

EC₅₀ value of each curcuminoid was found to be increasing in the order: curcumin (7.89 ± 0.04 µg/ml) < demethoxycurcumin (9.52 ± 0.23 µg/ml) < bisdemethoxycurcumin (149.09 ± 0.46 µg/ml) and this order is the same as that for *C. longa*¹².

The developed HPLC method was sensitive, precise, and accurate for detection and quantification of curcumin, demethoxycurcumin and bisdemethoxycurcumin in 70% alcoholic extracts of the rhizomes of *C. zedoaria*. TLC and HPLC fingerprints of the extracts from different locations showed a similar pattern, of which demethoxycurcumin was a major component. The average content of demethoxycurcumin in all extracts was 7.37 ± 2.71 %w/w. Curcumin was the second major constituent, whereas bisdemethoxycurcumin was the minor one. This result is different from a previous report of *C. longa* extract in which curcumin is a major component and demethoxycurcumin is a minor one¹¹. The HPLC method appeared to be a recommended method for quantitative analysis of the active compounds in *C. zedoaria* extracts and their pharmaceutical preparations. For free radical scavenging activity, EC₅₀ values were in accordance with the contents of curcumin and demethoxycurcumin in the extracts. EC₅₀ value of curcumin (7.89 µg/ml) is lower than those of demethoxycurcumin (9.52 µg/ml) and bisdemethoxycurcumin (149.09 µg/ml; Table 2). The results are the same as those reported in the case of *C. longa*¹².

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Relation between sedimentary layer thickness and fundamental frequency of the *H/V* spectra for Bangalore city

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Soil amplification and topographical effects play a major role in earthquake damage to civil structures. Study of sedimentary layer thickness and behaviour under stress cycles is crucial for earthquake hazard analysis. Borehole logs for Bangalore are used to benchmark the relation between sedimentary thickness and resonant frequency of the soil layer for this region. Microtremor measurements are carried out at the locations where borehole drilling was done and the frequencies corresponding to spectral peaks of the *H/V* ratio are estimated, where *H* and *V* denote the horizontal and vertical spectral component of the microtremor displacement respectively. The thicknesses of the soil layer (*D*), obtained from borehole logs and the soil layer resonant frequencies (*f_r*) determined from the *H/V* spectral peaks are used to obtain a regression relation between them. The regression relation obtained is given by $D = (58.29 \pm 8.8) \times f_r^{-(0.95 \pm 0.1)}$. Using the data from the work of Divya *et al.*, a similar regression relation is plotted. The results obtained are

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in agreement with the field data. This relation can be used for computing the depth to the bedrock for Bangalore using microtremor survey at a location where borehole data is not available.

Keywords: Microzonation, microtremor, resonant frequency, shear wave.

It is often seen that the local geological structure and soil properties play a vital role in earthquake engineering and contribute to the surface seismic motion which may result in damage to civil structures. Hence, it is necessary to study the local geological structure for designing buildings over them. Mapping of the soil thickness and properties is required for assessing the earthquake vulnerability, as the overburden soil may amplify or attenuate the ground motion at certain frequencies. When the fundamental frequency of the structure built on them matches with the sedimentary layer frequency, resonance occurs and this may result in damage to the overlying structures. One of the geophysical techniques widely used for obtaining the overburden sedimentary thickness is horizontal-to-vertical spectral ratio of ambient seismic noise recording¹, known as Nakamura technique or *H/V* ratio method. This technique makes use of the ambient microtremor noise measurement carried out using a three-component seismometer at a given site. This technique has been validated by comparing the results with those of earthquake recordings for different locations^{2,3}. These studies have shown that at locations where there is large impedance ratio between sediments and bedrock (>2.5), the horizontal-to-vertical spectral ratio method provides a good estimate of fundamental frequency of soft sedimentary layer.

In India, Nakamura's technique has been used for the seismic microzonation of Delhi, where Mukhopadhyay *et al.*⁴ have found that resonance frequencies obtained from all around Delhi using microtremor recordings are in good agreement with the results obtained from strong motion records. Parolai *et al.*⁵ have conducted the microtremor recording at Cologne sedimentary basins in Germany at known borehole locations to obtain characteristic frequency of the soil column and have established a regression relation between the thickness of the sedimentary column and the observed frequency of the *H/V* spectral peak. This work has been carried out in sedimentary basins where the depth to bedrock varies from 20 m to as high as 400 m.

