AUCTORES
Globalize your Research

Journal of Nutrition and Food Processing

Abdeen Mustafa Omer *

Open Access

Review Article

Cultivation of Organics in Controlled Environment Greenhouse

Abdeen Mustafa Omer *

Energy Research Institute (ERI), Forest Road West, Nottingham NG7 4EU, UK.

***Corresponding author:** Abdeen Mustafa Omer, Energy Research Institute (ERI), Forest Road West, Nottingham NG7 4EU, UK.

Received date: June 14, 2021; **Accepted date:** June 21, 2021; **Published date:** June 26, 2021

Citation: Abdeen M. Omer. (2021). Cultivation of Organics in Controlled Environment Greenhouse. *J. Nutrition and Food Processing*, 4(4); DOI:10.31579/2637-8914/056

Abstract

A greenhouse is essentially an enclosed structure, which traps the short wavelength solar radiation and stores the long wavelength thermal radiation to create a favourable microclimate for higher productivity. The sun's radiation incident on the greenhouse has two parts: direct radiation and an associated diffuse sky radiation. The diffuse part is not focused by the lenses and goes right through Frensel lenses onto the surface of the absorbers. This energy is absorbed and transformed into heat, which is then transported via the liquid medium in copper pipes to the water (heat) storage tanks or, if used, open fish tanks. In this way, an optimal temperature for both plant cultivation and fish production can be maintained. Stable plant growth conditions are light, temperature and air humidity. Light for the photosynthesis of plants comes from the diffuse radiation, which is without substantial fluctuations and variation throughout most of the day. The air temperature inside the greenhouse is one of the factors that have an influence on the precocity of production. The selective collector acts in a more perceptible way on extreme air temperatures inside the greenhouse. Hence, the system makes it possible to avoid the excessive deviation of the temperature inside the greenhouse and provides a favourable microclimate for the precocity of the culture. Sediment and some associated water from the sediment traps are used as organic fertiliser for the plant cultivation. The present trend in greenhouse cultivation is to extend the crop production season in order to maximise use of the equipment and increase annual productivity and profitability. However, in many Mediterranean greenhouses, such practices are limited because the improper cooling methods (mainly natural or forced ventilation) used do not provide the desired micro-climatic condition during the summer of a composite climate. Also, some of these greenhouses have been built where the meteorological conditions require some heating during the winter, particularly at night. The worst scenario is during the winter months when relatively large difference in temperature between day and night occurs. However, overheating of the greenhouse during the day is common, even in winter, requiring ventilation of the structure. Hence, several techniques have been proposed for the storage of the solar energy received by the greenhouse during the day and its use to heat the structure at night. Reviews of such techniques are presented in this article. Air or water can be used for heat transport. The circulating water is heated during the day via two processes. The water absorbs part of the infrared radiation of the solar spectrum. Since the water is transparent in the visible region, they do not compete with the plants that need it. Alternatively, the water exchanges heat with the greenhouse air through the walls. At night, if the greenhouse temperature goes down below a specified value, the water begins to circulate acting as heat transfer surfaces heating the air in the greenhouse.

Keywords: greenhouse environment; energy efficient comfort; ventilation; humidity; sustainable environmental impact; water vapour; hybrid ventilation; temperature

1. Introduction

Globally, buildings are responsible for approximately 40% of the total world annual energy consumption [1]. Most of this energy is for the provision of lighting, heating, cooling, and air conditioning. Increasing awareness of the environmental impact of CO_2 and NO_x emissions and CFCs triggered a renewed interest in environmentally friendly cooling, and heating technologies. Under the 1997 Montreal Protocol, governments agreed to phase out chemicals used as refrigerants that have the potential to destroy stratospheric ozone. It was therefore considered desirable to reduce energy consumption and decrease the rate of depletion of world energy reserves and pollution of the environment.

One way of reducing building energy consumption is to design building, which is more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption [2]. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the renewable energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels. This will also contribute to the amelioration of environmental conditions by replacing conventional fuels with renewable energies that produce no air pollution or greenhouse gases.

The provision of good indoor environmental quality while achieving energy and cost efficient operation of the heating, ventilating and air-conditioning (HVAC) plants in buildings represents a multi variant problem. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity and quality in addition to lighting and noise. The overall objective is to provide a high level of building performance (BP), which can be defined as indoor environmental quality (IEQ), energy efficiency (EE) and cost efficiency (CE).

- Indoor environmental quality is the perceived condition of comfort that building occupants experience due to the physical and psychological conditions to which they are exposed by their surroundings. The main physical parameters affecting IEQ are air speed, temperature, relative humidity and quality.
- Energy efficiency is related to the provision of the desired environmental conditions while consuming the minimal quantity of energy.
- Cost efficiency is the financial expenditure on energy relative to the level of environmental comfort and productivity that the building occupants attained. The overall cost efficiency can be improved by improving the indoor environmental quality and the energy efficiency of a building.

This communication describes various designs of low energy greenhouses. It also, outlines the effect of dense urban building nature on energy consumption, and its contribution to climate change. Measures, which would help to save energy in greenhouses, are also presented. It also enabled the minimisation of temperature variation and, hence avoided the hazard of any sudden climatic change inside the greenhouse.

An approach is needed to integrate renewable energies in a way to meet high building performance. However, because renewable energy sources are stochastic and geographically diffuse, their ability to match demand is determined by adoption of one of the following two approaches [2]: the utilisation of a capture area greater than that occupied by the community to be supplied, or the reduction of the community's energy demands to a level commensurate with the locally available renewable resources.

For a northern European climate, which is characterised by an average annual solar irradiance of 150 Wm^{-2}, the mean power production from a photovoltaic component of 13% conversion efficiency is approximately 20 Wm^{-2}. For an average wind speed of 5 ms^{-1}, the power produced by a micro wind turbine will be of a similar order of magnitude, though with a different profile shape. In the UK, for example, a typical office building will have a demand in the order of 300 $kWhm^{-2}yr^{-1}$. This translates into approximately 50 Wm^{-2} of façade, which is twice as much as the available renewable energies [3]. Thus, the aim is to utilise energy efficiency measures in order to reduce the overall energy consumption and adjust the demand profiles to be met by renewable energies. For instance, this approach can be applied to greenhouses, which use solar energy to provide indoor environmental quality. The greenhouse effect is one result of the differing properties of heat radiation when it is generated at different temperatures. Objects inside the greenhouse, or any other building, such as plants, re-radiate the heat or absorb it. Because the objects inside the greenhouse are at a lower temperature than the sun, the re-radiated heat is of longer wavelengths, and cannot penetrate the glass. This re-radiated heat is trapped and causes the temperature inside the greenhouse to rise. Note that the atmosphere surrounding the earth, also, behaves as a large greenhouse around the world. Changes to the gases in the atmosphere, such as increased carbon dioxide content from the burning of fossil fuels, can act like a layer of glass and reduce the quantity of heat that the planet earth would otherwise radiate back into space. This particular greenhouse effect, therefore, contributes to global warming. The application of greenhouses for plants growth can be considered one of the measures in the success of solving this problem. Maximising the efficiency gained from a greenhouse can be achieved using various approaches, employing different techniques that could be applied at the design, construction and operational stages. The development of greenhouses could be a solution to farming industry and food security.

