Study The Effects Of Radio Waves Propagation Under Sea At Pakistan Coastal Zones

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Abstract ─ In this communication the factors affecting the radio wave propagation at low, moderate and high salinity and temperatures conditions for different depths are studied. The propagation of radio waves under water is a severe technological task that requires specific attention for implementing suitable techniques and devices. This is because electromagnetic radiation is rather difficult to propagate to through sea water. Very low frequency (VLF) radio waves (3-30 KHz) can penetrate sea water down to depth of roughly 20 meters and extremely low frequency (ELF) waves penetrate sea to the depths of hundreds of feet. The range and quality of transmission varies with water conditions. In this communication we have selected few stations along the coastal zones of Pakistan to study the possible effects of fluctuating dynamics of water masses on the radio waves propagation by transmitting small power at VLF range. The physical problems, concerned with the issue of radio wave propagation under water at coastal environment are of great significance and accordingly the intended assessment needs to be dealt within the frame work of Ocean wave's dynamics. [Journal of American Science 2010;6(8):413-419]. (ISSN: 1545-1003).

Key words: T – S Model, Water Masses, communication between Submarines, VLF, Salinity and Temperature.

1. INTRODUCTION

The effects of natural environment on the propagation of radio waves are highly dependent on frequency used. The physical nature of the intervening paths show significant effects on the propagation such as the fluctuations in the T-S profiles of water masses expected to be affecting. Radio waves inside the sea increase with the frequency of the signal. This means that the lower the frequency a radio transmission, the deeper into the ocean a useable signal will travel. Radio waves in the very low frequency (VLF) band at frequencies about 20,000 Hertz (Hz) penetrates sea water to depths of only tens of feet. Whereas, extremely low frequency (ELF) waves penetrate sea to the depths of hundreds of feet, permitting communications with submarines while maintaining stealth [1]. Our purpose of studies is to make sure the qualification of signal to noise ratios. The performance of the communication link can be predicted on the basis of typical characteristics of the propagation path that is channeled by the fluctuation in the water masses profiles.

The assessment of the effects of water masses fluctuations on radio wave propagation are dealt in the form of the long-term variability in temperature, salinity, conductivity and density occurring in the Pakistan coastal zones. As it is well known fact that the sea water is a lossy dielectric medium characterize the different frequencies bands with relative permittivity or dielectric constant and average conductivity in S/m [2].

2. T – S REPRESENTATION OF STATIONS

In deep sea water mass is usually defined as a body of water with a common formation history. This is based on the observation that water renewal in the deep ocean is the result of water mass formation in contact with the atmosphere, spreading from the formation region without atmospheric contact, and decay through mixing with other water masses [3]. The basic tool for water mass classification and analysis is the temperature-salinity (T-S) diagram in which the two conservative properties are plotted against each other. The temperature-salinity combinations identified by the water mass points or curves are known as source water types. Coastal oceans are shallow ocean regions lying over continental shelves. They are strongly affected by nearby lands, river outflows, large human populations, and industrial and agricultural discharges. Coastal oceans are also highly variable. Their currents, water characteristics, and even marine life change over relatively short distances and short periods of time [4]. Coastal-ocean waters respond within a few hours to winds blowing over months. Coastal-ocean distances are also shorter than those involving the open ocean.

Many coastal waters are partially isolated from the open ocean [5]. For instance, parts of the Southern California Bight are partially isolated from the open Pacific Ocean by the Channel Islands, off Santa Barbara to the north Bays, harbors and fjords have restricted communication with the sea. Water characteristics commonly vary substantially in coastal waters. Rivers discharge large amounts of fresh water into coastal waters [6].

