Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 3, p. 535-541, 2015
http://www.innspub.net

INNSPUB
RESEARCH PAPER
OPEN ACCESS

Tourists and their role in microclimatic changes inside the caves case study: Ali Sadr Cave (Hamedan, Iran)

Amjad Maleki[1], Peyman Karimi Soltani[*2]

[1]*Geomorphology in Razi University of Kermanshah, Kermanshah Branch, Iran*

[2]*Geomorphology of Razi University of Kermanshah, Kermanshah Branch, Iran*

Article published on March 28, 2015

Key words: Microclimate, Tourists, Ali-sadr cave, Co_2, Temperature, Relative humidity.

Abstract

In the present paper we have attempted to divide Ali-Sadr Cave into two experimental areas (the place of tourists' traffic) and the control area (the newly discovered area and corridors) to calculate and analyze daily and monthly tourists' contribution in changes of carbon dioxide levels, temperature and relative humidity. Therefore, within a period of 30 days and by taking daily 3 times, the first in the morning (before the arrival of tourists) noon and night (after the departure of tourists) amounts of carbon dioxide, temperature and relative humidity using carbon dioxide detector model AZ (77535), in the two areas of control and experimental were measured and analyzed. The findings of the research show that tourists' presence inside Ali-Sadr cave of Hamedan and their inhaling and exhaling activity has changed the amount of climatic elements inside the cave and has transformed the microclimatic elements inside the cave. For example, the percentage of carbon dioxide from humans has risen more than 7% of carbon dioxide with natural origin. Moreover, the results indicate 1 to 2 degrees of temperature rise inside the cave due to the presence of tourists. Temperature increase inside the cave has led to increase in evaporation, on the one hand, and to decrease in the relative humidity on the other hand. Deformability of carbonate caves inside the cave, Impact on the health of tourists, Climatic discomfort of the tourists inside the cave.

***Corresponding Author:** Karimi Soltani ✉ kpeyman56@yahoo.com

Introduction

Unfortunately, the studies on climatic change inside caves and changes of the elements within them (due to the presence of tourists inside the caves) such as carbon dioxide, temperature, relative humidity and etc., in Iran, despite having numerous and various caves with a high proportion of tourist attraction, have not been much attended to, while studies of climatic elements inside the caves in some countries dates back to the 1950s and earlier on. In recent years the number of tourists who have been attracted to caves has had an increasing trend and in the future this trend is also going to continue. Although attracting tourists into caves is a suitable opportunity to revive and strengthen local economies, but it also leads to consequences and risks to ecosystems. Due to the nature of closed environment of caves, they are not threatened by the manipulation of mankind, but the presence and manipulation of the natural ecosystems by human beings has endangered them (Morini, 2013). The following studies have dealt with the effects of tourists on microclimatic elements inside the caves and their elemental climatic changes such as carbon dioxide, humidity and temperature (Russel & MacLean, 2007; Calaforrora *et al*, 2003; Song *et al*, 2000; Baker & Genty, 1998).

Pulido-Bosch *et al*., (1997), investigated the role and effects of human activities around and inside Marol Cave in Spain and recognized as effective exploiting water from the wells around the cave in lowering the water level inside the cave. Also, increased temperature, increased concentrations of carbon dioxide and reduced the relative humidity inside the cave is considered as the consequence of tourists' entry into the caves. The role of these changes in the evolution of geological and geomorphological phenomena inside the cave has been studied.

Each year over 800,000 individuals visit Ali-Sadr Cave (Ilderami *et al*, 2011) and considering the provided infrastructures and the plans made the number will rise to over 1,200,000 people yearly in the near future. Indeed, the presence of daily from 5000 to 7000 people and sometimes daily more than 10,000 tourists into the cave and the time they are inside the cave creates changes in climatic elements inside the cave such as amount of co_2, relative humidity percentage, temperature and etc. Rise in carbon dioxide percentage inside the caves is due to the weak acid that it produces and is followed by deformation of calcite forms inside the caves. Thus, calculation and studying the role of tourists in microclimatic changes inside the caves, due to their impacts on climatic welfare and also the evolution of geomorphological elements inside the caves, seems necessary. The goal of this research is to study the changes in climatic elements inside Ali-Sadr Cave of Hamedan including carbon dioxide, temperature and relative humidity due to the presence of tourists. In this study, by measuring, it has been tried to analyze daily and monthly changes of some of climatic elements inside the caves.

