On Carrying capacity of Cave Murals of Ajanta

M.Singh[1*] and B.R.Arbad[2*]

Abstract- With increasing population, the cave murals of Ajanta in combination to other factors are also being affected on account of visitor's impact in the form of rise in humidity, temperature, carbon dioxide content, dust fall etc. Experiment carried by monitoring the environmental parameters inside the cave clearly show 7-8% increase in humidity when more that recommended 40 number of visitors enter the cave at one time. Similarly, increase in carbon dioxide content has also been observed with increase in numbers of visitors causing long term effect on painted surface. Besides use of eatable by some visitors inside the cave give rise to food chain for insects. Archaeological Survey of India has given top priority for the conservation of Ajanta murals and has taken many steps for proper visitor management at Ajanta. This paper outlines the visitors impact vis-à-vis physical measures adopted for the long term survival of Ajanta murals.

Keywords- Relative humidity, environmental parameters, carbon dioxide monitoring, noise pollution

Introduction:

As half of the Ajanta cave faces east and other half the south with 178ft high waterfall in seven stages, microclimatic condition plays an important role in the survival of Ajanta murals. The unstable microclimatic condition is one of the factors that always affect the state of conservation of paintings. The mud plaster used as ground contains clay admixed with natural fibers such as rice husk, plant seeds and fibers. Pigment layers have been applied on dry mud plaster with color which is inorganic in nature. As the mud plaster contains clayey materials, it is very sensitive to humidity inside the cave. In case of high humidity as in rainy season, the clay portion of the mud plaster may absorb moisture through porous painted surface. In hot climate the moisture is given out as per the characteristic behavior of clay materials. Besides, the Ajanta painting has been identified to be executed in tempera technique with binder which is certainly of organic nature and tentatively detected as animal glue. The binder being organic in nature is also soluble in water. Hence, the nature of support and the pigment layer are vulnerable to environmental conditions. Due to this the Italian conservators of 1920 applied thick protective coating of unbleached shellac thus modifying the physical condition of the painted surface, which in course of time altered the chromatic appearance of the paintings[1]. Nearly two third of the paintings including the painting in famous cave no 1,2,16 & 17 Ajanta have been applied with shellac varnishes.

[1*]Archaeological Survey of India, Science Branch, Western Zone, Aurangabad-431004
e-mail:m_singh_asi@yahoo.com
[2*]Department of Chemistry, Dr.BabaSaheb Ambedkar Marathwada University, Aurangabad-431004)
e-mail:abr_chem@yahoo.co.in

In ancient cave no 9 &10 we observed many different layers of varnishes applied in the past for copying the painting in 19th century[2].

The Italian conservators have applied shellac resin without removing the earlier varnishes that resulted a very thick varnish coatings on some of the remains of most ancient (2nd BCE) painting of cave no 9 & 10, Ajanta. Fortunately, it is observed that these ancient painting of cave 9 & 10 have been executed on lime plaster ground. As the lime plaster is not as hygroscopic as the clay materials of mud plaster, the painting of 2nd BCE still survived in spite of thick varnish layer[3]. The ridges, gaps & lacuna observed on 2nd BCE murals are fewer in number as compared to paintings on mud plaster. Since the entrapped moisture of clay particle in mud plaster have to be driven out in hot season, it makes way through shellac coating by making gaps, ridges and lacuna on the painted surface. Thus out of many factors of deterioration of murals at Ajanta, the moisture plays one of the main reason of deterioration for the paintings on earthen support. Hence, anything that causes enhancement of moisture content inside the cave has to be properly regulated. The painting survive better when the humidity inside the cave is 55-60% and temperature around 25^{0}C.

Another factor that impacts the moisture content of cave interior is the visitors. The visitors have to climb the Ajanta hill to reach the cave. While climbing everyone has to breathe fast and exhale more moisture and carbon dioxides as they rush into the cave 1 & 2 at Ajanta. There is also particular mindset among the visitors to start with cave no 1 & 2 and hence there is quite a rush to these caves. As the sequence has nothing to do with the story of paintings at Ajanta, the guides also follow the same trend with group of visitors at Ajanta. This mind set

causes considerably pressure in cave no 1& 2 thus disturbing the microclimatic condition inside the cave[4].

