Error-rate Investigation of Chabahar Station Records, Related to Iranian National Broadband Seismic Network

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Abstract
In the last decade, the number of seismic stations has increased significantly, and new denser regional networks with advanced technology have been installed worldwide. Moreover, the recent improvements in the quality of seismological instruments have resulted in the application of modern broadband seismometers with high dynamic range digitizers for most seismological studies. Among various seismic data, broadband networks provide valuable data for seismological research. The purpose of this research is to survey the quality of Chabahar broadband seismic station records and study the site effect by recording the earthquakes in Iranian National Broadband Seismic Network related to International Institute of Earthquake Engineering and Seismology (IIEES) by using ۱۱۱ records. In this study, the error-rate of the station by ۸ earthquakes selected was recognized and in order to identify signal-to-noise ratio in a single earthquake was carried out. To determine the site effect, the method of H/V was used. In this method, it is supposed that this site is made of rock and so it has been researched in order to find the approximate causes of error-rate. Then, to show the background-noise on the site, power spectral density curve was plotted and finally a comparison based on noises and the site effect in Chabahar station to the other Iranian Broadband Seismic stations was made.

Keywords: Broadband seismic network, Record quality, Site effect, Signal-to-noise ratio, Power spectral density

۱- Introduction

The standard quality control procedure provides a useful tool for monitoring network performance, allowing identification of potential anomalous noise levels. It also helps to investigate the major sources of noise at different frequency bands and variations of background seismic noise with weather, season, and time of day. Moreover, it provides a quantitative measure to rank seismic stations according to quality of the raw data at different frequency ranges.

The broadband seismic network of Iran was designed and constructed to gather high-quality waveform data from the entire country. The quality of seismic signals is of primary interest, which requires special attention for the selection of proper location and construction of high-quality stations in the network.

In regard to the development of seismic network in the country by using the data obtained by resistant structure designs, losses and damages can be decreased. The characteristics of an earthquake in regard to physical and dynamic site can be intensified or weakened in specific frequency and finally affect signals from the seismic station. The rate of effect is subject to geometry, the material properties of the subsurface layers, site topography and input motion characteristics (Marshall, et al., ۱۹۷۲; Douglas, ۲۰۰۱). Recorded seismic signals always have noise. As a whole the noises in signals are divided in two groups, the noises produced by the instrument and the real noises due to ground shake (Borman, P. et al., ۲۰۰۲).

The experience shows that during the process of locating Iran earthquakes mostly in east and southeast causes confusion and embarrassment. As the station in this region is usually affected by tsunamis and strong earthquakes, it could mostly attract the seismologist's attention. The consequences obtained in this study by the survey of quality of seismic records based on site and the noise rate by plotting signal-to-noise ratio curve and power spectral density in Chabahar station can lead us to approach the main source of noise. If these surveys are carried out every year and the weaknesses demolished, the accurate location of earthquakes center in the country can be increased. In this way, to survey on increasing the quality of seismic records in broadband stations by PSD[۱] and PDF[۲] curves (McNamara and Buland,۲۰۰۴) and also to compare the earth acceleration in each period of time, two methods (NLNM)[۳],(NHMN)[٤] (Peterson,۱۹۹۳) were used. In this study the noise level in all broadband stations in three periods of time ۰,۱-۱, ۱-۱۰, ۱۰-۱۰۰ was compared. It must be mentioned that the survey was completed until ۲۰۱۲. The purpose of this study is to survey the noise effect and environment factors on location of earthquakes in Chabahar stations.

۲-Discussion

To monitor the seismicity of Iran and collect the required data for seismological studies, IIEES established the broadband seismic network of Iran. The main objectives of creating this network are to provide an online monitoring system for seismic activities in the Iranian plateau and to create accessible earthquake information database. This system can be further used for research purposes in the fields of seismology, earthquake engineering, and disaster management. To date, the network consists of ٢٦ stations.

