ANALYSIS OF REFRACTION LOSS, ATTENUATION AND WAVE LENGTH OF ELECTROMAGNETIC WAVES FROM SURFACE OF SEA TO 5500 M DEPTH OF SEA USING SEA WATER REAL TIME DATA AT 15KHz FREQUENCY

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ABSTRACT

In this paper we find out the Refraction Loss, Attenuation and wave length of electromagnetic waves from surface of sea water to 5500 m depth of sea water using real time data from National Oceanic and Atmospheric Administration (USA). It is a data base of real time data of salinities and temperatures of sea water from surface of sea water to depth of sea water at different latitude and longitude. We used this real time data and applying to modified version of Ellison et al model 1998, to find conductivity of sea water from surface of sea to depth of 5500 m, and we also from conductivity of sea water, we calculate Refraction Loss, Attenuation and wave length of Electromagnetic waves from surface of sea to depth of 5500 m using mat lab simulation as a tool.

Keywords: Refraction Loss, salinity, attenuation, Temperature, conductivity.

INTRODUCTION

In past the Researcher on sea water used data as a supposition to find different parameters of sea water. They take salinities, which is dissolved different salts in sea water ,and temperatures of sea water fixed , which is not possible in real world because the salinities ,which consists of different inorganic compounds varies with different depth ,latitudes and longitudes of sea water . Similarly Temperatures of sea water which shows coldness and hotness of sea water, also varies with depth, latitudes and longitudes of sea water. The temperature and salinity is a function of conductivity if the temperature and salinity varies the conductivity also varies in same fashion; they are directly proportional to each other. The conductivity of sea water affects the Refraction Loss, Attenuation and wave length of Electromagnetic waves.

METHODOLOGY AND RESULTS
ELECTROMAGNETIC WAVES OF SEA WATER

These are the waves which consist of magnetic field and electric field, which are perpendicular to each other**.**

It carries electromagnetic radiant energy. As shown in figure 1.

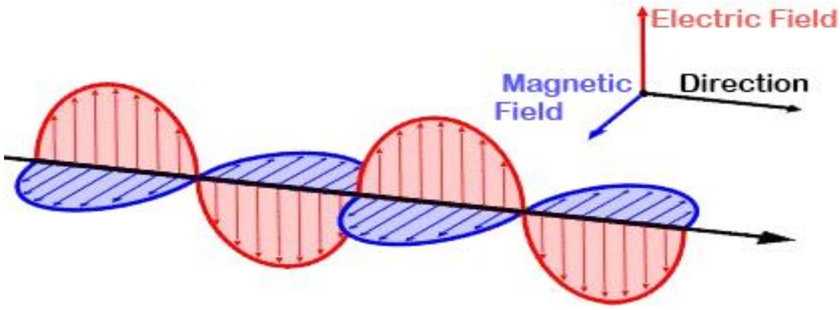


Fig 1 Electromagnetic waves

SEA WATER CHARACTERISTICS

The water is a mixture of organic compounds like bacteria and inorganic compounds like sodium chlorides sodium bicarbonate ($NAHCO_3$) , Potassium nitrate (KNO_3),and magnesium sulfate ($Mgso_4$). The salinity , temperature and conductivity of sea water is affected by these inorganic compounds and which varies from surface of sea to depth of sea of 6000m , the organic compounds have no effect on the salinity , temperature and conductivity of sea water from surface of sea to depth of sea of 6000 m. Sea water are shown in figure 2 below.**[1]**