2.1. Temperature

Changes in a substance's physical form, such as a solid changing to a liquid or to a vapor, are called changes of state. Changes of state require breaking of intermolecular bonds, or forming of new ones. If bonds are broken, energy is taken up; when new bonds are formed, energy is released, usually as heat. Temperatures in coastal waters are controlled primarily by the incoming energy received from solar radiation. Thus, water temperatures are highest in the mid-latitudes, where insulation is largest, and are lowest in Polar Regions, which receive little insulation and where sea ice buffers surface waters from temperature changes [7]. Temperatures of coastal waters are also affected by oceanic currents transporting either warm or cold waters and by wind-induced upwelling of cold, subsurface waters. Cold winds off the land chill coastal waters during winter and sea ice forms in higher-latitude waters and in isolated shallow bays and estuaries [8]. The surface temperatures of northern Arabian Sea is about 29ºC and the same increase when moving from north to South. However, at depth (500 and 1000m), there was a decrease in water temperature from North to South. In 1982 research found that during the pre-monsoon and NE monsoon period the difference between minimum and maximum temperature of the surface layer of Northern Arabian Sea is about 7ºC which increases to 12ºC in SW monsoon. McGill in 1973 gave a thorough account of Oceanographic Parameters extending from the surface layer down 4000 m depth layer in the western Indian Ocean during the South-West monsoon period. He reported a temperature of 1.6ºC to 1.8ºC for the 3000-4000 m deep [10].

Salinity

Seawater is a solution of salts, of nearly constant composition, dissolved in variable amounts of water. Water, its most abundant constituent, determines most of seawater's physical properties. The presence of salt in seawater influences its density and other physical characteristics [9]. The major constituents in sea salts come primarily from three sources: volcanic eruptions, chemical reactions between seawaters and hot, newly formed crustal rocks; and weathering of rocks on land. Some properties of seawater change as salt concentration increases [11]. For instance, changing salinity from 0 to 40 causes Viscosity (internal resistance to flow) to increase about 5%. Adding sea salts to water also changes its temperatures of maximum density and initial freezing. Because salt does not fit into the ice crystal structure, it inhibits ice formation and depresses the initial freezing point. Salinity variations in coastal waters persist longer than wind effects [12]. In the Northern most Arabian Sea the surface salinity ranges from about 36.2‰ to about 36.5‰. Salinity decreases, from surface to 1000 m, from North to South and from West to East. The high salinity Arabian Sea water is formed at the surface and intensified by the outflow of salinity water from the Persian Gulf at approximately 300 m and from the Red Sea at approximately 800 m at 2000 m salinity in the Arabian Sea is still as high a 34.8‰ found similar values at 3000 m and 4000 m from the Northern Arabian Sea [13].

The graphical analysis will clearly explain and gives the easy understanding to the readers to evaluate the difference between the physical properties of coastal regions of Arabian Sea and other regions of the oceans

3. MATERIAL AND METHOD

For study and analysis water masses at Pakistan coastal regions (stations) were selected at different locations along the coastal zones of Arabian Sea. It has been observed that the basis of water mass analysis in the deep ocean is the derivation of water mass properties in the formation region are small compared to the property differences that are observed between different water masses at some distance from their formation region. The graphical views of the stations are given below:

The data used in the under study area is collected by the help of equipment provided by the Pakistan Naval Authority and Institute of Oceanography, Karachi regions. Survey Echo Sounder (Hydro Star 4900) is used to measure deep sea depth where as Echo Sounder (NJA – 193S) is utilized to determine low depth data. Temperature, pressure and conductivity parameters are computed by use current meters of models, 108,308 MKIII. Besides MTCD is utilized to quantify salinity and density of the under study area.

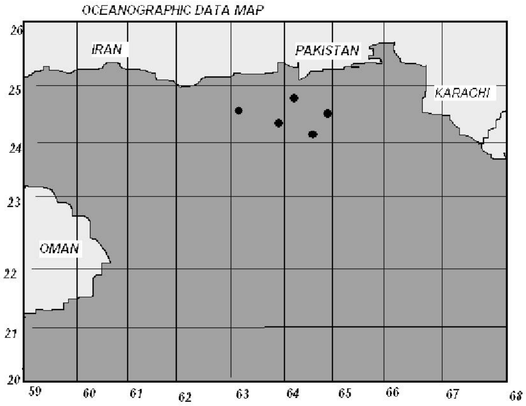

Figure 1. Graphical view of understudy stations

4. T –S MODEL CURVES OF THE STATIONS

The graphical analyses of parameters evaluated at different locations are described under figures.2 to 6.

