



Chronology of micro earthquakes in the environs of Hyderabad: a historical perspective

K.Sudarshan * Prof .VijayaBhole **

*Research Scholar, Department of Geography, Osmania University, Hyderabad. 500007

** Professor, ICSSR Senior Fellow, Department of Geography, Osmania University, Hyderabad.500007,

Abstract

Information on the past history of seismic events provides an insight into the seismic status of an area. Historical data on micro earthquakes is the pre requisite for the better understanding the vulnerability of seismic activity and risk preparedness, more so in an urban environment. The environs of Hyderabad which form a part of Deccan shield area and categorized as zone II i.e. a zone of low intensity of earthquakes occurrence. In the last 4 decades, the environs of Hyderabad registered a large no. of micro earthquakes which are in the form of mild tremors and low intensity. Based on the time line data obtained from NGRI, the study brought out the temporal dimension by analysing the seismic events on yearly and monthly basis. The study revealed large decadal, yearly and monthly variations. The seismic events occurred during the period 1972-2016 where categorized in to various phases depending on it's frequency of occurrence.

Keywords: Phases of seismic activity, Seismic events - frequency, Temporal analysis, vulnerability of seismic activity.

Introduction

Micro earthquakes are very low intensity earthquakes generally in the form of foreshocks and aftershocks. Micro earthquakes may be associated with mild tremors and it's intensity will be less than 2 on richter scale. The focus of micro earthquakes will be very shallow and its depth rarely exceeds 1.5 – 2.0 kms. They are mostly localized and are confined to few square kilometres as in case of surroundings of Hyderabad. Though the Bureau of Indian Standards (BIS) has categorized the environs of Hyderabad in zone II i.e. a zone of low intensity of earthquake occurrence, still the city and it's surroundings has a history of seismic events more than one a century. The environs of Hyderabad recorded earthquakes of 3 – 5 intensity on richter scale in the past. The earliest one was recorded in 1843 measuring 3.5 on richter scale, the second in 1876 measuring 5.0 on richter scale. The most recent one occurred at Gandipet in 1982 measuring 3.2 on richter scale and at Medchal in 1983 measuring 4.0 on richter scale. With increasing urbanization, the occurrence of micro earthquakes is significantly increasing making the earth scientist and urban planners to reorient their thought process on causes consequences of chorology and distribution of earthquakes. Seismic risk analysis based on historic earthquakes and the presence of active faults is an established method for locating and degning complex and massive civil structures in seismically active area.(Suniletal (2016).