Another way some of the visitors impact the Ajanta murals is by eating eatable inside the cave. It is estimated that ¼ of Ajanta murals has been lost due to insect activity ever since the cave was abandoned by Buddhist-monks in 6th century A.D. Although Archaeological Survey of India keeps strict vigil, the visitor's were found sometimes making use of cave for their eating. This process gives way to food chain inside the cave which may cause long term impact on the paintings. On many occasions some non-serious visitors to the cave were found talking loudly increasing the noise level inside the cave. Even some guides in big group were found lecturing loudly so that the voice reaches to all. The Archaeological Survey has put silence board at the entry of cave, but many of the visitors are not aware about their pitch of the voice vis-à-vis its impact on Ajanta murals. Attempt has been made to monitor all these parameters inside the Ajanta cave for taking appropriate measures towards its long term conservation.

Discussion:

The temperature & relative humidity both inside and outside the important cave no 1,2,16 & 17 are constantly being monitored at Ajanta by ISUZU model 3126 thermo-hygrograph. In recent years monitoring of these data are being carried out by data logger. Comparison of data by both the technique, show that they are almost similar and in consonance with the data also being measured with dry and wet bulb thermometer. All the three kinds of instruments are presently in use for measuring temperature/humidity at Ajanta on long term basis. From the recorded data it is observed that caves are thermally stable with temperature always remaining between 27^{0}C-30^{0}C, irrespective of humidity. The recorded data for average relative humidity inside the cave no. 17 is shown in figure-1 for a 5 year period. It can be seen that there is about 50% variation in relative humidity from the rainy season to that of dry season, which is one to the reason for the formation of ridges, gaps, lacuna and sometime flaking of pigments of Ajanta. Some of the pigments make weak bond with the animal glue used for bonding and fall very easily due to variation in relative humidity within the cave. One of the pigments noticed is kaoline used at some place in Ajanta painting. Figure2 shows the white kaoline and its fall grain by grain from the ceiling paintings of cave no 2, Ajanta.

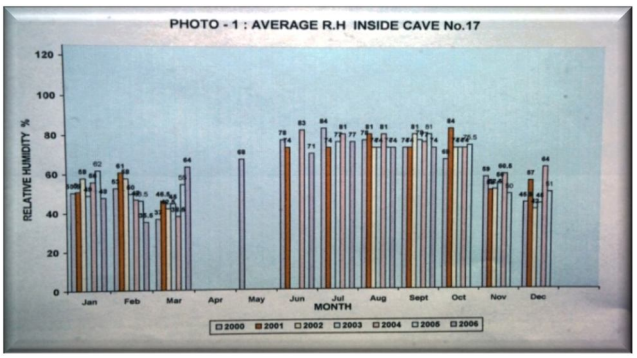

Figure 1: Average relative humidity inside the cave no. 17

Figure 2: Fall of white pigments and its conservation from ceiling of cave no 2.

The problem of humidity is further enhanced when more than recommended number of visitors enters the cave. Ajanta cave attract around 6000-7000 visitors daily in the tourist season of October to January and 2500-4000 visitors daily in other month and lean period (children below 15 years also included) which can be shown in figure 3 .

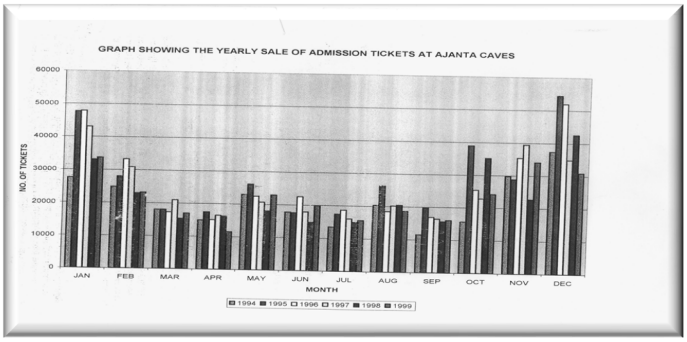

Figure-3: shows the purchase of ticket in various season excluding children.

There is large rush to enter cave no 1 &2 as its fall at the main entry point. Experiments were carried out in cave no 17 & cave no 2 to know the increase in humidity

due to entry of more than recommended number of visitors. In cave no 17 visitors numbering 40 or less showed no increase in humidity inside the cave, whereas in cave no 2 when more than recommended number of visitors entered inside, about 7-8% increase in humidity was observed which adds to the existing relative humidity causing further problem for delicate painted materials this can be shown in figure 4 & 5.