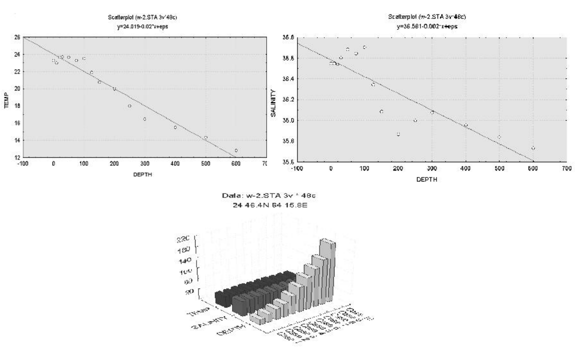

Figure 2. T-S model of station No. 1.

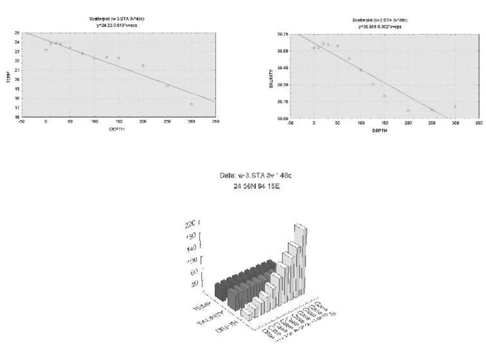

Figure 3. T-S model of station No. 2.

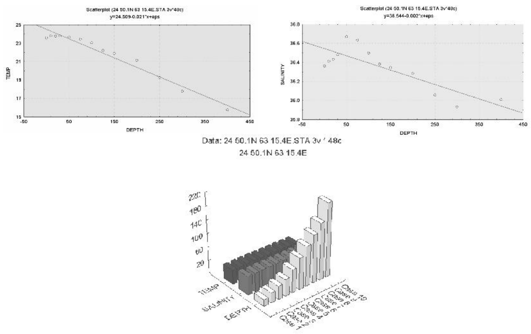

Figure 4. T-S model of station No. 3.

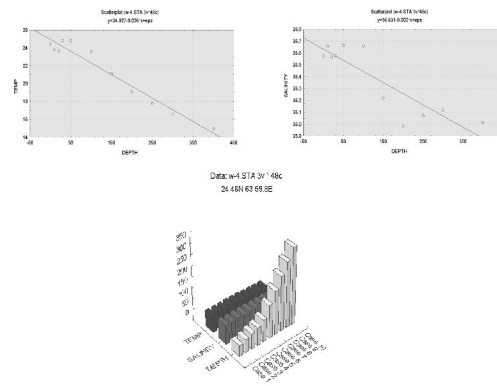

Figure 5. T-S model of station No. 4.

5. ESTIMATION OF DENSITY

Temperature, salinity and pressure control seawater density. Of the three, temperature and salinity are the most important. In the open ocean, seawater density varies only a small amount. These slight density differences cause ocean currents [14]. It is noticeable that this piece of investigation is crucially based on the utilization of observed data obtained at various stations. Figure below shows maximum water-density changes for salinities between 30 and 37 and temperatures from -3 to 30ºC [15]. This encompasses the temperature and salinity ranges of the entire ocean. At 30ºC, a change in salinity from 34 to 35 changes the density from 1.021 to about 1.022 [16]. Density is changed an equal amount by cooling water with a salinity of 37 from 27.5 to 24.3ºC, a change of 3.2ºC. Such temperature changes occur commonly at the ocean surface. Large salinity changes usually occur near land, as a result of river discharges and increased precipitation there, and in Polar Regions, because of ice formation. Specifically, a stable water column is one in which density increases monotonically with depth [17].

