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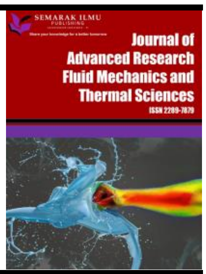

The Effect of Rain on Porous Pavers Daily Temperature Reduction and Environmental Performances

Xiao Xiao[1], Abdul Naser Abdul Ghani[1,*]

[1] School of Housing Building and Planning, Universiti Sains Malaysia, 11800 Penang, Malaysia

ARTICLE INFO	ABSTRACT

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Porous paver is becoming the new trend for outdoor paving material. The perceived benefits are mostly related to surface runoff and flood management. At the same time, pavement, porous or otherwise, is the source of increasing temperature in the outdoor environment. How does the wetting of porous pavers from rain help reduce especially the overall environmental temperature remain to be further enlightened. This study observed and measured the pavers and environmental temperatures variations in the same plot during the same time period, as well as their temperatures after rainfall event. By analyzing and transforming the collected data into heat map, charts and mathematical relationship, the mechanism of the temperature reduction could be illustrated qualitatively and quantitatively. The results indicated that the temperature of porous paver is generally lower than that of conventional paver both after rain and without rain by 7.75%. While the environmental temperature of air above porous paver is also generally lower than that of conventional paver by 1.04%. The fact that rain could further reduce the environmental temperature, future works should be focused towards a wetting system for porous pavers during dry season. Porous paver is superior to conventional paver in terms of impact on environmental temperature and especially suitable for sidewalk, parking lot and other large area involving pedestrians and vehicular traffics.

Keywords:
Porous paver; temperature; rain; pavement

1. Introduction

In modern society, especially with the rapid development of world economy and technology in recent years, environmental problems are increasingly concerned. How to give people a comfortable living environment is a problem we should consider on the technical level. The construction industry and urbanization are responsible for a large part of the increasing urban heat island effect [1,2], and the use of cool pavements in a large urban area has become one of the solutions to this problem [3]. Research shows that permeable concrete does give off more heat on sunny days, but 25% to 30% less after it rains [4]. Porous pavements allow water to drain through during rainstorm and evaporate during hot, sunny weather. Evaporation keeps the pavement cooler because heat is pulled out from

* *Corresponding author.*
E-mail address: anaser@usm.my

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the pavement during hot weather, changing water from liquid to gas when water is present in or on top of the pavement [5]. Evaporative pavements use the evaporation of water to carry heat away from the pavement [6]. The porous paver has many small holes and a cellular grid structure inside, its thermal conductivity and infiltration rate are higher relative to conventional pavers [4,17,18]. Porous paver has three main characteristics: albedo, thermal emittance, cooling through evaporation. In this study, the effect of rainwater on the temperature reduction of porous pavers and the air above them is studied from the aspects of thermal emittance and evaporation.

This research uses heat maps and charts to illustrate the effect of rain on porous pavers temperature reduction and environmental performances. That is to say, during the study, different colors are used to indicate the changes of different temperatures of the ground and air around the building. The heat maps can visually present the temperatures of the pavers and air, so that people have an intuitive perception of the effect of porous pavers on surrounding temperature reduction. While this paper is to study the main characteristics of porous pavers, and the air temperature above porous pavers are analyzed and show how it influences the environment.

Through the study of thermal emittance and evaporation, this paper studies how rain cools the porous pavers and its influence on the ambient temperature, so as to reduce the urban heat island effect. The thermal emittance of a material indicates how much heat it will emit per unit area at a particular temperature, or how easily a surface will shed heat. Any surface that comes into contact with radiant energy will heat up until it reaches thermal equilibrium (i.e., gives off as much heat as it receives). A surface with a high emittance will reach thermal equilibrium at a lower temperature than a surface with a low emittance when exposed to sunlight [7], since the high-emittance surface gives off its heat more readily. Evaporative cooling can lower temperatures when porous pavers are wet [7]. The concept of evaporative cooling is well known in the air conditioning industry [8,9]. In the case of pavement, water seeps into the spaces and into the soil or supporting materials below. Similar to evaporative cooling from vegetative land cover, moisture inside the pavement structure evaporates as the surface heats, pulling heat off of the pavement. Several methods can be used to keep the pavement cool, namely: increase pavement surface reflectance, increase pavement thermal emittance, increase pavement surface convection, evaporation cooling, shading pavements [7,10,11].

This study, by investigating and demonstrating the effect of rain on the porous pavers daily temperature reduction and the environmental performances, has important implications for improving technology to produce more efficient and environmentally friendly porous pavers and reduce the cost, which is conducive to promotion and wide use. Public spaces, pool areas, alfresco and patio areas, environmentally-friendly building projects, driveways, shopping centers, entrances, commercial and industrial storage facilities are the places where porous pavers can be widely used. And especially a wetting system for porous pavers should be set up. Usually, the most frequently used method is rewetting the pavement with sprinkler or roadside sprinkle pipe [12]. Therefore, practical and cost-effective methods are needed to reduce surface temperature of porous pavement and extend the application of porous pavement in alleviating urban heat island effect.

2. Methodology

2.1 Material

Porous pavers generally are a cellular grid system and have many small holes inside. The size of this kind of porous pavers is 200*100*60mm, that is to say 50 bricks per square meter. And the ingredients are mainly cement and sand. As shown in Figure 1.

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Fig. 1. Porous paver and its construction

2.2 Instrumentation and Site

The instruments are a temperature sensor and a galvanic couple. As in Figure 2 and Figure 3. The temperature sensor connects with a galvanic couple, turn on the temperature sensor, the end of the galvanic couple touches the pavers, then the temperature data is shown on the screen.

Fig. 2. Temperature Sensor

Fig. 3. Galvanic Couple

A plot of land in front of a residential building with a street front was chosen as the test site. As shown in Figure 4. This site is in the west section of Renmin Avenue, Anyang city, Henan Province, China. This site is a regular rectangle. The site is made up of two parts, porous pavers are laid on the outside near the main road and conventional pavers are laid on the inside near the building. The road is east-west direction.

Since porous pavers and conventional pavers are adjacent, they have similar ground conditions. Because it is the same piece of land, the drainage conditions are the same, the sunshine conditions are the same, the shade conditions are similar, and the effects of wind are the same, so the temperature of porous pavers and conventional pavers measured at the same time are comparable. The same effect of drainage and infiltration also makes the temperature of porous pavers and conventional pavers measured after rain comparable.

Fig. 4. A view of the site from above

2.3 Methods and Data Collection

This study starts with field observations and experiments. The site is divided into 14 parts of similar size, 7 parts are porous pavers, 7 parts are conventional pavers, respectively measured the temperatures of these 14 pieces of land in 24 hours, every hour once. Then, divide the site into 10 plots of similar size to measure the temperatures of the air above the pavers. Air temperatures were respectively measured at the height of 0.3m 1m and 1.5m above each plot. Measure the temperatures in the same day every two hours once, 12 times in total 24 hours. As shown in Figure 5.

The same temperature tests were carried out twice, that is, over two days, on May 13, just after it rained, and on May 16, when it was sunny. In the year 2022. Temperatures were similar on both days, with highs around 28°C and lows around 13°C. It is reported that the cooling effect of permeable pavement can last for 1–2 days after a single rainfall [13,14].

Then the data are made into heat maps and charts to be analyzed. In the heat maps, different colors represent different temperatures. The warmer the color, the higher the temperature. By comparing the data when no rain and when after rain, and making the data into mathematical relationship, the effect of rain on the porous pavers' temperature reduction and the environmental performances and its mechanism could be obtained.

