the cooling tower. Finally, relative humidity (RH) also exhibits a negative relationship with efficiency, accompanied by the lowest partial R^2 value of 36%. Although its contribution is smaller compared to the other variables, RH still plays a relevant role. High humidity levels reduce the air's capacity to absorb water vapor, thereby hindering the evaporative cooling process, which is the primary mechanism of the cooling tower.



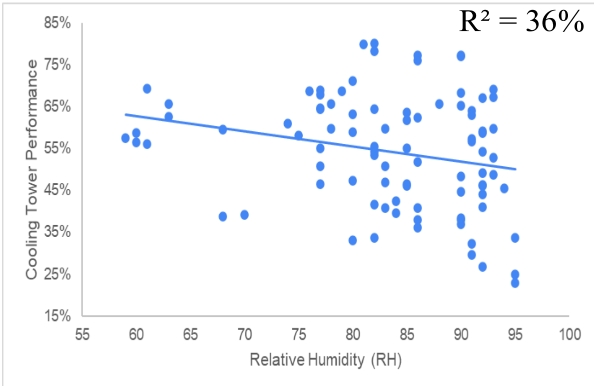
(1) Water Flow Inlet



(2) Water Flow Outlet



(3) Ambient Temperature



(4) Relative Humidity

Figure 3: Scatter Plot: (1) Water Flow Inlet, (2) Water Flow Outlet, (3) Ambient Temperature, (4) Relative Humidity

To strengthen the previous findings, Table 2 presents the results of the partial significance (t-test) analysis and p-value. The |t-stat| values for all independent variables exceed the critical value of 1.98 (based on the t-distribution table), Resulting in the null hypothesis (H_0) being rejected and the alternative hypothesis (H_1) being supported. Furthermore, the p-values for each independent variable are well below the 0.05 significance threshold, indicating that their contributions to the model are statistically significant and not due to random chance.

Based on the findings analyzed with Microsoft Excel in Table 3, various statistical metrics were derived to illustrate the connection between the independent and dependent variables. With a total of 90 observations, the correlation coefficient (r) stands at 0.90, showing that the dependent and independent variables are strongly related. This reading also shows a positive relationship trend. Additionally, the determination test (R^2), which is 0.80, suggests that approximately 80% of the changes in the output variable can be accounted for by the regression model built from the independent variables. The remaining percentage is affected by other elements not included in this model. This conclusion is supported by an adjusted R^2 of 0.79, which has been modified to reflect the number of variables included and still demonstrates an excellent fit for the model. The standard error recorded at 0.06 implies that the spread of the data around the regression line is minimal, indicating that the model reliably predicts the data. The F-test conducted to assess the overall significance of the model yielded a calculated F value of 87.14 > 2.47 (f table) with a significance level (p-value) lower than the α value of 0.05. The regression model is statistically significant according to this finding. As supplementary material in Appendeces (Tables 4 through 12) present the raw data collected during the field investigation. These datasets are expected to serve as a valuable reference for future research and further development in this area of study.

Table 2: Multiple linear regression analysis result

Name	Coefficients	Standard error	t-stat	p-value
Intercept	-0.13	0.345	-0.366	0.7156
Incoming Water Temperature	0.06	0.006	9.989	5.41E-16
Outcoming Water Temperature	-0.16	0.009	-17.054	3.57E-29
Ambient Temperature	0.08	0.007	12.703	2.42E-21
Relative Humidity	0.01	0.002	6.890	9.12E-10

Table 3: Regression Statistic

Observations	Correlation coefficient	Determination coefficient	Adjusted Rexpand square	Standard error	F-test	Significance F
90	0.90	0.80	0.79	0.06	87.14	2.97E-46

4.0 CONCLUSIONS

Overall, the statistical analysis of the relationship between all independent variables and cooling tower efficiency yielded highly satisfactory results. These findings confirm that the observational data is statistically valid and may serve as a reliable reference for future studies. From a theoretical standpoint, the performance of a cooling tower reaches optimal levels when the temperature gap between the discharged water and the wet bulb temperature is minimized. However, under real-world conditions, this is difficult to achieve due to the highly fluctuating nature of environmental variables, particularly in tropical regions. This study aimed to identify the most favorable environmental conditions for cooling tower operation in tropical climates such as Indonesia. Among the nine observed combinations of time and weather, sunny mornings were found to deliver the highest efficiency, whereas rainy conditions at midday resulted in the lowest performance. These findings emphasize the importance of developing adaptive operational control strategies for cooling towers in tropical environments, considering daily variations in temperature and humidity. To advance this line of research, future studies are advised to broaden the environmental context by examining high-altitude or mountainous conditions, wind speed variations, and seasonal patterns. Additionally, the application of predictive algorithms based on machine learning, along with the assessment of alternative cooling tower designs, may offer valuable insights for enhancing cooling performance and energy efficiency in dynamically changing tropical environments.