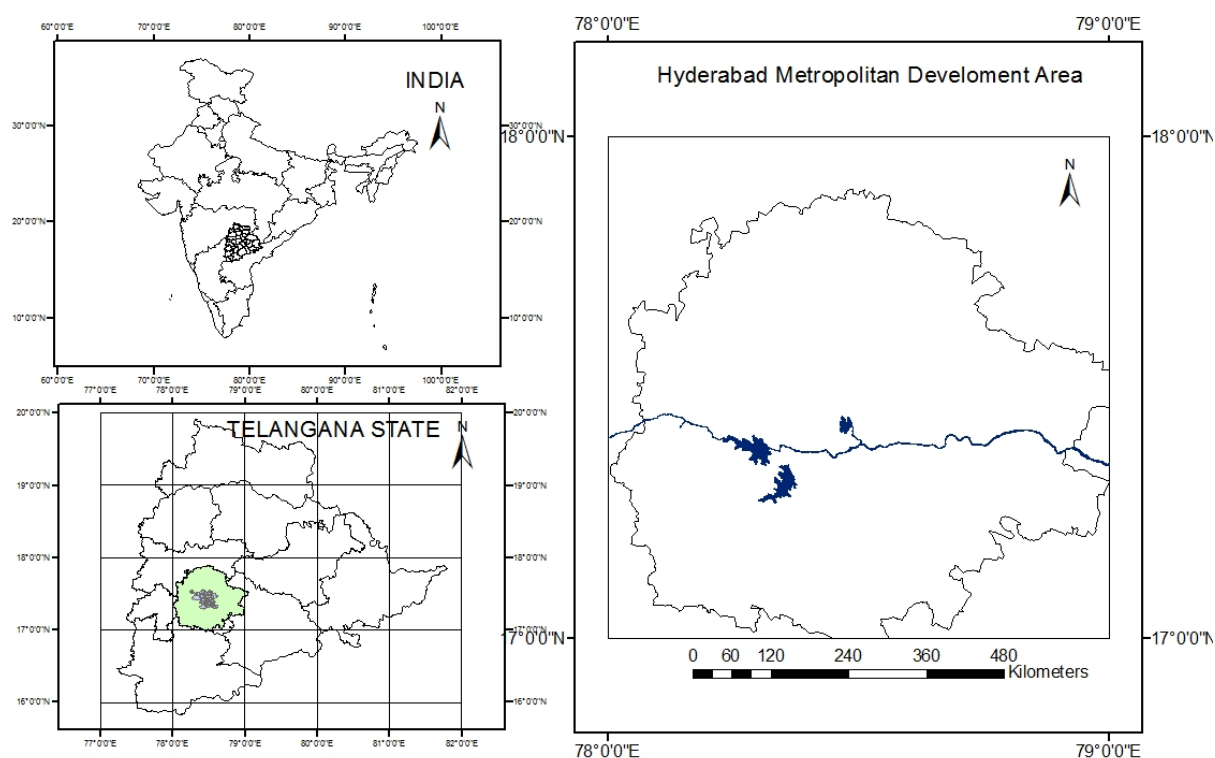


Study area

Hyderabad, the mega city is one of the fastest growing city in India. It is the capital of recently formed state of Telangana. The Hyderabad Metropolitan Development Area (HMDA) extends approximately between 78° E to 79° E and 17° N to 18° N. It covers part of Hyderabad, Rangareddy, Medak, Mahbubnagar and Nalgonda, Warangal Districts.

Fig 1

Location of study area



The study area is a part of Indian peninsular shield zone. The environs of Hyderabad is located in Deccan plateau region which has long been considered as seismically stable shield area. The major rock formation is granites which exhibits structural features characterized by fractures, joints, faults. Morpho-structurally, the Hyderabad region is classified as a circular morpho-structure and represents a bowl-like depression with elevated margins with altitudes varying from 300 to 600m. above msl. Sunil., etal (2016) Geomorphically the surrounding of Hyderabad is characterized by undulating terrain conditions with residual hills, inselbergs, pediplains and pediment zones and valley fills. The study area covering HMDA is spread over a radius of 60 kms.



The Hyderabad Metropolitan Area (HMA), also known as the Hyderabad Development Area (HDA), is under the jurisdiction of Hyderabad Urban Development Authority (HUDA) covers an area of 1,905 kms.

Data base and Methodology

The data for analysing chronology or historical perspective of micro earthquakes requires time series data. The data pertaining to the occurrence of micro earthquakes is obtained from National Geophysical Research Institute (NGRI). NGRI, which is the repository of data on earthquakes in India. The data pertaining to is collected on monthly and yearly basis. The monthly and yearly on micro seismic events is collected for a period extending from 1972 to 2016. The historical seismic data is compiled and computed according to the objectives of the study and presented in the form of tables. The tabulated data is represented with the help of suitable graphs. To analyse the trend and various phases of micro seismic events, cumulative frequency curve is drawn. The seismic data pertaining to the environs of Hyderabad is collected for an area 1° graticule area extending between 78° E - 79° E longitude and 17° - 18° E latitude, which approximately coincides with Hyderabad Metropolitan Development Area (HMDA).

Results and Discussions

Information on the past history of seismic events provides an insight into the seismic status of an area. The environs of Hyderabad has not experienced high intensity earthquakes in last 50 years, excepting Gandipet earthquakes of 3.5 intensity (1982) and Medchal earthquake of (1983). In last few decades, the frequency of micro earthquakes is increasing. The historical perspective or the temporal analysis is presented here in yearly, decadal and monthly basis.