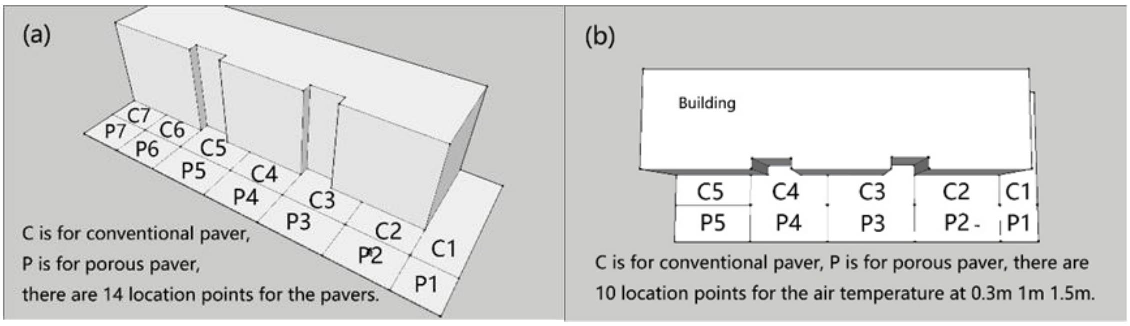


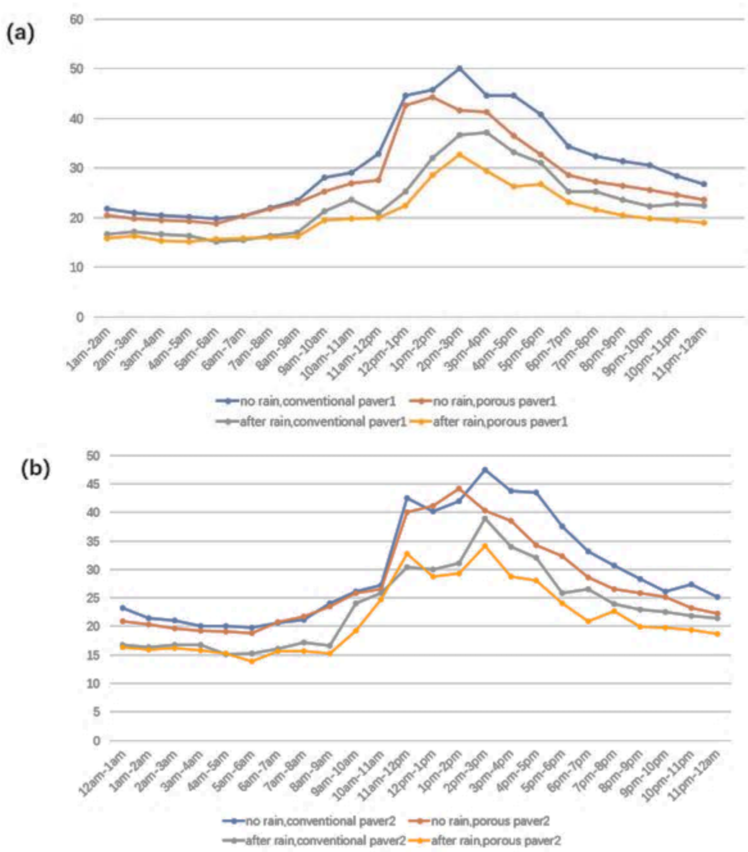
Fig. 5. (a) Sketch map for how to collect temperature data of pavers (b) Sketch map for how to collect temperature data of the air

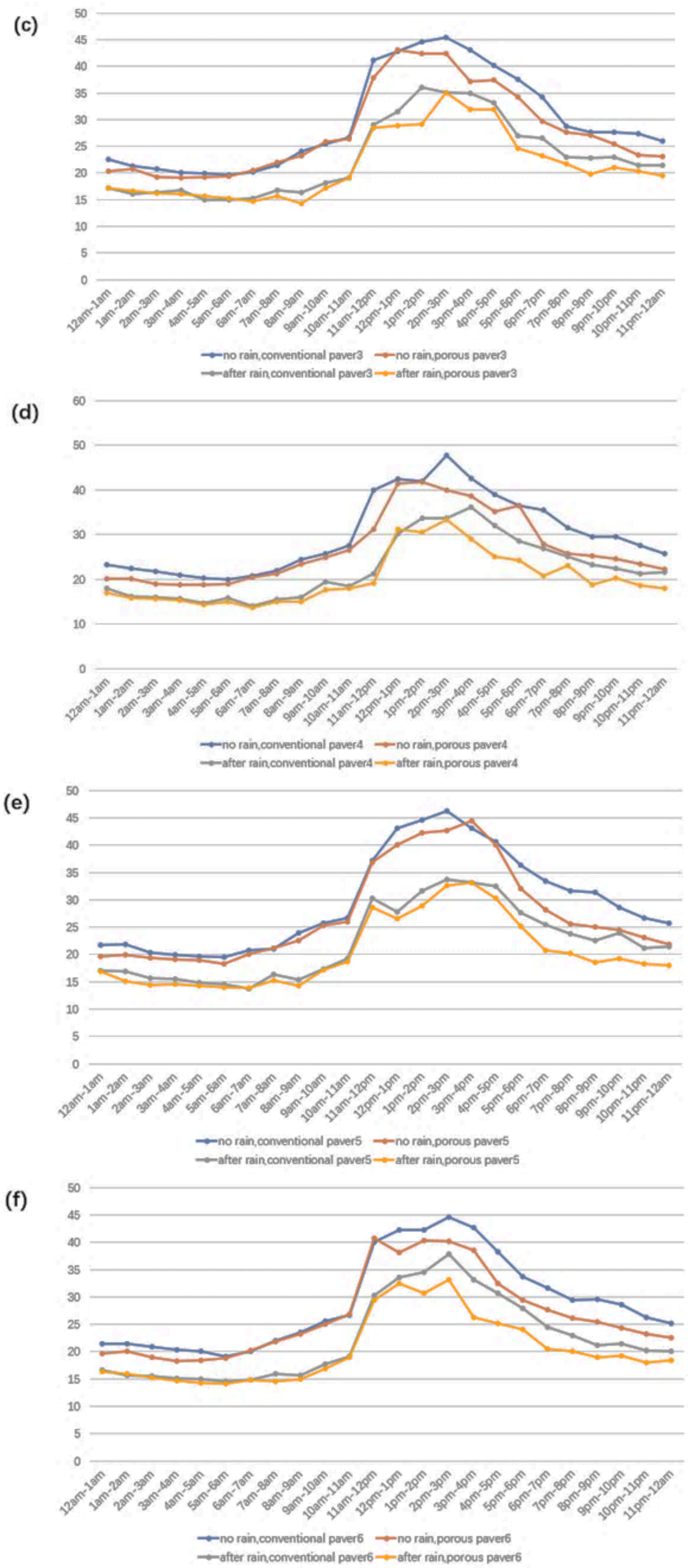
3. Results and Discussion

3.1 Temperature Variations

The line charts in Figure 6 show the collected temperature data of porous pavers and conventional pavers, after rain and without rain. When there is no rain, the temperatures of porous pavers are generally lower than that of conventional pavers. This shows that under the same conditions, the temperatures of porous paver are indeed lower than that of conventional paver. This is because porous paver has a lot of tiny holes in interior, its coming loose heat performance is better, thermal conductivity is higher. Both heat up and cool down faster. Additionally, it can be seen that rain will cause the temperatures of both porous and conventional pavers to drop a lot. Much heat is taken away by rainwater from both the porous pavers and conventional pavers, causing the reduction of their temperatures. After it rains, the temperatures of porous pavers are also generally lower than that of conventional pavers.

This is because there are many holes in the interior of the porous pavers. This porous structure system allows the rainwater flow into the void of the porous pavers after rain. In this process, the rainwater is easier to take away a lot of heat, and many holes also cause more intense evaporation, which also takes away a lot of heat. The evaporation rate of porous paver is higher. The rainwater then drains into the support structures under the pavers, flowing into the underground drainage system. This is the reason why the temperatures of porous pavers are lower than that of conventional pavers after rain. Moreover, the temperatures of porous pavers are lower than that of conventional pavers when it does not rain. This is because there are a lot of space inside the porous pavers because of the small holes, so it has rough surface, surface area of the porous paver is bigger. The internal porosity is filled with air, which makes the materials of porous pavers heated by sunlight are easier to emit heat to the air, so that the porous pavers are at a lower temperature to reach thermal equilibrium, so the temperatures of porous pavers are lower than that of conventional pavers. That is to say, the thermal emittance of porous pavers is higher. At the same time, porous pavers have a greater convection effect with air due to their larger surface area, which also makes them cooler. Compared with conventional pavers, the advantage of porous pavers is preliminarily reflected.