Anbazhagan and Sitharam⁶ have carried out a study on velocity structure and seismic hazard of Bangalore. They have created a borehole log database for Bangalore region, which provides information about the soil strata along with standard penetration test (SPT) *N* value. This value gives the number of hammer blows in a standard penetration test. At some of these borehole locations, they have also conducted MASW survey for obtaining

shear wave velocity. They have estimated the average shear wave velocity for overburden soil in Bangalore region and the average velocities were found to vary between 180 and 360 m/s. They have established a power law for the regression relation between the SPT-*N* values and measured shear wave velocity.

In the present study, a method similar to that adopted by Parolai *et al.* has been used to find the relation between resonance frequency for Bangalore region and the thickness of sediment obtained from borehole logs. Bangalore is one of the fast growing cities in India, with many new infrastructure development projects coming up. The Bangalore earthquake on 29 January 2001 of magnitude 4.1 has aroused concern regarding the safety of civil structures in the city.

Bangalore had a large system of lakes, which were the main source of water for the city. With time, many of these lakes have dried up and due to rapid urbanization, many residential buildings and infrastructural projects have come up at these locations. Thick sedimentary deposits in these regions could amplify the surface seismic motion from an earthquake which may result in failure of civil structures. Hence, for assessment of seismic vulnerability of the city, a soil thickness determination of this region is required.

Bangalore is located in Deccan Peninsular region of India (13.0°N lat. and 77.5°E long). The highest location of this city is at 950 m above mean sea level (msl) and the average altitude is about 910 m above msl. Bangalore is a city of hillocks and valleys, and its topography slopes from northeast to southwest direction. From the borehole logs available to the authors, it is observed that the soil is generally either silty sand or clayey sand at these locations. In most cases the overburden soil layer is directly overlying the weathered or hard rock layer. The SPT-*N* values for the soil are in the range 24–83, while N_{spt} values greater than 100 are taken as the bedrock layer. The bedrock layer is unclassified gneiss and the depth to the bedrock layer varied from 2 to 40 m.

As the first step for microzonation of Bangalore city, borehole logs were used to identify the depth of the weathered or hard rock strata. The borehole data were made available by M/s Civil Aids Technoclinic Pvt Ltd. which specializes in geotechnical investigations. Thirty four locations, where the borehole noise survey has been carried out, are shown in Figure 1. At these borehole locations, three-component recordings of seismic microtremor were carried out using Guralp-40T seismic sensor and CMG-24, a 24-bit digitizer. The data from the digitizer were recorded by a PC through serial interface. The three seismometers were mounted on a common base plate in east–west (EW), north–south (NS) and vertical directions. The base plate marked with an arrow corresponding to the north direction was carefully oriented along the north using a magnetic compass at each location. For the recording site preparation, the base plate was levelled and

made to rest firmly on the soil surface. The recordings were mostly carried out at late night hours to ensure that the cultural and traffic noise is low. At each location, recording was carried out for a minimum of 20 min duration at a sampling rate of 100 Hz. Care was taken to ensure that the location chosen for the survey is close to the borehole site and is not located over underground structures such as car park, sewer or pipes, as these structures may significantly alter the amplitude of the vertical motion. The spacing between borehole locations was so chosen for the survey such that at least they are about 0.75–1 km apart. A typical ambient noise recording obtained from the three-component seismometer is shown in Figure 2 for one of the locations.

From the data, DC is subtracted and the data is band-pass filtered in the pass band of 0.5–25 Hz. From the above three-component filtered data, Fourier spectra for the components were generated for multiple windows of

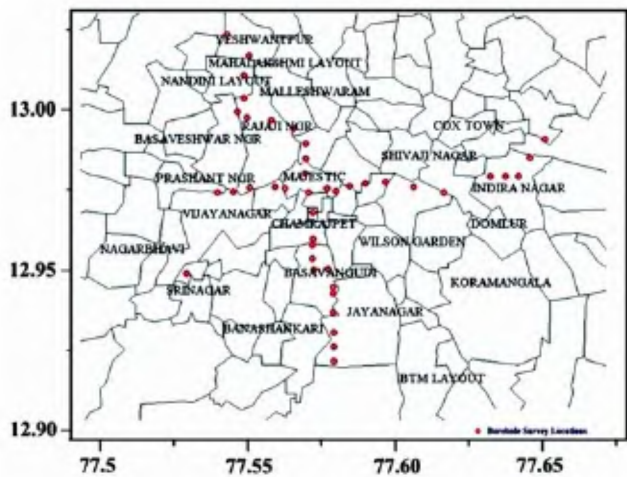


Figure 1. Map showing locations of borehole where seismic noise survey was performed.

