


# Thermal Injuries Caused by Water from Loose Garden Hoses

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## Abstract

This is a monitoring research, the purpose of which is to point out the danger of scalding with water from loose garden hoses. All the stated data are the result of this research, which occurred during the month of August. To adequately compare the maximum temperature that the water reaches in garden hoses exposed to sunlight, 2 different surfaces were chosen, namely grass and concrete. It has been found that water in garden hoses, which lie in a place exposed to sunlight, is able to reach temperatures at which, in case of contact with human skin, there is a risk of scalding. The results confirmed the assumption that the temperature in the grass will be lower in the hoses than in the concrete surface. At an air temperature of 35°C, the water in the hoses on the grass reached a temperature of up to 47.3°C. On a concrete surface at an air temperature of 28.5°C, the water in the hoses reached 49.8°C. There is a risk of scalding from such hot water contact with the skin, and especially with sensitive baby skin. The aim of this research is to provide valid data on the risk of spilling hyperthermic water in free-lying garden hoses exposed to sunlight. The threat of scalding can occur unknowingly or through negligence, the risk of scalding with such water increases during tropical days significantly.

## Keywords

burns, scalds, garden hose, hyperthermic water, child

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## Introduction

Burns are among the most difficult conditions in human traumatology, both in terms of treatment and long-term consequences. The most endangered in terms of complications and consequences are extreme age groups, especially in children, the consequences of burns can affect the future quality of life. The main threat of childhood burns is improper adult supervision. A significant number of children's burns are due to child abuse.

Burns are defined as damage or destruction of the layers of body tissue that make up the skin, muscles, bones, and subcutaneous tissue. They are formed by direct contact, by the action of radiant energy, or by the action of electric current at temperatures approaching 50°C.<sup>1,2</sup> The most devastating injuries are caused by thermal effect. They are the fifth most common cause in terms of trauma mortality.<sup>3,4</sup> The Wallace rule of nines, used in adults and large children, is used to estimate the percentage of burned area affected. In young children, this rule cannot be used due to disproportions in the

child's body. More precisely, we determine the extent of the burned area according to the Lund-Browder table, which we can use for all age categories.<sup>1</sup>

In humans, cell death and tissue breakdown occur in contact burns that exceed 43.5°C. Another factor that contributes to burns in addition to temperature, is the duration of action.<sup>5</sup> The relation of the action of contact heat over-time to the occurrence of burns is illustrated in Figure 3.

Investigations into the consequences of accurately measured thermal injuries are not known. It is not possible to establish precise criteria for significant irreversible changes in an organism due to the variables of each

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**Table 1.** Selected Garden Hoses.

	No. 1	No. 2	No. 3	No. 4	No. 5
Length (cm)	801	808	804	806	996
Wall thickness (cm)	0.4	0.2	0.2	0.3	0.3
Inner diameter of hose (cm)	1.3	1.3	1.3	1.4	1.4
Volume (l)	4.25	4.29	4.27	4.96	6.13
Material	Rubber	PVC + polyester	PVC + polyester	PVC + polyester	PVC + polyester
Hose color	Black	Dark green	Light green	Blue	Blue

individual person. In balneology, total hyperthermic baths above 42.5°C are contraindicated due to the proven risk of overheating of the nucleus and thus damage primarily to the brain, liver. Elevated blood and extracellular fluid temperatures above 41.5°C lead to denaturation to necrosis of proteins in the central nervous system and liver with a lethal outcome.<sup>6</sup>

The research aims to prove that there is a risk of real scalding with water from a loose garden hose exposed to sunlight. The most common hoses surroundings surfaces are concrete and grass. Namely, concrete and grass. Grassland, which is a common part of gardens and flower beds at family houses, reflects approximately 20% of sunlight. The same common type of surface concrete reflects up to 50% of sunlight. The surface, which absorbs a higher dose of sunlight, heats up more and by subsequent radiation heats its surroundings as well. Garden hoses can be placed near the house in a way that the sun shines on them during the day, which leads to the heating of the water temperature in the garden hoses exposed to sunlight.<sup>7</sup> Improper manipulation and non-release of water when sprinkling a person may cause scalding of an exposed individual.

## Methods

Five different garden hoses were selected for the research, in which the temperature of their surface was measured. These garden hoses were chosen for their affordability and wide use by the public. For correct identification, the individual garden hoses were marked with a number and color. Four garden hoses were connected to 1 water source. Garden hose No. 5 was placed on a stand for garden hoses, so it did not lie directly on the grass/concrete surface like the others (Table 1).