The study region is the site of seismic station with the abbreviate code (CHBR) longitude ٦٠,٤٨٢ and latitude ٢٥,٥٩٥ located in Sistan and Balu-chestan province. Sistan plain that is located in east of Iran has a dry and unpleasant climate and sand storms and movement of dunes are one of the threatening factors in this area. Draught occurrence in Sistan region and subsequent decrease in vegetation, dryness of the Hamoon Lake and ۱۲۰ Days wind caused windy erosion and sand storms conditions. Chabahar is situated

[۱] Power Spectral Density
[۲] Probability Density Function
[۳] New Low-Noise Model
[٤] New High-Noise Model

on the Makran coast of the Sistan and Balu-chestan province of Iran and is officially designated as a free trade and industrial zone by Iran's government (A. R. Payandeh, et al.,۲۰۱٤). Makran subduction zone was

previously the origin of several tsunamis and had generated the deadliest tsunami in the Indian Ocean region prior to the ۲۰۰٤ tragedy, Makran tsunami of ۱۹٤٥ with the death toll of about ٤۰۰۰۰ people (Heck, ۱۹٤۷). This zone extends east from the Strait of Hormoz in Iran to near Karachi in Pakistan with the length of about ۹۰۰ km. This subduction zone is formed between the Arabian plate and the Eurasian plate (Farhoudi and Karig, ۱۹۷۷).
The data completely taken from records by Iranian National Broadband Seismic Network involving three components of every earthquake between the years ۲۰۱۲ to ۲۰۱٤, ۲۸۰۸ seismic records in this study were used. ۱۱۱ records related to Chabahar station for surveying the effects on the site and the rest is to survey the signal-to-noise ratio and power spectral density. Figure ۱ shows Chabahar station (yellow triangle) and important faults of the region by GIS software.

Figure ۱. Location of Chabahar broadband seismic station

۲-۱- The epicenter location

VSAT communication system is applied to transmit waveform data in real time and sent to Iranian National Broadband Seismic Network Stations (INSN) and shown by SCREAM software for processing by Seisan software. In this study to recognize the nature of Chabahar station, ۸ earthquakes as a selection have been located and ۳ of them mentioned as follows.
As we know we need at least three stations to locate an earthquake. The maximum azimuthal gap of this configuration will be ۱٥۰°. In other word, epicenter is set inside the network and the more outside epicenter is from the network, the less accurate location of earthquake epicenter will be. For example figure ۲ shows an earthquake near Kerman in east of Iran in ۲۰۱٤/۱۰/۲۲ at ۱۲:۰۰ according to UTC by SCREAM software. Chabahar station (CHBR) is one of the three required stations to locate the earthquake epicenter, but unfortunately the earthquake record in this station has not been well received and also the waves of P and S have not been clearly observed.

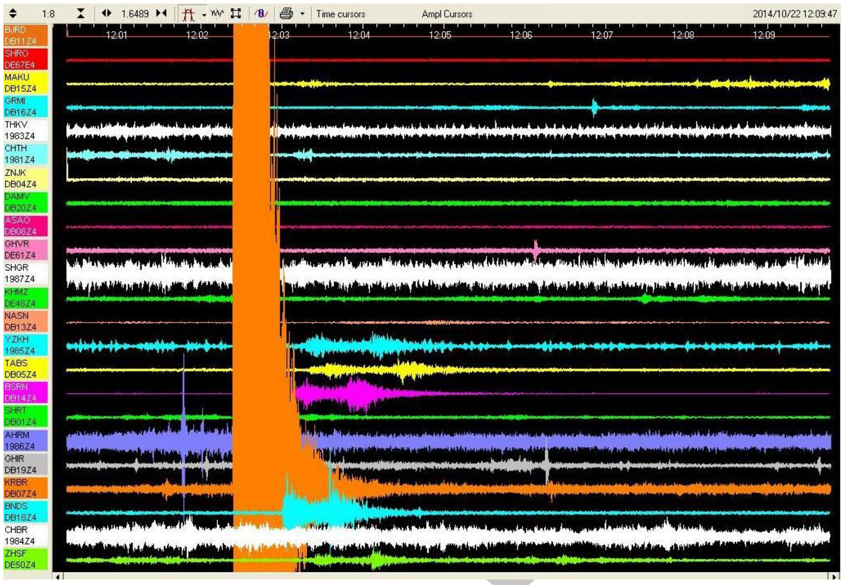

Figure ۲. Recording the earthquake near Kerman ۲۰۱۴/۱۰/۲۲ at ۱۲:۰۰ according to UTC by SCREAM software

Figure ۳ shows the receiving earthquake record in Ahar–Varzaghan situated in North-west of Iran with magnitude ٦,۲ in ۲۰۱۲/۰۸/۱۱ at ۱۲:۲۲ according to UTC.

