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ORIGINAL ARTICLE

A SURVEY ON THE TOURISTS' ROLE IN THE CHANGES OF THE RELATIVE HUMIDITY PERCENTAGE INSIDE THE CAVES (CASE STUDY: ALISADR CAVE, HAMEDAN)

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Abstract: If we assume that human being lived on the earth for a year, they have spent 364 days in the caves and only come out of the cave on the last day. In the recent years significant changes have been observed in the cave ecosystem due to the manipulation which is inside and around the caves and also a large number of tourists. Alisadr Cave in Hamadan, Iran is one of the most famous tourist attractions in the country which attracts thousands of tourists every year. Naturally, as tourists enter the cave, the climatic elements of the cave change and transform the micro-climate inside the cave dramatically. So this study aims to investigate the daily and monthly variations in relative humidity inside the cave and the role of tourism in making these changes. To this end, the interior space of the cave was divided into two areas: the experimental areas (where tourists have access and visit) and the control area (prohibited points and the new discovered corridors). By using a tri-functional psychomotor, the relative humidity of these areas was measured three times a day: in the morning (before tourists' arrival) , in the afternoon and in the evening at night (after tourists' departure).Due to the variations in the relative humidity inside the caves, the corridors inside the cave were divided into three areas: small corridors (whose ceiling height is less than 3 meters) medium-sized corridors (with ceiling height between 3 to 7 meters), and large corridors (their ceiling height is above 7 meters). The results of the study show that tourists' presence changes the relative humidity inside different corridors.

Keywords: Relative Humidity Variations, Tourist, Alisadr Cave, Experimental Areas, Control Areas.

INTRODUCTION

The caves manifest the world of beauty and also the wonders of the creation. When limestone cave decorations are damaged and the original space of the caves is covered by trash, we can find out that a main reason is the cavers and the tourists visiting the cave and they intentionally and unintentionally destroy the cave structure. The destroyed stalactites and stalagmites that have been formed during thousands of years may never grow again and they never return to their original shapes. Rare species of bats that only live in a special cave may extinct forever. Although many carvers and biologists have contributed to the protection and decontamination of caves but most often the consequences of its contamination and pollution cannot be removed or before they are removed, they have already affected the environment.

Relative humidity is the ratio of the water vapor in the air compared to the amount of water vapor that at the same temperature would be saturated. Relative humidity changes as the temperature changes. Decrease in the temperature leads to the decrease in the capacity of water vapor in the air and if it happens, the relative humidity increases because the air approaches its saturation point. (Alizade et al., 2007-90).

Humidity inside the cave is one of the most important climatic aspects. Unlike open air areas and the atmosphere around the earth that usually has the humidity under the saturation point and show high fluctuations in the relative humidity, the caves show high humidity and minor daily and annual changes (Michie, 1990, 48).

The effect of minor changes in the relative humidity on the carbonate forms existing inside the caves is still unknown. However, recent studies in Guadalupe Mountains of New Mexico show that relative humidity variations can be significant due to the effect on evaporation condensation process in caves. (Forbes , 1998, 32).

Gilleson (1996), Bogli (1980), Moore & Sullivan (1978) in their studies investigated micro-climate and climatic elements in the caves and the role of the tourists in changing climate elements inside the caves.

Michie (1997), in his Ph.D. thesis examined the climate elements (temperature and humidity), the amount of carbon dioxide and the amount of dust inside the caves with focus on Jenolan caves in Australia in part of his thesis He also examined the effectiveness and the role of

tourism in changing the climate elements, carbon dioxide and the dust in the caves. He also explored a significant amount of increase in the temperature due to the presence of tourists and he argued that this increase in temperature affects evaporation, condensation and the other factors inside the caves