Materials and methods

Sampling method

The sampling was done using a Three–Functional Temperature, Relative Humidity and Carbone Dioxide Detector Machine AZ (77535) made in Taiwan

Taking times have been done three times daily, in the morning and before the tourists' entry (from 8-8:30), at noon (from 13-13:30) and at night after the tourists' exit (on not off days from 20-20:30 and on off days from 22-22:30). Due to the possibility of heterogeneous distribution of climatic elements in the environment, corridors and hallways of different dimensions, the internal space of the cave was divided into three parts of low-altitude (utmost 3 meters of high from the land and water), the average altitude was considered (from 3-7 meters of altitude from the water and land from the roof) and high (over 7 meters highness from the roof). In order to compare the amount and percentage of natural climatic elements inside Ali-Sadr Cave with the amounts and changes created due to the presence of tourists inside the cave, inside the cave was divided into two areas of control (proof or evidence) and experimental areas. In fact, the experimental area is the parts on which the tourists have commuted or gone and returned inside the cave and the control area, is the corridors inside the cave which have recently been discovered and are by no means the passageway for humans. And there have been no operations done yet such as wiring and they are over 200 meters from the main corridors, though the control area has a very limited connection with the experimental area. But because of very slight changes and differences in the taken climatic elements inside it, it is reliable. The samples were taken regularly from 13th of August 2014 until 11th of September 2014 during 30 days at both experimental and control areas.

Results and discussion

Carbon dioxide

One of the main mechanisms of basic changes due to human's activities inside the caves is because of co_2 concentration which causes deformation of forms inside the caves such as stalactites, stalagmites, etc. Basically the existing co_2 concentration in the caves has natural and biological origin but inside the caves that are faced with high numbers of tourists, their respiration processes result in the accumulation of large volumes of carbon dioxide gas in the caves. While carbon dioxide gas might cause calcium sequestration, high-humidity of calcite levels due to the condensation of water vapor inside the cave, can result in the absorption of co2 in the air and production of carbonic acid and then can cause the dissolution of calcite. This phenomenon is called deformability and its amount depends on the pressure amount of co2 inside the cave (Baldini *et al*, 2006).

Tourists' daily share of Co_2

In Table 1, the average amount of monthly carbon dioxide (in ppm) taken from the two areas of control and experimental inside Ali-Sadr Cave in Hamedan is shown. As it is observed in Table 1, the average monthly carbon dioxide amount in the small, medium and big corridors of the cave have respectively been 370, 366 and 565 ppm and at the same time, the average monthly carbon dioxide in the small, medium and large corridors have been 3429, 3403 and 3365 ppm. The difference between the amounts of carbon dioxide in the experimental and control areas, the amount of carbon dioxide produced in the cave by the tourists is in order the values of 3059, 2958 and 2800 ppm. Overall several peak points are observed in carbon dioxide levels recorded in different areas. These peak points are exactly in accordance with the weekend holidays and the time of increase in the number of tourists.

Table 1. The Monthly Average of Carbon Dioxide (Co2), Taken from Experimental and Control Areas (Ali-Sadr Cave of Hamedan).

Row	Taking time	Dimensions of the sample corridors → / Taking area ↓	Small corridors	Medium corridors	Large corridors
1	The average of morning time	Experimental area	3096	3156	3129
		Control area	311	388	484
2	The average of noon time	Experimental area	3449	3384	3332
		Control area	357	454	566
3	The average of night time	Experimental area	3743	3671	3632
		Control area	444	497	645
4	The total average	Experimental area	3429	3404	3365
		Control area	370	446	565
5	The tourists' share		3059	2958	2800

The role of the number of tourists in Co2 concentration

The number of tourists, their age, their duration of presence and their kind of physical activity plays a determining role in the amount of carbon dioxide produced by their respiration.

