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Age determination of living Banyan tree using Optically Stimulated Luminescence: A study in Chandigarh region (India)

Rita Rani
Research Scholar,Guru Kashi University,Talwandi Sabo,Bathinda,Punjab(India)

Ramesh Kumar

Professor in Physics,Guru Kashi University,Talwandi Sabo,Bathinda,Punjab(India)

Abstract –

Intend of the present work is to relate the age of living old Banyan tree which is 'Heritage Tree' of Chandigarh region with the sediments beneath the roots of trees using Optically Stimulated Luminescence. The site for the study is capital of northern states Haryana and Punjab and located close to the foothills of Shivalik range of Himalaya. Requirement of wood from living tree ruled out the conventional dating methods like Radiocarbon dating and Dendrochronology. Luminescence dating considered the sedimentary grains as the indicative of last exposure to sunlight hence estimating the age of planting event .The protocols and methodology for dose rate estimation and equivalent dose calculation are discussed. Sedimentary relation with age of living planting event is studied first time in the area. The extrapolation of optically stimulated luminescence ages gives the date of planting event. Present study gives the experimental age of the 'Heritage Tree'

Keywords – Bleaching, Equivalent dose, OSL Dating, , quartz, sediment mixing

INTRODUCTION

The Banyan (Ficus benghalensis) are considered as the monumental trees in India. The spices belongs to moraceae family and have religious importance in Indian community. Banyan tree is deciduous evergreen and the national tree of India.It grows as an epiphyte and thus attained the nick name 'the strangler fig'. Older Banyan trees characterized with prop roots and can spread widely covering the significant area The average lifespan of this spices ranges between 900 years to 1500 years and even more. These are native to Indian subcontinent and tropical Asia.. Ideal altitudes for its growth ranges from 10 m to 1500 m and prefers loamy soil .In earlier times these are planted as shade trees .However the religious myths are featured by these trees as the name'Bahupada' (one with many feet) given to Banyan tree due to its prop roots hanging down and its expanded canopy. So, the present study attempted an indirect procedure to assess the age of the Banyan tree which is the 'Heritage tree' in Chandigarh region. The age estimation of the monumental tree involves the study of sediments present beneath the tree. Optical luminescence of the sedimentary grains would be related with the age of planting event using quartz. The optical stimulated luminescence dating procedure is conventionally used to date the events like rock art ,bricks or graves .But relating the sediment age with the planting event is the first attempt in India so far (as per author's knowledge).The dating procedure of the sediments includes dose rate estimation and the equivalent dose calculation.

MATERIALS AND METHODS

SAMPLING SITE

The monumental 'Heritage tree' includes the Banyan tree whose age determination by OSL is the aim of the study. This specific tree is located in the Chandigarh region which is situated on Indo Gangetic plain.The city lies southwest of Shivalik range of Himalyas.The land of this region is flat and fertile alluvoil soil producing wheat, maize as the primary crops. This city is Union territory of India and its capital complex(includes many monuments and buildings) has been declared as World Heritage by UNESCO. The dense plantations like Banyan, Ashoka, Peepal flourish the ecosystem of this 'city beautiful'. The 31 such old trees has got the status of 'Heritage trees' by the Chandigarh Administration. Out of these 31 trees this banyan tree site has been selected for the present study. This tree is a magnificent Banyan tree planted along northern boundary of 'Indira Holiday Home' at Sector 26-B of Chandigarh.This area was once a part of Kalibard village.The proliferation of arial roots turned into the five additional trunks supporting the beautiful canopy of about 30 meters. The length of tree is about 55 feet with the trunk circumference of 27 feet.

Fig(1)View of the historical Banyan tree at Indira Holiday Home

Fig(2) Location map of Indira holiday home(site location)

The primary data revealed by the Forest and wildlife department shows that the age of indigenous tree considered for the present study is approximately 200 years. Other than this tree there are many ancient trees in the region which are several years old. This city is situated at 321 m above the sea level. The estimation of age of this tree is scientifically important for the union territory so as to provide geo-archaeological information about the sampling area. Also these trees are serving as landmarks of inhabitation so their conservation also requires the actual dating of the events.