Unfortunately, in our country, despite the large number of the caves which attract tourists, there are no serious and scientific studies on the changes in the caves due to the presence of tourists and also interested people who visit caves regularly. Although many studies investigated the potential capacity and the importance of the underground caves in attracting people but it can be said with certainty that no studies have been conducted on the changes due to the presence of tourists in climate elements inside the caves. In spite of their efforts, the authors of the present study have not found any research in this regard. Alisadr Cave Kabodarahang, Hamadan is the most important water cave in Iran which attracts more than 1000000 tourists each year and more than 10000 tourists visit this cave daily during vacations and especially in the summer. It seems that due to the increase in the number of tourists their respiration activity, lighting system inside the cave and so on, carbon dioxide values , temperature, relative humidity change inside the cave daily and monthly. So this study tries to investigate the daily and monthly changes inside the Alisadr Cave within 30 days.

Areas of the Study

Alisadr Cave in Alisadr village in Kaboudarahang is located 75 kilometers northwest of Hamadan (longitude 48 degrees and latitudes 35 degrees 18 minutes). It has a height of 1900 meters above sea level. Water level in different parts of the cave varies from zero to 14.This area has semi-arid weather. The average annual rainfall is 300mm. In the late spring, 1339 the cave was discovered by a group of mountain climbers from Hamedan and they the cave visited by them as the first visitors of the e cave. Visitors travel the water path of the cave using boats. It is 2100 meters long and it is the longest water cave among the other water caves in the world. All the channels inside the cave have not been discovered yet. But the progress in exploring its different parts in some of the channels inside the cave have been up to 10 to 11 km. It was officially stated that 2100 meters of the cave pass had been discovered until 2005. From among all the 14 km area of the discovered corridors, 4 km which have been lightened using spotlight and projectors are being visited by the tourists and visitors now. The cave ceiling (which is in some parts 10 meters above water level is covered with pure calcium carbonate and is mixed with other elements. Based on the thermal classification of Astrue Jadin , the cave water is categorized as the cold water (about 12 degrees) .

Alisadr is a part of a series which have formed in the west part of Iran belonging to the Jurassic Period with an alternating sequence of Schist and sandy rocks between its base and a series of limestone compounds such as dark grey clay which has placed on schist as thin layers and a lighter layer of limestone crystals have placed above it. These phenomena occurred due to the temperature and pressure changes caused by the volcanic activities in the western part of Alisadr Mountain. Alisadr Mountain itself is a strata (a part that is above the ground) of a large anticline with its main axis extending from north to south.

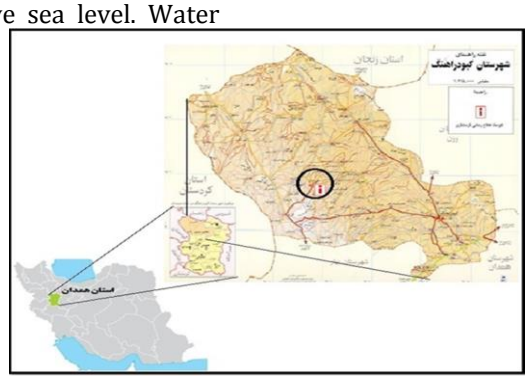

Figure 1: The position of the studied area

METHODOLOGY

In order to achieve the aims of the study, the corridors inside Alisadr Cave have been divided into two parts: experimental region (where visitors and tourists can visit) and the control region (the prohibited region for the public and those areas which have not hooked up to the electricity yet and are far from the tourists access). Sampling procedure was done three

times a day in the morning (before tourists arrival) and at noon and at night (after tourists arrival) in different parts of the experimental and the control area. The sampling was done using a three –functional Carbone Dioxide Detector Machine AZ (77535) made in Taiwan.

Due to the relative humidity change in different areas inside the cave, the halls and the corridors inside the cave have been divided into three parts:

1. Low height corridors (its ceiling height ranges between 0 to 3 meters above the ground surface and water level)
2. Medium height corridors (their ceiling height ranges between 3 to 7 meters above the ground surface and the water level)
3. High corridors (their ceiling high is above 7 meters). Considering the vast number of halls and corridors, the samples (relative humidity measurement) were not extracted from the pre-determined areas but the researchers moved inside the cave and measured the relative humidity at different distances and then these random measurements determined the average relative humidity along with the time of recording.