The move towards a de-carbonised world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilisation level of atmospheric carbon dioxide is to be achieved. This requires the harnessing and use of natural resources that produce no air pollution or greenhouse gases and provides comfortable coexistence of human, livestock, and plants. This study reviews the energy-using technologies based on natural resources, which are available to and applicable in the farming industry. Integral concept for buildings with both excellent indoor environment control and sustainable environmental impact are reported in the present communication. Techniques considered are hybrid (controlled natural and mechanical) ventilation including night ventilation, thermo-active building mass systems with free cooling in a cooling tower, and air intake via ground heat exchangers. Special emphasis is put on ventilation concepts utilising ambient energy from air ground and other renewable energy sources, and on the interaction with heating and cooling. It has been observed that for both residential and office buildings, the electricity demand of ventilation systems is related to the overall demand of the building and the potential of photovoltaic systems and advanced co-generation units. The focus of the world's attention on environmental issues in recent years has stimulated response in many countries, which have led to a closer examination of energy conservation strategies for conventional fossil fuels. One way of reducing building energy consumption is to design buildings, which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels.

The main advantages of solar greenhouse are summarised as follows:

- In the climatic conditions of Europe, the collector system equipped with linear raster lenses is able to absorb, on average, 12% of the total incoming global solar energy on the collector and convert this energy into heat at a temperature of between 30 to 50ºC. The system, therefore, consumes approximately 50% less energy for heating purposes than would a traditional normal greenhouse.
- The system provides suitable, perhaps ideal, conditions for the cultivation of high quality vegetables, and even during periods of maximum solar energy absorption on the collectors, there still remains sufficient light for good vegetable growth under the area of the collectors.
- Due to the almost continuous high humidity levels and to the applied nutrient solution being rich in organic matter and microorganisms, organic matter is hardly mineralising in the

soil, hence, does not degrade in patches. On the contrary, organic matter content in the soil increased during cultivation.

- In comparison with a traditional greenhouse, the system does not overheat inside. Therefore, less ventilation is necessary, which brings the benefits of smaller losses of water. Furthermore, the system saves energy, allows the efficient recycling of water and nutrients, and provides suitable growth conditions with a smaller range of extreme humidity, temperature and light allowing the cultivated plants to face less stress and have a higher quality.
- Due to the relatively low temperature in the greenhouse, additional heating might be required. Therefore, vegetables will adapt to low radiation levels, and low temperatures and, consequently, quality is preserved even during failure of control system.

This study describes various designs of low energy buildings. It also, outline the effect of dense urban building nature on energy consumption, the problems related to inadequate ventilation in buildings, and its contribution to climate change. Measures, which would help to save energy in buildings, are also presented.

2. Air Pollutants and Transmutation

Controlling the pollution of the present civilisation is an increasing concern. More importance is given to control global carbon dioxide, which is considered to be the main factor of green house effect. Though the complete experimental result on the fact is yet to be debated, the immense heat, temperature and turbulence of nuclear explosion oxidising the atmospheric nitrogen into nitric oxide, are considered to be similarly responsible for depletion of ozone layer [4]. At present, more importance is given for plantation to reduce the level of global carbon dioxide. The plantation over the whole earth surface may control only 50% of carbon dioxide disposed to atmosphere and its greenhouse effect. There are, also, explosions in the ozone layer time to time to add to the problem. Irrespective of the relative importance of each factor, the ozone layer protects us from harmful cosmic radiations and it is believed that the depletion of ozone layer increases the threat of outer radiations to human habitation if environmental pollution is not controlled or there is no possibility of self-sustainable stability in nature [5].

The presence of ionosphere in the outer-sphere is most probably for ionic dissociation of the gases of the outer-sphere in the presence of low pressure and cosmic radiation [6]. Moreover the ionosphere contains charged helium ions (alpha particle). Therefore, it may be concluded that the explosion in the ozone and transmission of radiations through it are the possible effects of transmutation of pollutants with exothermic reaction (emission of radiations) [7]. The existence of a black hole in the space, which is found in the photo camera of astrologist, is still unexplored. This black hole may be an effect of transmutation process with absorption of heat energy (endothermic reaction). The idea of transmutation of pollutants has been proposed for one or more of the following reasons:

- The experimental results support the transmutation of materials.
- To search the sinks of the remaining carbon dioxide not absorbed by plants or seawater.
- To find out the possible causes of explosion in the ozone layer other than the depletion of ozone layer.
- To investigate the possibilities of the self-sustaining stability of global environment.

To prove the portable of transmutation of pollutants, experimental investigations may be conducted to bombard C or CO_2 or CH_4 or other air pollutants by accelerated alpha particles in a low-pressure vacuum tube in a similar condition of ionosphere. Heating them with gamma radiation can accelerate the alpha particles. The results of such experimental investigation may prove the probable transmutation of pollutants and self-sustaining equilibrium of the global environment.

3. Greenhouses

Population growth and less availability of food material have become global concerns. The world population increases exponentially whereas food production has increased only arithmetically, meaning that the availability of food per capita has decreased. This is more pronounced in the cases of oils, vegetables, fruits and milk, whereas it is marginal, rather than minimum, in cereals. The increase in population has also resulted in the use of more urban areas for habitation, less land available for cultivation and, hence, more food requirements. The resultant need is, therefore, to increase productivity and year round cultivation. To maximise production and meet the global demand on food, vegetables, flowers and horticultural crops, it is necessary to increase the effective production span of crops. The sun is the source of energy for plants and animals. This energy is converted into food (i.e., carbohydrates) by plants through a process called photosynthesis. This process is accomplished at suitable atmospheric conditions. These conditions are provided by nature in different seasons and artificially by a greenhouse. The primary objective of greenhouses is to produce agricultural products outside the cultivation season. They offer a suitable microclimate for plants and make possible growth and fruiting, where it is not possible in open fields. This is why a greenhouse is also known as a "controlled environment greenhouse". Through a controlled environment, greenhouse production is advanced and can be continued for longer duration, and finally, production is increased [8]. The off-season production of flowers and vegetables is the unique feature of the controlled environment greenhouse. Hence, greenhouse technology has evolved to create the favourable environment, or maintaining the climate, in order to cultivate the desirable crop the year round. The use of "maintaining the climate" concept may be extended for crop drying, distillation, biogas plant heating and space conditioning. The use of greenhouses is widespread. During the last 10 years, the amount of greenhouses has increased considerably to cover up to several hundred hectares at present. Most of the production is commercialised locally or exported. In India, about 300 ha of land are under greenhouse cultivation. On the higher side, however, it is 98600 ha in Netherlands, 48000 ha in China and 40000 ha in Japan [9]. This shows that there is a large scope to extend greenhouse technology for various climates.