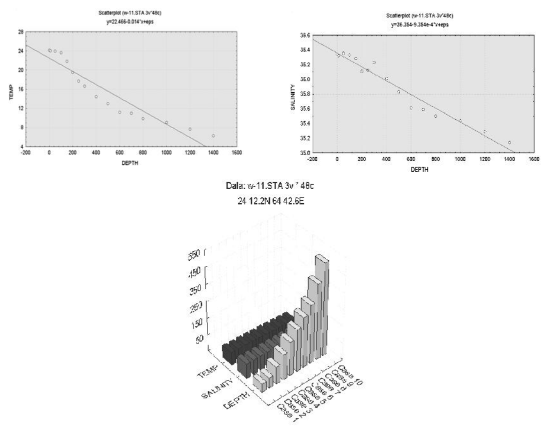

Figure 6. T-S model of station No. 5

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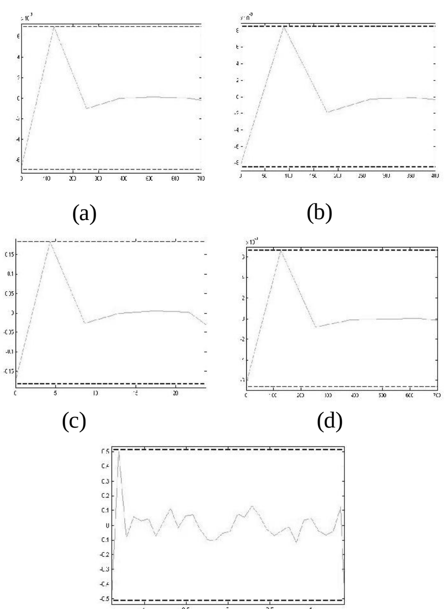


Figure 7. Changes in seawater density are caused by variations in salinity and temperature.

7. WAVELET CONSIDERATIONS

Wavelet technique has been used for the analysis of oceanographic and communication data and results received at different locations. It provides engineers, scientists and other technical professionals with a single interactive system that integrates numeric computation; visualization and programming. Graphical analyses of the results of density at different stations with respect to salinity and temperature are given below:

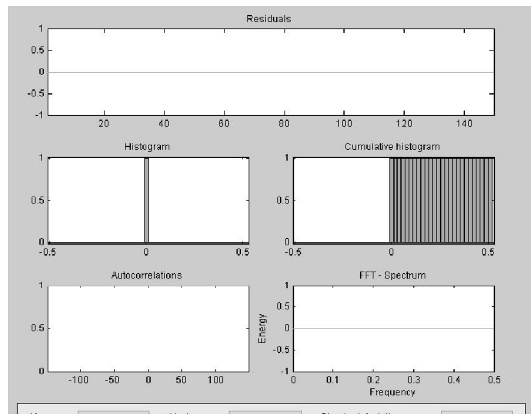


Figure 8. Graphical analysis of the results of density with respect to temperature and salinity of the understudy stations

8. BEHAVIOUR OF THE SIGNAL AT THE WATER MASSES

As a result of the high electrical conductivity of sea water, signals are attenuated rapidly as they propagate downward through thick conductors such as salt water. In many cases, the obvious solution is to surface and raise an antenna above the water surface to use standard technology. This is not sufficient, however, for nuclear-powered submarines. VLF radio waves (3-30 KHz) can penetrate sea water down to a depth of roughly 20 meters. The range and quality of transmission varies with water conditions, local noise level, and reverberation effects. Continuous wave energy radiated by antennas oscillates at radio frequencies. The associated free-space waves range in length from thousands of meters at the long-wave extreme to fractions of a millimeter at the short-wave extreme. Short radio waves and long infrared waves overlap into a twilight zone that may be regarded as belonging to both [18].