Temporal / Yearly analysis of micro earthquakes

The yearly analysis of micro earthquakes is undertaken for 44 years i.e. from 1972-2016. During a span of 44 years, the environs of Hyderabad witnessed micro earthquakes during 25 years only i.e. seismic events were registered in these years. Remaining 14 years, the environs of Hyderabad registered a seismic lull or seismic activity was in dormatic state. During these 25 years, the environs of Hyderabad experienced 154 micro earthquakes. The yearly number of occurrence of micro earthquakes or their annual frequency greatly varied. The years 1975, 1992, 1993, 1994, 1995, 1996, 2000, 2004, 2007 and 2013 witnessed only single micro seismic (Table 1) events one of the most revealing feature of the yearly analysis of seismic events, is that out of 154 events, 48 events has been registered in the year 1982 only. Besides, these, micro seismic events were highly localized around Gandipet reservoir. The foreshock and aftershock pattern indicate the possibility that seismicity in Gandipet area may be affected by reservoir water or may be it is reservoir induced seismicity (Rastogi, B.K etal 1986). The seismic events confined to an around Gandipet reservoir area of 2×4 sq. kms. Another striking feature brought out by table 1 is that, during the year 2010, 32 micro earthquakes were registered in Jubilee hills in the north western part of the city. The micro earthquakes were swarm type according to NGRI scientist. According to NGRI, expert seismologist Dr. SrinageshDevluri, the micro earthquakes in Jubilee hills were a result of hydro seismicity condition when high intensity rainfall can trigger earthquakes (Times of India 23 October 2017). A WNW-ESE trending shear zone extending from Banjara lake near hotel



Taj Residency passes through KasuBrahmananda Reddy National park and terminates near Durgam (cheruvu) reservoir. The micro tremors recorded in this area are probably related to this shear zone. P Soloman., etal (2000).

Table 1

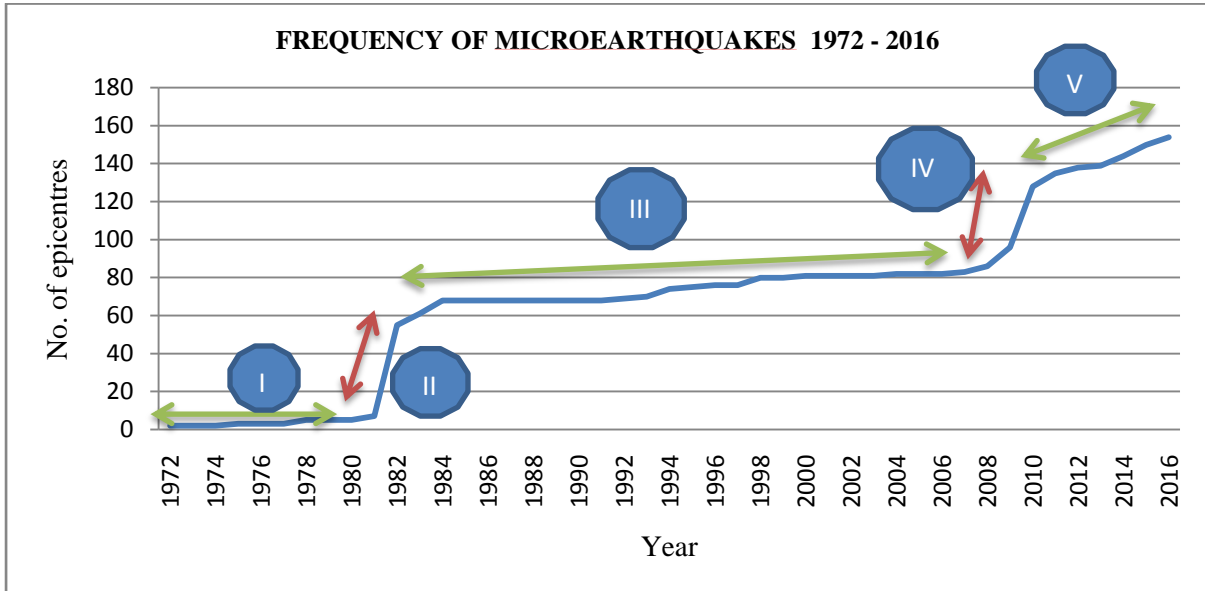
No. Of micro earthquakes in the environs of hyderabad