However, the effective utilisation of greenhouses has to deal with some specific climate problems like frost, during winter and overheating in summer days. These problems show the necessity of having a tool capable of predicting the thermal behaviour of a greenhouse under specific exterior conditions. Also, greenhouse industry has to deal with some problems related to a poor design of a great number of greenhouses. Such problems are mostly related to, on the one hand, its incapacity to deal with the problem of frost, which in the cold clear sky days of winter can destroy the whole work of a season, and, on the other hand, the question of overheating in the summer days.

4. Greenhouse Environment

The comfort in a greenhouse depends on many environmental parameters. These include temperature, relative humidity, air quality and lighting. Although greenhouse and conservatory originally both meant a place to house or conserve greens (variegated hollies, cirrus, myrtles and oleanders), a greenhouse today implies a place in which plants are raised while conservatory usually describes a glazed room where plants may or may not play a significant role. Indeed, a greenhouse can be used for so many different purposes. It is, therefore, difficult to decide how to group the information about the plants that can be grown inside it. Whereas heat loss in winter a problem, it can be a positive advantage when greenhouse temperatures soar considerably above outside temperatures in summer. Indoor relative humidity control is one of the most effective long-term mite control measures. There are many ways in which the internal relative humidity can be controlled including the use of appropriate ventilation, the reduction of internal moisture production and maintenance of adequate internal temperatures through the use of efficient heating and insulation.

The introduction of a reflecting wall at the back of a greenhouse considerably enhances the solar radiation that reaches the ground level at any particular time of the day. The energy yield of the greenhouse with any type of reflecting wall was also significantly increased. The increase in energy efficiency was obtained by calculating the ratio between the total energy received during the day in greenhouse with a reflecting wall, compared to that in a classical greenhouse. Hence, the energy balance was significantly shifted towards conservation of classical energy for heating or lighting. The four-fold greater amount of energy that can be captured by virtue of using a reflecting wall with an adjustable inclination and louvers during winter attracts special attention. When sky (diffuse) radiation that was received by the ground in amounts shown in Figure 1, were taken into account, the values of the enhancement coefficients were reduced to some extent: this was due to the fact that they added up to the direct radiation from the sun in both new and classical greenhouses. However, this is a useful effect as further increases overall energy gain. There is also an ironing out effect expressed in terms of the ratios between peak and average insolations [10].

Finally, the presented theory can be used to calculate the expected effects of the reflecting wall at any particular latitude, under different weather conditions, and when the average numbers of clear days are taken into account. Thereby an assessment of the cost of a particular setup can be obtained. Under circumstances of a few clear days, it may still be worthwhile from a financial point of view to turn a classical greenhouse into one with a reflecting wall by simply covering the glass wall on the north-facing side with aluminum foil with virtually negligible expenditure.

4.1. Relative Humidity

Air humidity is measured as a percentage of water vapour in the air on a scale from 0% to 100%, where 0% being dry and 100% being full saturation level. The main environmental control factor for dust mites is relative humidity. The followings are the practical methods of controlling measures available for reducing dust mite populations:

- Chemical control.
- Cleaning and vacuuming.
- Use of electric blankets, and
- Indoor humidity.

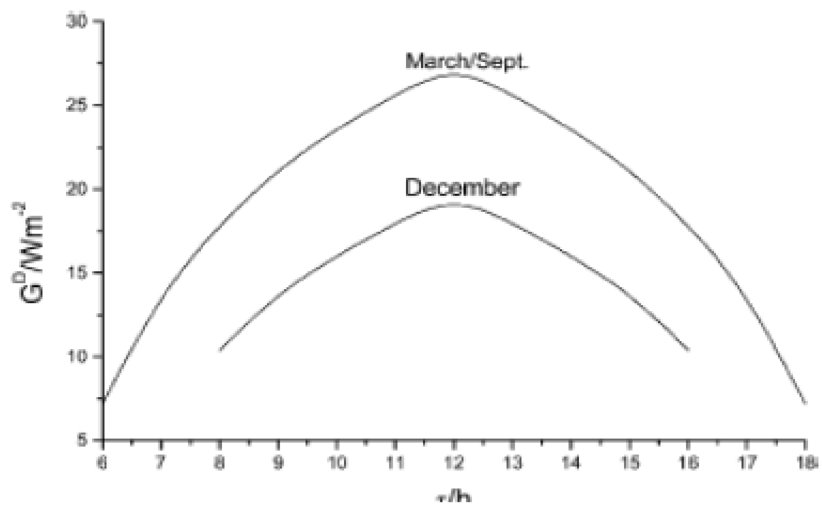
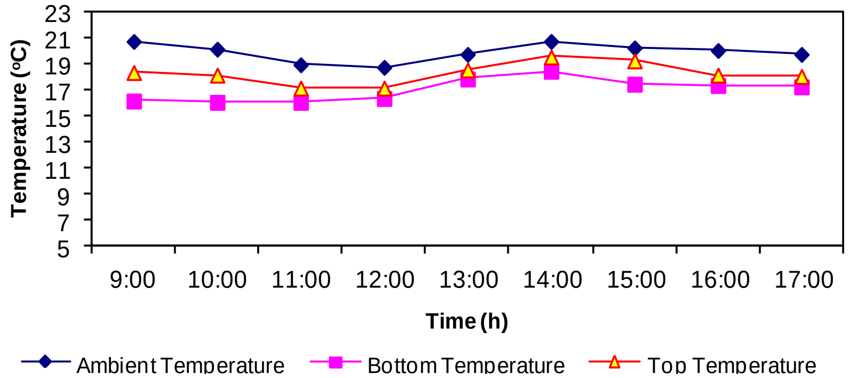


Figure 1. *Ground irradiance from diffuse (sky) radiation from a clear sky at the shortest winter day and at equinox.*

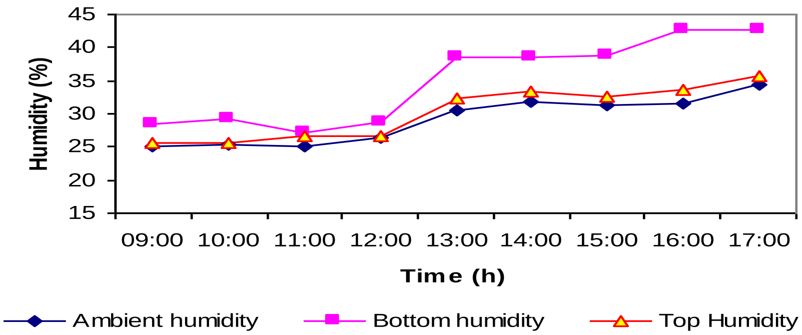
The introduction of a reflecting wall at the back of a greenhouse considerably enhances the solar radiation that reaches the ground level at any particular time of the day. The energy yield of the greenhouse with any type of reflecting wall was also significantly increased. The increase in energy efficiency was obtained by calculating the ratio between the total energy received during the day in greenhouse with a reflecting wall, compared to that in a classical greenhouse. Hence, the energy balance was significantly shifted towards conservation of classical energy for heating or lighting. The four-fold greater amount of energy that can be captured by virtue of using a reflecting wall with an adjustable inclination and louvers during winter attracts special attention. When sky (diffuse) radiation that was received by the ground in amounts shown in Figure 10, were taken into account, the values of the enhancement coefficients were reduced to some extent: this was due to the fact that they added up to the direct radiation from the sun in both new and classical greenhouses. However, this is a useful effect as further increases overall energy gain (Figures 2-23). There is also an ironing out effect expressed in terms of the ratios between peak and average insolations [10-19].