(c)
no rain,conventional paver3
no rain,porous paver3
after rain,conventional paver3
after rain,porous paver3
(d)
no rain,conventional paver4
no rain,porous paver4
after rain,conventional paver4
after rain,porous paver4
(e)
no rain,conventional paver5
no rain,porous paver5
after rain,conventional paver5
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(f)
no rain,conventional paver6
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after rain,conventional paver6
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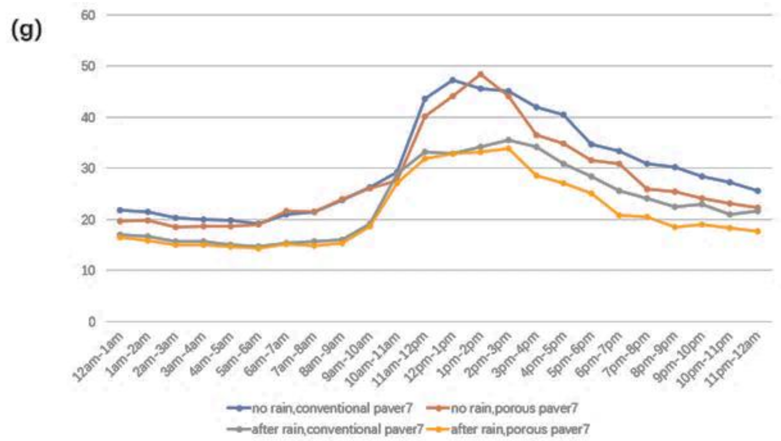
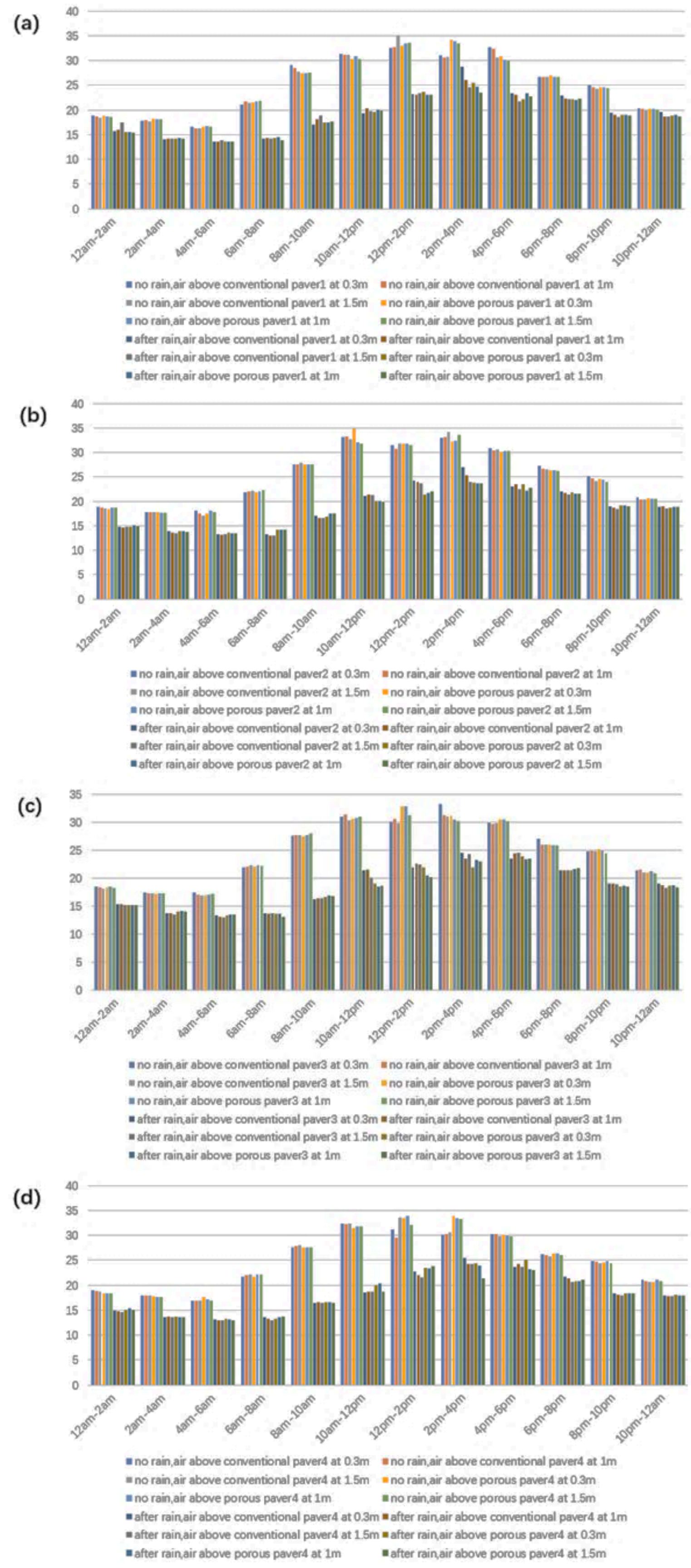


Fig. 6. (a) Temperatures of pavers 1 (b) Temperatures of pavers 2 (c) Temperatures of pavers 3 (d) Temperatures of pavers 4 (e) Temperatures of pavers 5 (f) Temperatures of pavers 6 (g) Temperatures of pavers 7

The bar charts in Figure 7 show the collected temperature data of the air above porous pavers and conventional pavers at 0.3m 1m 1.5m respectively, both after rain and without rain. The air temperatures don't vary as much as pavers temperatures, ranging from 13°C to 35°C. It is obvious from the charts that the air temperatures above the pavers when it is not raining are significantly higher than that after rain. The difference is particularly pronounced in the morning and noon, which can reach about 13°C. At night, the difference is smaller, about 3°C. This is because rain takes away much of the heat from pavers, and less heat is emitted into the air by the pavers [15,16]. The permeability is much stronger when after rain, rainwater goes though the pavers (both porous pavers and conventional pavers), rainwater is heated by the pavers, heat flows into the underground with rainwater. Consequently, the temperatures of the pavers are reduced, less heat can be emitted into the air, the thermal emission is much weaker, the conduction and radiation effect will be also weaker, so the air temperatures above ground are much lower when after rain than when there is no rain. Rain can greatly reduce the temperatures of the air above pavements.

When there is no rain, the air temperatures above the porous pavers are generally slightly higher than the air temperature above the conventional pavers. This is because the porous paver has many small holes inside, the surface area of porous paver is bigger than conventional paver, so the porous paver can easily emit more heat into the air than the conventional paver at the same time, causing the air temperature above porous paver is higher. And another reason is the convection. The surface of porous paver is rougher and contains more voids than conventional paver due to the many small holes in its interior. Roughness and additional voids increase the availability of surface area exposed to the air, thus creating circulating turbulence within the porous pavers. This improves the convection between air and porous paver, causing more heat is transferred into the air from porous pavers. Also, the thermal conductivity of porous pavers is higher. Therefore, when there is no rain, even though the temperatures of porous pavers are lower than that of conventional pavers, the temperatures of the air above porous pavers are higher than that of conventional pavers.

But the air temperatures above the porous pavers are generally slightly lower than the air temperatures above the conventional pavers when after rain, which may be because the porous paver has a lot of small holes inside, the rainwater goes through the porous pavers, taking away a lot of heat. Less heat will be transferred into the air from pavers by thermal emission and radiation. Additionally, the evaporation of porous pavers is stronger, evaporation rate becomes higher, heat is largely carried away from water as it evaporates into water vapor. As a result, the air temperatures above porous pavers are slightly lower than the air temperatures above conventional pavers when after rain.



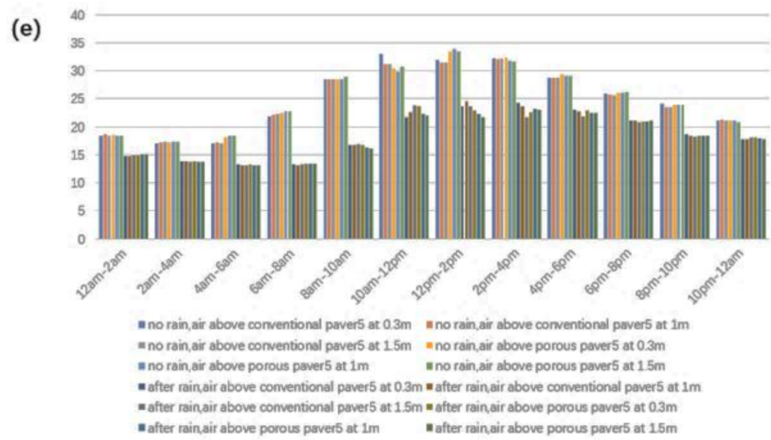


Fig. 7. (a) Temperatures of the air above paver 1 (b) Temperatures of the air above paver 2 (c) Temperatures of the air above paver 3 (d) Temperatures of the air above paver 4 (e) Temperatures of the air above paver 5

3.2 Heat Maps

Heat maps are made from the large amount of temperature data collected. In these heat maps, the color changes show the temperature distribution and changes of site during the experiment time period.

