ASSESSMENT OF CLIMATE CHANGE IMPACT ON RECESSION OF ADI KAILASH GLACIER KUMAUN HIMALAYA : A LICHENOMETRIC OBSERVATION

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ABSTRACT

Evidences have suggested that most of the Himalayan Glaciers have receded in recent past under the influence of global warming. However, the rate of recession remains a subject of debate. Lichenometry, which uses lichens to estimate the age of the substrate on which it grows, is attracting attention to rapidly estimate the rate of recession of glaciers. The present study conducted with the help of lichen species *Rusavskia elegans* (Link) S.Y. Kondr. & Kamefelt on the moraine of Adi Kailash Glacier revealed that this glacier has receded 470 m during the last 41.37 years with an average recession rate of 11.36 meters/year.

Keywords: Adi Kailash, Kumaun Himalaya, Lichenometry, Retreat.

INTRODUCTION

Climate change is one of the most burning issues at present that has emerged as a global threat. The glaciers being exposed to low temperature climates are very sensitive to global warming and are considered as important indicators of global climate change. The glacier fluctuation (*i.e.* advancement and recession) depends on the prevailing climatic conditions and a slight increase in the global earth temperature can lead to drastic glacier retreats across the globe. For monitoring glacier variations across the globe and to understand its mechanism, International Glacier Commission was established in 1984 in Zurich, Switzerland (Haeberli *et al.*, 1996). This organization has monitored drastic glacial retreats during the last century and indicated the ongoing process of global warming (Beniston *et al.*, 1996). Though monitoring of glaciers is a time taking and resource intensive process, hence in this context, lichens can play a significant role in estimating/measuring the approximate time of glacier retreat via lichenometry and therefore can be considered useful proxy in determining the impact of global warming on glaciers.

Lichenometry was first of all introduced and applied by Roland Beschel in glacier chronology (Beschel 1950, 1958, 1959, 1961) and after him a number of workers followed this technique in glacier retreat studies in different countries (Benedict 1967; Rodbell 1992; McCarroll 1993; Begét 1994; Matthews 1994, 2005; Winchester 2004; McCarthy 2003; Winkler 2004; Hansen 2008; Roberts *et al.*, 2010; Trenbirth *et al.*, 2010; Loso *et al.*, 2013; Decaulne 2016). However, in India the use of lichenometry in glacier retreat studies was first of all carried out in Gangotri Glacier of Uttarakhand. Srivastava *et al.*, 2004 attempted to date moraines in Gangotri Glacier via lichenometry using *Rhizocarpon sublisidum*, *Rinodina oreina* (*Dimelaena oreina*) and *Xanthoria elegans* (*Rusavskia elegans*) and estimated the age of three moraines as 1782 AD, 1849 AD and 1865 AD. Awasthi *et al.*, 2005 used lichenometry and Schmidt Hammer techniques for relative dating of moraines in Gangotri glacier. They estimated relative ages of two moraines on the downstream side as 1897 AD and 1881 AD by lichenometry using *Dimelaena oreina* and another moraine on the upstream side as 1970 AD by Schmidt Hammer technique. Thereafter Chaujar 2009 studied impact of climate change on Himalayan glaciers based on the dating of lichens. He showed that the date of the largest lichen on the loop of moraine that indicated the position of maximum advance of the glacier was 258 yrs. It shows the period when the Chorabari glacier started receding from the point of its maximum advancement in this part of the Himalaya. Earlier work in the Dokriani Bamak (glacier) showed a retreat of around 314 yrs. Joshi *et al.,* 2010 used *R. geographicum* with a slow growth rate of 0.2 mm/yr, to estimate the retreat of Pindari glacier. They estimated approximate age of the surface exposed at a distance of 1 km from the glacier snout ranged from 550 to 600 yrs. Bajpai *et al.,* 2016 studied Kupup and Thangu area of eastern Himalaya in Sikkim and Thajiwas glacier in Ganderbal district of north western Himalaya of Jammu and Kashmir with the help of *R. geographicum.* The Thajiwas glacier showed vertical retreat of 200 m in 279 yrs, while in Thangu and Kupup area of eastern Himalaya the vertical retreat was estimated 200 m in 100 and 91 yrs respectively. They observed faster recession rates in eastern Himalayan (20 mm/century) than the north-western Himalaya region (18.5 mm/century). Bisht *et al.,* 2018 conducted lichenometric studies on Milam Glacier in Uttarakhand using the lichen *Dimelaena oreina* and showed that the Milam Glacier has receded 1450 m in last 70 yrs with an average recession rate of about 20 meters/year.

Studies have shown that Himalaya is warming more than the global average rate ranging from 0.06℃ to 0.12℃ per year Shrestha *et al.,*1999 temperature increases are greater during the winter and autumn than during the summer (0.16℃/decade for the annual mean and 0.32℃/decade for the winter mean); and the increases are larger at higher altitudes (Liu *et al.,* 2000); hence in the present study we focused on Adi Kailash glacier because it is located at higher altitude (4600 m asl at snout) as compared to the other major glaciers of Uttarakhand e.g. Gangotri, Milam, Pindari, etc. which are located <4000 m altitude (at snout).