Finally, the presented theory can be used to calculate the expected effects of the reflecting wall at any particular latitude, under different weather conditions, and when the average numbers of clear days are taken into account. Thereby an assessment of the cost of a particular setup can be obtained. Under circumstances of a few clear days, it may still be worthwhile from a financial point of view to turn a classical greenhouse into one with a reflecting wall by simply covering the glass wall on the north-facing side with aluminum foil with virtually negligible expenditure.



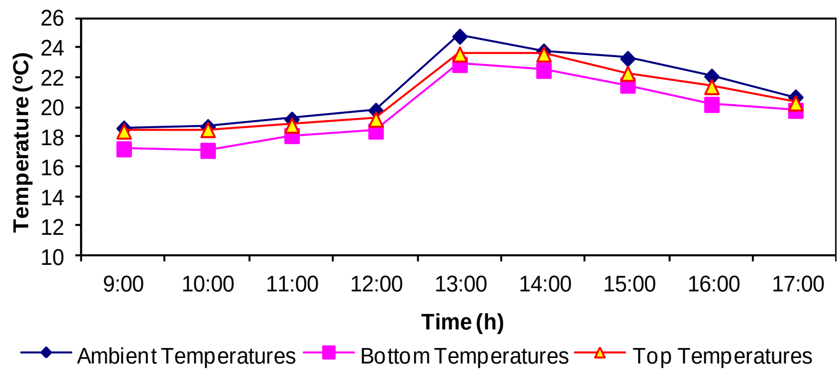
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm)

Figure 2. *Temperature variation in January.*



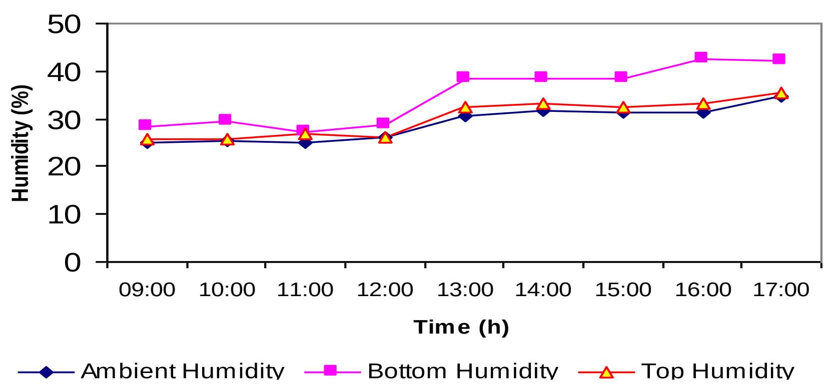
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 3. *Average daily variation of humidity in January.*



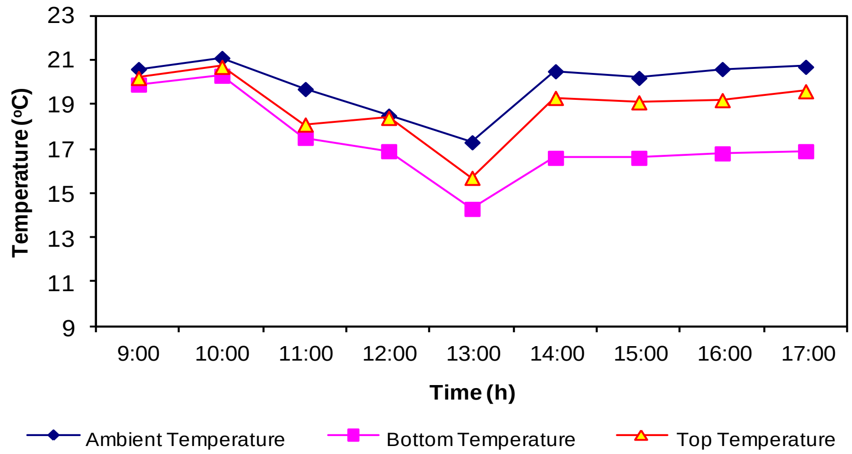
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 4. *Temperature variation in February.*



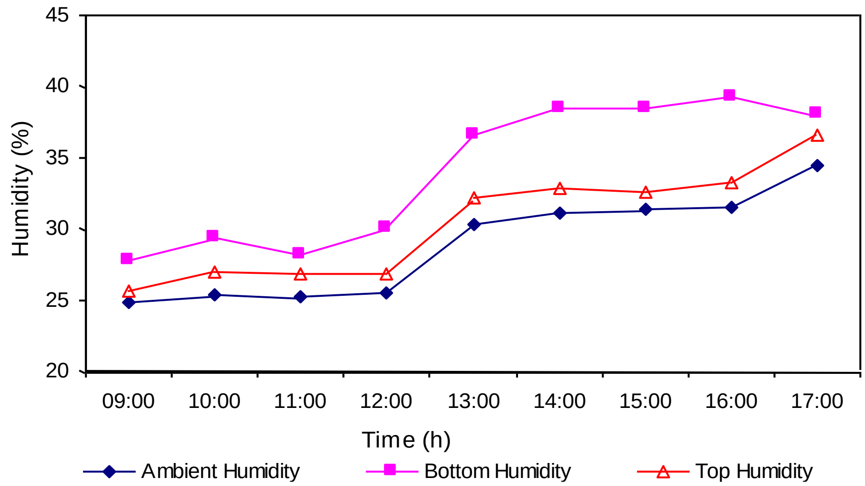
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 5. *Average daily variation of humidity in February.*



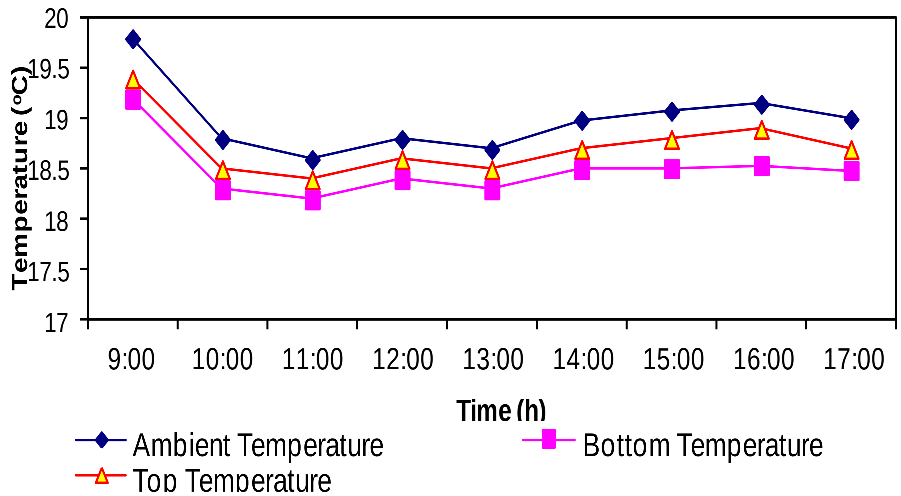
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 6. *Temperature variation in March.*