The present study has been an attempt to determine the role of the tourists in changing the relative humidity inside Alisadr Cave based on measuring the relative humidity of the control and the experimental areas inside the cave and find the gap between these two areas. Because it was likely that the entered air from the entrances affected the relative humidity inside the cave, relative humidity was measured at a distance of 200 meters far from the cave entrance. The sampling was done within 30 full days between the dates 22.5.1393 to 20.6.1393.

RESULTS
Small corridors

Table 1 shows the daily average measurements of the relative humidity within 30 days in both the experimental and control areas of the small corridors inside Alisadr Cave. The average of the relative humidity in the experimental areas of the small corridors were 96.6, 95 and 94.6% in the morning, at noon and at night respectively. At the same time, the average of the relative humidity in the control areas of the small corridors were 97.5, 97 and 96.7 % respectively. The average of the relative humidity in the control areas in the morning was 97.5%. An important point is that at the same time, this relative humidity for the experimental areas was 94.6%. This difference is the result of the temperature changes in the previous days. The average of the relative humidity measured within 30 days in the small corridors and at night after the departure of the tourist in the experimental areas was 94.6%. Thus, the difference between the average of the relative humidity in the morning in the control areas and at night in the experimental areas, ignoring 0.9% (the difference between the relative humidity of the samples taken in the morning in the experimental and control areas of small corridors, i.e. 2 .1% can be considered as the role of the tourism in decreasing the relative humidity inside the Alisadr Cave, Hamadan. The important point is that the above-mentioned difference is 2.9% but ignoring 0.8 % (the natural variation and fluctuation in the relative frequency and the difference between the relative humidity of the samples taken in the morning and at night in the control areas of small corridors) 2.1 is obtained.

Table1: The monthly average score of relative humidity of the samples taken from the experimental and control areas of the small corridors (Alisadr Cave, Hamadan).

No	Time of sample taking	Dimensions of corridors	Small corridors
		Areas of sample taking	
1	Average of morning sample taking	Experimental area	96.6
		Control area	97.5
2	Average of noon sample taking	Experimental area	95
		Control area	97
3	Average of evening sample taking	Experimental area	94.6
		Control area	96.7
4	Total average(morning, noon and evening)	Experimental area	95.4
		Control area	97
5	Difference between control and experimental areas(morning and evening)		2.1

1.1: The daily variations in relative humidity inside small corridors

Daily variations (during the morning, noon and night) in the relative humidity in small corridors in the Alisadr Cave are illustrated in figure2. As this figure shows, within 30 days and consistent with the increase in the tourist numbers, the relative humidity inside the cave varies from 93% to 98%. Also, variation in the relative humidity of the morning samples was lower compared to that of the night. An

important point is that figure 2 shows several drop points which are consistent with the final days of the week i.e. weekends when more tourists visit the area.