It can be seen from the heat maps in Figure 8 that temperatures are lower at night and higher during the daytime. Porous pavers at night cool faster, and in the daytime heating up faster and faster. Because the porous paver has many small internal holes to make it have a lot of space and internal air, also make its density is very low, when the environment temperature drops at night, with the decrease of the air temperature inside the porous paver, more heat more easily from porous paver is sending out to air, heat emission will increase, more intense than conventional paver. Porous paver has a smaller heat capacity than conventional pavers. At the same time, because the holes of porous paver make its surface area increase, the heat conduction and heat radiation of porous paver are stronger. The heat transferred into the air will soon dissipate into the atmosphere. Conversely, when daytime temperatures rise, the temperatures of the porous pavers also rise faster. Comparing the porous and conventional pavers, we can see that the temperatures of the porous pavers on the outside are generally lower than that of the conventional pavers on the inside, and almost in every period of time, the temperatures of the porous pavers are lower than that of the conventional pavers. This is because the small holes inside the porous paver make it have a larger surface area, and heat is easier to emit into the air from the pavers at the same time, so that the temperatures of the porous pavers are lower than that of the conventional pavers when the thermal equilibrium is reached, that is to say, the thermal emittance of the porous paver is higher. Additionally, the small holes and larger surface area make the evaporation of porous pavers more intense, the evaporation rate is higher.

After rain the temperatures of pavers are generally much lower than the temperatures of pavers when no rain. Both conventional pavers and porous pavers were cooler than when it didn't rain, even though the weather were similar. Rain can greatly reduce the temperatures of pavers. Because rain takes away a lot of heat, heat seeps into the soil or underground drainage systems with rainwater. After rain, the evaporation effect could be enhanced, heat turns some of the water into water vapor. Another phenomenon is the temperatures of pavers decrease obviously after it rains, but the decrease is small at night, and the decrease is great during the daytime, especially at noon. The lowest temperature occurs at night, when the sun is not shining and the ambient temperature is low, so evaporation is lower than during the day. During the daytime, the sun is very direct, the ambient temperature and the pavers temperatures are very high, which causes the evaporation to be very strong, and much stronger than at night. As a result, more heat is taken away by evaporation, which turns the water into water vapor.

It should be noted that after rain, the temperatures of porous pavers drop even lower, by an average of 4 °C to 16 °C, compared with 2 °C to 14 °C for conventional pavers. In the porous pavers, more heat is carried away by the rain, because the porous paver has many pores inside, the interconnected voids make more rainwater into the pavers when the rainwater flow through the porous pavers, the infiltration rate of porous pavers is higher [17]. At the same time, the surface area of the porous paver is larger, the area of the porous pavers exposed to the air is also larger, so the evaporation rate is higher, so during the same time period more heat is taken away due to the evaporation effect. Therefore, when the rain flows through the pavers, the heat in the porous pavers is carried away more than the heat in the conventional pavers, which is why the temperatures of the porous pavers drop more than the conventional pavers after rain.

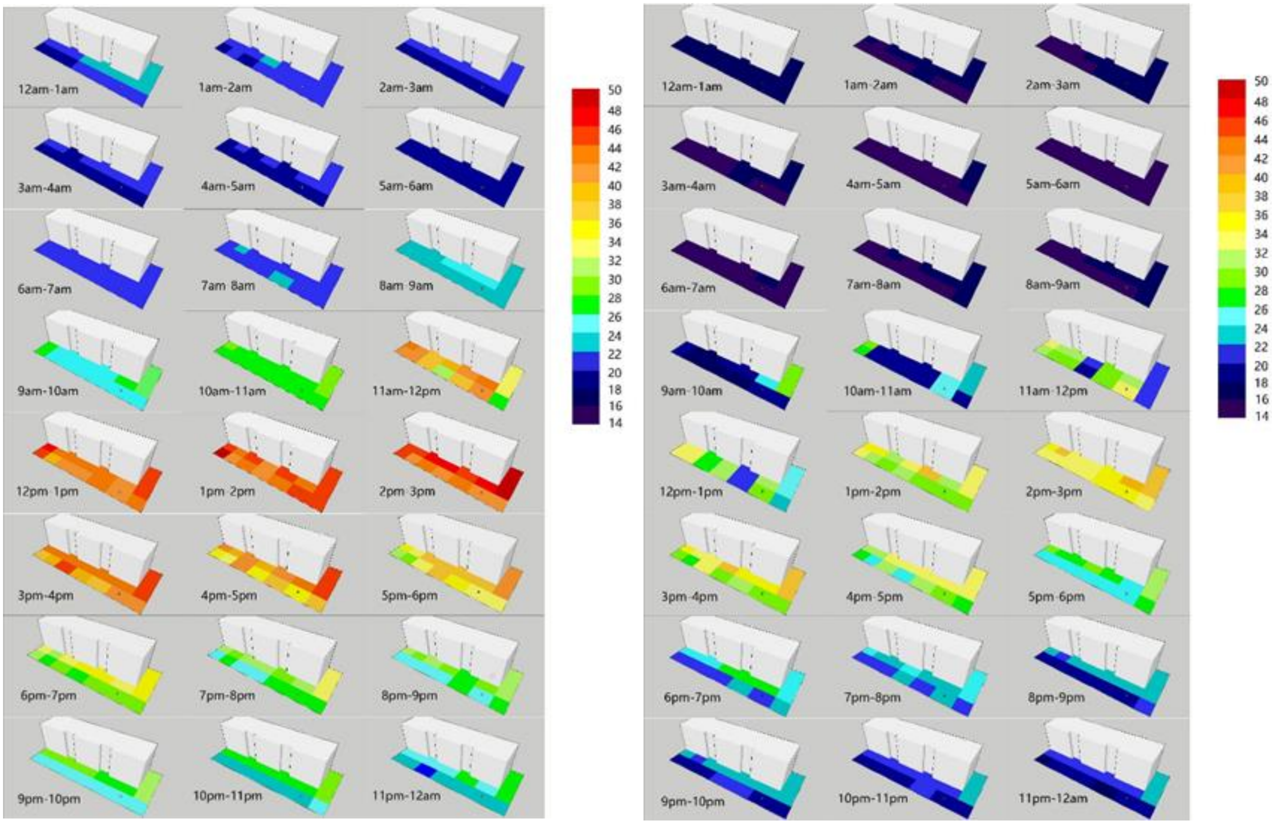


Fig. 8. Heat maps for pavers when no rain (left) and after rain (right)

As can be seen from the heat maps in Figure 9, basically the air temperatures above the porous pavers are higher than the air temperatures above the conventional pavers when no rain, but on the contrary, the air temperatures above the porous pavers are generally lower than that of the conventional pavers when after rain, while the air temperatures above both porous pavers and conventional pavers decrease a lot after rain. Because there are many tiny pores inside the porous paver, its surface area is larger. Heat can be transferred from porous paver into the air more easily and faster than conventional paver due to the stronger thermal emission, causing the air temperatures above the porous pavers are slightly higher than the air temperatures above the conventional pavers when no rain. At last, heat is lost to the atmosphere. After rain, a lot of heat is taken away by rainwater, then flowing into the underground drainage system. More intense evaporation after rain also takes away much heat. Less heat can be emitted into the air above, so the air temperatures above both porous and conventional pavers decrease a lot. Because of the inside voids and the larger surface area of the porous paver, when rainwater flow through porous pavers, more heat can be taken away more easily, and the evaporation rate in porous pavers is higher than that in conventional pavers [16]. Because the contact area of water and pavers is larger. The rain removes a great deal of heat, reducing both the conduction and emission of the heat of the porous pavers into the air, while evaporation further cools the air. These effects are more pronounced the closer to the ground. Therefore, the air temperatures above porous pavers are generally lower than the air temperatures above conventional pavers when after rain. This is the mechanism by which porous pavers can lower the ambient temperature, thus reducing the urban heat island effect.