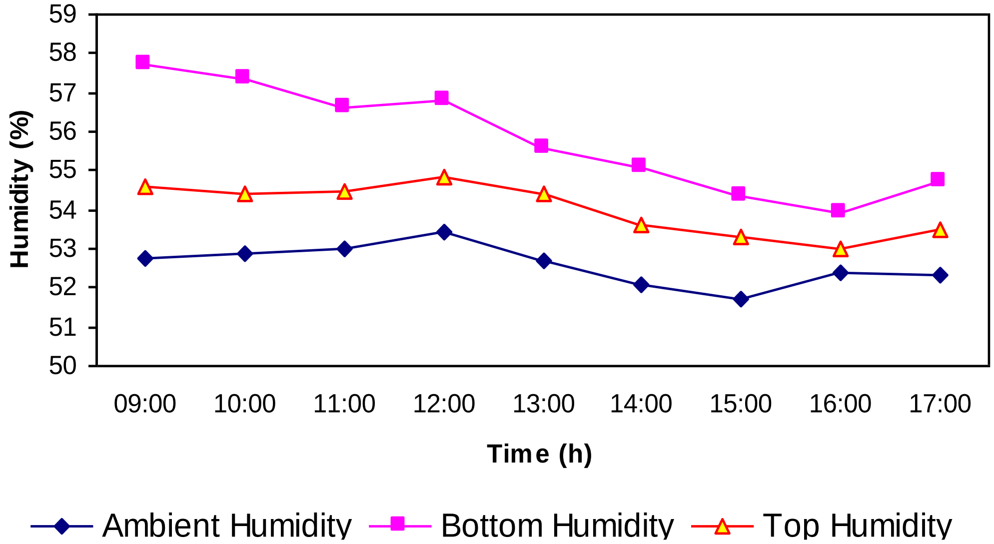
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 7. *Average daily variation of humidity in March.*



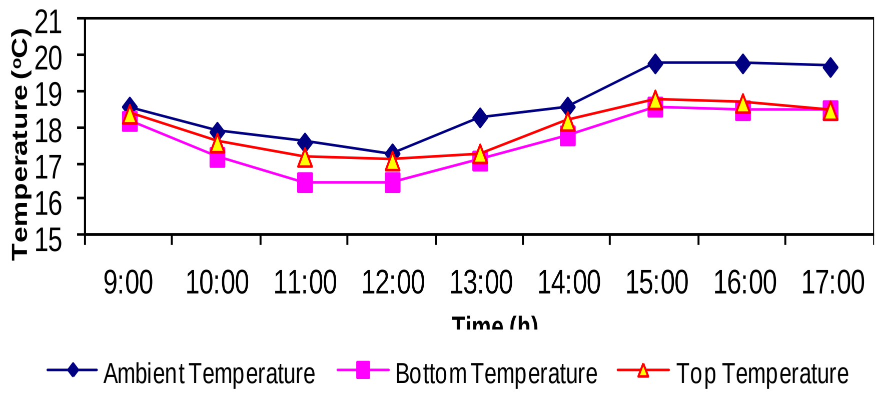
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 8. *Temperature variation in May.*



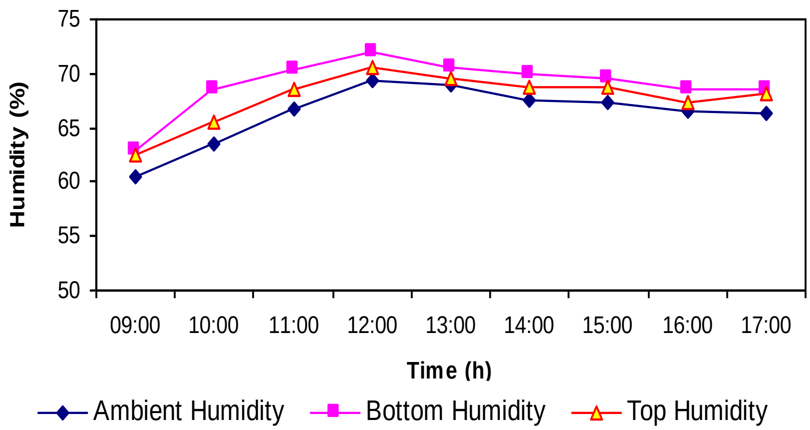
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 9. *Average daily variation of humidity in May.*



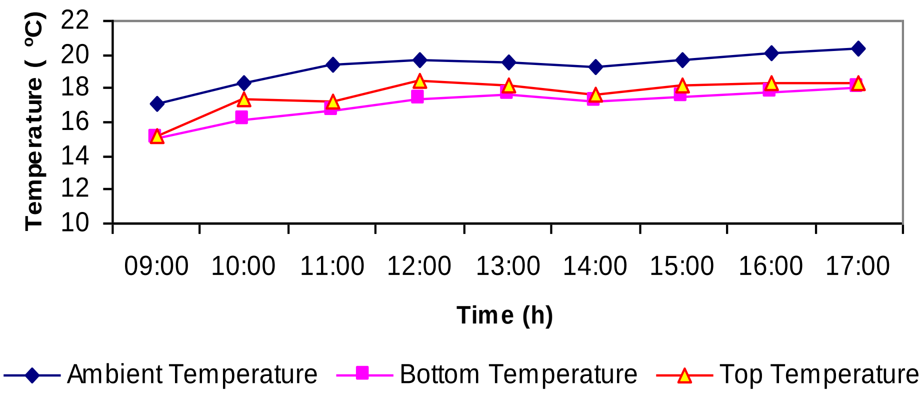
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 10. *Temperature variation in June.*