The lengths of the individual garden hoses were adjusted so that they were all around 8 m (diameter 843 cm) and together with the length we evaluated the same volumes of water in the individual hoses. The only hose that was not modified to the same length as the remaining ones was hose No. 5, due to different placement (wound on a drum stand for hoses).

The research was conducted over 2 days. The first measurement was performed on a grassy area on Tuesday, August 11, 2020 in the Pardubice Region. On this day, the air temperature reached a maximum of 35°C, which is considered a tropical day in the Czech Republic. The average daily air temperature was 22.7°C. The measurement occurred on the concrete surface for the second time on Monday, August 17, 2020 in Prague. This day is evaluated in the Czech Republic as an average summer day. The daily temperature did not exceed 30°C. The average air temperature during this day was 20.2°C.<sup>8</sup>

Two certified thermometers were used to measure the surface temperature of the garden hoses and the water temperature. Parkside PTIA 1 infrared thermometer with a possible measuring range from -50°C to +380°C. If the air temperature exceeds 0°C, its measurement deviation is 0.3°C. If the air temperature falls below the freezing point, its measurement deviation is 1.5°C. The measurement was checked by a Geratherm Non Contact non-contact thermometer, which has a measuring range from 0°C to 100°C, and its measurement deviation is 0.2°C. The only hose that was not modified to the same length as the remaining ones was hose No. 5, due to different placement (wound on a drum stand for hoses).

The measurement occurred throughout the day for 12 hours, from 7 a.m. to 7 p.m. At first, all garden hoses were filled with water. The surface temperature of the individual garden hoses was measured with both thermometers, the air temperature and the humidity of air was measured every half-hour. The water temperature was measured 3 times during the day. All garden hoses were filled with water (a cap was attached to the end of the hoses to prevent the filled water from leaking) at 7 o'clock in the morning. Afterwards there was no more water added into the garden hose (when measuring the water temperature, only a part of the filled water was poured from the garden hose).

From the garden hose, which was filled with water, 500 mL was always drained into the container when measuring the water temperature, and the temperature of the water recorded was measured from the cast 500 mL. The first water temperature measurement was at 7 o'clock in

**Table 2.** Sunlight during Measurement (Origin, Czech Hydrometeorological Institute<sup>9</sup>).

Date	11.8.2020 (4) <sup>10</sup>	17.8.2020 <sup>9</sup>
6:00	30	0
7:00	54	30
8:00	60	60
9:00	60	60
10:00	48	60
11:00	36	60
12:00	30	60
13:00	24	60
14:00	60	60
15:00	42	54
16:00	24	42
17:00	0	42
18:00	24	6
19:00	42	0
Total	534	594

the morning. For the second time, the water temperature was measured 3 hours after the sun began to shine on the garden hoses. The recording system chronologically included—recording the time when the sun began to shine on the place and where the garden hoses were laid. From this point on, 3 hours were counted, and after 3 hours, the water temperature was measured for the first time. On the first day of the measurement, the sun began to shine to the place where the garden hoses were placed, at 12:30 p.m., so the water temperature was measured at 15:30. On the second day of the measurement, the sun began to shine on the garden hoses at 14:00 recorded at 16:00. The third and at the same time the last water measurement on both days occurred at the end of the whole research day at 19 hours.

The air humidity during the measurement on 11 August 2020 in the Pardubice Region at 7:00 a.m. was 80% and was stabilized from 12 p.m. in the range of 45% to 50%. During the second measurement in Prague on 17 August 2020, the air humidity was 85% and was stabilized from 12 p.m. between 60% and 65%.

Table 2 shows the data on sunlight during the individual days when the research occurred. The time of sunshine is given in tenths of an hour. The total time of sunshine on 11 August 2020 in the Pardubice Region was 534 minutes. In Prague on 17 August 2020, the total time of sunshine was several 10s greater, namely, 594 minutes.

## Results

The Czech Republic lies in a temperate climate zone, where the summer temperatures rarely exceed 30°C. The average temperature during the summer months in

**Table 3.** The Highest Measured Surface Temperature of Garden Hoses that were Placed on the Grass Area.

Garden hose	Time	Surface temperature of garden hose (°C)
No. 1	15:00	53.6
No. 2	12:30	57.8
No. 3	12:30	45
No. 4	14:00	47.2
No. 5	15:00	56.3

**Table 4.** The Highest Measured Surface Temperature of Garden Hoses that were Placed on a Concrete Surface.

Garden hose	Time	Surface temperature of garden hose (°C)
No. 1	15:30	51.2
No. 2	15:00	51.5
No. 3	15:30	51.4
No. 4	15:30	50.2
No. 5	15:30	50.5