SAMPLING METHODOLOGY

In order to extrapolate the age of sedimentary grains to the age of planting event ,the sample of sediments were extracted from the site very close to the trunk of the tree from a depth of 1 meter .The fig.(2) represents the location map of the sampling site .The sample were collected by digging a pit of depth more than 1 meter near the trunk of tree. The roots of tree got exposed during digging and the homogeneous profile at a depth of 1 meter beneath the roots was selected for inserting the sampling tube. The cylindrical opaque sampling tubes of stainless steel having a length of 30 cm and diameter of 5 cm with Styrofoam plug were used for sampling. The horizontal samples were collected obeying the sampling protocols for luminescence dating .The tubes completely filled with sediments were immediately covered at both end and sealed with tape to avoid any exposure of light. The labelling of tubes was completed by providing the special code(shown in table 1) to sample.

PREPARATION OF SAMPLE

In the laboratory, the low light ambience is preferred to open the sampling pipe. As the grains at the extreme corners of the pipe are less reliable for equivalent dose determination so it is preferred to remove the sample from 3 cms from each end of the pipe. This sample can be used for dose rate determination and hence can be placed in the laboratory without any special light conditions.

In order to get more luminescence from the grains, the size of sample should be very small (Murray and Wintle).Although the type of mineral grain (quartz, fledspar) and the mineral size(fine or coarse) determines the technique to be used for sample preparation. In the present study, the abundance of quartz grains in the sediments promotes the use of OSL. The chemical treatment was followed to get the required mineral grain .The sample preparation procedure by using suitable chemicals and separators was used.

- The sediments are treated with HCl to remove carbonates followed by its treatment with 30% H_2O_2 to eliminate any organic matter present.
- It is then sieved to obtain grains and magnetic separation is done to extract the grains of quartz from the remaining sample.
- The obtained grains then undergo the etching process by using 40 %HF for 80 minutes .Etching will help in removing any fledspar present and also for alpha dose removal.
- The treatment of grains is done with HCl for nearly 30 minutes to ensure the removal of fluoride ions which are otherwise likely to contribute to the luminescence.
- A disc made up of stainless steel is used to hold these grains for the further observation.

LUMINESCENCE MEASUREMENTS

For measuring equivalent dose the (TL/OSL –DA-20) model of Riso TL/OSL Reader is used. TL/OSL reader is equipped with $^{90}Sr/^{90}Y$ source

Equivalent dose measurement:

Long lived naturally occurring radioactive nuclides like ^{232}Th,^{87}Rb decay to natural Uranium to produce the dose. This dose helps in irradiation of natural sediment mineral grains like quartz which stores this dose as signal(Aitken 1985,1998).The signal stored in these natural dosimeters appears as luminescence. Consequently ,the brightness reflects the amount of accumulated dose during burial. Dose measurement of coarse and fine grains follows the same protocol..Main quantities to be measured for age determination includes the

dose accumulated i.e. equivalent dose and the elemental concentration measurement of radionuclides.

$$\text{Age equation} = \frac{\text{Equivalent Dose (E.D.)}}{\text{Dose rate } (D_r)}$$

Sar Procedure:

The methodology widely used for ED calculation is SAR procedure (Wintle and Murray,2003) in which regeneration of signal of single aliquots or the single grain can be done by β source ($^{90}Sr/^{90}Y$) in the lab. The SAR(Single Aliquot Regeneration) procedure for this study uses the preheat 240 ºC in order to get the equivalent dose. For present study, the aliquot is studied for natural luminescence and then laboratory dose is given using $^{90}Sr/^{90}Y$ source to measure laboratory dose. Repetition of the same procedure for different laboratory doses helps in plotting the dose response curve(Fig 4). For measuring De the trapped signal in the form of charges released and luminescence produced due to de-excitation followed by the recombination. Laboratory calibrations helps in computing total dose received.