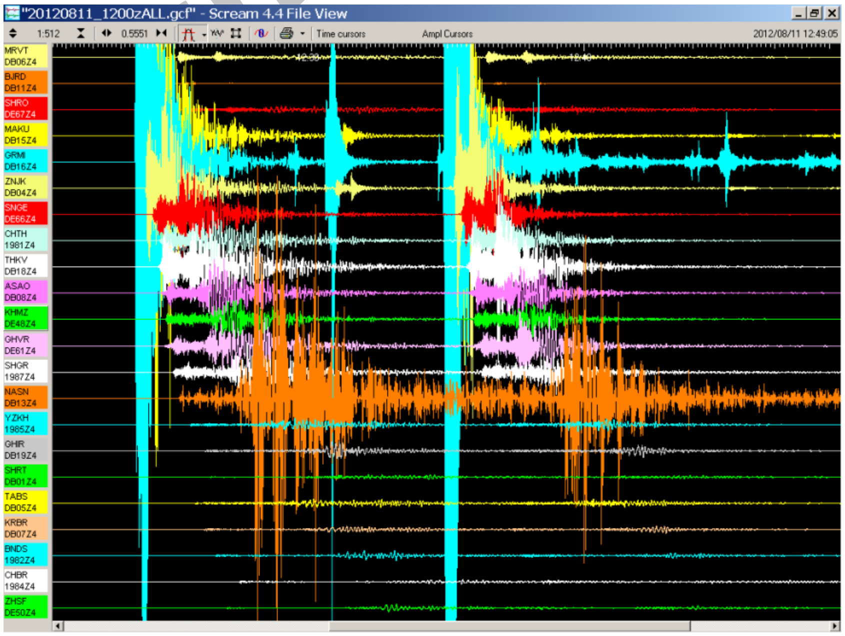

Figure ۳. Recording the Ahar-Varzaghan earthquake in ۲۰۱۲/۰۸/۱۱ at ۱۲:۲۲ according to UTC by SCREAM software

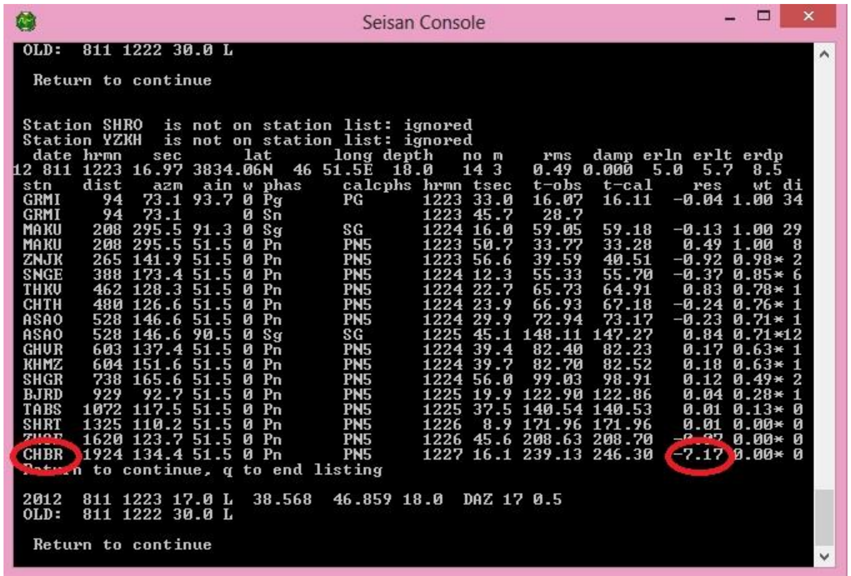

Figure ۴. Window of errors and epicenter of Ahar-Varzaghan earthquake

During the process to locate the earthquake, a lot of errors were observed due to the components of Chabahar station which eventually we had to omit this station.