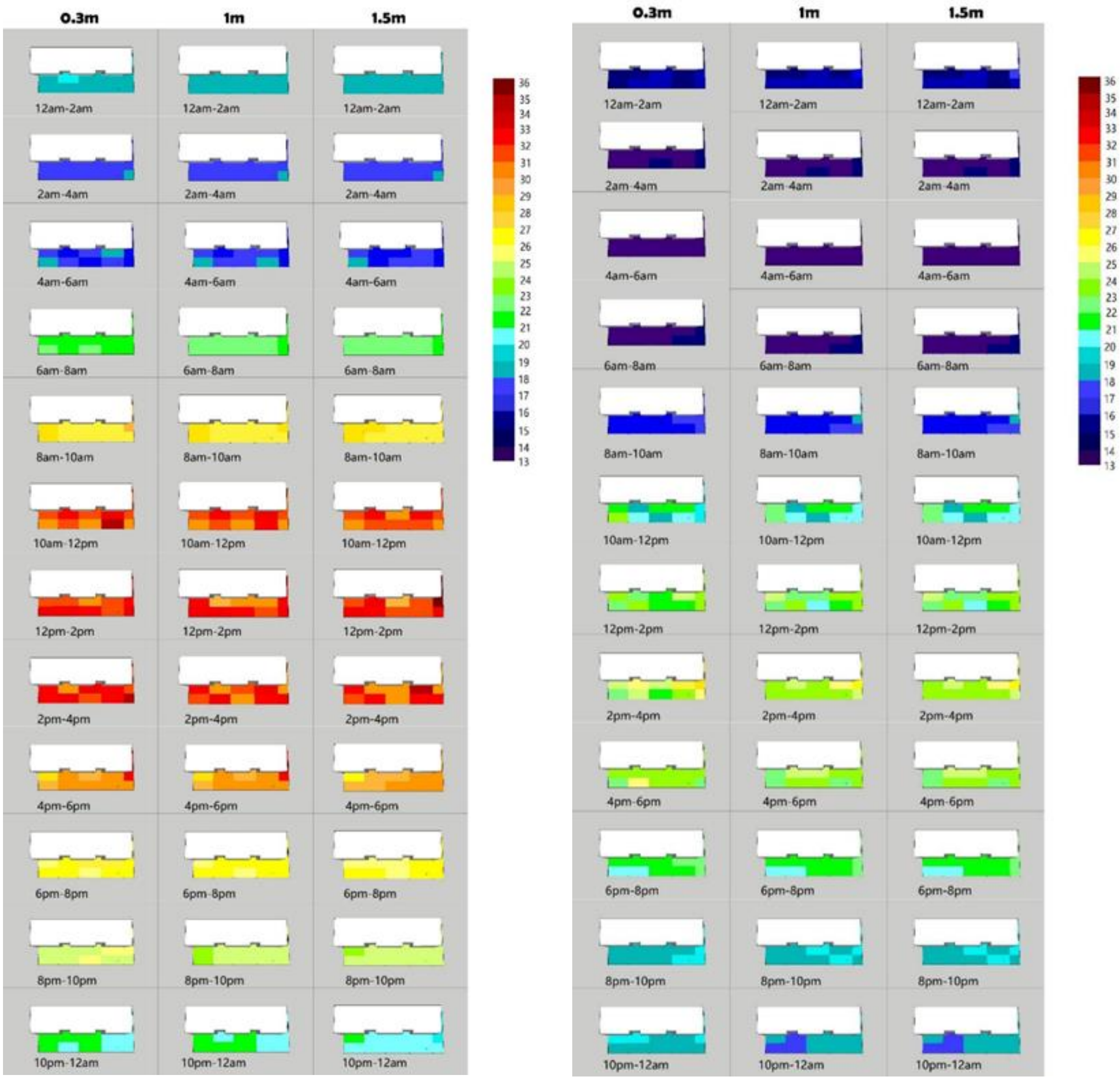


Fig. 9. Heat maps for the air at 0.3m 1m 1.5m, when no rain (left) and after rain (right)

3.3 Temperature Reduction

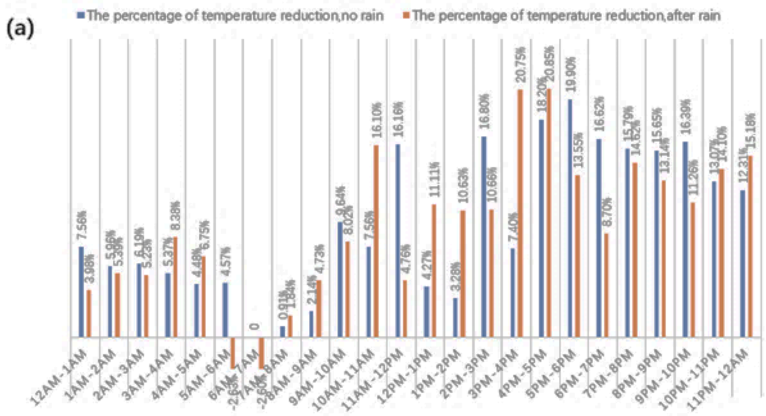
In order to analyze the temperature reduction of porous pavers compared with conventional pavers, the percentage of temperature reduction of porous pavers compared with conventional pavers can be calculated according to the following formula:

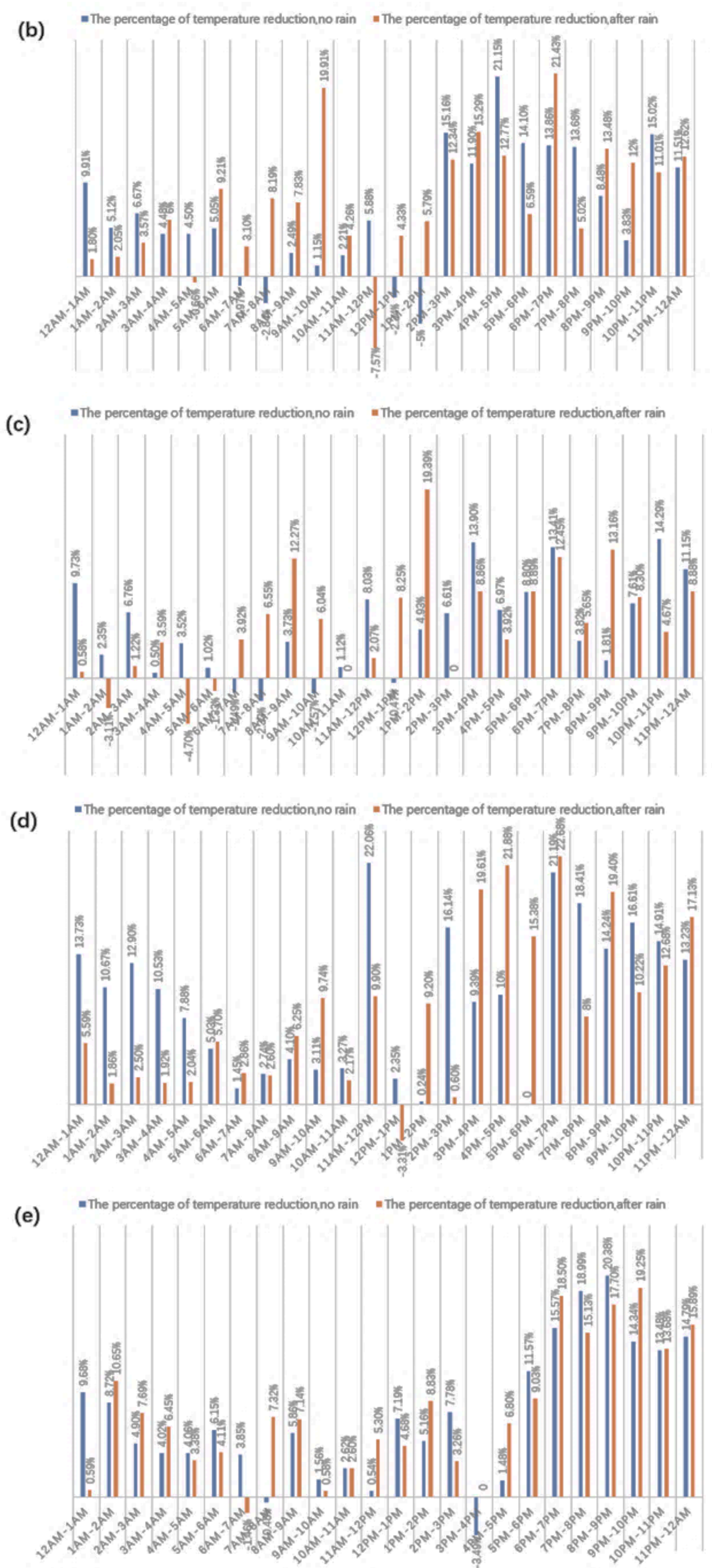
The percentage of temperature reduction= (the temperature of conventional paver – the temperature of porous paver) / the temperature of conventional paver * 100%