The wavelength λ of a wave is related to the frequency f and velocity υ of the wave by

$$\lambda = \upsilon / f \qquad (1)$$

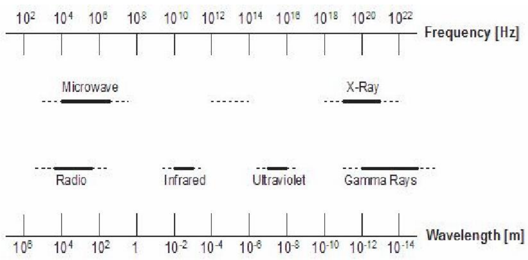


Figure 9. The electromagnetic spectrum with wavelength on a logarithm scale from shortest gamma rays to the longest radio waves.

Thus the wavelength depends on the velocity υ which depends on the medium. In this sense, frequency is a more fundamental quality since it is independent of the medium, when the medium is free space.

$$\upsilon = c = 3x10^{8} m/s \qquad (2)$$

$$\lambda = c / f = 3x10^{8} / 3000x10^{6} = 1m \qquad (3)$$

The propagation of an electromagnetic wave is described through different parameters: the electric and magnetic fields E and H, the electric flux density

D and the magnetic induction B. Only vectors $\vec{E}$ and $\vec{B}$ generate effects allowing the determination of the electromagnetic field. The vectors $\vec{D}$ and $\vec{B}$ are linked to vectors $\vec{E}$ and $\vec{H}$ through the following linear relations:

$$\vec{D} = \varepsilon * \vec{E} \qquad (4)$$

$$\vec{B} = \mu * \vec{H} \qquad (5)$$

The ε and μ coefficients depend on the nature of the medium where the electromagnetic wave propagates. In the case of homogeneous, isotropic media, ε and μ are constants, whereas inside vacuum, these coefficients, respectively referred to as the permittivity and magnetic permeability of the medium, assume the following values:

$$\varepsilon_0 = 10^{-9} / 36\pi = 8.842 * 10^{-12}$$

(Farad per meter) (6)

$$\mu_0 = 4\pi * 10^{-7}$$

(Henry per meter) (7)

For any material medium, these coefficients can be deduced from the previous values using the following two equations:

$$\varepsilon = \varepsilon_0 * \varepsilon_0 \qquad (8)$$

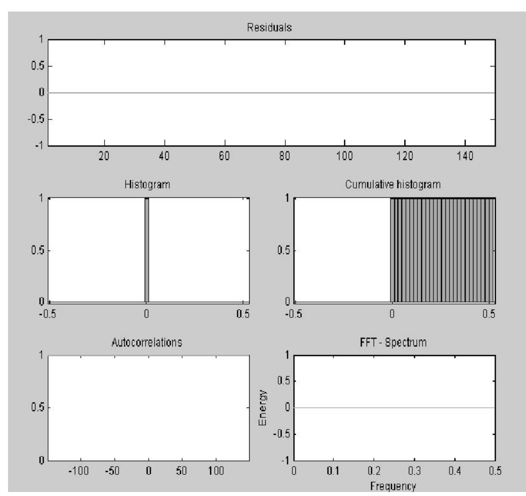
$$\mu = \mu_0 * \mu_r \qquad (9)$$

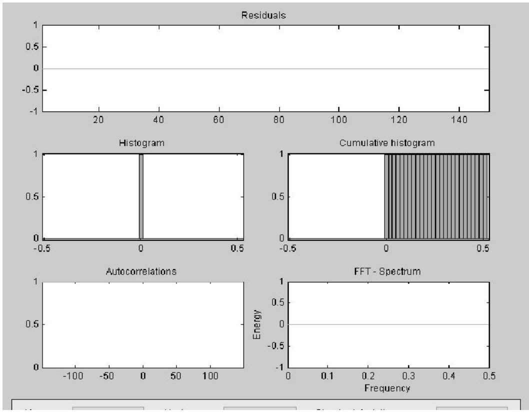
Where εr and μr are the permittivity and the relative magnetic permeability of the medium respectively [18].