It is indicated that locating the earthquake epicenter must be less than ۱۰ km and the more approximate to zero this error is, the more approximate to reality will be related to the determined epicenter.

Figure ٥ shows the record of strong earthquake in Saravan, the South-east of Iran in ۲۰۱۳/۰٤/۱٥ at ۱۰:٤٤ according to UTC. Chabahar station is the first one recorded this earthquake and by a lot of struggles we could decrease the errors. Figures ٦ and ٧ show the errors window related to stations and read phases.

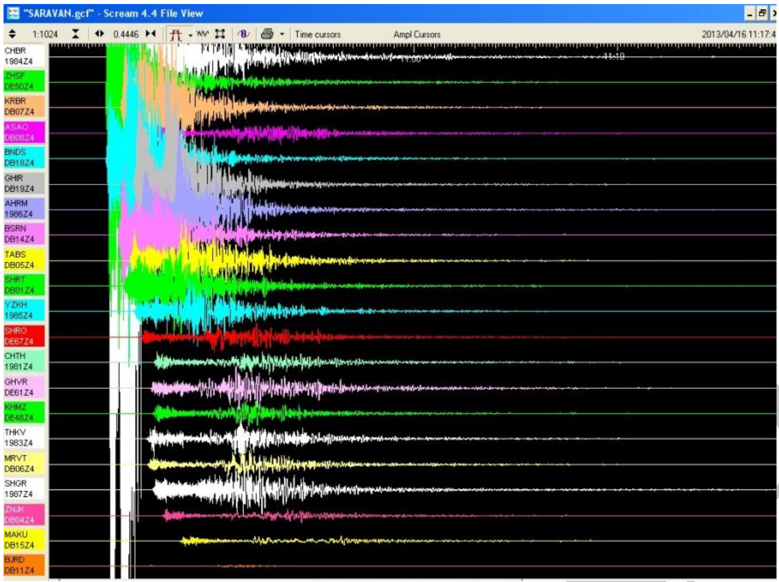

Figure ۵. Recording the Saravan earthquake in ۲۰۱۳/۰۴/۱۵ at ۱۰:۴۴ according to UTC by SCREAM software