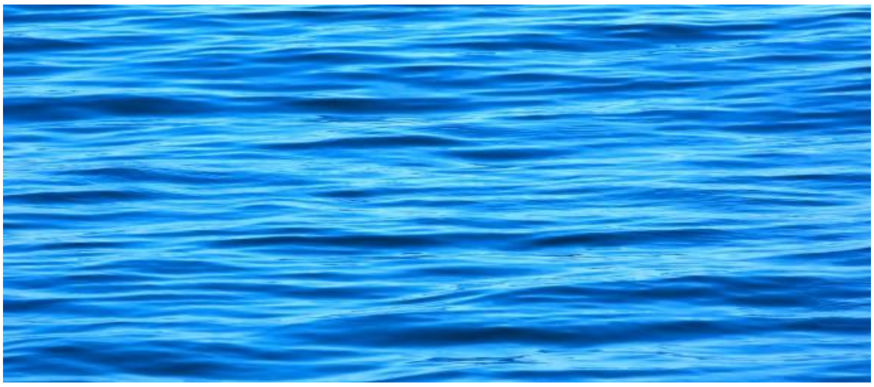


Fig 2 Sea water

FACTORS AFFECTING REFRACTION LOSS, ATTENUATION ,AND WAVE LENGTH OF ELECTROMAGNETIC WAVES FROM SURFACE OF SEA TO 5500 M DEPTH OF SEA AND MAT LAB SIMULATION RESULTS

a) FREQUENCY

In Physics the frequency is the number of cycles per second, its unit in SI system is Hertz denoted by Hz.
Mathematically Frequency

$$f = 1/t \quad \text{Hz.} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

While in sea water we study travelling of Electromagnetic waves from surface of sea to depth of 5500 m to find out refraction loss, Attenuation and Wavelength of Electromagnetic waves. If the frequency increases or decreases, the refraction loss ,Attenuation and wave length of Electromagnetic waves affected. Frequency is shown in figure 3.

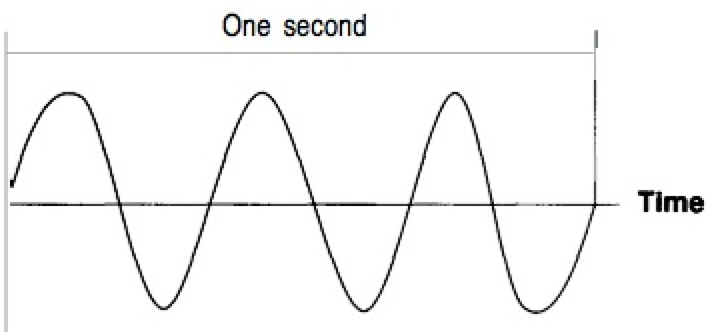


Fig 3 frequency

SALINITY OF SEA WATER MAT LAB SIMULATION RESULT

It shows how much amount of salt is dissolved in sea water , the major content of these salt is sodium chlorides and other salts are Potassium nitrate (KNO_3), magnesium sulfate ($Mgso_4$) and sodium bicarbonate ($NAHCO_3$). The becomes more denser at surface of sea while it is less denser at depth of sea, which affects the temperatures and conductivity of sea water. If the salinity is denser at the surface of sea water the temperature and conductivity of sea water is also very high so the refraction loss ,Attenuation are high and wave length of Electromagnetic waves decreases and vice versa.