S. No	Year	No of Earthquakes	Cumulative	S. No	Year	No of Earthquakes	Cumulative
1	1972	2	2	24	1995	1	75
2	1973	0	2	25	1996	1	76
3	1974	0	2	26	1997	0	76
4	1975	1	3	27	1998	4	80
5	1976	0	3	28	1999	0	80
6	1977	0	3	29	2000	1	81
7	1978	2	5	30	2001	0	81
8	1979	0	5	31	2002	0	81
9	1980	0	5	32	2003	0	81
10	1981	2	7	33	2004	1	82
11	1982	48	55	34	2005	0	82
12	1983	6	61	35	2006	0	82
13	1984	7	68	36	2007	1	83
14	1985	0	68	37	2008	3	86
15	1986	0	68	38	2009	10	96
16	1987	0	68	39	2010	32	128
17	1988	0	68	40	2011	7	135
18	1989	0	68	41	2012	3	138
19	1990	0	68	42	2013	1	139
20	1991	0	68	43	2014	5	144
21	1992	1	69	44	2015	6	150
22	1993	1	70	45	2016	4	154
23	1994	4	74				

Source: Compiled and computed based on NGRI data



Fig 2



Source: Based on Table 1

To get into a deeper insight into the temporal analysis and phase of micro earthquake occurrence, cumulative frequency curve is drawn. Based on the trend and nature of cumulative curve, five phases of seismic events is identified as:

Table 2

Phases of micro earthquakes.

S.No	Phases	Years	Remarks
i	Phase I	1972 - 1980	Initial slow active phase of seismic activity.
ii	Phase II	1981 - 1982	Initial accelerated phase of seismic activity. (restricted to Gandipet)
iii	Phase III	1983 - 2008	Secondary slow active phase of seismic activity.
iv	Phase IV	2009 - 2010	Secondary accelerated phase of seismic activity.
v	Phase V	2011 - 2016	Slow and continuous active phase of seismic activity.

Source: Based on Fig 2



The period 1972-80 is associated with a slow and low level of seismic activity. As seen from (Fig) a steep rise in seismic activity is witnessed during the year 1981-1982, which as seen earlier is attributed to aftershocks in form swarm type of seismic activity. The years following 2009 registered a low frequency but continuous seismic activity. It is thus seen that, the micro seismic activity registered in the environs of Hyderabad showed a peculiar trend. It was in the form of single seismic events, while in few cases it was in the form of swarm type of micro earthquakes as in case of Gandipet and Jubilee hills.

Decadal analysis of micro earthquakes

The decade 1971-80 registered very insignificant seismic activity. Out of 154 micro earthquakes only 5 events constituting 3% of the total seismic events occurred during this decade. The decade 1981-90 registered on acceleration in the seismic activity. Nearly 63 seismic events out of 154, constituting 41% of the total seismic events occurred during this decade. As evident from Table 3 out of 63 seismic events, 48 were recorded in Gandipet area. The decade 1991-2000, registered only 13 events making up 8% of the total number of micro earthquakes experienced in this area.

Table 3

Decade wise occurrence of micro earthquakes in the environs of hyderabad.

Year	No	%
1971-1980	5	3%
1981-1990	63	41%
1991-2000	13	8%
2001-2010	47	31%
2011-2016	26	17%
Total	154	100%