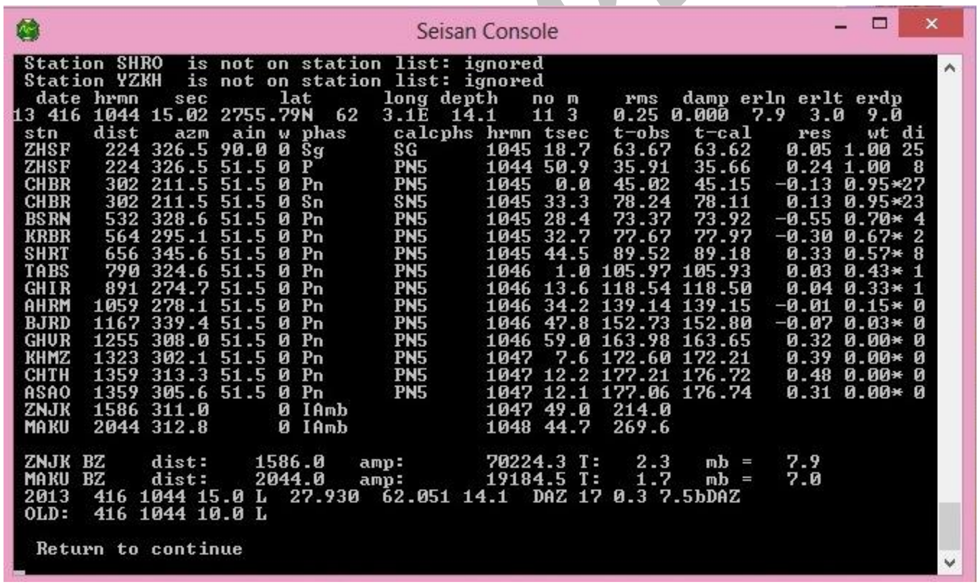

Figure ۶. Window of errors display and epicenter of Saravan earthquake

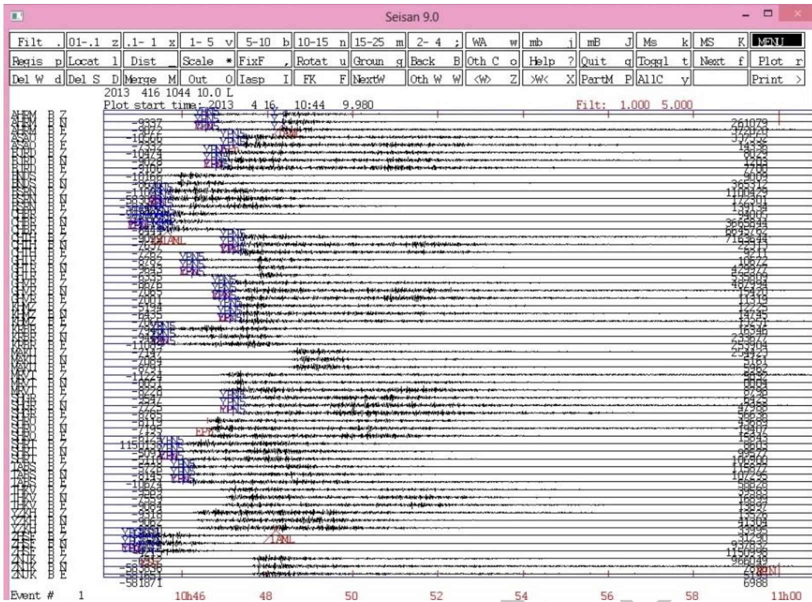

Figure ۷. The phases read on stations in Saravan earthquake by Seisan software

۲-۲ The signal-to-noise ratio

The signal-to-noise ratio by using MATLAB software has been carried out. A part of S earthquake wave as a signal and before beginning the P wave as noise considered. Basically more S/N and equal ۱ is acceptable and the more the rate is, the more accurate is to locate earthquakes by the stations.

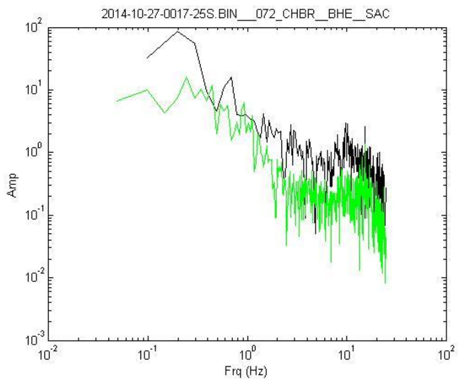

Figure ۸. Separation of signal and noise

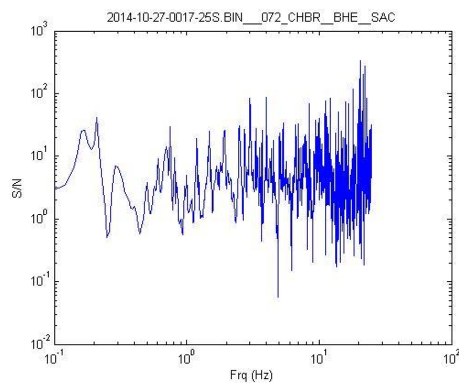

Figure ۹ . Signal-to-noise ratio curve

In figures ۸ and ۹, separation of signal and noise in Chabahar station is low and S/N is higher than ۱. It can be said that locating earthquake epicenter processing over components of this station can be phased, but there is probability of being effected by errors.

