Experimental study, design and analysis of automatic air heater with various flow rates using for solar still system

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Abstract –
In this article, the automatic electric heaters are used for solar still for the purpose of preheated inlet water at certain temperature. There are several interaction parameters that affect system efficiency using various flow rates. These parameters are: speed of fan, heater coil, heater wall radiation, applied voltage, air flow rate, heater outlet air temperature, insulation thickness, and heater size. The temperature rises over time (10-60 minutes) when using fans at speeds of 200, 400, 600, 800 and 1000 rpm. When using a fan at 1200 rpm and maintaining the temperature at 62.3 °C for a period of time (40-60 minutes) at the same fan speed. It was also noticed that the temperature was high over time (10-60 minutes) at a fan speed of 1400 rpm.

Keyword: Automatic air heater; Fan speed; Solar still:

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1. Introduction

Automatic electric heaters have a wide range of applications such as drying and water heaters for solar still. An electric heater includes many parameters for interaction, such as air flow rate and heater size. Increasing the fan speed increases the heat transfer area. Changing the coil size also affects the temperature, which affects the ambient temperature and the properties of the air. This affects the heat transfer coefficient of the coil, which affects its temperature. Reducing coil radiation reduces radiation losses to the environment and increases heater efficiency.

Simulating an electric heater is an important step for optimization and efficiency analysis. The ideal electrical heater design reduces the extremely high coil temperatures and associated thermal stresses, resulting in longer cycle times, resulting in longer life and energy savings. The model determines the power loss of the heater, the temperature distribution along the coil. Modeled as separate ring coils along the heater wall and air passing through each ring coil [1]. The efficiency of air heaters is influenced by the length and height of the coil, the type of absorber plate, glass cover, wind speed and many other parameters [2].

The cavity for the liquid consists of two ribs arranged as bottom insulation and has a uniform heat flow to the upper surface of the sorbent. Influence parameters such as mass flow and system parameters such as rib intervals affecting heat and thermohydraulic properties are taken into account, and the results are compared with energy air heaters [3]. The efficiency of a flat panel solar heater is lower than that of a solar water heater due to the low coefficient of thermal conductivity between the adsorbent plate and the air causing the air temperature [4]. Air heaters are used for many purposes, such as heating and dehydrating the air, drying various fruits and vegetables, and storing energy. The heaters are a direct dependence on heated surfaces, usually made of copper or aluminum and having a low air heat transfer coefficient [5]. Drinking water is one of the most important issues in the world today. Drinking water sources remain very low and consumption is very high for industry and households [6].

The water shortages and declining water quality have deteriorated and are one of the most serious water problems in the world. Factors that cause these problems are climate change, rapid population growth, technological changes, and new ways of life [7]. The use of solar energy has existed since the very beginning of human existence on Earth, so the demand and supply of energy in modern society is growing, today 77% of the world's energy comes from fuel emissions and greenhouse gases that reduce the ozone layer, and this is extremely dangerous for the environment [8]. Air heaters are efficient devices for using solar still for water heating and other purposes, and they can improve the efficiency of air heater through the development of new models, due to their simple design and low cost [9]. Methods of increasing productivity in a few days were still being studied, and it was concluded that a few productive days are still better than one day in the pool [10].

2. Experimental setup and explanation

The experimental setup consisted of several devices, such as an electric heater, fan, fan blades, upper metal parts, control panel, digital temperature controller and connector, all mounted on the frame. The experimental setup, air heater coil, control panel of air heater, single phase A.C. fan for air heater, experimental setup with digital temperature controller device, connector for digital temperature controller device and various reading of temperature a, b, c and d using digital temperature controller device shown in Figure 1-7. The effective size of the structure is 770 mm height, length 470 mm and width 290 mm. The single phase AC motor has a diameter of 8 mm and a maximum speed of 1,400 rpm.