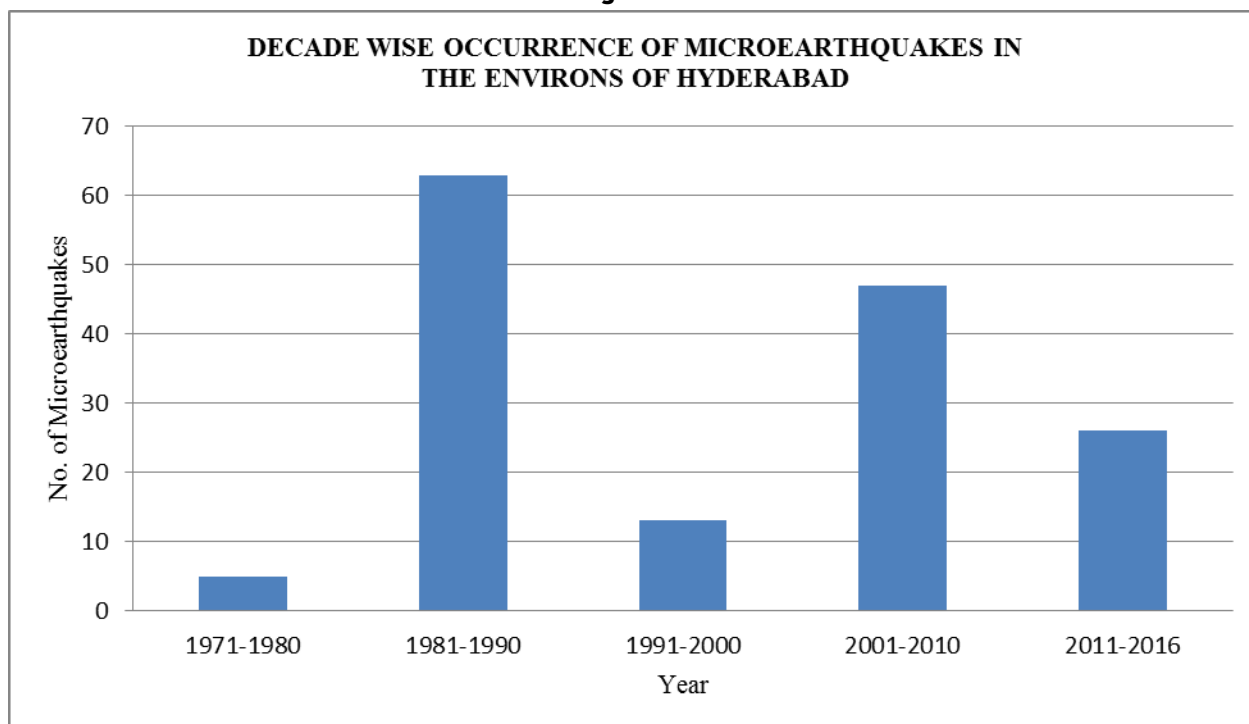
Source: Compiled and computed based on NGRI data

The decade 2009-2010 registered an increase in the number of seismic activity which mostly occurred in Jubilee hills region. The period between 2011-2016, recorded micro earthquakes constituting 17% of total occurrence of micro earthquakes in the environs of Hyderabad. A decadal analysis of micro earthquakes revealed that

- Every decade experienced the occurrence of micro earthquakes through with varying frequencies.
- Highest number of micro earthquakes occurred during the decade 1981-1990.
- Highest number of swarm type of micro earthquakes were localized in two areas i.e. near Gandipet reservoir (1981-1990) and in the vicinity of Jubilee hills area (1994-2000) in the North western part of the city.



Fig 3



Source: Based on table 3

Monthly / seasonal analysis of occurrence of micro earthquakes

In the study of micro earthquakes, monthly or seasonal analysis rarely do find a place in seismology, but in case of Hyderabad, it do has a relevance. A month wise occurrence of micro earthquakes is undertaken here to find out whether the monthly analysis has bearing on the occurrence of micro seismic activity. An evident fromtable 4 and fig 4, the months of January and February, the post monsoon months recorded highest number of micro earthquakes which were experienced near Gandipet reservoir in the south western part of the city. Rastogietal (1986) observed that during these months, due to high rainfall, there was presence of reservoir water in the wells of epicentral areas.