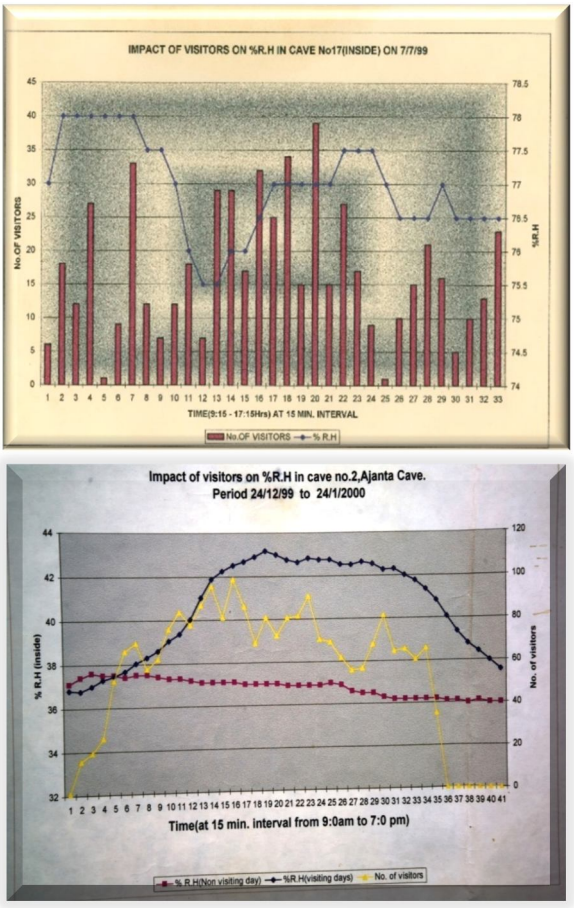

Figure 4 & 5: shows data of humidity on account of visitors.

It should be noticed that although Archaeological Survey of India displayed noticed board for not more than 40 visitors to enter the cave, in tourist season it is not possible to adhere it due to visitor's pressure.

The impact of visitors inside the cave not only causes an increase in relative humidity, but also increases carbon dioxide concentration during day time as shown in figure 6. For this purpose CO_2 monitoring using portable airflow model equipment was carried out in cave no 2 & 17 covering almost entire cave area. To record any gradient in CO_2concentration monitoring was done at the floor level as well as at a height of 8 feet from the floor. The CO_2 recorded was 600 PPM at 5 pm on Monday when the cave is closed for visitors.

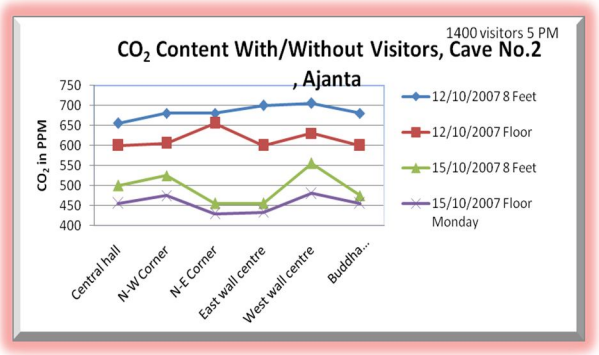

Figure 6: Carbon dioxide content in the cave due to visitors

The slightly higher value of carbon dioxide is due to non-circulation of air, as the doors are mostly kept closed on Monday. However, with 1400 visitors entering the cave the next day, the CO_2 concentration reached up to 800 PPM in the central hall. Visitors are not allowed to move in the aisle area on all sides due to barricades installed inside the cave to restrict movement. In other parts of cave interiors, CO_2 concentration is also high during day and higher concentration recorded near the east wall center. As all the visitors have to climb the Ajanta hill and are generally found rushing to enter cave 1 and 2 with fast breath, there is slightly more impact on relative humidity and CO_2 level inside the cave. When humidity is high inside the cave there is a chance of reaction of CO_2 with white pigment changing calcium carbonate into calcium bicarbonate and causing loosening of grains. This property is still to be numerically studied at Ajanta to know the long term impact of this phenomenon on the Ajanta pigments.

Another problem encountered inside the cave is the accumulation of dust on painted surface. Archaeological Survey of India has taken bold step about removing shoes for visitors while entering some of the best precious painted cave no. 1, 2, 10, 16, 17, 19 & 26 at Ajanta. Feather brushes are also being used to remove dust from painted surface. To assess the air quality inside the cave, it was decided to collect the suspended particle matter on cellulose acetate fibers under Indo-Italian conservation programme of cave no. 17, Ajanta. For this purpose Gelman Hawksley airborne particle sampler with an air flow rate of 20 lit/min was used. The duration of sampling period was kept 6 hours a day, compatible to the time allowed for visitors at Ajanta cave. The filters were analyzed with high performance ion chromatography to

determine the soluble salt content. The data obtained is shown in Table-1.