Microcontroller based Temperature Controller System

The aim of this experiment is to develop a controller for measuring and controlling room temperature. The motivation for the study was the fact that temperature measurement became an integral part of any control system operating under temperature sensitive conditions and the learning results involved in conducting the study. In this experiment, an on-off control was used. Here, it set the outside temperature. The actual temperature is defined by the thermocouple temperature sensor, displayed on 7-segment cathode LED with a preset value. If the set value is exceeded, the heater will be turned off. Then, when the temperature is below the set limit, the heater will be turned on again. The control button is also used to set the temperature according to the application that has a selection range.

Figure.1 Experimental setup

Figure.2 Air heater coil

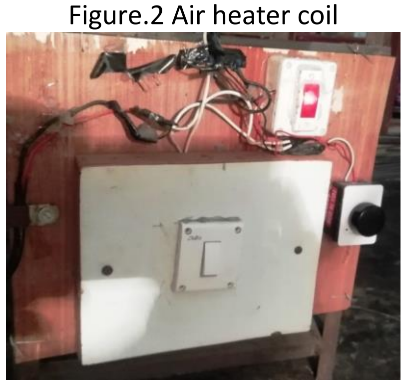


Figure.3 Control panel of air heater

Figure.4 Single phase A.C. fan for air heater

Figure.5 Experimental setup with digital temperature controller device

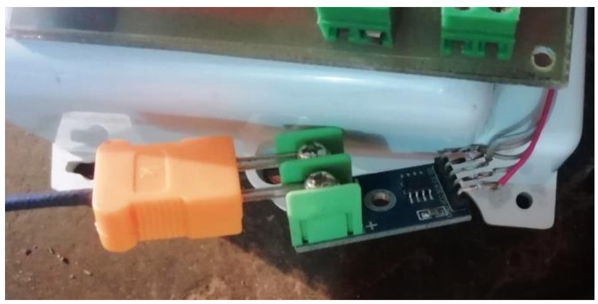
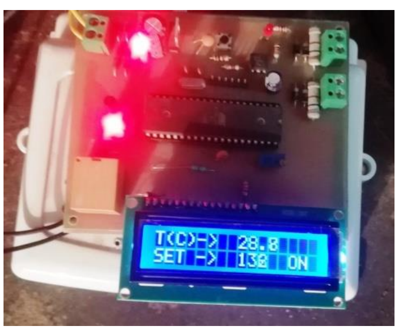
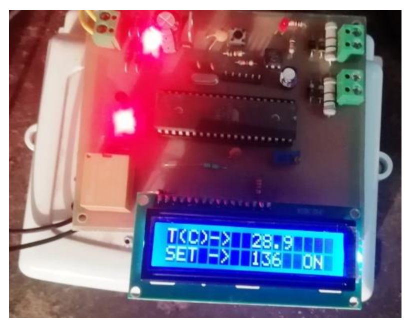


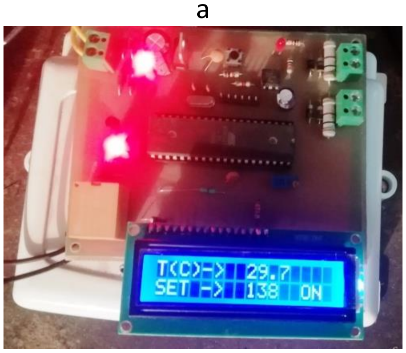
Figure.6 Connector for digital temperature controller device



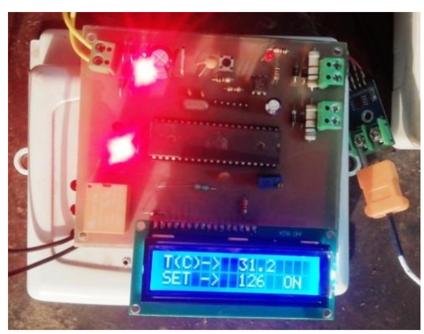
a



b



c



d

Figure.7 various reading of temperature a, b, c and d using digital temperature controller device

3. Methodology

The analysis was based on the highest optimization of the heater on high metal surfaces with fan speed, radiation, and air temperature. The increase in power used by the fan speed regulator raises the temperature of the coil and the temperature of the air.