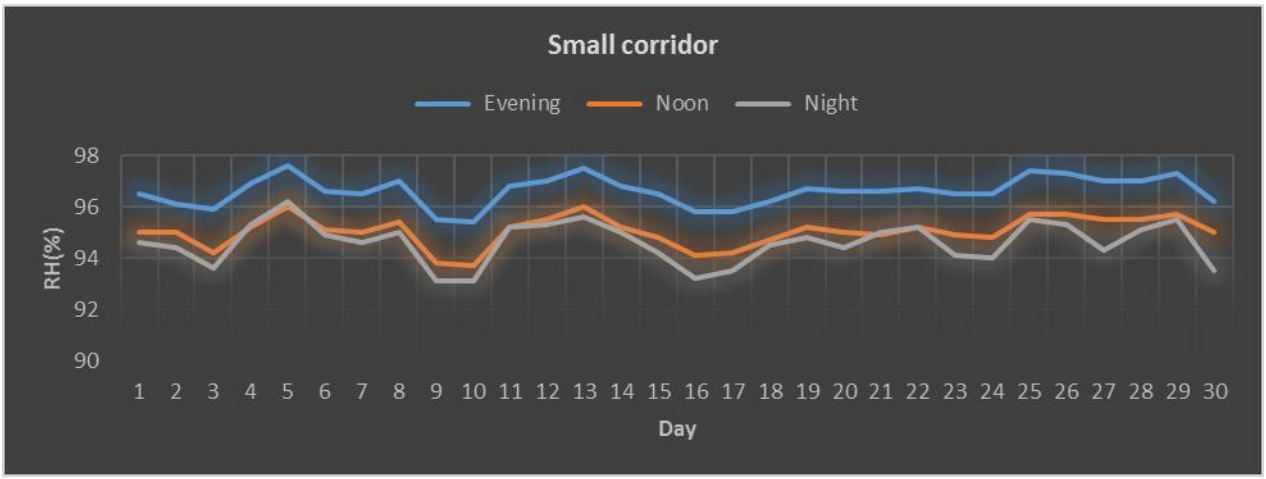

Figure 2: Daily variations in relative humidity in small corridors:

2. Medium Corridors

Table 2 shows the average monthly relative humidity of the samples taken from the experimental points and the control points of the medium-sized corridors in the Alisadr Cave. The average scores of the relative humidity of the samples taken within 30 days in the morning, at noon and at night were 97, 95.5 and 94% respectively. Thus, the average monthly relative humidity in the medium-sized corridors in the experimental points was 95.5%. At the same time the average monthly relative humidity in the control areas inside the cave for the samples obtained in the morning, at noon and at night were 98%, 97.6% and 97% respectively. The difference between the control area samples which were taken in the morning and those taken at night and those of the experimental areas minus 1% of the natural variations in the relative humidity inside the cave and without taking into account the difference between the samples taken in the morning in the control and the experimental areas (98-97=1) can be considered as the effect of the tourists on changing the relative humidity inside the medium-sized corridors inside the Alisadr Cave. Another significant point is that the average daily variations in relative humidity inside the cave in experimental areas was 3% while that of the control areas was 1% , so the impact of tourists excluding the difference between the average daily samples taken in the morning in the control and experimental group was 3%.

Table2: The average monthly relative humidity of the sample taken in the control and experimental points of medium-sized corridors inside Alisadr Cave (Hamadan).

No	Time of sample taking	Dimensions of corridors / Areas of sample taking	medium-sized corridors
1	Average of morning sample taking	Experimental area	97
		Control area	98
2	Average of noon sample taking	Experimental area	95.5
		Control area	97.6
3	Average of evening sample taking	Experimental area	94
		Control area	97
4	Total average(morning, noon and evening)	Experimental area	95.5
		Control area	97.5
5	Difference between control and experimental areas(morning and evening)		3

2.2: The average daily relative humidity variations in the medium-sized corridors

Figure 3 shows the daily average values of the relative humidity in the corridors of Alisadr Cave (during morning, noon, and night). The minimum relative humidity of the samples were taken within 30 days at night was 92 %. The samples were taken on the weekends because on these days more tourists visited the cave.

Generally, four drop points are seen in figure 3. The drop in the relative humidity values exactly match the final days of the week in which more tourists visit the cave. Most samples of the relative humidity which were taken from the medium-sized corridors in the morning were 98%.