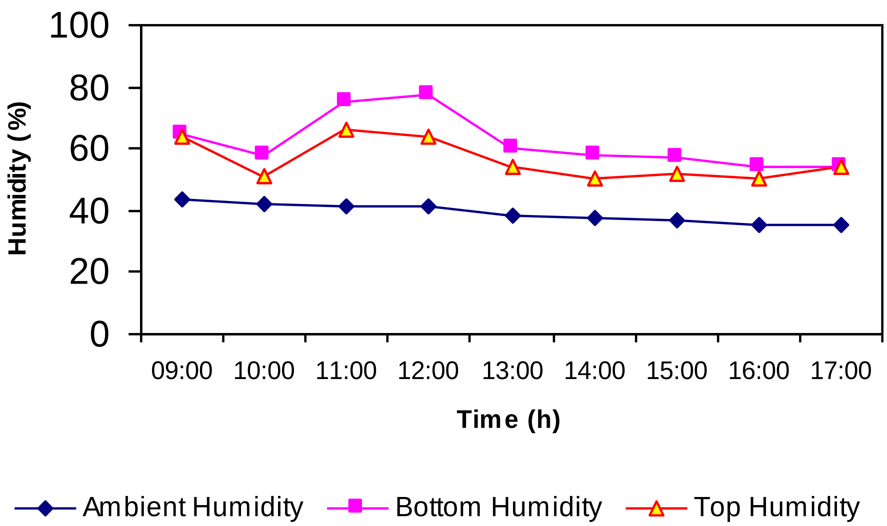
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 11. *Average daily variation of humidity in June.*



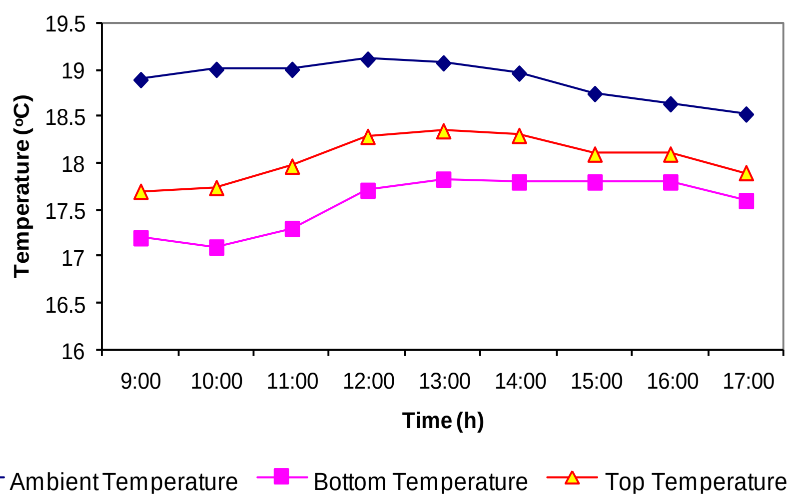
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 12. *Temperature variation in July.*



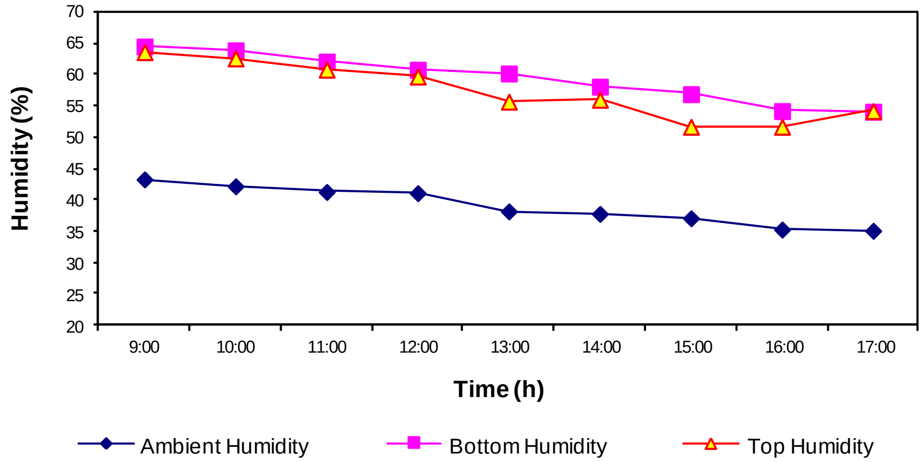
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 13. *Average daily variation of humidity in July.*



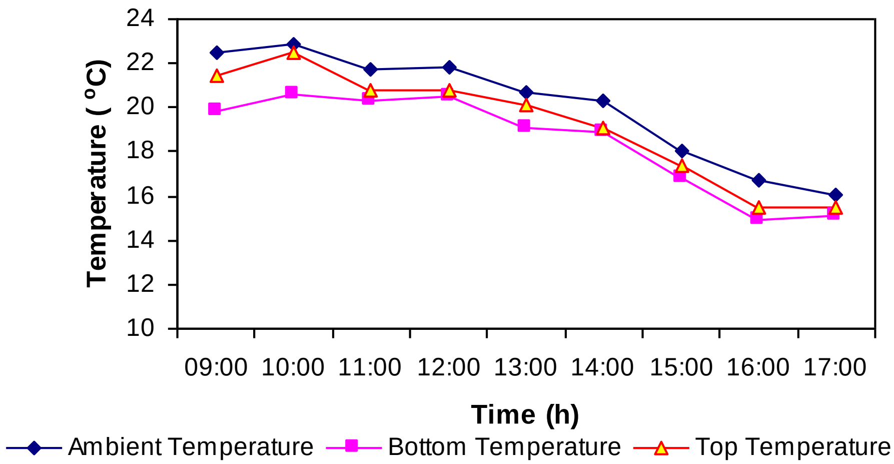
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 14. *Temperature variation in August.*



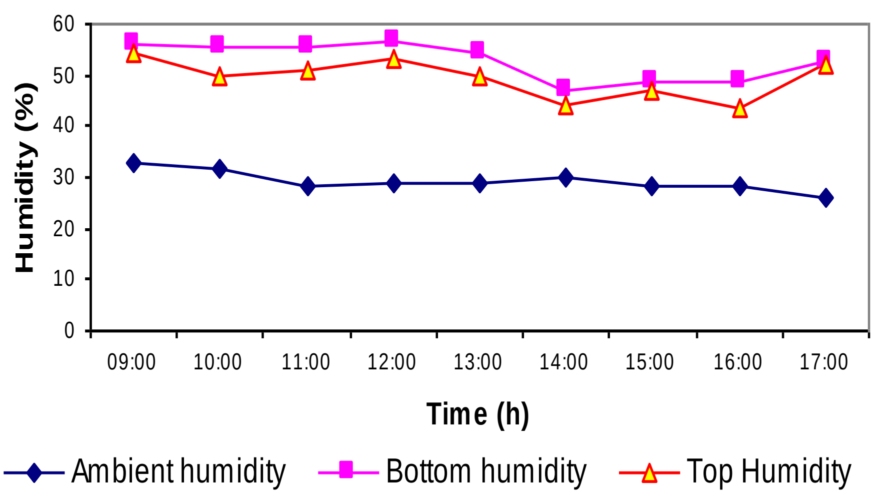
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 15. *Average daily variation of humidity in August.*