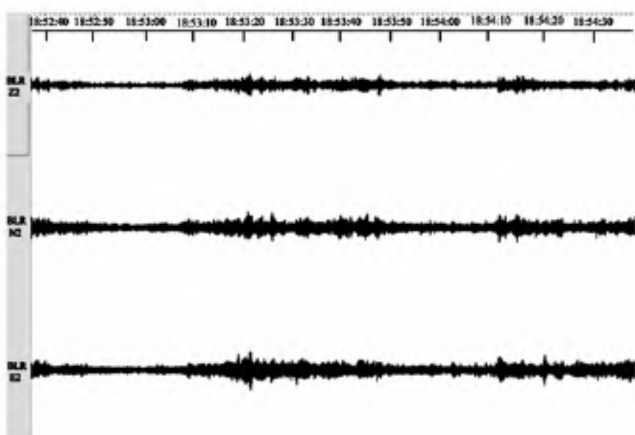


Figure 2. Typical time series spectrum obtained at a recording station. The trace label Z2, N2, E2 stand for the vertical, north–south, east–west component seismometer recordings respectively.

25 s duration. While selecting the data windows, care was taken to exclude portions of data with traffic noise. For each window of 25 s duration data, the two horizontal component spectra, EW and NS, were summed vectorially to obtain the resultant horizontal spectrum (H). The H/V spectrum is obtained by dividing the horizontal spectral amplitude (H) with the vertical component spectral amplitude (V) at each frequency. These H/V spectra are averaged over all time windows to obtain the average H/V spectrum. The average H/V spectrum is smoothed using 11-point ‘moving average’ window technique to eliminate high frequency oscillations on the spectra. Typical H/V ratio spectra obtained for four borehole locations are shown in Figure 3. The spectra shown are in the log-linear scale plotted only up to 25 Hz frequency. However, the spectral values, beyond 10 Hz, are not of importance for civil engineering purpose. In the H/V ratio plot, along with the mean ratio, its spread for one standard deviation is also shown. It can be seen that each H/V ratio curve shows a clear peak and the frequency value for each borehole is different. Thus, the resonance frequency for each borehole location is determined from frequency corresponding to the peak of the H/V spectrum. Table 1 shows borehole locations where noise survey was conducted, along with the soil strata thickness and corresponding resonance frequency.

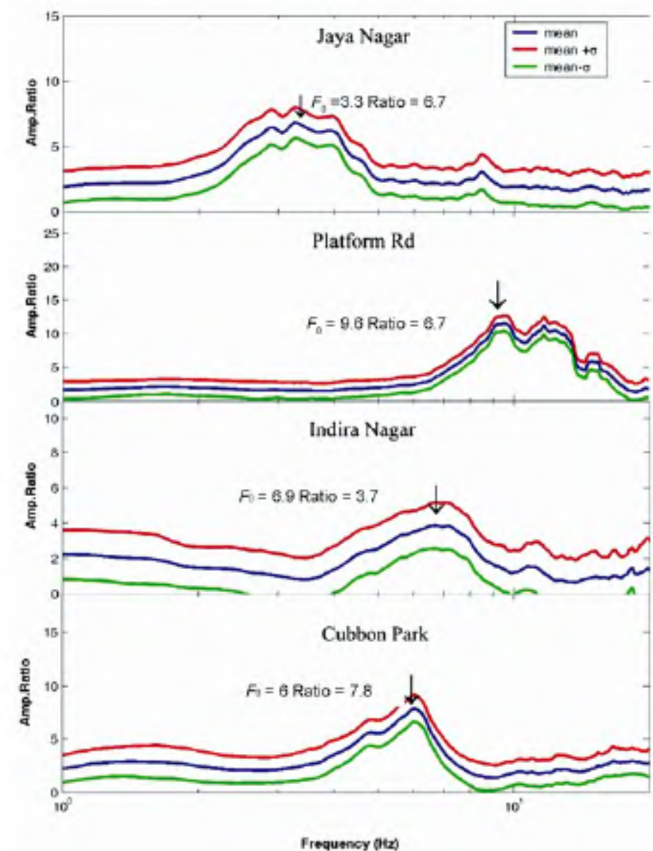


Figure 3. H/V spectrum obtained from microtremor analysis. Ratio denotes H/V values.