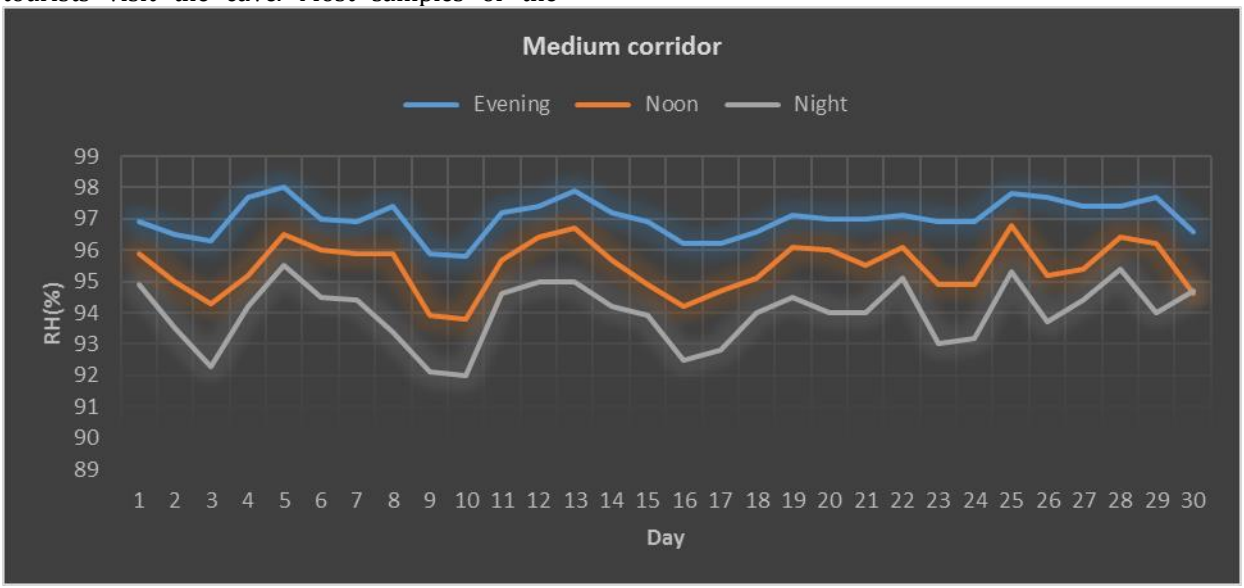

Figure 3 the daily variations in relative humidity in the medium-sized corridors. (Alisadr Cave, Hamadan)

3. Large corridors

Table 3 shows the average monthly relative humidity taken from the control and the experimental points in the large corridors of Alisadr Cave. The average samples taken from the experimental points during morning, noon and night were 95.5%, 97%, 97.7% respectively. At the same time, those of the control points at the same corridors were 97.5, 97.7, and 98% respectively. The average scores of the daily variations in the control and the experimental points in large corridors were 2.3 and 0.5 % respectively. Thus, the difference between the average of the relative humidity of the samples taken during the morning in the control points and that of the samples taken at night in the experimental points the daily natural variations inside the cave and excluding the difference between the samples taken from the experimental and the control points in the morning (2%) can be considered as the impact of the tourists on changing the relative humidity in the large corridors in Alisadr Cave, Hamadan.

Table 3. the average monthly relative humidity of the samples taken from the control and experimental points in large corridors (Alisadr Cave, Hamadan).

No	Time of sample taking	Dimensions of corridors / Areas of sample taking	Large corridors
1	Average of morning sample taking	Experimental area	97.7
		Control area	98
2	Average of noon sample taking	Experimental area	97
		Control area	97.7
3	Average of evening sample taking	Experimental area	95.5
		Control area	97.5
4	Total average(morning, noon and evening)	Experimental area	96.7
		Control area	97.7
5	Difference between control and experimental areas(morning and evening)		2

3.1: Daily variations and fluctuations in the relative humidity in the large corridors

Figure 4 shows the daily fluctuations and variations in the relative humidity in large corridors. The minimum and maximum amounts of relative humidity taken within 30 days at night and in the morning were 93.6 and 98.8 respectively. Just as figure 2 and 3 show, the decrease in the relative humidity was consistent with the increase in the tourists in tourists' number on the weekends.