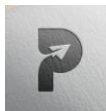


Table 4

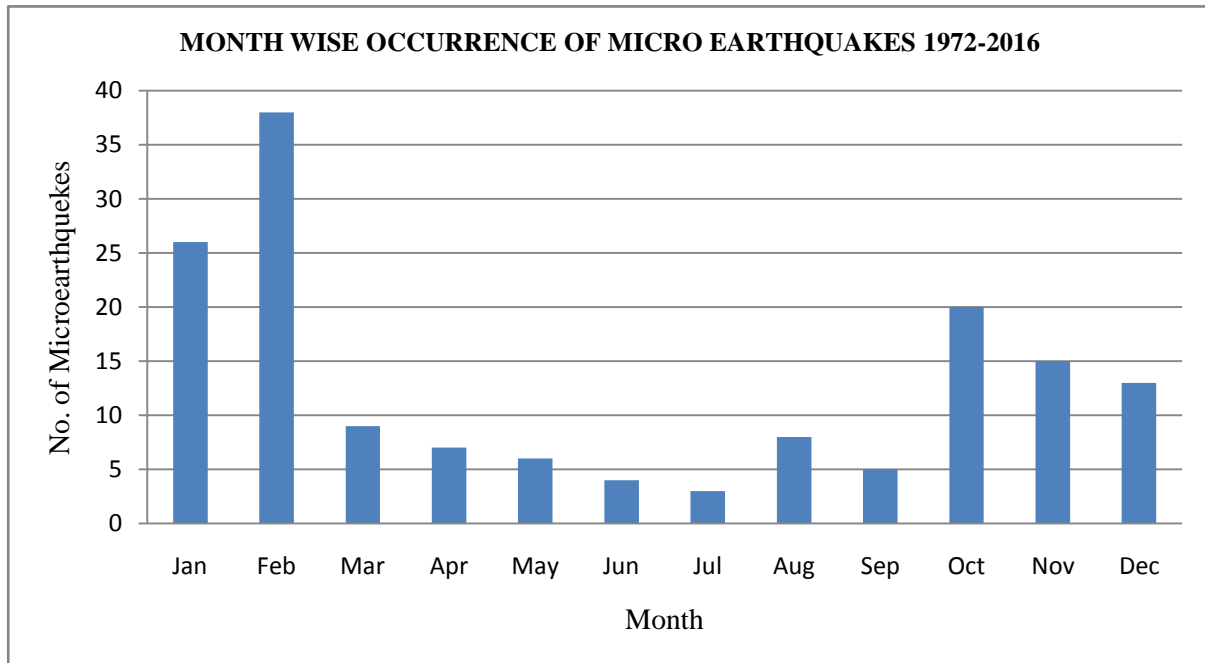
Month wise occurrence of micro earthquakes 1972-2016

Year	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
1972				1							1		2
1975			1										1
1978								2					2
1981			1									1	2
1982	21	27											48
1983					1	1				2		2	6
1984		1						4	1		1		7
1992					1								1
1993		1											1
1994										4			4
1995										1			1
1996						1							1
1998										4			4
2000									1				1
2004											1		1
2007									1				1
2008											3		3
2009		1		1	3						4	1	10
2010		4	1	2		3	1	1	1	9	4	6	32
2011			1	3	1							2	7
2012	1		1								1		3
2013		1											1
2014	1		2				1	1					5
2015	3	1	2										6
2016		2							1			1	4
Total	26	38	9	7	6	4	3	8	5	20	15	13	154

Source: Compiled and computed based on NGRI data



Fig 4



Source: Based on table 4

The month of October, November and December were associated with increased seismic activity in Jubilee hills and surrounding areas. These months of Northeast monsoons registered an increase in ground water level. The senior seismologist said the micro earthquakes were a result of hydro seismicity. A condition when rainfall variation can trigger earthquakes.

Recently November 2017, Jubilee hills and surrounding areas Bora Banda, Rahmathnagar, also recorded a mild tremor which according to NGRI is due to high intensity rainfall in the month of November.

A monthly/seasonal analysis of occurrence of seismic events reveals that, even though seismic activity occurred in a every month of the year during 1972-2016, still it is observed that seasonal impact is very much evident. The post monsoon months and months associated with Northeast monsoon during which rainfall received was very high, received mild tremors and a loud sound which is attributed increase in ground water levels, according to NGRI.