Compare adjacent porous pavers with conventional pavers, such as P1 and C1, P2 and C2, because they are in the same condition. Therefore, seven sets of data of after rain and seven sets of data of no rain can be obtained. Summarize the data into the charts. We can get 7 charts for the percentage of temperature reduction of the pavers, they are for paver1 to paver7. And we can study the thermal emittance characteristic for porous pavers through these charts. The charts are as in Figure 10.

As can be seen from the charts in Figure 10, the temperatures of porous pavers are generally lower compared with the conventional pavers both after rain and without rain. And the overall decrease rate of all the temperatures were between -7.57% and 22.69% when after rain, and between -6.37% and 21.19% when no rain. Calculate the average values of the percentages in temperature reduction without rain and after rain, the results indicate the temperature of porous paver is generally lower than that of conventional paver by 7.66% when no rain and by 7.84% after rain. So, the temperature of porous paver is generally lower than that of conventional paver by 7.75% both after rain and without rain. Apparently, the temperature difference between the porous and conventional pavers is greater after rain than when it does not rain. This may be due to the evaporation, where the concentration of water vapor affects the temperatures around the pavers and thus affects the thermal emittance. Both evaporation and thermal emission are stronger after rain.

The temperature difference between porous pavers and conventional pavers is larger at nighttime, between 10% and 20%, and the temperature difference between the two is smaller during the daytime, between 1% and 15%. Porous paver because of its porous characteristic, heat capacity is smaller, at night when the temperature is lower, the thermal emission is stronger, heat dissipation is faster. Porous paver has a higher thermal emittance than conventional paver at low temperature. That is to say, at night the temperatures of porous pavers are even lower. This also suggests that the effect of porous pavers on reducing the urban heat island effect is more pronounced at night.




(b)
The percentage of temperature reduction,no rain
The percentage of temperature reduction,after rain
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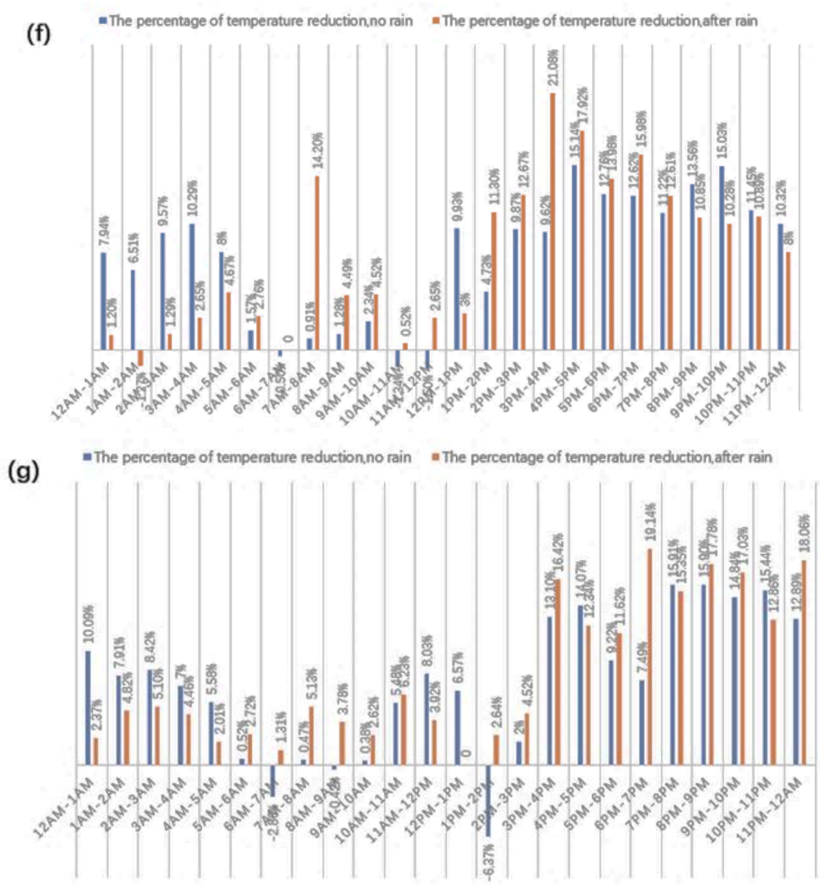


Fig. 10. The percentage of temperature reduction of (a) paver 1 (b) paver 2 (c) paver 3 (d) paver 4 (e) paver 5 (f) paver 6 (g) paver 7

3.4 Rain and Temperature Reduction

In order to analyze the temperature reduction for rain effect of porous pavers, the percentage of temperature reduction of porous pavers when after rain compared with when no rain can be calculated according to the following formula:

The percentage of temperature reduction for rain effect = (the temperature of porous paver when no rain – the temperature of porous paver when after rain) / the temperature of porous paver when no rain * 100%

In order to compare the rain effect with conventional pavers，the percentage of temperature reduction of conventional pavers for rain effect also need to be calculated:

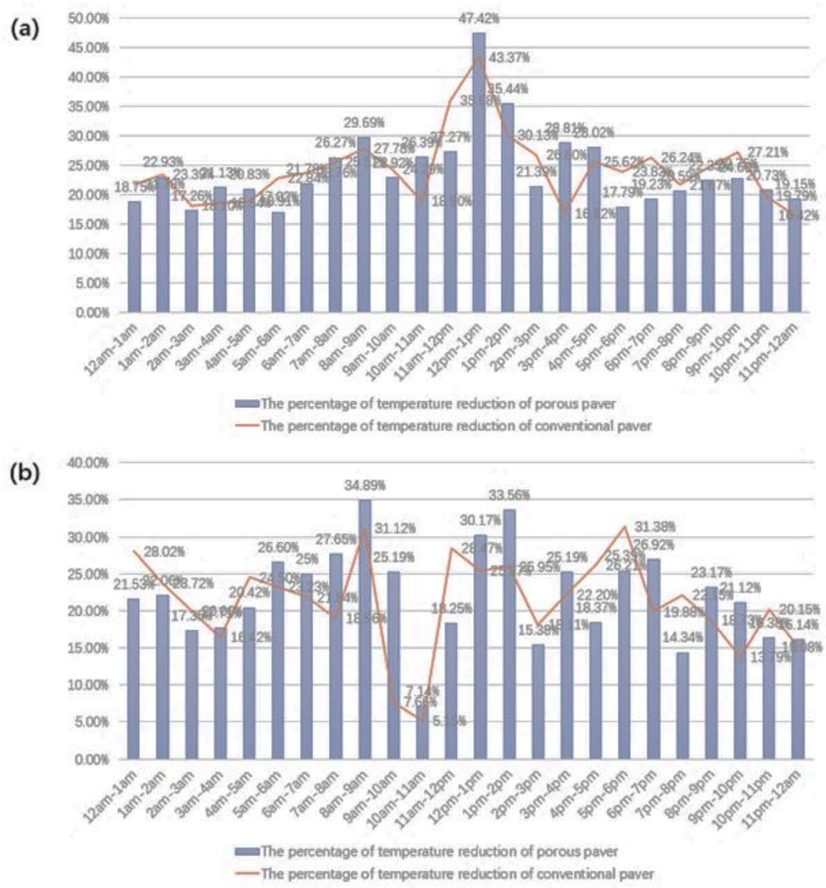
The percentage of temperature reduction for rain effect = (the temperature of conventional paver when no rain – the temperature of conventional paver when after rain) / the temperature of conventional paver when no rain * 100%