This study aims to monitor the temperature of the compost process heated with a 1000 watt heating element. Electricity is controlled through the heating element to control the temperature of the heating coil. The thermal energy produced by the atomizer is directly proportional to the square of the current through the heating coil. Therefore, by controlling the current through the heating coil, the heat generated by the heater is controlled. It is designed to regulate the temperature of the table from room temperature to 100 ° C with the most suitable control range between 30 °C and 100 °C. Different types of controller are used with solar distillation systems.

If the temperature of the electric heater is higher than the set temperature, the electric heater will turn OFF and if the temperature is lower than the specified value, the electric heater will ON. Thus, the temperature of the electric heater is maintained at a predetermined temperature. It also has a safety feature that detects at very high temperatures.

4. Result and Discussion

Temperatures (°C) are measured 10 minutes apart using different fan speeds and initial temperatures was 27.6 °C. The temperature is recorded with the help of the digital temperature controller device and the fan speed is measured by a digital tachometer. The temperature (°C) in relation to time (minutes) is experimentally analyzed using a fan with different speeds such as 200, 400, 600, 800, 1000, 1200 and 1400 RPM which is shown in Table 1-7 respectively, and it is also shown in Figure.8-14. It is observed that the temperature is increased with respect to time (10-60 minutes) using a fan with a speed of 200, 400, 600, 800 and 1000 RPM. It is also observed that the temperatures are increased with respect to time (10-30 minutes) using a fan with a speed of 1200 RPM and the temperatures are constant as 62.3 °C with respect to time (40-60 minutes) using the same fan speed. It is also observed that the temperature is high with respect to time (10-60 minutes) using a fan with a speed of 1400 RPM. It was found that the temperature was maintained at 62.3 °C versus time (40-60 minutes) using fan speeds of 1200 rpm as shown in Table 6 and Figure 13. It was concluded that the temperature was maintained at 62.3 ° C over time (40-60 minutes), which is suitable for solar still system.

Table.1 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 200 RPM

Sl. No.	**Time (minutes)**	**Temperature (°C)**
1	10	36.2
2	20	42.6
3	30	44.5
4	40	46.3
5	50	48.9
6	60	51.2

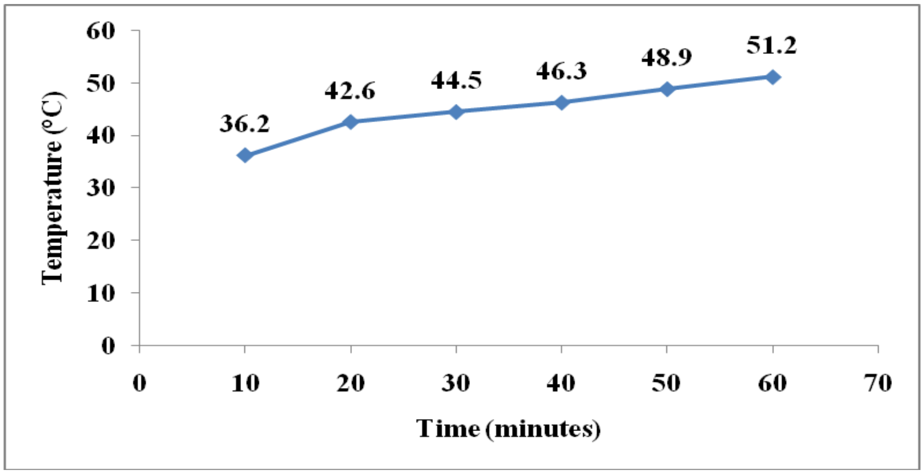


Figure.8 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 200 RPM

Table.2 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 400 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	38.5
2	20	43.2
3	30	45.6
4	40	47.8
5	50	50.2
6	60	52.6