Following the SAR criteria for a number of discs, the luminescence is yielded which consequently produce the glow curve (Fig 4) to estimate the ED. To provide the age of event, dose is measured in seconds which needs to be converted in Gy from the instrument's calibrated dose rate ($Gy.s^{-1}$) . The age of current sample is shown In table (1) .

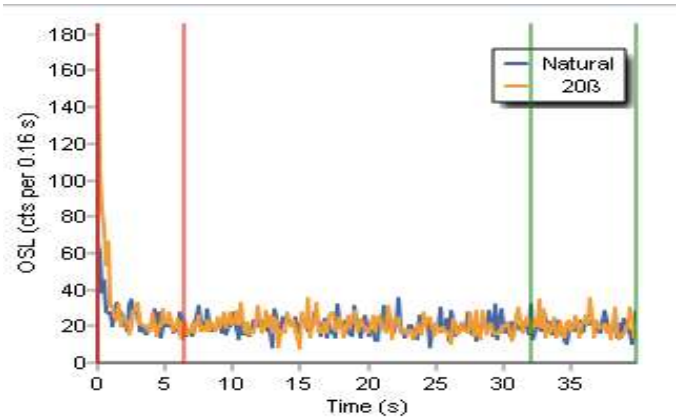

Fig (3) comparison of OSL counts of the sample

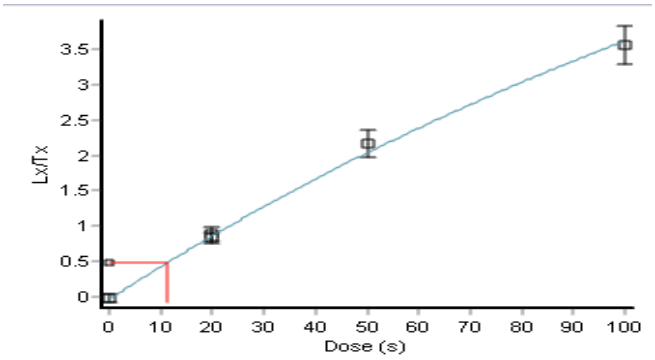

Fig (4) represents dose response curve using quartz

Dose rate measurement (D_R)

The concentrations of the radioactive nuclides i.e. U, Th, K in the sedimentary sample is calculated by using Gamma spectroscopy (High purity Germanium Gamma detector-HpGe).The values obtained are shown in the table(1) yielding the dose rate.

Table (1) Annual dose rate and equivalent dose components of the sample

S. Name	U (ppm)	Th (ppm)	K%	Dose rate(Gy. ka^{-1})	D_e(Gy)	Age(ka)
CHD_3	2.7±0.3	22.3±13.9	1.9±0.1	3.8±0.7	1.0±0.01	0.26±0.05

RESULTS AND DISCUSSION

The equivalent dose from the dose response curve is found to be 1.0±0.01 Gy and the annual dose rate as obtained by gamma spectroscopy is 3.8±0.7 $Gy.ka^{-1}$. Applying the age calculation formula the age of the studied event is 0.26±0.05 ka. The recycling ratio is found to be 0.94 which is in the range 0.91 - 1.15 which strongly recommends the suitability of the procedure. Using optically stimulated luminescence dating procedure, the date of the Banyan tree is found to be 263 years which is very close to the approximate age mentioned by the related agency.

CONCLUSION

As the Banyan trees are the ancient trees and geological evidences reveals their existence from the ancient times .Although a number of conventional methods have been used for dating trees but the application of optical dating to date Banyan tree by using the sediments under its roots is the first time in India. Present study gives the first experimental age of the Banyan tree which is entitled as 'Heritage tree' also. The age revealed by current study is in good agreement with the related age declaration by the Forest and Wildlife Department, Chandigarh. Present study shows that luminescence dating can be successfully applied to date the living tree without harming it. Consequently ,the study opens the multidisciplinary interest.

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