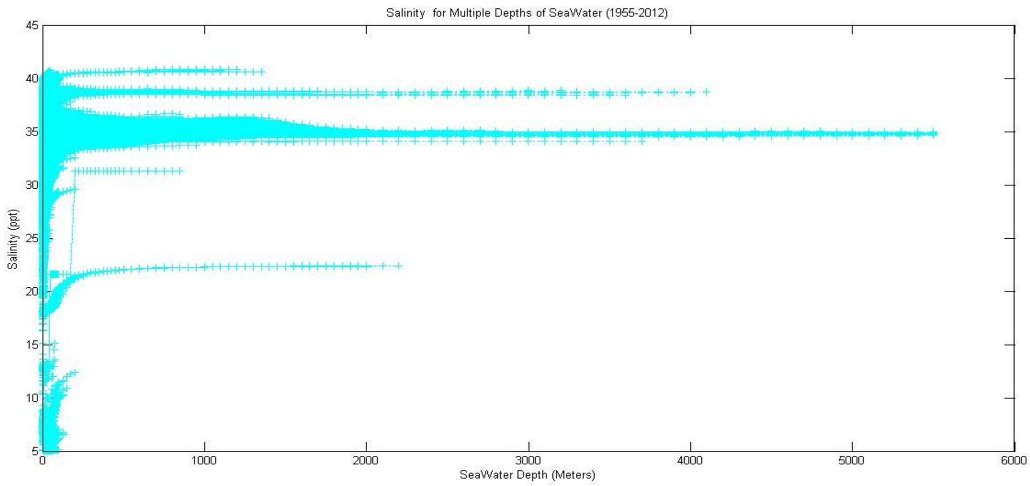


Fig 4 salinity vs. depth of 5500 m [1]

The above figure 4 shows that salinity decreases with depth due to insufficient amount of inorganic compounds while it is increase at surface of sea water due to abundant amount of inorganic compounds. As in figure 4 from 0 to 25 ppt. the salinity is in less amount which means its depth of sea at this level the temperature and conductivity is minimum and the refraction loss ,attenuation and wave length of electromagnetic waves is also minimum. The salinity concentration is maximum from 25 to 40 ppt. it's the surface of sea at this level temperature and conductivity is maximum and refraction loss .attenuation and wavelength of electromagnetic waves due conductivity of sea water is also maximum**. [1,2,3,4]**

TEMPERATURE OF SEA WATER

It is a measure of hotness and coldness, it also varies from surface of sea to depth of sea depending upon the amount of salinity of sea water . if the temperature is high like at surface of sea water the salinity concentration is also very high ,which increase the conductivity of sea water , at this stage

Vol. 5 No. 3, 2017
ISSN 2056-5860

refraction loss , attenuation and wave length of electromagnetic waves is high and vice versa. It is calculated in SI unit Celsius, denoted by (c^o). The sea water temperature varies in between -2 to 30(c^o). **[1,2,3,4]**

CONDUCTIVITY OF SEA WATER MAT LAB SIMULATION RESULT

In Engineering field conductivity is ability of a substance to pass electric current, while in sea water it's the ability of sea water to pass electric current. It is Measured in Siemens per meter (s/m). the conductivity of sea water changes according to weather of sea water, in winter climate the conductivity of sea water is 2 s/m and 8 s/m in summer climate . The reference conductivity of sea water is 4 s/m.

The conductivity of sea water is also dependent on salinity concentration like Magnesium chloride, Potassium nitrate (KNO_3), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_4$) and sodium chlorides and temperature of sea water. At surface of sea water these parameters are in abundant form which increase refraction loss, attenuation and wave length of electromagnetic waves , while at depth of sea these parameters are in insufficient forms so refraction loss, attenuation and wave length of electromagnetic waves decreases. Conductivity of sea water are shown in figure 5.

Mathematically conductivity

$$\sigma(s, t) = K(t) + L(t)\, s \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$K(t)=0.086374+.030606t-.0004121t^2$$

$$L(t)=0.077454+.001687t$$

Where "K" and "L" are coefficients

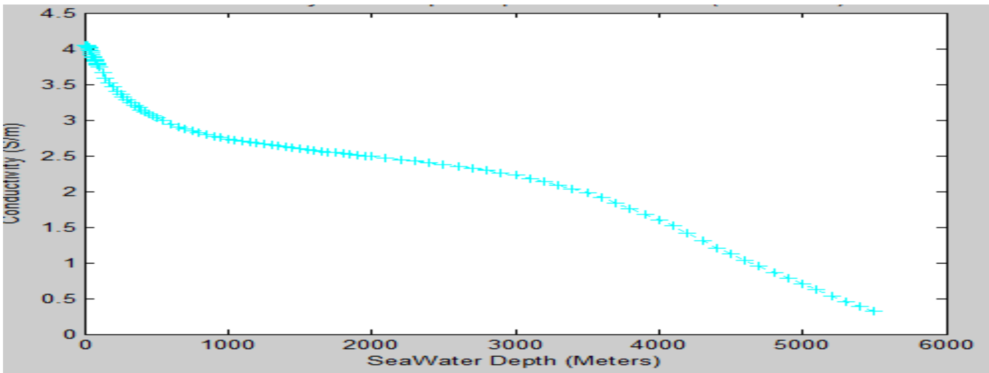


Fig 5 conductivity vs. depth of 5500 m. [1]