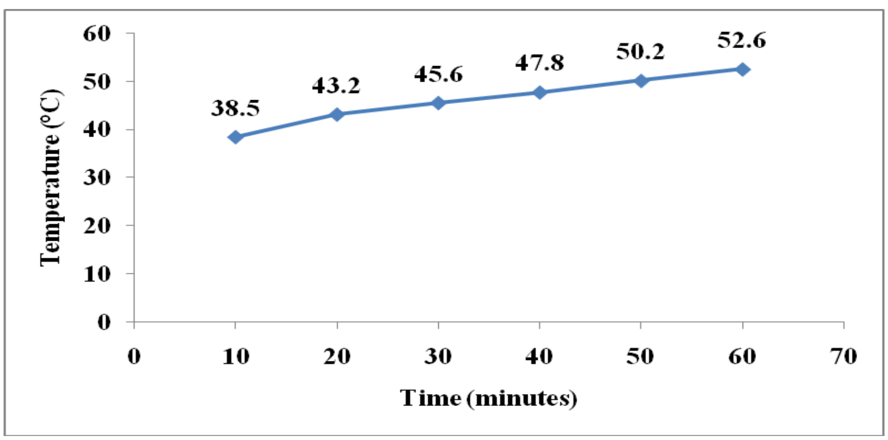


Figure.9 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 400 RPM

Table.3 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 600 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	40.6
2	20	44.5
3	30	48.6
4	40	49.5
5	50	52.3

6	60	55.2

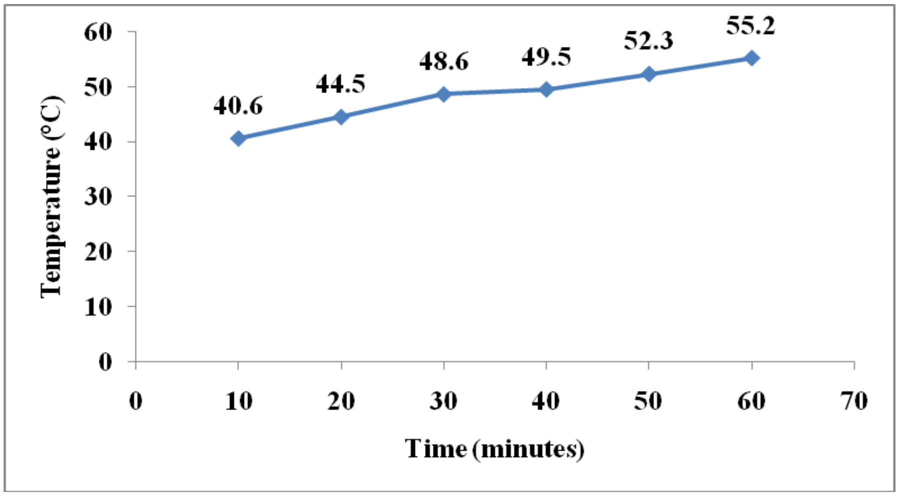


Figure.10 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 600 RPM

Table.4 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 800 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	41.6
2	20	46.3
3	30	49.6
4	40	51.6
5	50	53.6
6	60	59.3

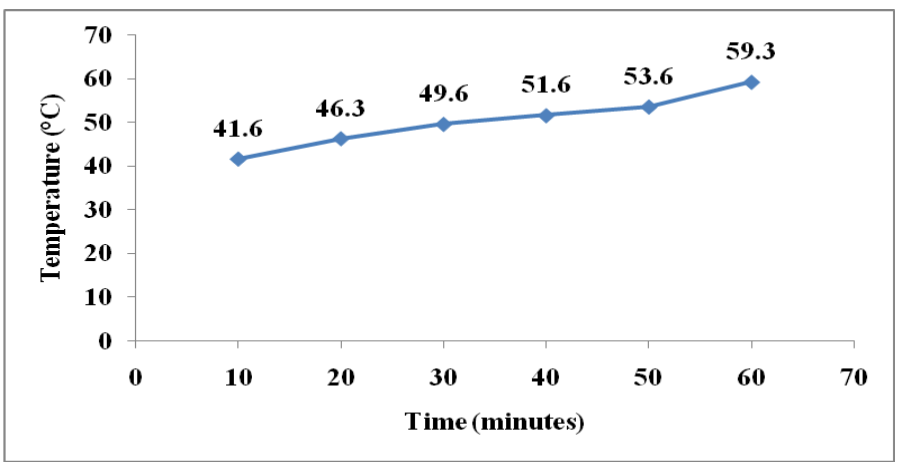


Figure.11 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 800 RPM

Table.5 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1000 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	43.6
2	20	48.9
3	30	51.2
4	40	53.8
5	50	56.9
6	60	61.2