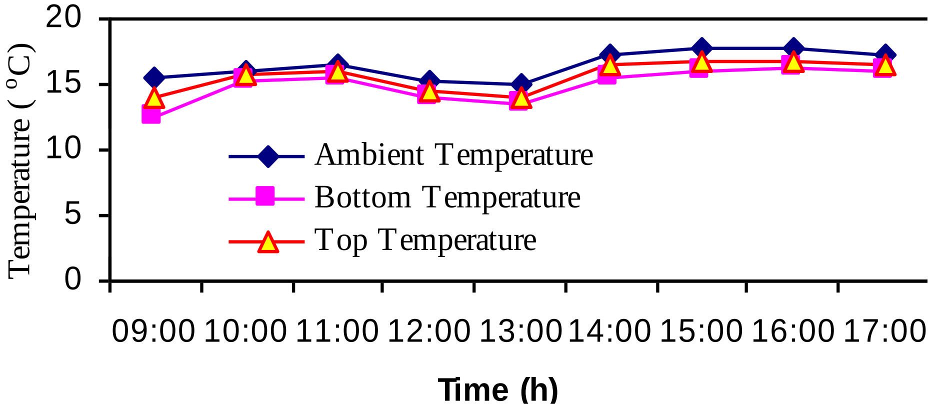
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 16. *Temperature variation in September.*



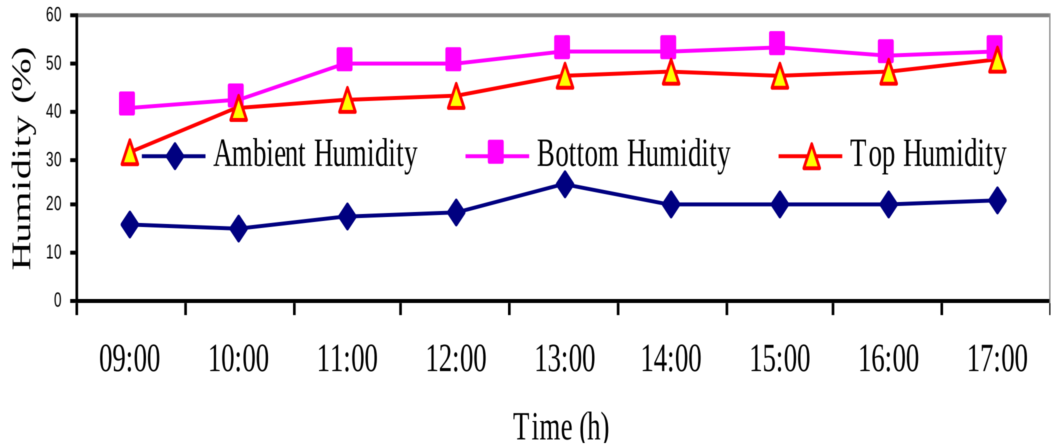
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 17. *Average daily variation of humidity in September.*



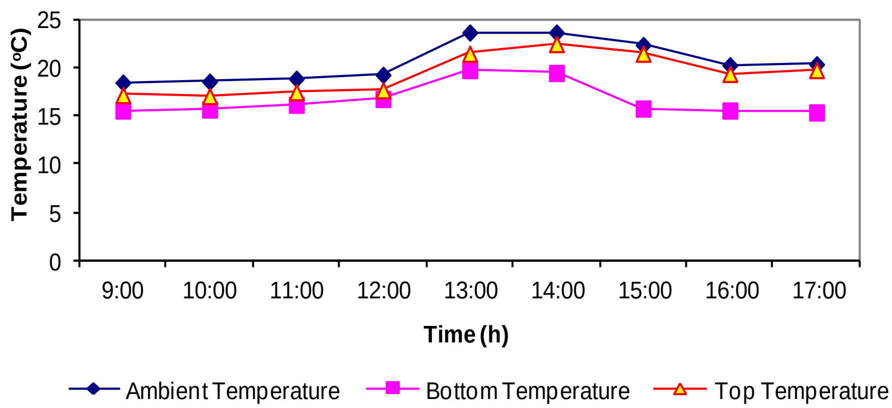
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 18. *Temperature variation in October.*



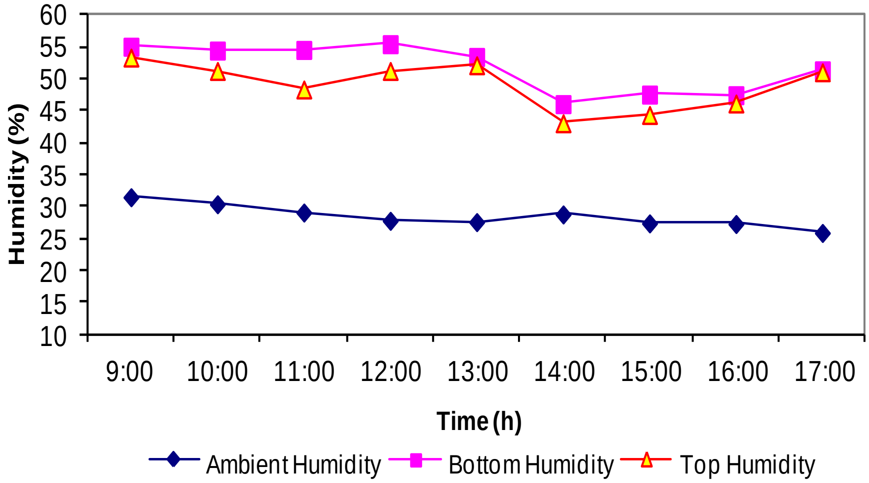
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 19. *Average daily variation of humidity in October.*



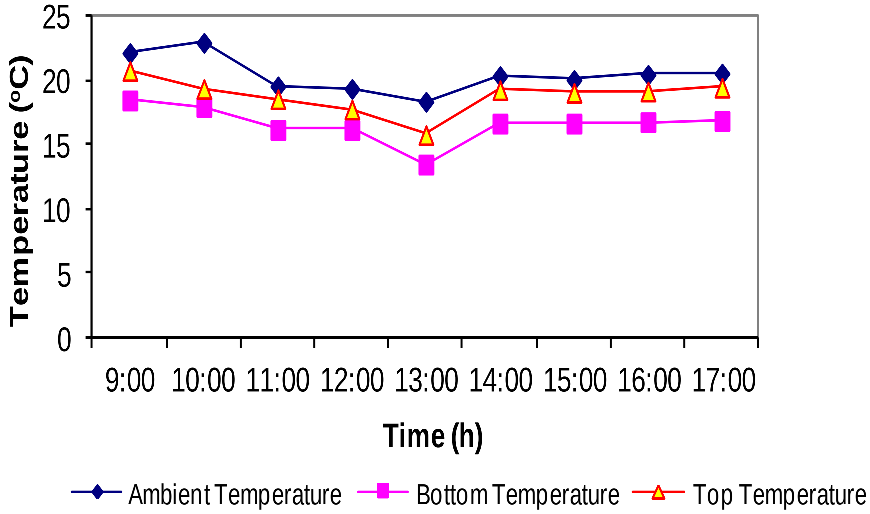
(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm)