In Fig. 1, changes and fluctuations of the extracted values of carbon dioxide at night time and after the tourists' exiting the cave during 30 days is indicated. As it can be observed, in small corridors there are very slight fluctuations and the highest changes are observed in the large corridors of the cave.

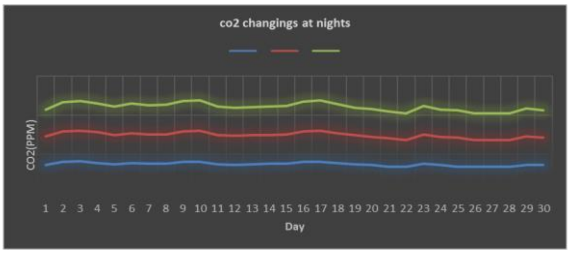

Fig. 1. Changes and Fluctuations of Values of Carbon Dioxide Taken in 30 Days at Night (Ali-Sadr Cave).

Temperature

Every person's share for each hour of presence inside the cave is production of more than 60 calories of heat and 40 grams of evaporation, thus the presence of visitors causes the increase in temperature and the existing humidity inside the cave (Hotzl, 1999).

As shown in Table 2, the recorded monthly average for mornings, afternoons and nights for the small, medium and big corridors are the numbers 15.4, 15.2 and 15 degrees centigrade while at the same time in the corridors of control area, in small, medium and large corridors the numbers 1.2, 1 and 1.1 degrees centigrade in order which are the tourists' share in increasing the temperature inside the cave. Rising temperature inside the caves on the one hand causes the increase in water vapor in water caves and on the other hand, causes the decrease in the percentage of relative humidity. The decrease in relative humidity percentage inside the caves leads to dryness of the cave environment and fragility of calcite forms.

Table 2. Average of Monthly Temperature ©, Taken from Control and Experimental Areas (Ali-Sadr Cave).

Row	**Taking time**	**Dimensions of the sample corridors →** / **Taking area ↓**	**Small corridors**	**Medium corridors**	**Large corridors**
1	The average of morning time	Experimental area	14.3	14.2	14.2
		Control area	14	14	14
2	The average of noon time	Experimental area	15.3	15.1	14.9
		Control area	14.2	14.3	14.1
3	The average of night time	Experimental area	16.6	16.3	16.1
		Control area	14.4	14.5	14.6
4	The total average	Experimental area	15	15.2	15.4
		Control area	14.2	14.2	14.1
5	The tourists' share		1.2	1	1.1

The role of tourists' number in increasing the temperature

In Fig. 2, changes and fluctuations of temperature during the period of 30 days in the corridors of small dimensions (roof altitude of less than 3 meters) are indicated.

As is shown above, range of changes has been increasing from morning to night. Also in the Fig., 4 peak points can be observed that are exactly in accordance with the weekend and the increasing number of tourists into the cave.

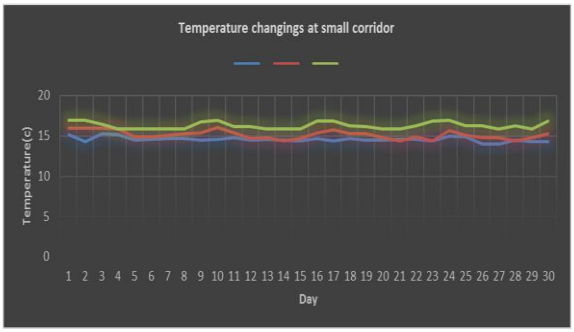

Fig. 2. Changes and fluctuations of temperature during 30 days in the corridors of small dimensions (Ali-Sadr cave of Hamedan).

As is shown above, range of changes has been increasing from morning to night. Also in the Fig., 4 peak points can be observed that are exactly in accordance with the weekend and the increasing number of tourists into the cave.