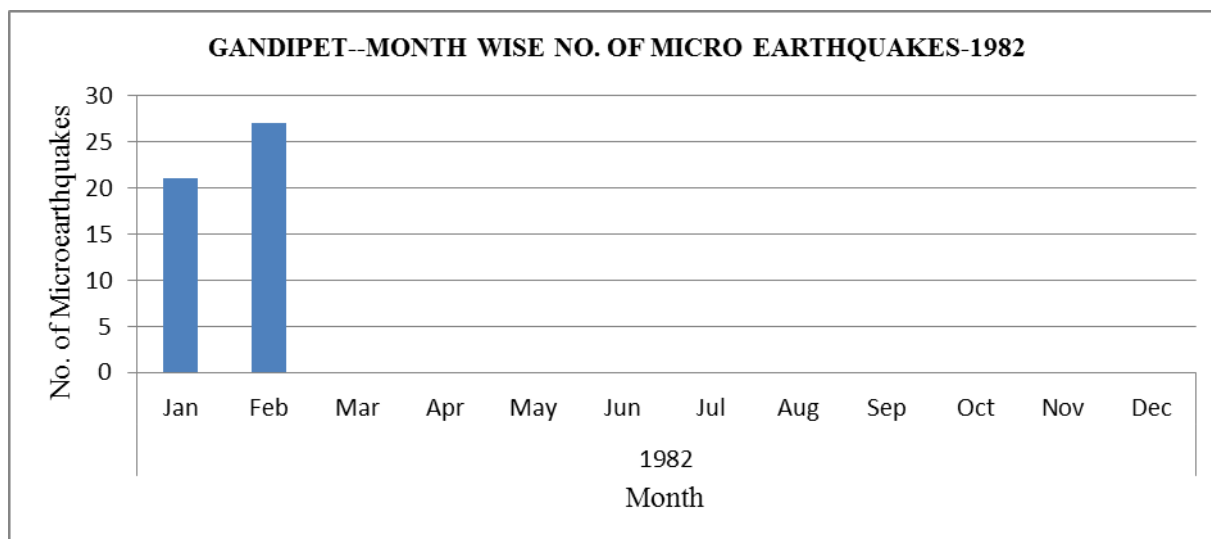
Table 5

Gandipet--month wise no. Of micro earthquakes-1982

Year	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
1982	21	27	-	-	-	-	-	-	-	-	-	-	48