۲-۳- Site effect and H/V method

After general recognition of error rate from Chabahar station by locating earthquakes and signal-to-noise ratio we survey the site effect by using seismic data in which the method of horizontal to vertical component ratio can be used. As in earthquakes there are always horizontal and vertical components on the surface, using the H/V method as one of the independent methods from the origin site in rating the site effect can be sufficiently applied. In H/V method of the site based on fundamental frequency is sorted. In this method firstly the amplification of the site, using the horizontal to vertical component ratio in each site calculated and then the fundamental frequency as peak based on the received fundamental frequency is determined.

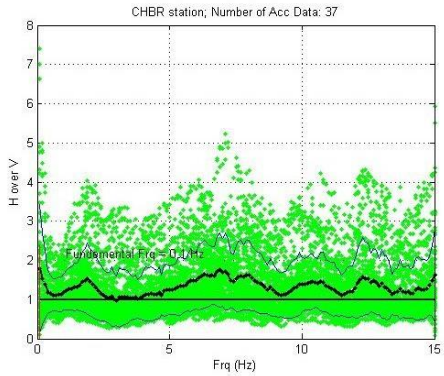

Figure ۱۰. H/V curve of Chabahar broadband seismic station

Chabahar station by using the MATLAB software has been researched. In figure ۱۰ no clear fundamental frequency was observed, so this station has got a suitable site.

۲-٤- The power spectral density based on Peterson (۱۹۹۳) curves

Background seismic noise with atmospheric source, oceanic, industrial activities and traffic are accidental and different from earthquake signals which are usually transient. To show the noise, power spectral density according to dB is usually used whose unit is $(m/s)^۲/Hz$. Source noise level is shown by Peterson standard curve which shows up and down limitation of collective component for calm and noisy periods of time by which seismic noise level in other places can be estimated (Havskov, J., and G. Alguacil, ۲۰۰٦). In this study Chabahar station has been surveyed without any earthquake occurrence.

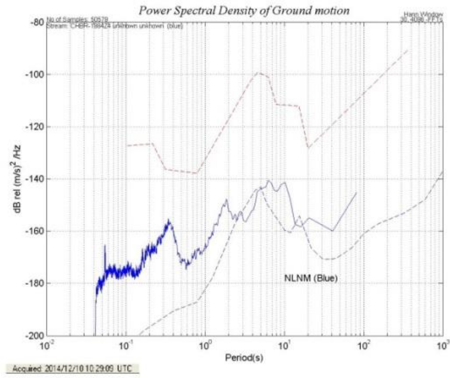

Figure ١١. Power density spectral curve in Chabahar broadband seismic station

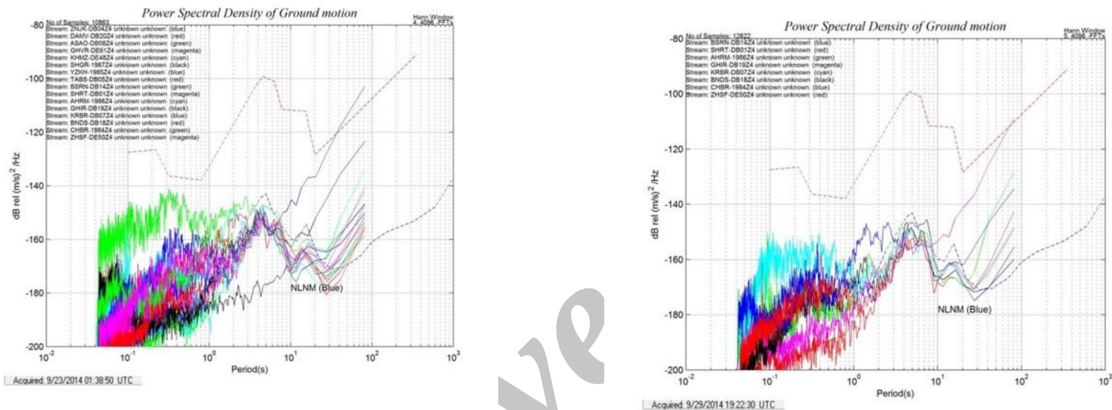

Figure ١٢. The comparison of power spectral density curves in Chabahar broadband seismic station with the INSN stations