Relative Humidity

Humidity is a relational word which is used to express the weather condition and states how much in a definite climate, the air is near to saturation point. Relative air humidity and air temperature are inversely related meaning that when the relative humidity increases the temperature decreases. Humidity in the caves is one of the most important aspects and microclimatic elements inside the caves. Unlike open-air atmosphere surrounding, the earth that usually has saturated humidity and show very high changes and fluctuations in the humidity percentage (Michie, 1990).

In Table 3, amounts of measured relative humidity in control and experimental areas of Ali-Sadr Cave in Hamedan during 30 days are indicated. The point worth mentioning is that time samples taken inside the cave were not in the form of fixed points and predetermined places but they were from everywhere inside the cave with the distance intervals of 40 to 50 meters in the corridors and hallways of the cave and at last average was taken from all the samples and they were considered as values of morning, afternoon and night. That is why the average of obtained humidity values is under 100%; while in many of the time samples taken, relative humidity has been measured as 100%.

Table 3. Monthly Average of Relative Humidity Percentage Taken in Control and Experimental Areas (Ali-Sadr Cave in Hamedan).

Row	Taking time	Dimensions of the sample corridors → / Taking area ↓	Small corridors	Medium corridors	Large corridors
1	The average of morning time	Experimental area	96.6	97	97.7
		Control area	97.5	98	98
2	The average of noon time	Experimental area	95	95.5	97
		Control area	97	97.6	97.7
3	The average of night time	Experimental area	94.6	94	95.4
		Control area	96.7	97	97.5
4	The total average	Experimental area	95.4	95.5	96.7
		Control area	97	97.5	97.7
5	The tourists' share		1.6	2	1

As it is observed in Table 3, the averages of relative humidity samples of morning, afternoon and night in the small, medium and large corridors of the experimental area are the values of 95.4, 95.5 and 96.7. While at the same moment and in the control area respectively the values of relative humidity of 97, 97.5 and 97.7 percentage were calculated.

In other words, unlike the two other climatic elements that are temperature and carbon dioxide which the tourists' presence has increased their amount in Ali-Sadr Cave, the presence of tourists in Ali-Sadr Cave has caused decrease in the percentage of relative humidity to the extent of 1.6, 2 and 1 respectively in small, medium and large corridors during the thirty days. The reason for this issue as mentioned above has been increase in temperature inside the cave because as the temperature rises, the relative humidity decreases.

The role of the number of tourists in relative humidity percentage changes

Along with increase in the number of tourists entering Ali-Sadr Cave, the trend of decrease or increase in climatic elements inside the cave is accelerated so that with increase in the number of tourists into the cave in the weekend, carbon dioxide amounts and temperature also increase (Figs. 1 & 2) while the relative humidity percentage has decreased (Fig. 3).

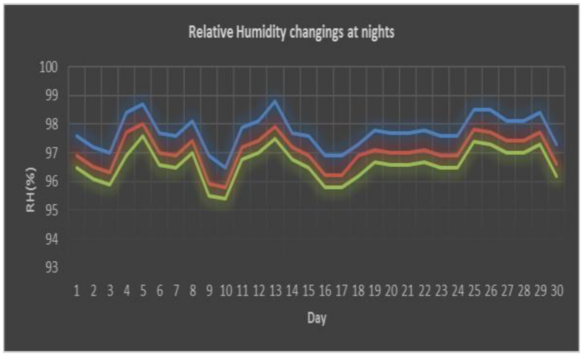

Fig. 3. The percentage of changes and fluctua-tions of relative humidity in the small, medium and large corridors measured during 30 nights.

In Fig. 3, changes and fluctuations of values of the percentage of relative humidity during the nights (after the tourists have exited the cave) in the small, medium and large corridors and high hallways are displayed. As it is indicated in the Fig., overall 4 points of fall can be observed which are points of fall and decrease in relative humidity exactly coincided with the weekend and rise in the number of tourists visiting the cave. The values of relative humidity percentage inside the cave do not have great fluctuations, however, the percentage of relative humidity swings in the hallways and is a little less in smaller corridors than that of medium and large ones. Also, changes and fluctuations in relative humidity values percentage in the larger corridors of the cave is more than that of the medium hallways.