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APPENDICES

Table 4: Sunny in the morning

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	33.6	29.0	29.5	86	27.5	76
2	33.2	30.7	30.3	83	27.9	47
3	32.4	30.3	30.7	83	28.3	51
4	30.6	28.5	29.3	85	27.2	62
5	33.0	28.8	30.2	82	27.6	78
6	31.9	28.4	30.1	82	27.5	80
7	32.2	28.5	30.3	81	27.6	80
8	31.5	28.8	30.6	80	27.7	71
9	31.0	28.7	30.7	78	27.6	66
10	33.6	30.6	31.8	80	28.9	63
Average	32.3	29.2	30.4	82	27.8	67

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Table 5: Sunny at midday

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	33.1	31.0	32.3	70	27.7	39
2	33.5	31.1	32.2	68	27.3	39
3	35.4	30.7	32.4	68	27.5	60
4	35.8	30.6	33.3	63	27.5	63
5	35.6	30.7	34.0	63	28.1	66
6	34.2	30.8	34.4	61	28.1	56
7	35.7	30.7	34.8	61	28.5	69
8	34.8	31.1	35.0	60	28.5	59
9	33.7	30.6	34.7	60	28.2	57
10	34.3	30.6	34.5	59	27.9	57
Average	34.6	30.8	33.8	63	27.9	56

Table 6: Sunny in the afternoon

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	33.5	30.5	32.5	74	28.6	61
2	32.5	30.2	32.3	75	28.5	58
3	33.6	30.7	32.0	78	28.7	60
4	33.6	30.6	32.7	77	29.2	69
5	33.3	30.8	32.8	79	29.7	69
6	33.9	30.9	32.7	77	29.2	64
7	33.4	30.8	32.1	77	28.7	55
8	33.9	31.2	32.0	77	28.6	51
9	34.0	30.3	32.2	76	28.6	69
10	33.3	30.1	32.0	77	28.6	68
Average	33.5	30.6	32.3	77	28.8	62

Table 7: Overcast in the morning

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	32.2	28.3	28.5	90	27.1	77
2	31.9	29.7	29.7	92	28.6	67
3	31.2	28.9	29.2	90	27.8	68
4	31.7	28.8	29.3	90	27.9	77
5	31.6	29.0	29.3	88	27.6	66
6	31.2	28.8	29.3	86	27.3	62
7	32.5	30.5	29.7	84	27.4	40
8	33.5	30.5	29.1	85	27.0	46
9	32.3	28.7	29.6	86	27.6	77
10	32.0	30.0	30.5	85	28.4	55
Average	32.0	29.3	29.4	88	27.7	64

Table 8: Overcast at midday

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	29.0	27.5	30.0	77	26.7	65
2	32.9	30.3	30.7	82	28.1	54
3	33.4	30.2	30.2	82	27.6	55
4	33.2	29.8	30.3	80	27.4	59
5	34.2	30.3	30.1	83	27.7	60
6	32.2	30.8	30.3	86	28.3	36
7	34.9	30.0	29.3	85	27.2	64
8	34.1	30.3	30.8	82	28.2	64
9	31.5	30.6	31.3	86	29.3	41
10	32.6	29.4	29.0	77	25.7	47
Average	32.8	29.9	30.2	82	27.6	54

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Table 9: Overcast in the afternoon

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	31.3	29.1	29.5	80	26.6	47
2	32.0	29.3	29.5	82	26.9	53
3	31.9	30.2	29.4	82	26.9	34
4	31.4	29.8	29.4	80	26.6	33
5	31.9	29.9	29.4	83	27.0	41
6	31.3	29.8	29.3	86	27.3	38
7	31.6	29.6	29.4	85	27.3	46
8	31.6	29.7	29.6	82	27.0	42
9	30.5	29.2	29.7	84	27.4	42
10	31.5	29.5	29.6	86	27.6	52
Average	31.5	29.6	29.5	83	27.1	43

Table 10: Rainy in the morning

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	30.4	27.0	24.5	92	23.5	49
2	31.5	26.6	24.2	93	23.3	60
3	30.9	27.3	24.4	93	23.5	49
4	32.3	27.6	24.3	93	23.4	53
5	33.6	29.3	24.9	94	24.1	45
6	32.2	29.6	25.1	95	24.5	34
7	31.5	26.6	25.3	93	24.4	69
8	30.9	29.4	25.5	95	24.9	25
9	30.7	29.5	26.1	95	25.5	23
10	30.6	26.7	25.7	93	24.8	67
Average	31.5	28.0	25.0	94	24.2	47

Table 11: Rainy at midday

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	31.2	29.0	27.5	92	26.4	46
2	31.9	30.1	26.2	92	25.2	27
3	31.3	29.5	26.4	91	25.2	30
4	32.8	30.2	27.3	90	26.0	38
5	31.8	29.9	28.0	90	26.6	37
6	31.3	29.1	28.1	90	26.7	48
7	33.2	29.7	28.3	91	27.1	57
8	30.8	29.7	28.6	91	27.4	32
9	32.7	29.7	28.7	92	27.6	59
10	30.8	29.1	28.0	92	26.9	44
Average	31.8	29.6	27.7	91	26.5	42

Table 12: Rainy in the afternoon

Data	Water temperature (°C)		Ambient temperature (°C)	Relative humidity (%)	Wet bulb temperature (°C)	CT Efficiency (%)
	Water Inlet	Water Outlet				
1	35.2	30.9	26.5	95	25.9	46
2	34.9	29.3	26.0	95	25.4	59
3	35.1	29.2	26.5	95	25.9	64
4	33.4	28.0	25.6	96	25.1	65
5	33.8	30.5	25.7	96	25.2	38
6	33.5	29.8	25.7	96	25.2	45
7	33.8	28.6	25.9	97	25.5	63
8	33.9	29.0	25.6	97	25.2	57
9	33.4	29.4	24.0	97	23.6	41
10	33.8	28.3	24.0	97	23.6	54
Average	34.1	29.3	25.6	96	25.1	53

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