In this study we design the VLF antenna in which we used copper wires which are rewound just like a transformer core in either direction. The gap between the two windings is filled with ferrite material. In this construction we can't ignore the basic parameters without which it is very difficult to

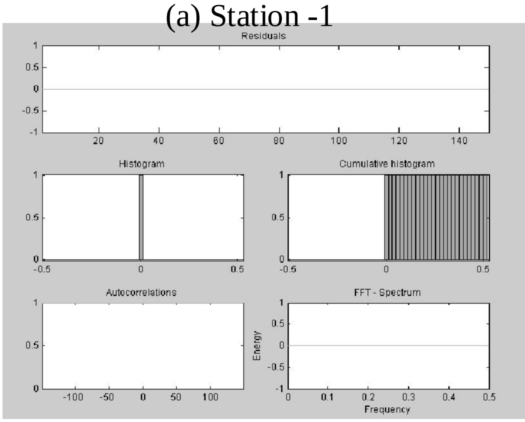
fulfill a good and efficient antenna. The low power modulated and amplifier circuit is design to transmit the signal for short distance. This is an experimental effort to enquire the live data and with the passage of time and effort it can be used for both way communications between two submarines [19].

The graphical analyses of the results of radio waves communication through wavelets are given below:

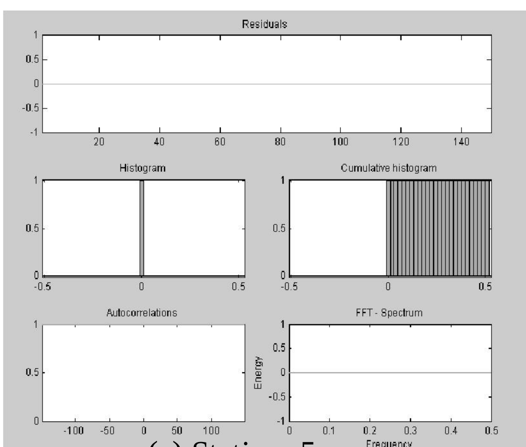




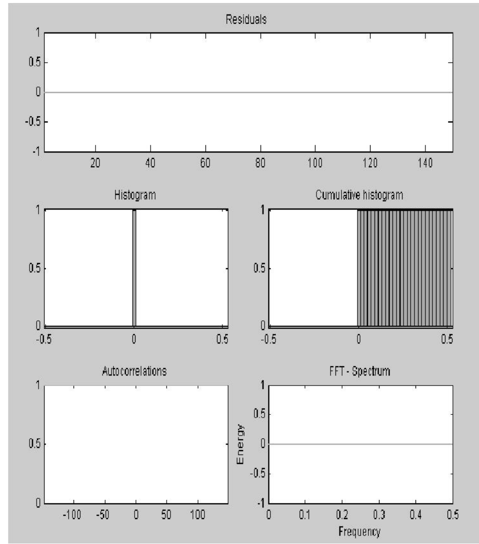
(a) Station -1



(c) Station -3



(e) Station -5



(d) Station -4

Figure 10: Wavelet analysis of radio wave communication on water masses of understudy stations.

7. CONCLUSION

In this study we have observed that physical variables i.e. temperature and salinity have some diverse effects to study the fluctuating dynamics of water masses on radio wave propagation under sea at Pakistan coastal environment. It has been examined that long wavelength can easily penetrate on those areas where the salinity and temperature are very low. In our analysis it has been observed that out 05 stations, there are 04 positions (24 46.4N 64 15.8E, 24 50.1N 63 15.4E, 24 56N 64 15E and 24 46N 63 59.8E) in which the density is not vary normally. Whereas, position 24 12.2N 64 42.6E the density is drastically change due to variation in temperature and salinity.

Geo-morphological studies are necessary to understand the physics and underlying structure of natural coastal zones and to build models that monitor some aspects of these investigations. Often this is achieved by analyzing observations of the process, extracting important features regarding its morphological and statistical structure, and using this information for model building. Wavelet technique has been used for oceanographic and communication data received at different locations. It provides engineers, scientists and other technical professionals with a single interactive system that integrates numeric computation; visualization and programming. On some occasions, physical considerations directly guide model construction and in such cases, observations are used to validate and refine the model presented in this paper.

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