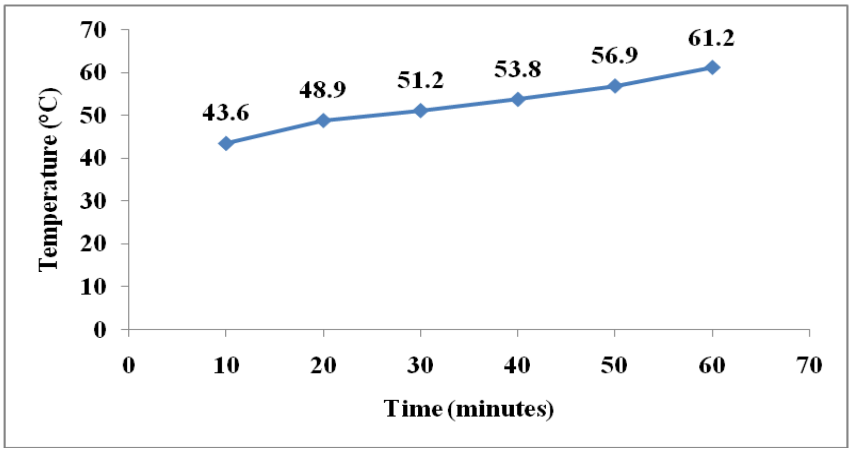


Figure.12 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1000 RPM

Table.6 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1200 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	48.5
2	20	50.2
3	30	58.9
4	40	62.3
5	50	62.3
6	60	62.3

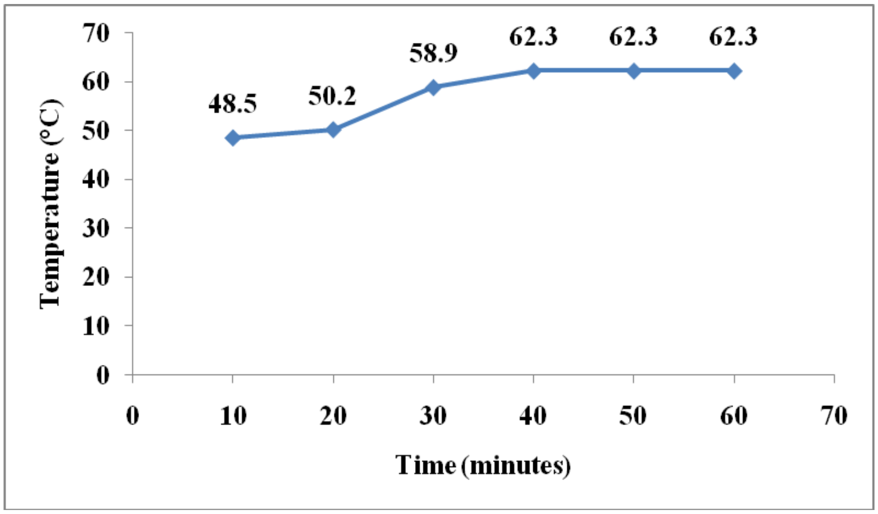


Figure.13 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1200 RPM

Table.7 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1400 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	50.3
2	20	51.6
3	30	60.2
4	40	64.2
5	50	68.9
6	60	69.8