MATERIALS AND METHODS

Present study was conducted on the moraines of Adi Kailash glacier (N30°20.180' E80°38.645'; 4609 m asl at the snout) also known as 'Chhota Kailash' and 'Baba Kailash' which is located in Byans Valley of Dharchula block of Pithoragarh district, Uttarakhand (Fig.1). The Adi Kailash peak is of great religious importance due to its resemblance with the Holy Mount Kailash and every year a pilgrimage is organized to this region by the Government of Uttarakhand.

Sampling was done at the moraine of glacier towards the lower side from the snout. As the sampling area was very small (about 500 m from the snout) the boulders were devoid of lichen populations. Only a few lichen species *Physcia caesia* (Hoffm.) Fürnr., *Rhizoplaca chrysoleuca* (Sm.) Zopf**,** *Rusavskia elegans* (Link) S.Y. Kondr. & Kämefelt and *Umbilicaria indica* Frey were found growing on these boulders, and of these lichens, *R. elegans* was selected to conduct the study due to its known growth rate (0.7 mm/year; McCarthy *et al.,* 1995) and circular size. The diameter of *R. elegans* was measured with the help of digital vernier caliper. The distances of these points (where the measurements of diameters of lichen thalli were taken) from the snout were also measured with the help of meter tape.

RESULTS AND DISCUSSION

On the moraines of Adi Kailash a total of three measurements were taken. The first thallus of *R. elegans* was encountered at 45 m (N30°20.726' E80°39.271'; 4413 m asl) distance from the snout, second at 160 m (N30°20.744' E80°39.299'; 4402 m) and third at 470 m distance (N30°20.673' E80°39.544'; 4398 m). At these locations the diameters of lichen thalli were measured. The measurements observed were 9.86 mm, 17.71 mm and 28.96 mm respectively (Fig.2). The diameters of lichen thalli were increasing with increased distance from the snout. By dividing the diameters with 0.7 (annual growth rate of *R. elegans*) the age of lichen thalli were calculated at each of the three locations (Table 1). The age of the lichen thallus is considered as the minimum time of exposure of that boulder. The largest thallus measured at a distance of 470 meters from the snout showed an age of 41.37 years *i.e.* that boulder on which the lichen was growing might be exposed at least 41.37 years ago. From the above calculations it can be assumed that 41.37 years ago the snout was 470 meters down from its current position. The Adi Kailash glacier was estimated 470 meters in last 41.37 years with an average annual recession rate about 11.36 meters**.** The monitoring of Adi Kailash glacier for a period of 40 years between the years 1962-2002 has observed 13 meters/year retreat (Sangewar *et al.,* 2011). Present results are corroborating with the previous study. Majority of the glacier retreat studies are based on satellite observations. Lichenometry a cost effective and user friendly technique provides field based observations for rapid assessment of glacier retreat hence it should be promoted in the Himalayan glaciers.

Table 1. Thallus diameters of *R. elegans* at different locations, their age and recession rate of Adi Kailash glaciers over time

Location	Geo-coordinates	Altitude (m asl)	Distance from snout (m)	Thallus diameter (mm)	Age of lichen (year)	Recession Rate (m/year)
1	N30°20.726' E80°39.271'	4413	45.00	9.86	14.09	3.19
2	N30°20.744' E80°39.299'	4402	160.00	17.71	25.30	6.32
3	N30°20.673' E80°39.544'	4398	470.00	28.96	41.37	11.36

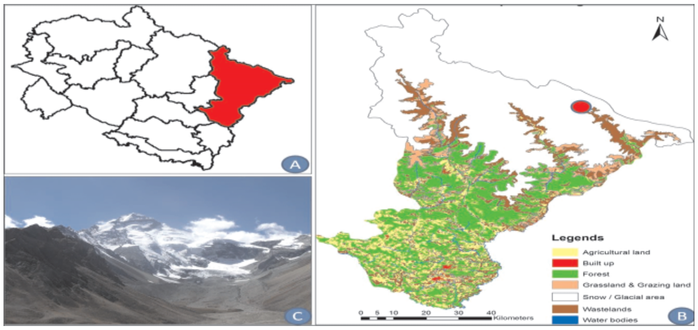

Fig. 1. Location map of Adi Kailash Glacier a) Uttarakhand b) Pithoragarh district c) Adi Kailash glacier

Fig. 2. Diameters of *R. elegans* at different locations from the snout

CONCLUSION

Is it okay for a glacier to recede 11.36 meters/year? Majority of the Himalayan glaciers are less than 1 km^2 in area; if the recession prevails with the same rate, in a century a large number of glaciers will be vanished. This will drastically affect the perennial fresh water supply in the Indian states.

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