RESEARCH COMMUNICATIONS

The resonance frequencies observed at 34 locations are nonlinear fitted with the depth of the hard rock layer using Iba-von seht and Wohlenberg⁷ formula between the reso-

Table 1. Borehole survey data used for calibration

Location	Soil thickness (m)	Frequency (Hz)
Vittal Malya Scientific Research Foundation	21	2.8
Parvati Chandrashekar Park, K.R. Road	10.5	5.4
National College Circle, Vani Vilas Road	22.5	2.6
Jaya Infotech, Vani Vilas Road	5	13
Silicon Honda Showroom, R.V. Road	4.5	8
Vijaya College Gate, R.V. Road	8.7	10
Laxman Rao Park, South End Circle	10.5	7.1
Diagonal Road, Jayanagar	18	3.3
36th Cross, Jayanagar–R.V. Road intersection	11	3.3
Canara Bank, 4th Main, Jayanagar	19.5	3.6
Krishna Flour Mills, Platform Road	7.5	9.6
Harishchandra Ghat, Rajajinagar	3.5	18
Navrang Theatre, Rajajinagar	9.5	7.6
Shakthi Building, West of Chord Road	4.5	9.8
Rajajinagar 1st Block	3.5	13
Narayana Nethralaya, West of Chord Road	7.5	10
Swati International Hotel, Seshadripuram	11	4.4
Cauvery Hotel, Majestic	18	4.6
STI School, Chikka Lalbagh	12	6.2
Government Boys School, Sultanpet	13.5	4.6
NGEF Play Ground	10.5	3.9
Indira Nagar 80ft Road	6	8.5
Karnataka Bank, Indira Nagar	9	6.9
Vivek Home Appliances, Indira Nagar	16.5	4.4
Burial Ground, C.M.H. Road	6	8.5
Nalli Silks, M.G. Road	26	2.9
Deepam Silk, M.G. Road	17	4.7
Victoria Statue, Cubbon Park	13.5	6
Cubbon Park	21	3.8
UVCE Mech Engg Department, K.R. Circle	19.5	3.4
Cauvery Bhavan, Westgate	15	4.2
Leprosy Hospital, Magadi Road	7.5	18
BWSSB, Magadi Road	6	5.8
RK Colour Lab, Vijaya Nagar Main Road	6.5	7.8

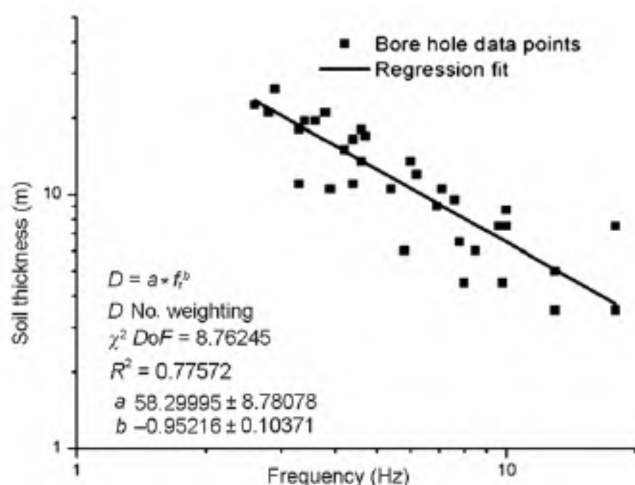


Figure 4. Frequency vs soil thickness plot.

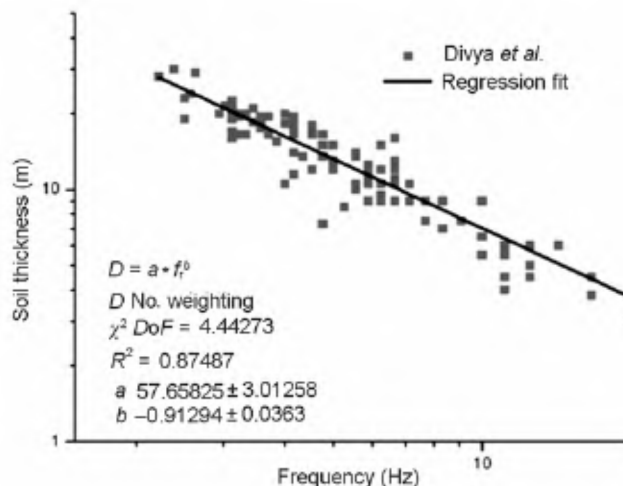


Figure 5. Data by Divya *et al.* along with the regression fit.