Figure 20. *Temperature variation in November.*



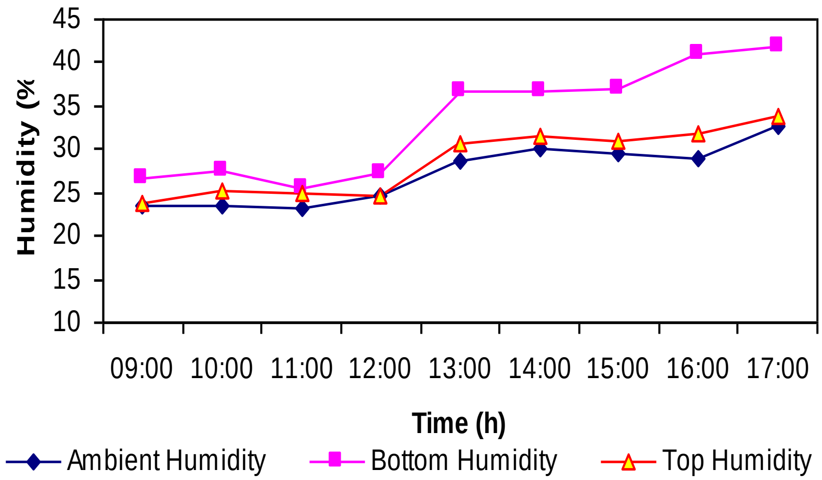
(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 21. *Average daily variation of humidity in November.*



(T_{indoor}) (T_{bottom} at 50 cm) (T_{top} at 150 cm).

Figure 22. *Temperature variation in December.*



(H_{indoor}) (H_{bottom} at 50 cm) (H_{top} at 150 cm).

Figure 23. *Average daily variation of humidity in December.*

5. Conclusions

Thermal comfort is an important aspect of human life. Buildings where people work require more light than buildings where people live. In buildings where people live the energy is used for maintaining both the temperature and lighting. Hence, natural ventilation is rapidly becoming a significant part in the design strategy for non-domestic buildings because of its potential to reduce the environmental impact of building operation, due to lower energy demand for cooling. A traditional, naturally ventilated building can readily provide a high ventilation rate. On the other hand, the mechanical ventilation systems are very expensive. However, a comprehensive ecological concept can be developed to achieve a reduction of electrical and heating energy consumption, optimise natural air condition and ventilation, improve the use of daylight and choose environmentally adequate building materials. Plants, like human beings, need tender loving care in the form of optimum settings of light, sunshine, nourishment, and water. Hence, the control of sunlight, air humidity and temperatures in greenhouses are the key to successful greenhouse gardening. The mop fan is a simple and novel air humidifier; which is capable of removing particulate and gaseous pollutants while providing ventilation. It is a device ideally suited to greenhouse applications, which require robustness, low cost, minimum maintenance and high efficiency. A device meeting these requirements is not yet available to the farming community. Hence, implementing mop fans aids sustainable development through using a clean, environmentally friendly device that decreases load in the greenhouse and reduces energy consumption.

References

1. Jeremy, L. (2005). The energy crisis, global warming and the role of renewables. *Renewable Energy World* 2005; 8 (2).
2. Omer, A (2010). Low energy building materials: an overview. In: Proceedings of the Environment. *Situation and Perspectives for the European Union*. p. 16-21. Porto: Portugal. 6-10.
3. UNEP. Handbook for the International Treaties for the Protection of the Ozone Layer. *United Nations Environment Programme*. Nairobi: Kenya. (2003).
4. Viktor, D. (2002). Ventilation concepts for sustainable buildings. In: Proceedings of the World Renewable Energy Congress VII, p. 551, Cologne: Germany.
5. Lam, J.C. (2005) Shading effects due to nearby buildings and energy implications. *Energy Conservation and Management*; 47 (7): 647-659.
6. Raja, J., Nichol, F., and McCartney, K. (1998). Natural ventilated buildings use of controls for changing indoor climate. In: Proceedings of the 5th World Renewable Energy Congress V. p. 391-394. Florence: Italy.
7. Limb, M.J. (1995). Air intake positioning to avoid contamination of ventilation. AIVC.
8. Miller, G. (1990). Resource conservation and management. Wadsworth Publishers. California: USA, p.51-62.
9. Erlich, P. (1991). Forward Facing up to Climate Change, in Global Climate Change and Life on Earth. R.C. Wyman (ed), Chapman and Hall, London.
10. ASHRAE. Energy efficient design of new building except new low-rise residential buildings. BSRIASHRAE proposed standards 90-2P-1993, alternative GA. American Society of Heating, Refrigerating, and Air Conditioning Engineers Inc., USA. (1993).
11. Fabio Tittarelli. (2020). Organic Greenhouse Production: Towards an Agroecological Approach in the Framework of the New European Regulation-A Review.
12. Foley, J.A.; Ramankutty, N.; Brauman, K.A.; Cassidy, E.S.; Gerber, J.S.; Johnston, M.; Mueller, N.D.; O'Connell, C.; Ray, D.K.; West, P.C.; et al. (2011). Solutions for a cultivated planet. Nature. 478, 337–342.
13. Eyhorn, F.; Muller, A.; Reganold, J.P.; Frison, E.; Herren, H.R.; Luttikholt, L.; Mueller, A.; Sanders, J.; El-Hage Scialabba, N.; Seufert, V.; et al. (2019). Sustainability in global agriculture driven by organic farming. Nat. Sustain. 2, 253–255.
14. Skinner, C.; Gattinger, A.; Krauss, M.; Krause, H.M.; Mayer, J.; van der Heijden, M.G.A.; Mäder, P. (2019). The impact of long-term organic farming on soil-derived greenhouse gas emissions. Sci. Rep. UK 2019, 9, 1702.
15. Rahmann, G.; Reza Ardakani, M.; Bàrberi, P.; Boehm, H.; Canali, S.; Chander, M.;Wahyudi, D.; Dengel, L.; Erisman, J.W.; Galvis-Martinez, A.C.; et al. (2017). Organic Agriculture 3.0 is innovation with research. Org. Agric. 2017, 7, 169–197.
16. IPES-Food. From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems. International Panel of Experts on Sustainable Food Systems. (2016).
17. Tittarelli, F.; Båth, B.; Ceglie, F.G.; García, M.C.; Möller, K.; Reents, H.J.; Védie, H.; Voogt, W. (2017). Soil fertility management in organic green house: An analysis of the European context. Acta Hortic. 1164, 113–126.
18. Ciaccia, C.; Ceglie, F.G.; Burgio, G.; Madžaric, S.; Testani, E.; Muzzi, E.; Mimiola, G.; Tittarelli, F. (2019). Impact of agroecological practices on greenhouse vegetable production: Comparison among organic production systems. Agronomy 2019, 9, 372.
19. Stanghellini, C.; Baptista, F.; Eriksson, E.; Gilli, C.; Giurida, F.; Kempkes, F.; Muñoz, P.; Stepowska, A.; Montero, J.I. (). Sensible Use of Primary Energy in Organic Greenhouse Production.

DOI: 10.31579/2637-8914/056