Conclusions

Unfortunately studies related to ecosystem, geology, climate and geomorphology of the caves in our country despite the variety and numerousness of caves have been overlooked and even in some respects such as outcomes of uncontrolled visiting by the tourists and without plans or supervisions, almost no exact investigation has been done on any of the caves of Iran and only in some conferences are in the form of descriptive or literature review and no case study presented. Caves have integral microclimatic elements and geological forms and phenomena and the existing geomorphology in them on the basis of the natural conditions inside the cave have developed and evolved. Along with the entrance of swarm of tourists into the caves, microclimatic elements inside the caves have undergone changes and thus the evolution of the existing phenomena inside the caves has also been disrupted. On the other hand, Karst ecosystems are very sensitive and fragile and due to the extent of the damage incurred, they require long time to repair and restore themselves and this has aggravated the sensitivity of the issue. Unfortunately, uncontrolled entry, lack of adequate studies on the impact of tourism on the ecosystem in our caves and other management principles and the installation of facilities for tourists in the caves, has endangered the natural evolution of geomorphological features of some of our tourist-receiving caves. Due to human's presence, the created changes inside the caves lead to a function of number of visitors, their spending time average in the cave, and the features of the cave such as its magnitude, size, position and also its capacity of conditioning. Ali-Sadr Cave of Hamadan, as the most tourist friendly cave in the country, is exposed to the damages by the lack of controlling of great number of tourists entry into the cave. Presence of thousands of tourists daily into the cave has evolved the microclimatic elements inside the cave and has changed the percentage of the elements inside the cave. Change in climatic elements inside the cave can result in the following consequences:

Deformability of carbonate caves inside the cave, Impact on the health of tourists, Climatic discomfort of the tourists inside the cave. By and large, the careful and systematic studies of all aspects of the caves, and particularly investigation of the consequences of uncontrolled entry of tourists into Ali-Sadr Cave of Hamedan becomes necessary.

References

Baker A, Genty D. 1998. Environmental pressures on conserving cave speleothems. Effects of changing cave tourism. *Journal of Environmental Management* **53**, 165-175.

Baldini James UL, Baldini Lisa M, McDermott F, Nicholas C. 2006. Carbon dioxide sources, sinks, and spatial variability in shallow temperate zone caves: Evidence from Ballynamintra Cave. Ireland. *Journal of Cave and Karst Studies* **68**, 1. 1-4.

Calaforra JM, Fernández-Cortés A, Sánchez-Martos F, Gisbert J, Pulido-Bosch A. 2003. Environmental control for determining human impact and permanent visitor capacity in a potential show cave before tourist use. Environmental Conservation **30(2),** 160-167.

Hotzl H. 1999. Industerial and urban produced impacts. *UNESCO project IGCP379. karst processes and the carbon cycle* 178-183.

Ilderami A, Mirmehrdad S. 2011. Studying the environmental potentials of the goe-park of Ali-Sadr Cave to develop the economic. social stability of the region. *Journal* of *Environment and Development* ***3***. *116-122*.

Michie Neville A. 1990. *An Investigation of the Climate. Carbon Dioxide and Dust in Jenolan Caves. N.S.W.* A Thesis presented for the degree of Doctor of Philosoplly in the School of Earth Sciences Macquarie University 298.

Moroni M. 2013. Radon and Carbon Dioxide Monitoring: An approach to touristic exploitation of Caves. *5ème Colloque National du Patrimoine Geologique*-Tunis 7-9 Mai.

Pulido-Bosch A, Martín-Rosales W, López-Chicano M, Rodríguez-Navarro CM, Vallejos A. 1997. Human impact in a tourist karstic cave (Arecena,spain). *Environmental Geology* **31,** 142-149.

Russel MJ, Maclean VL. 2007. Management issues in a Tasmanian tourist cave. Potential microclimatic impacts of cave modifications. *Journal of Environmental Management* **87**, 474-483.

Song L, Wei X, Liang F. 2000. The influences of cave tourism on CO2 and Cave. temperature in Baiyun Hebei. China. *International Journal of Speleology* **29 B (1/4).** 77-87.