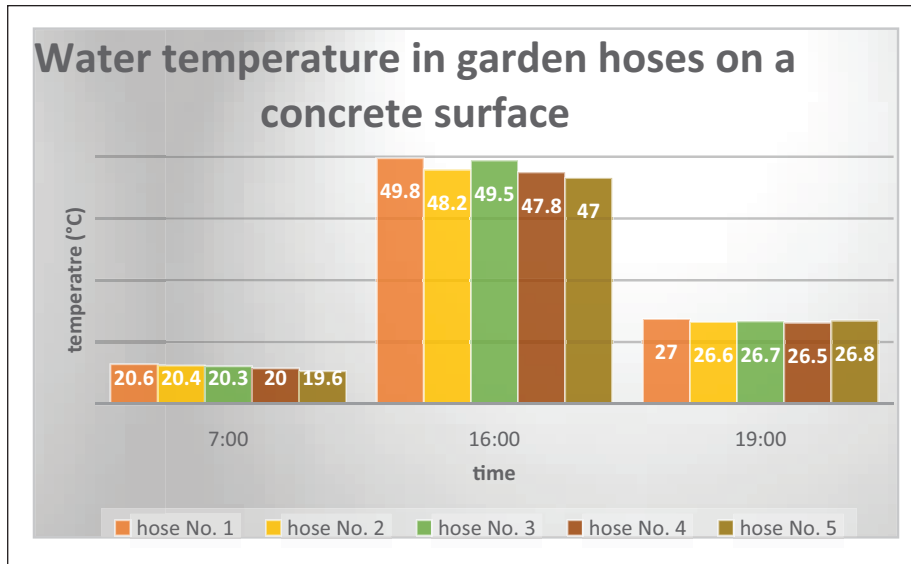
**Table 5.** The Highest Measured Water Temperature in Garden Hoses Lying on a Concrete Surface (°C).

Time	No. 1	No. 2	No. 3	No. 4	No. 5
7:00	20.6	20.4	20.3	20	19.6
16:00	49.8	48.2	49.5	47.8	47
19:00	27	26.6	26.7	26.5	26.8

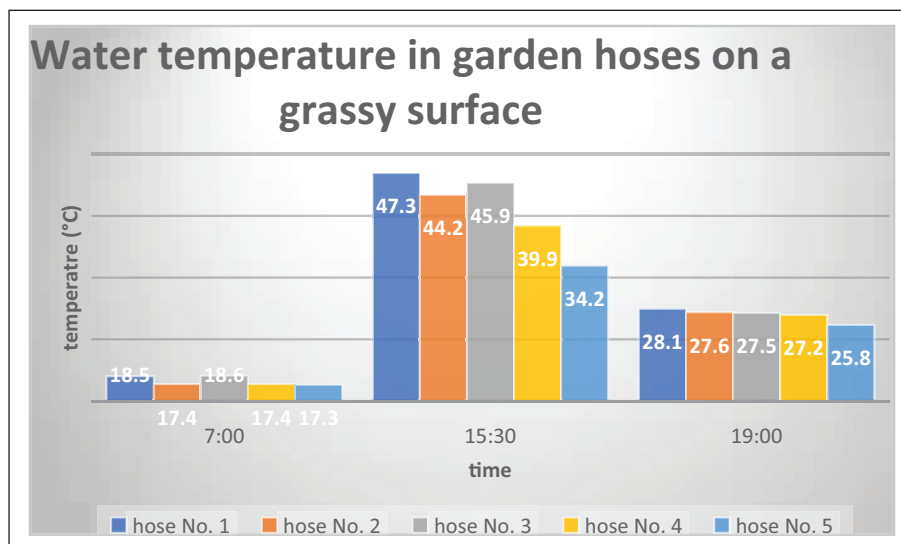
2020 was 18.3°C. We consider the days when the temperature exceeds the 30° limit to be tropical. The summer of 2020 was average in terms of air temperature with a total of 28 tropical days (Table 3).<sup>8</sup>

The largest part of this research was measuring the surface of garden hoses. The surface temperature of these hoses is one of the factors that determine the temperature of the water they are filled with. The surface temperature of the garden hoses on the grass reached its maximum in the time from 12:30 to 15:00. On the other hand, the surface of the garden hoses, which were placed on the concrete surface, reached the highest temperature at 15:30 (Tables 4 and 5).