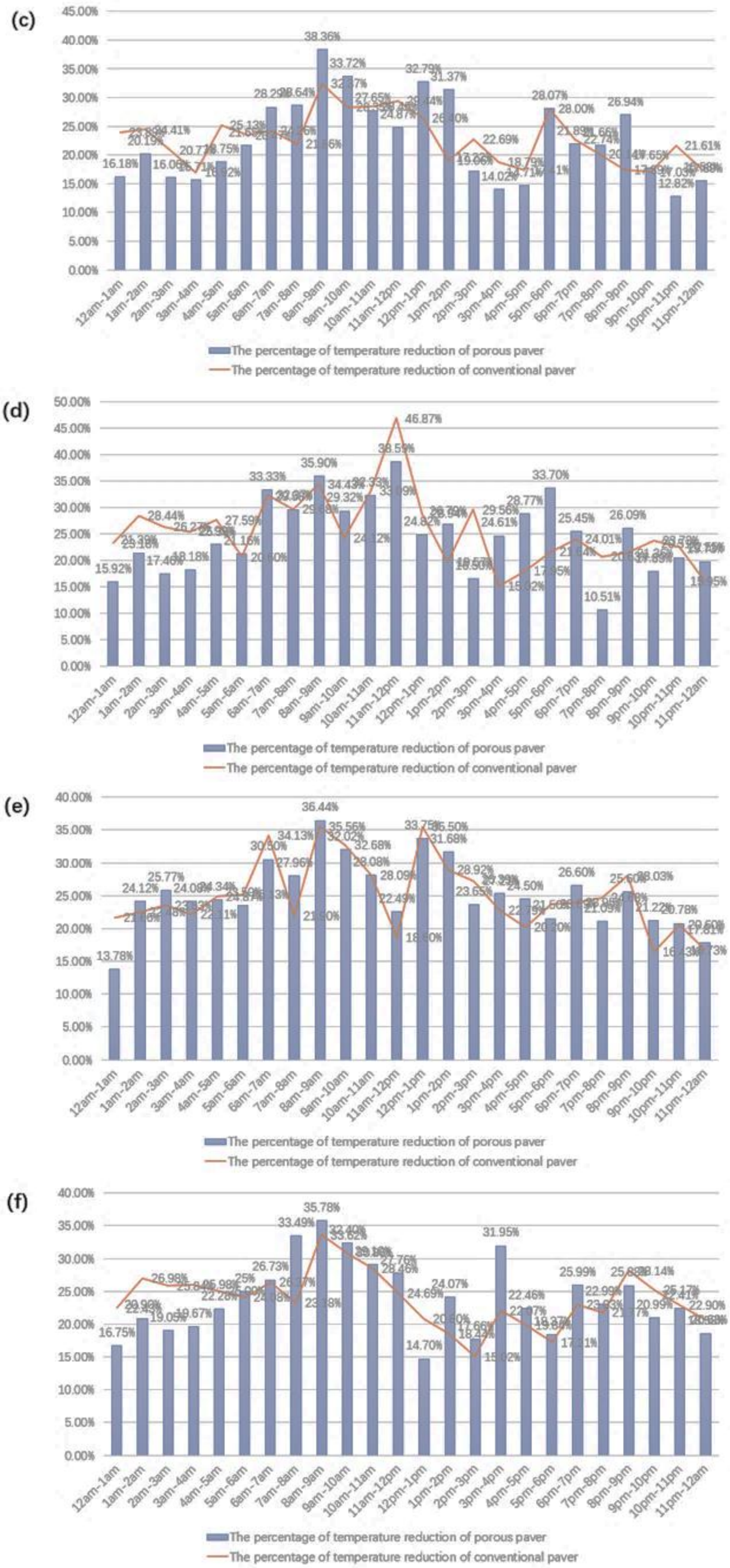
Therefore, seven sets of data of porous pavers and seven sets of data of conventional pavers can be obtained. Summarize the data into the charts. We can get 7 charts for the percentage of temperature reduction for rain effect both of the porous pavers and conventional pavers, they are for paver1 to paver7. These 7 charts show the percentages of temperature reduction for rain effect both of porous pavers and conventional pavers.

As can be seen from the seven charts in Figure 11, the temperatures of the porous pavers drop at a high percentage after rain, generally between 15% and 35%. This shows that rain has a great impact on the temperatures of porous pavers, which will undergo evaporation and lead to a significant reduction in temperature. The temperature of porous pavers under the effect of rain can be reduced by as much as 47.42% compared with that without rain, as the rain takes away a lot of heat and more intense evaporation.

Comparing the percentages of the temperature reduction for rain effect of the porous pavers with that of the conventional pavers, we can see that in most cases the porous pavers' are larger. This means that under the same conditions, porous pavers drop more temperature after rain than conventional pavers. In general, porous pavers have a stronger evaporation effect after rain, evaporation rate is higher, and the rainwater takes more heat away from porous pavers still because of the many small holes in porous paver.

These percentage values of porous pavers are larger during the daytime when the sun is shining, compared to conventional pavers. This shows that the evaporation action of porous pavers is stronger than that of conventional pavers in the daytime. But when there is no sun at night, conventional pavers lose a greater percentage of their temperature due to rain. This may be due to the occur of condensation. Porous pavers allow more water to stick to the inside of the small holes. However, the temperatures of porous pavers are still lower than that of conventional pavers at night after rain, but the decrease rate is not as large. In short, porous pavers are cooler than conventional pavers after rain, day and night. Especially during the day, the temperature decrease of porous pavers is more obvious than conventional pavers due do the rain effect. This shows that porous paver is a superior material than conventional paver in reducing the urban heat island effect.

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The percentage of temperature reduction of porous paver
The percentage of temperature reduction of conventional paver

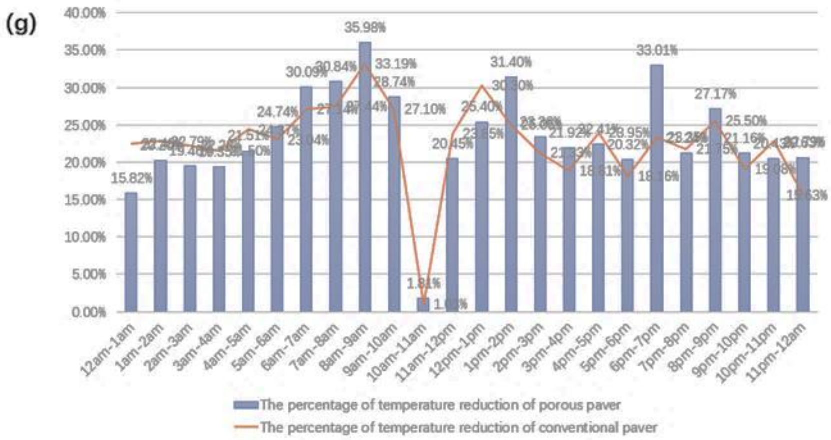


Fig. 11. The percentage of temperature reduction for rain effect of (a) paver 1 (b) paver 2 (c) paver 3 (d) paver 4 (e) paver 5 (f) paver 6 (g) paver 7