nance frequency (f_r) of a soil layer thickness, D , by a relation of the form

$$D = a \times f_r^b, \quad (1)$$

where a and b are constants. For negative values of b , the formula shows that the resonant frequency decreases with increase in strata thickness. The plot of thickness of the soil as a function of resonance frequency observed at each borehole survey location is shown in Figure 4. A nonlinear regression relation of the form suggested by Iba-von seht and Wohlenberg is fitted to these data points. The best fit equation thus obtained is given below.

$$D = 58.29 \times f_r^{-0.95}. \quad (2)$$

The errors in the parameters a and b are ± 8.8 and ± 0.1 respectively.

For the Bangalore region, Divya *et al.*⁸ utilized the soil strata information from 125 borehole logs and obtained the characteristic period for those locations in their simulation study of ground response analysis using SHAKE-2000. The fundamental frequency for these locations is obtained from the reciprocal of the characteristic period. We have plotted the depth to the rock strata and the fundamental frequency along with the best fit regression relation in Figure 5.

The regression values obtained with error in the fit values are 57.65 ± 3.01 and -0.91 ± 0.036 which are in good agreement with the findings from microtremor measurements. Parolai *et al.* had obtained a similar relation for Cologne region, where the parameters for a and b are obtained as 108 and -1.55 respectively, which is in contrast to the values obtained in this work. This indicates that the soil properties of these two regions are different.

Thus, the relation derived can be used to assess the soil layer thickness at locations where there are no borehole data available.

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Understanding future changes in snow and glacier melt runoff due to global warming in Wangar Gad basin, India

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Himalayas has one of the largest concentrations of glaciers and permanent snow fields. These are sensitive to climate change. Snow and glacier runoffs are important sources of water for the Himalayan rivers. Due to steep slopes, all these streams are potential sites for hydropower generation. To understand the power

potential of small sub-basins, a snowmelt run-off model has been developed for Malana nala located in the Parbati river basin near Kullu in Himachal Pradesh and validated at the adjacent Tosh nala in the same basin. In the model, information generated through remote sensing techniques were used in conjunction with the daily maximum and minimum temperatures, rainfall and snow fall. This model is now extended to understand the effect of global warming in stream runoff and power generation.

To understand changes in runoff and power potential, possible changes in the input parameters were estimated by considering 1°C rise in temperature from 2004 to 2040. Snow line is calculated for 2040 using present altitude and lapse rate. Future change in areal extent of glacier and permanent snow were estimated using mass balance, response time and rate of melting at terminus for all glaciers in the basin. The model was validated for all seasons in 2004 and for selected seasons from 1997 to 2002. The error in runoff estimate was observed between 2 and 5%, except for the summer of 2002. The model suggests overall reduction in stream runoff by 8–28%, depending on the season.

Keywords: Global warming, glacier, hydropower, runoff, snow, Wangar Gad.

OVER the past millions of years, the earth's surface has experienced repeated large periods of glaciations separated by short warm interglacial periods. During the peak of glaciations, an approximately 47 million sq. km area was covered by glaciers, three times more than the present ice cover of the earth¹. Natural variations in the earth's orbit are well synchronized with atmospheric variations in methane and carbon dioxide, leading to repeated cycles of glaciations. However, this natural cycle might have altered due to the greenhouse effect, caused by man-made changes in the earth's environment. Some of the hypotheses suggest that this alteration might have started long before the beginning of the industrial revolution². This has led to an increase in the global average temperature by $0.6 \pm 0.2^\circ\text{C}$ from 1900 (ref. 3). In addition, recent developments in climate modelling suggest that existing greenhouse gases and aerosols in the atmosphere have led to the absorption of $0.85 \pm 0.15 \text{ W/m}^2$ more energy by the earth than emitted into space. This means additional global warming of about 0.6°C without further change in atmospheric composition⁴. This observation was further supported by the Fourth Assessment Report published by Intergovernmental Panel on Climate Change in 2007, where warming of 0.2°C per decade is projected for the next two decades, even if the concentration of all greenhouse gases and aerosols remain constant at the year 2000 level. In addition, best estimates of globally average surface air warming for different warming scenarios vary between 1.8°C and 4.0°C (ref. 5). This will have a profound effect on the Himalayan cryosphere.

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