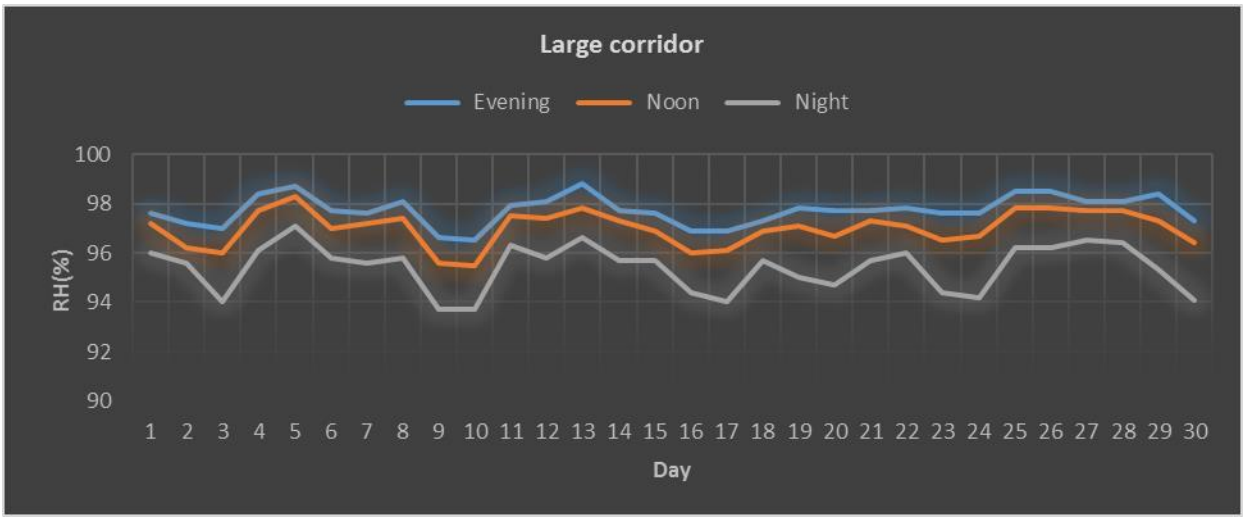

Figure 4: The daily variations in the relative humidity in the large corridors (Alisadr Cave).

DISCUSSION AND CONCLUSION

The caves and the Karst formations have sensitive ecosystems. They are samples of the beauty and the originality in the nature. Human beings have always been attracted by the caves beauty and these attractions have stimulated them to visit the caves, find and discover their unknown facts. In spite of this fact, human being have not always been cautious and careful creatures. This interest has destroyed some parts of the caves. Ignoring the fact that animals which live in the caves threat them, destroying the caves' formations have been occurred over thousands of years and this destroys their beauty and is not something that can be compensated easily.

Alisadr Cave in Hamadan as one of the most famous caves to attract tourists nowadays is in poor conditions. Each year the number of the tourists visiting the cave increases and unfortunately in spite of the large amount of income that the respective authorities obtain from the tourists' visit, no effective and scientific study has ever been conducted on the effects of the tourists' presence in the cave. There is no research about the changes in the climate relief of the tourists and above all there has been no survey on the effects of the tourists' presence on the changes of Karst forms inside the cave. The authorities aim to increase the number of the tourists up to 50% and to this end, they have bought the lands around the cave and prepared physical considerations to attract more tourists.

Relative humidity as one of the climatic elements inside the caves has not changed significantly but these minor changes may change Karst secondary forms inside the caves due to the changes in the evaporation, density, and so on. Generally, the effects of the tourism on the relative humidity inside Alisadr Cave with corridors with small, middle-sized and large scales are 2.1 , 3 and 2 percent respectively.

The least changes occur inside the large corridors and the least changes inside the small corridors. Another point is that in order to determine the above values some factors including the daily temperature outside the caves, cracks and gaps, Spaces and natural ventilation of the cave have been eliminated and may be they affect the results of the study.

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