3.5 Rain and Air Temperature Reduction

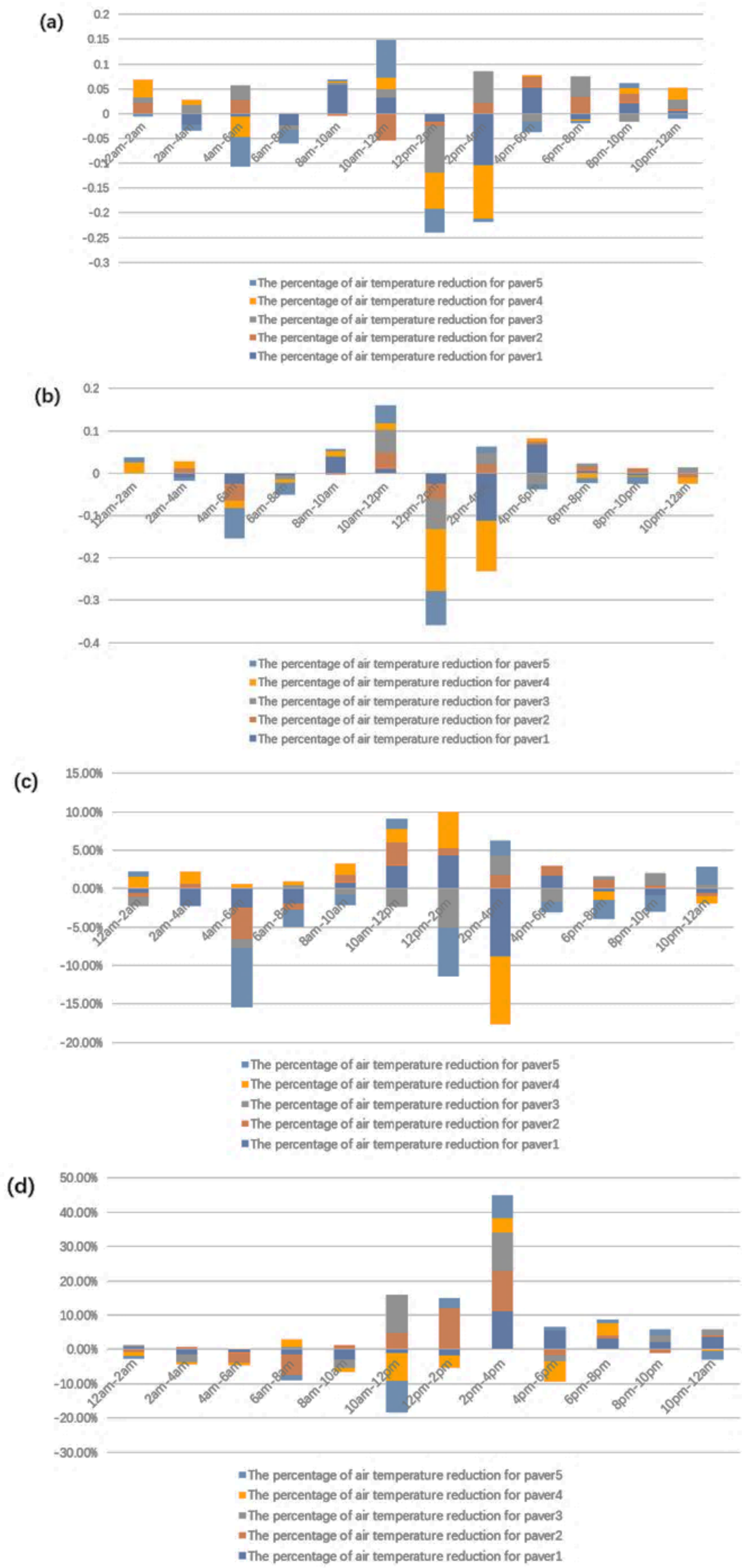
In order to analyze the effect of rain on air temperature reduction, the percentage of the air temperature reduction above porous pavers compared with the air temperature reduction above conventional pavers after rain and without rain should be calculated according to the following formula. The data were measured at 0.3m, 1m, 1.5m respectively, compare the air temperatures above adjacent porous pavers with conventional pavers at the same height, such as P1 and C1 at 0.3m, because they are in the same condition.

The percentage of air temperature reduction above pavers = (the air temperature above conventional paver – the air temperature above porous paver) / the air temperature above conventional paver * 100%

Calculate the percentage of air temperature above pavers at 0.3m, 1m, 1.5m, when there is no rain and after rain respectively. Then summarize the data into the charts, six charts could be obtained as shown in Figure 12.

Also, calculate the average value of the percentage of air temperature reduction above pavers, an average value of 0.3m, 1m and 1.5m, it can be realized that the average percentage of air temperature reduction when no rain is -0.44%, the average percentage of air temperature reduction when after rain is 0.60%. That is to say, when there is no rain the environmental temperature of air above porous pavers is generally higher than that of conventional pavers, by 0.44%, but after rain the air temperature above porous pavers is generally lower than that of conventional pavers, by 0.60%. Rain has a great impact on the environmental temperature reduction of air above porous pavers, the air temperature above porous pavers overall decrease 1.04% compared to after rain and without rain. The reasons have been introduced, here again has the data to support. The environmental temperature of air above porous pavers does higher than that of conventional pavers when no rain, but it can be greatly reduced by rain. In addition to lowering the temperature of the porous pavers themselves, rain can further reduce the temperature of the air above them, thereby lowering the environmental temperature. Therefore, keeping the porous pavers wet is especially important, thus helping to mitigate the urban heat island effect.

It is worth noting that when there is no rain, the percentage of air temperature increase of the porous pavers is much bigger during the daytime than at night, and after rain, the percentage of air temperature reduction of the porous pavers is still much bigger during the daytime than at night. In other words, the cooling effect of rain on the air temperature above the porous pavers is more obvious during the day than at night. This suggests that keeping the pavers wet is most effective during the daytime.



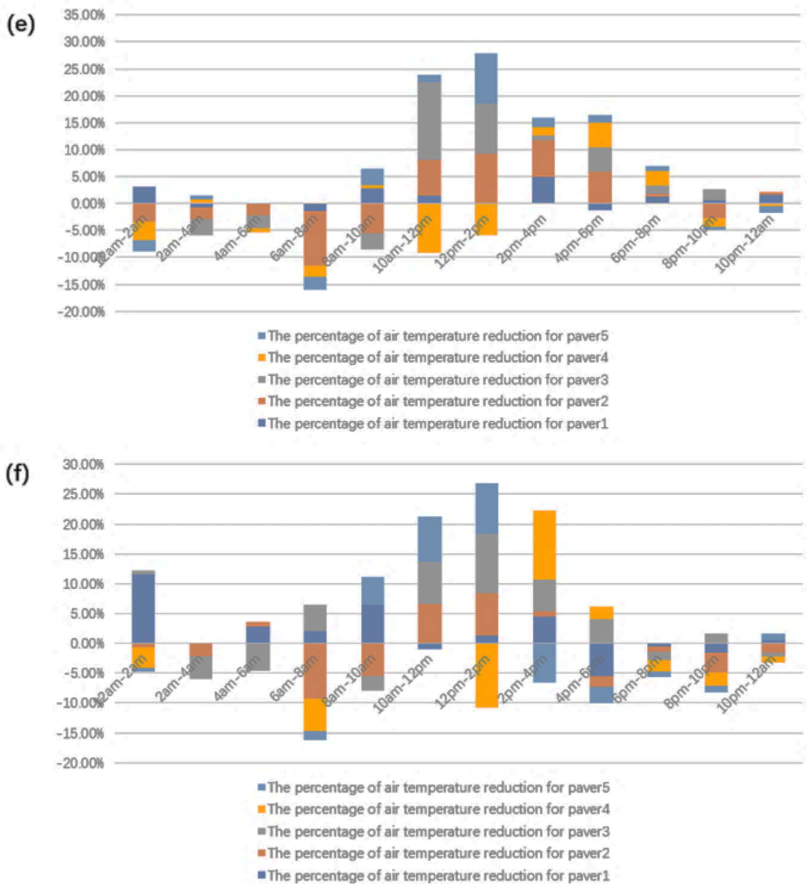


Fig.12. The percentages of air temperature reduction above pavers (a) at 0.3m no rain (b) at 1m no rain (c) at 1.5m no rain (d) at 0.3m after rain (e) at 1m after rain (f) at 1.5m after rain

4. Conclusions

Urban heat island effects cause climate change, affect water quality, damage the environment and harm people's health. In this study, while the heat maps allow for intuitive recognition of the temperature differences and changes of pavers and air, the analysis results show that the temperature of the porous pavers is generally lower than that of the conventional pavers both after rain and without rain, especially after rain. The air temperature above the porous pavers is generally higher than that of conventional pavers when no rain, but after rain, the air temperature above the porous pavers will be greatly reduced, generally lower than the air temperature above the conventional pavers. Rain has a significant effect on the cooling of porous pavers and the air above, as porous pavers have higher thermal emittance and evaporation rate than conventional pavers due to their porous characteristic. Porous pavers can help mitigate the urban heat island effects, especially at night time, a wetting system for porous pavers during dry season should be set up. Porous paver is superior to conventional paver in terms of impact on environmental temperature, and especially suitable for sidewalk, parking lot and other large area involving pedestrians and vehicular traffics.

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