To measure the highest water temperature achieved in the garden hoses, a moment of 3 hours from the time when the sun began to shine on the garden hoses was chosen. At this time, we assumed the highest water temperature measurement during the day. This hypothesis was confirmed. The surface of the garden hoses reached the highest temperature at this moment (see Figures 1 and 2). At this point, the measurement of the water



**Figure 1.** Complete representation of water temperature in garden hoses on a concrete surface.



**Figure 2.** Complete representation of water temperature in garden hoses on a grassy surface.

temperature in the garden hoses on the grass surface was different from the surface with concrete. On garden hoses laid on a grassy surface, the sun began to shine at 12:30 p.m., therefore the water in them was measured at 15:30. With garden hoses placed on a concrete surface, the sun began to shine at 13:00, so the water temperature was measured at 16:00. Both measurements had to meet the parameter of 3 hours of solar exposure (Table 6).

Common garden hoses of various materials and colors were chosen for this research. Garden hose No. 1 was black. Our assumption of the water in the black hose having the highest temperature has been confirmed.

The water temperature in this hose reached 49.8°C on the concrete surface. However, the highest measured surface temperature was for garden hose No. 5, which had a blue color, namely 56.3°C on the grass surface. Although the black color absorbs the whole spectrum of sunlight and does not reflect any, it does not mean the water in the garden hoses, other than black colored ones, does not reach such a high water temperature, which would lead to scalding.<sup>6,11</sup>

Hose No. 5 was placed on the stand for garden hoses; hence it did not directly lie on the ground as the remaining hoses. However, the water temperature in this hose

was altogether similar as the free-lying garden hoses. There was not a great difference in the surface temperature of the remaining hoses lying on the ground either. The temperature fluctuation has occurred while measuring the surface temperature of the hose lying on the grass surface. The measured temperature was one of the highest ones noted (56.3°C). Despite the grey color of the stand and the hose being individually wounded on top of itself on each turn so it was overlapping in its length, it led to a significant raise of its surface temperature and most importantly, the water in it (47°C).

### Discussion

This research work is focused on monitoring and recording the temperature of water found in loose garden hoses. There is a real danger of scalding from water that is inside them if they are exposed to sunlight.

During our research, the garden hoses were intentionally placed in the place where the sun shines the most during the day. This is to prove that there is a risk of real scalding with water from a loose garden hose, which is exposed to sunlight even in temperate climates.

If the garden hose is located in a place where the sun does not shine all day, the water temperature in the

garden hose should not reach such a high value that it would lead to scalding, even if the air temperature exceeds 30°C. This statement results from the measured data, as the surface temperature of the garden hoses was not even 30°C when the sun was no longer shining on them. Therefore, we assume that the water in the garden hose whose surface temperature does not exceed the 30° limit, will not exceed a temperature value that is no longer tolerable for the human individual.

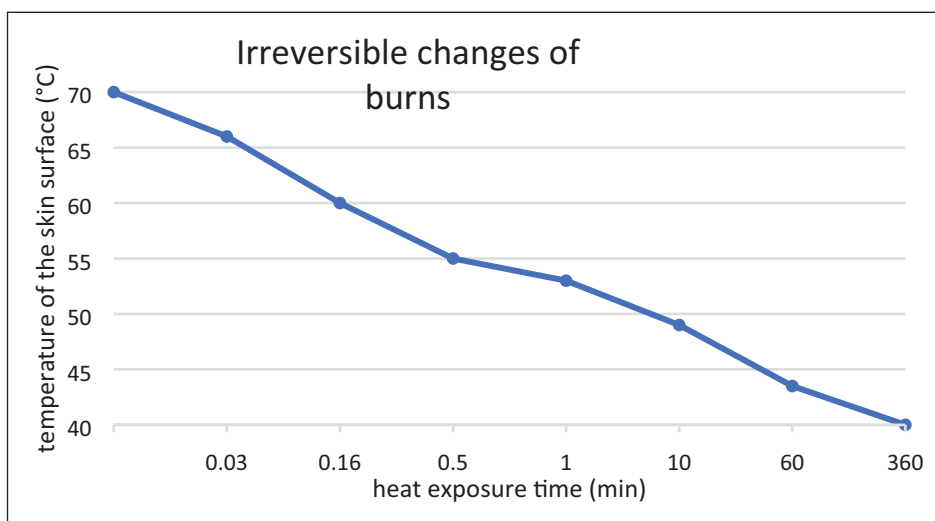
The maximum tolerable water temperature in contact with human skin is 43.5°C. As shown in Figure 3, which is based on the original survey by König and Bláha,<sup>5</sup> which shows irreversible changes in human skin that are caused by scalds. Figure 3 shows how the effect of heat over time affects the temperature of the skin.