Source: Compiled based on NGRI data

Fig 5



Source: Based on table 5



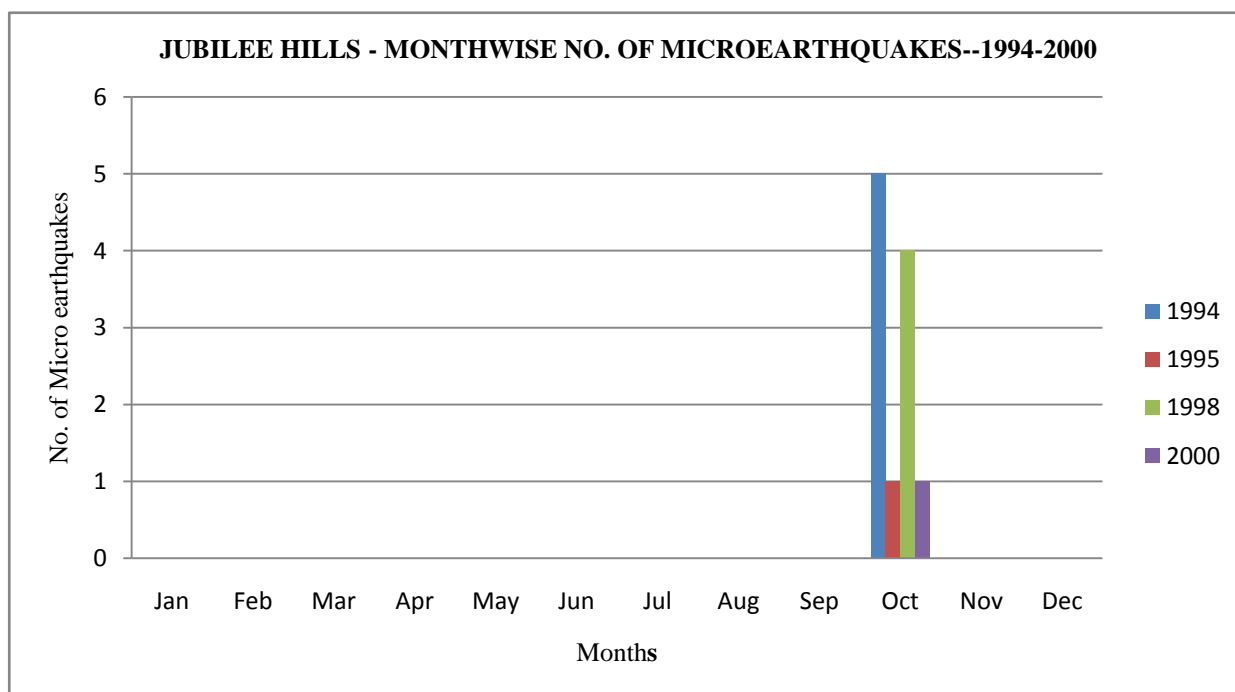
Table 6

Jubilee hills - month wise no. Of micro earthquakes-1982

Year	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1994	-	-	-	-	-	-	-	-	-	5	-	-	5
1995	-	-	-	-	-	-	-	-	-	1	-	-	1
1998	-	-	-	-	-	-	-	-	-	4	-	-	4
2000	-	-	-	-	-	-	-	-	-	1	-	-	1

Source: Compiled based on NGRI data

Fig 6



Source: Based on table 6



Conclusion

The major current thrust of seismology is towards application of existing knowledge on use of available historical data to significantly reduce the economic and human loss occurring during earthquakes. The chronology of micro earthquakes revealed that there is an increase in its frequency last 40 years. The study revealed large scale decadal variation and localized swarm type of micro earthquakes. The increase in the frequency of seismic events could be attributed to rapid and unsustainable urban growth which has further increase the vulnerability of study area to seismic events. The cumulative frequency curve revealed distinct phases in the occurrence of micro earthquakes revealing static or inactive and active seismic events. The micro earthquakes were of highly localized in nature which is substantiated by the fact that they were mostly agglomerated around Gandipet reservoir and in the vicinity of Jubilee hills in the south western and north western part of Hyderabad. Historical data on micro earthquakes is pre requisite for better understanding the vulnerability to seismic activity, more so in an urban environment. Historical study of micro earthquakes may also be useful in predicting potential risk and risk preparedness in urban environment.

References

- 1) Handbook on 50 years of seismological observatory (2017), CSIR-National Geophysical Research Institute (NGRI) Hyderabad.
- 2) Rastogi, B. K., Ramakrishna Rao, C. V., Chadha, R. K. and Gupta, H. K., (1986), "Micro earthquakes near Osmansagar reservoir", Hyderabad, India, *Phy. Of Earth and Planet. Inte.*, 44, 134-141.
- 3) Rao, Ramakrishna C. V. and Solomon Raju, P., 1996, "A note on micro tremor activity in Jubilee Hills area of Hyderabad during 1994 and (1995)", *Jour. Geol. Soc. India*, 48, 467-469.
- 4) Sunil "Free vibration analysis of multi-storeyed buildings resting on different soil /rock media at Hyderabad, Telangana State (2016), India", *Indian journal of science and technology*, vol 9 (37), October.
- 5) Sunil "Terrain analysis of exponentially sprawling urban environs of Hyderabad, Telangana, India- an integrated geospatial and Seismo-tectonic approach" *International Journal of Applied Engineering Research* (2016) ,Vol 11, Number 2 ,pp 1282-1286.
- 6) Solomon Raju, P., Srinivasan, A., Raghavan, R. V. and Kousalya, M., 2000, "Micro-tremor activity in Jubilee Hills area of Hyderabad", *Andhra Pradesh., Jour. Geol. Soc. India*, 55, 443-446.

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