The characteristics and nature of background seismic noise are different in various frequency ranges. At periods less than ١ s, sources of noise are mainly human activities and wind effects (McNamara and Buland, ٢٠٠٤). At periods above ٢ s, noise sources are oceanic and large-scale meteorological conditions. However, at long-period ranges of more than ٢٠ s, horizontal components of noise differ more from NLNM of Peterson (١٩٩٣) than do the vertical components. This is attributed to the sensitivity of surface-mounted broadband seismometers to local, dynamic tilting caused by thermal and barometric induced surface displacements. In this period range which is of great importance in seismic source studies, background noise is sensitive to diurnal and seasonal variations of the temperature.

The experience in the previous study shows that installing sensor at YAZD station, a comprehensive experiment was carried out to study the influence of the new design of seismic stations on increasing quality of seismic recordings. For this purpose, simultaneous measurement of background noise on the ground surface and inside the vault was performed for ٩٠ days. Wind speed and direction, humidity, and temperature inside and outside of the vault were also measured in this period of time. The humidity and temperature inside the vault became stationary after ١٢ days. The step-like shape of vault temperature and humidity in day ٢ is due to opening of the vault door, which was done to study the influence of door opening on changing the stationary condition of the vault. The maximum measured wind speed during the ٩٠ day period of experiment was ٢١,٠ m/s. The results of this experiment reveal that installation of broadband sensors inside a buried vault will increase the quality of recording in short periods, especially due to protection of the sensor against wind. For long periods, thermal instabilities around sensors and fluctuation of air pressure due to local winds will increase background noise, especially in horizontal components (Ansari and Amini, ۲۰۱٤). In this survey, figures ۱۱ and ۱۲ show that increasing the power spectral density in Chabahar station in long period is due to thermal instability and wind-induced.

۳- Conclusion

There are both far-and near-field tsunamis that need to be considered for the Oman sea region, and in addition, the landslide as a minor source requires special attention. The Makran subduction zone to the neighboring coastlines of Iran, Pakistan, Oman and India, there is a need for further seismic profiling investigations. The Chabahar broadband seismic station which situated on the Makran zone related to International Institute of Earthquake Engineering and Seismology (IIEES), after a relative recognition of station by locating some earthquakes and plotting signal-to-noise ratio and power spectral density curves and the site effect in regard to the station situation on the bedrock, proper results were not obtained.

As a whole the stations in regard to the site and noise level are divided into three groups; the first is about the stations which have not a suitable site, so they are affected by noise. The second is about the stations have either a suitable site and far from the noise sources, such as Basiran station (BSRN) related to Iranian National Broadband Seismic Network (INSN) which is famous in the world for its sensitivity (Ansari and Amini, ۲۰۱٤). The third is about stations which have a suitable site, but affected by instrumental or environmental noises. Unfortunately Chabahar station is one of them due to factors such as barometric changes, thermal instabilities and wind-induced. To locate the broadband seismic station in Chabahar during some surveys in this region, three places around the free trade zone in Chabahar fairly suitable were recognized. They are situated in Ripake Abdou village, upper Mouman and middle Mouman and also characteristics such as geology, barometric changes and noise rate were investigated, so it has been introduced to launch broadband seismic station in Chabahar as the best option. Nevertheless, owing to adjacency to Oman Sea and specific climate conditions of this region it is often affected by noise.

Construction of the seismometer vault is the most important aspect of station installation. The purpose of the station is to acquire the best seismic data available at the location, and the quality of the vault construction will affect the environment of the seismometers and the quality of the data. The purpose of the vault is to provide a dry, thermally stable environment of the sensors (McMillan, j., ۲۰۰۲). We recommend using Acoustic Foam and foam in place "minimal" expanding polyurethane foam insulation as a thermal insulator. Acoustic foam is cell foam used for acoustic treatment. It attenuates airborne sound waves by increasing air resistance. Also add dry sand evenly around the high-gain sensors until they are completely covered to prevent any possibility of thermal air currents. In this way the quality of seismic recordings can be increased.

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