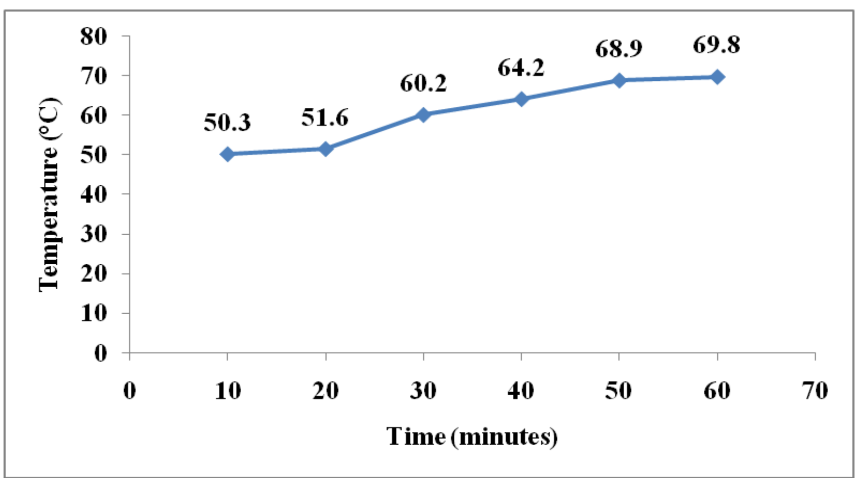


Figure.14 Recorded Temperature (°C) with respect to Time (minutes) using constant fan speed of 1400 RPM

5. Conclusions

Peripheral Interface Controller (PIC) is an automatic temperature control system used to improve the operation of the automation feature. The electrical resistance turns on automatically when it is below the defined limit, the temperature will be monitored from the thermocouple temperature sensor, which will control the electrical resistance according to the programmed configuration value. Using the fan at speeds of 200, 400, 400, 400 and 1000 rpm, the temperature increases over time (10–60 minutes). It is also observed that temperatures are increased as a function of time (10-30 minutes) using a fan with a speed of 1200 RPM and temperatures are constant at 62.3 °C relative to time (40-60 minutes) using the same fan speed. It was also observed that the temperature was higher with the fan speed of 1400 rpm over time (10–60 minutes). It was found that the temperature was maintained at 62.3 °C (40-60 minutes) at a speed of 1200 revolutions as shown in Table 6 and Figure 13, it was concluded that the temperature was maintained at 62.3 °C over time of 40-60 minutes, which is suitable for solar still systems.

References

[1] Ashraf M. Bassily and Gerald M. Colver, Modeling and performance analysis of an electric heater, international journal of energy research Int. J. Energy Res. 2004; 28:1269–1291.

[2] Raheleh Nowzari et al. Single and double pass solar air heaters with partially perforated cover and packed mesh, Science Direct, Energy 73 (2014) 694-702.

[3] Abhishek Priyam and Prabha Chand, Thermal and thermohydraulic performance of wavy finned absorber solar air heater, Solar Energy 130 (2016) 250–259.

[4] Rajendra Karwa and Girish Chitoshiya, Performance study of solar air heater having v-down discrete ribs on absorber plate, Science Direct, Energy 55 (2013) 939-955.

[5] Qusay A. Jawad et.al, Improve the performance of a solar air heater by adding aluminum chip, paraffin wax, and nano-SiC, Science Direct, Case Studies in Thermal Engineering 19 (2020) 100622.

[6] Hitesh Panchal et.al, Experimental investigation on the yield of solar still using manganese oxide nanoparticles coated absorber, Science Direct, Case Studies in Thermal Engineering 25 (2021) 100905.

[7] Ali M. Aqlan et.al, Solar-powered desalination, a novel solar still directly connected to solar parabolic trough, Science Direct, Energy Reports 7 (2021) 2245–2254.

[8] Messaoud Sandali et.al, Improvement of the Thermal Performance of Solar Drying Systems Using Different Techniques: A Review, Journal of Solar Energy Engineering, October 2019, Vol. 141 / 050802-1.

[9] Foued Chabane et.al, Experimental study of heat transfer and thermal performance with longitudinal fins of solar air heater, Journal of Advanced Research (2014) 5, 183–192.

[10] T. Rajaseenivasan et.al, Glass basin solar still with integrated preheated water supply Theoretical and experimental investigation, Science Direct, Desalination 398 (2016) 214–221.