The determining factor that affects the water temperature in the garden hose is the surface on which the garden hose is laid. According to a study by Coakley,<sup>7</sup> a concrete surface reflects 30% more sunlight than a grassy surface. This results in the measurement of a higher temperature of the object, in our case the surface temperature of the garden hose, which is placed on the concrete surface than in the case of placing the object on the grass surface. The reason is the heating of the stored object by thermal energy from the surface below it.<sup>7</sup>

To compare the measured results, 5 hoses of different colors and materials, which are commonly used, were chosen. We assumed that the water temperature in the garden hose No. 1, which was black, would have the highest temperature. Because of the black color, unlike other colors, absorbs the entire spectrum of sunlight. Our assumption has been confirmed. The highest measured water temperature was in garden hose No. 1, which was black. Despite this, the surface of this hose did not reach

**Table 6.** The Highest Measured Water Temperature in Garden Hoses that Lay on the Grass (°C).

Time	No. 1	No. 2	No. 3	No. 4	No. 5
7:00	18.5	17.4	18.6	17.4	17.3
16:00	47.3	44.2	45.9	39.9	34.2
19:00	28.1	27.6	27.5	27.2	25.8



**Figure 3.** Irreversible changes of burns (custom processing, origin, Königová and Bláha<sup>5</sup>).

the highest temperature. The highest measured surface temperature of the garden hose was for garden hose No. 2. The surface temperature of the garden hoses placed on the grass surface during the day is shown in Figure 2. For comparison, Figure 1 is also included, which shows the change of the surface temperature of the hoses on the concrete surface.

The volume of an 8-m hose with an inner diameter of 1.3 cm is equal to 4.25 L. There may be a situation where the parent will want to cool down the child with water from a garden hose during a hot day, but the hose is located in a warm sunny place. If the parent does not realize this fact, the child will use 4.25 L of water, which exceeds the limit of tolerability of human skin. This mechanism will cause scalding. The volume of heated water increases with the increasing inner diameter and length of the garden hose, which means an increased risk of scalding if the garden hose is left in a sunny place during a tropical day. Children's skin is significantly more sensitive than in an adult, the affected area also plays a role. Even with this potential risk, according to Jandová,<sup>6</sup> a total thermal bath is not recommended for children in balneology.

Research shows that one of the measures to scalding with hot water from a free-lying garden hose is to be placed on a stand designed for garden hoses, which will be in a shady place during a sunny day. If water is to be used to cool a person, it is necessary to first reduce the temperature of the water by forgiving so that it is not too hot.

Scalds will not be fatal, as the water that flows into the garden hose is taken from an underground source and is cold. However, if the hose is not filled with water the day and is located in a place where the sun shines during the day, hot water will flow out first and then cold water. How much hot water flows depends on the size of the garden hose and on how large the piece of hose is where the sunlight rests.

On the day of the monitoring research on the concrete surface, the air temperature did not exceed the 30° limit. For valid results, it would be good to repeat the measurement on the concrete surface on the day when the air temperature will reach tropical values, exceeding the 30° limit. Nevertheless, we measured the temperature of the water in the garden hoses, which can cause scalding when in contact with the skin.

## Limits of Study

The work-focused only on determining the temperature of garden hoses and its internal water exposed to sunlight by conventional methods. The thesis operates with the possibility of scalding with such heated water

without taking into account variables such as the distance of the person from the mouth of the hose, the dispersion of the water flow, the speed of water flow, the duration of hyperthermic water. Significant variables will also be in other material types of garden hoses, color, and thickness, both in terms of increased and reduced risk of scalding.

The Czech Republic is a country with a temperate climate zone, where there is a minimum number of tropical days for the total number of days in a year. The significantly different temperatures in such stored hoses would be measured in subtropical and tropical climates.

## Conclusion

We were able to prove that the water in loose garden hoses exposed to sunlight notably warms up and in case of contact with the skin can cause scalding. The temperature of water in mention has been measured in the range of 39.9°C to 49.8°C on different surfaces. There is a real risk of a healthy individual getting scalded with this water when its temperature is over 43°C. In the case of people with circulatory disorders, skin diseases or children are scalding almost certainly.

The results of this thesis should also be used to inform the public of the possibility of scalding from garden hoses that were exposed to sunlight. Most important is the enlightenment within injury prevention, especially with children.

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## Author Contributions

Karolína Uhrová and Pavel Böhm contributed to the conception of the study, data analysis, drafting or revising the article, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Ethics Statement

Ethics approval and informed consent were not required for this monitoring research.

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