Table-1: Soluble salt content in mg/lit for October-2005

Date	Na	K	Mg	Ca	Cl	NO_2	NO_3	SO_4	NH_4	PO_4
18	1.12	0.37	0.17	3.28	0.68	0.47	2.6	1.29	0.93	0.09
20	1.33	0.50	0.21	3.24	0.95	0.68	3.13	2.16	1.09	0.06
21	1.11	0.51	0.18	2.68	0.78	0.56	2.95	2.24	1.19	0.07
24	1.07	0.33	0.07	2.45	0.65	0.53	2.61	1.77	1.29	0.05
25	1.77	0.78	0.2	4.04	1.04	0.67	2.66	4.38	2.88	0.12
26	1.22	0.38	0.19	3.3	0.82	0.58	3.02	3.18	1.76	0.12
27	1.27	0.62	0.2	3.41	0.93	0.47	2.87	2.73	1.62	0.05
28	1.2	0.57	0.2	2.47	0.81	0.78	2.77	3.03	1.92	0.06
29	1.1	0.4	0.22	2.56	0.53	0.37	2.1	1.37	0.81	0.04
30	1.2	0.79	0.21	2.56	0.71	0.79	3.93	2.51	1.58	0.03

Sulphates and calcium value are little higher side which must be attributed to the influx of visitors even they have to enter the cave without shoes.

The noise level inside the cave no 2 measured with cygnet system is shown in figure-7.

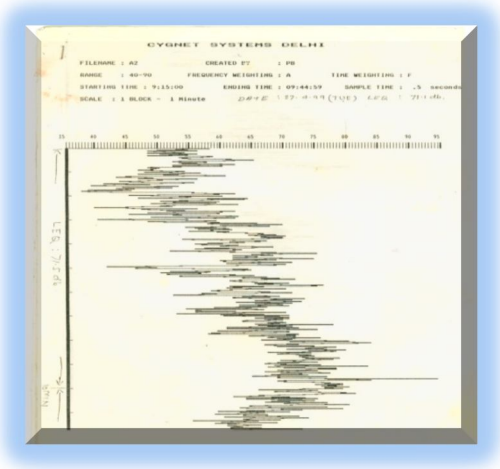

Figure- 7: Noise level monitored inside the cave

It is observed that against the recommended 45-55 db noise in silent zone, the noise level mostly recorded is 70-75 db with occasional rise up to 95 db causing further problem to the delicate painting in long run. It is observed that some non-serious group of visitors creates more noise being unaware about their pitch of the voice and it impact on the painted plaster. To undo the cause the Archaeological Survey of India has taken following measures for visitor's management at Ajanta.

1. Two cause ways on Waghura River have been constructed for proper distribution of visitor and stop rush to cave no1 and 2 at Ajanta.
2. All the caves at Ajanta have now been properly illuminated so that visitor can see each and every part of the cave and there is no need to rush for important painted cave.
3. Some of the important cave like 1,2,16 & 17 has now been illuminated with optical fiber light causing no radiation or heat for better posterity of the painted surface.
4. Regular spray of pyrethrum extract in kerosene is being carried out every fortnight to eradicate insect activity from the cave.
5. Sometimes fumigation with ethoxide gas is also carried out to eradicate those silver fishes that have migrated into mud plaster and thriving on the organic matter present in the earthen support.
6. Visitor centers are being planned to teach about the delicate nature of painted surface and what the visitors not supposed to do during their visit. We feel that with the co-operation and support of public at large we can together help in conservation and posterity of paintings of Ajanta.

References:

1. The preservation and maintenance of cave temple of Ajanta. Annual Report of Archaeological Department of Nizam,1949,pp.1-16
2. Subbaraman S., Conservation of the mural paintings. Current Science, 1993, 64(10), pp.736-753.
3. Sharma R.K., Painting techniques and materials of cave mural paintings in India and their conservation problems, in Mural paintings on the silk Route, In proceedings of the 29th Annual International Symposium on the Conservation and Restoration of Cultural Property, Tokyo, 2007, pp.102-106.
4. Singh M., Microclimatic condition in relation to conservation of cave no.2 murals of Ajanta, current science, Vol.101, No.1 2011, pp. 89- 94.