The figure 4 shows that conductivity is directly proportional to depth of sea, from 0 to 1000 m depth of sea, the conductivity varies from 4 to 2.5 s/m. The reason is that at 0 meter depth of sea water the salinity and temperature of sea is maximum ,so the conductivity is 4 s/m , while at 1000 m depth of sea water the salinity and temperature is at minimum quantity so the conductivity falls to 2.5 s/m .In figure 5 it drops to 0.2 s/m if we go deeper and deeper because salinity and temperature decreases like at 5500 m depth of sea. The conductivity is a major factor to affects refraction loss , attenuation and wavelength of sea water. If the conductivity is high the refraction loss, attenuation increases and wave length of electromagnetic waves will be decreases and vice versa. **[5,6,7]**

ATTENUATION OF ELECTROMAGNETIC WAVES FROM SURFACE OF SEA TO 5500 M DEPTH OF SEA USING 15 KHz FREQUENCY

The attenuation of Electromagnetic waves in sea water is directly proportional to conductivity of sea water It can be affected by salinity, temperature and conductivity of sea water , at surface of sea it is maximum because at surface of sea the salinity, temperature and conductivity of sea water is maximum , while at depth it is minimum. It is also affected by frequency of Electromagnetic waves if the frequency is high it will be high if low it will be low
.Mathematically attenuation is

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f}$ ………………………………… (3)

Where in equation (3) "σ" is the conductivity in s/m and "f" is the frequency in hertz (Hz) ranging from 10 kHz to 30 kHz. So we concluded that if the frequency and conductivity of sea water is low the attenuation of Electromagnetic waves is less and vice versa. **[8 , 9]**

Suppose if we consider a constant frequency Electromagnetic wave of 15khz in rang of 10 kHz to 30 kHz ,so we can find the attenuation of Electromagnetic wave at 5500 m from equation (3) easily.

Case 1: f = 15 kHz =15*1000 = 15000 Hz depth = 0 m conductivity (σ) = 4 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{4*15000}$ = 4.2376 dB/ m

Case 2: f = 15 kHz depth =1000 m conductivity (σ) = 2.7 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{2.7*15000}$ = 3.4815 dB/ m

Case 3: f = 15 kHz depth =2000 m conductivity (σ) = 2.5 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{2.5*15000}$ = 3.3501 dB/ m

Case 4: f = 15 kHz depth =3000 m conductivity (σ) = 2.2 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{2.2*15000}$ = 3.1427 dB/ m

Case 5: f = 15 kHz depth =4000 m conductivity (σ) = 1.2 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{1.5*15000}$ = 2.595 dB/ m

Case 6: f = 15 kHz depth =5000 m conductivity (σ) = 0.5 s/m putting in equation (3) the following values

Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{0.5*15000}$ = 1.4982 dB/ m

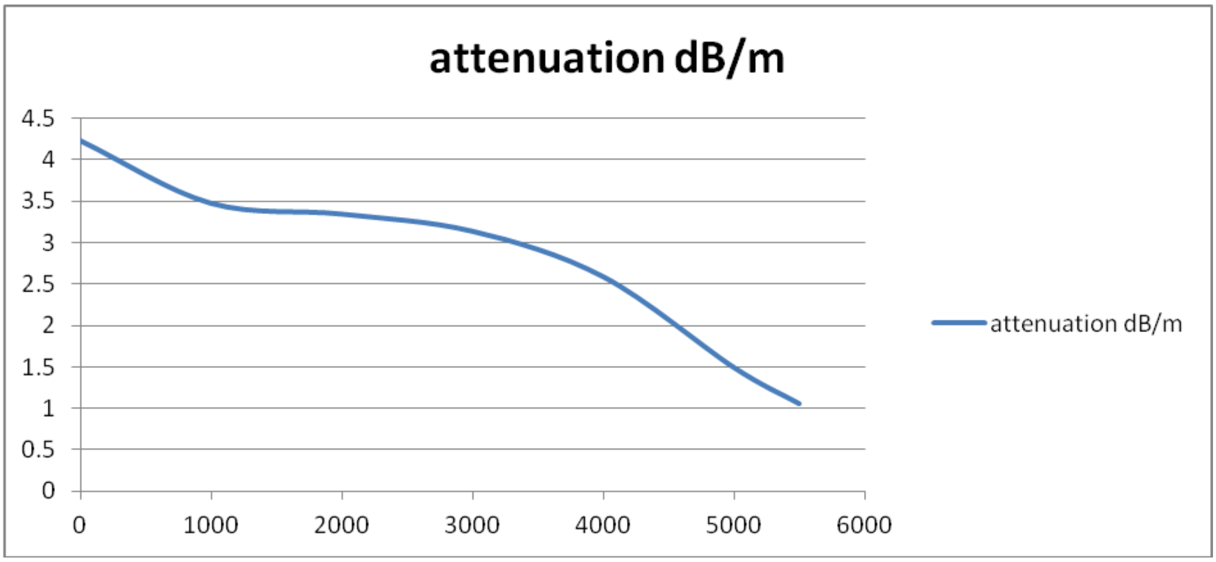
Case 7: f = 15 kHz depth =5500 m conductivity (σ) = 0.25 s/m putting in equation (3) the following values

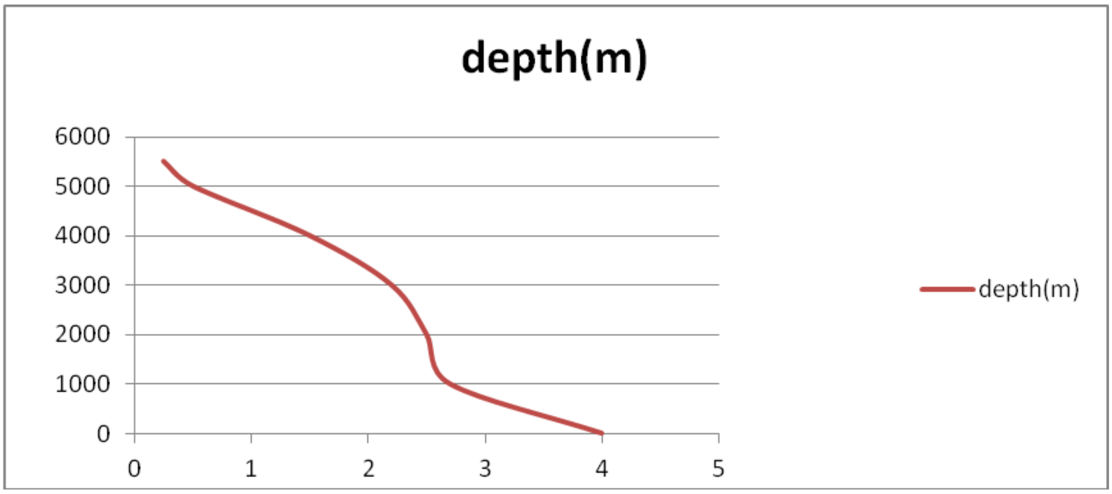
Attenuation (dB/ m) = $0.0173 \sqrt{\sigma f} = 0.0173 \sqrt{0.25*15000}$ = 1.0594 dB/ m

So we concluded for every frequency ranges from 10 to 30 kHz, we can find attenuation of Electromagnetic waves. At low frequency and low conductivity attenuation of electromagnetic waves should be minimum and vice versa. As shown table 1.

S:no	Conductivity(s/m)	Depth (m)	Attenuation (dB/ m)
1	4	0	4.2376
2	2.7	1000	3.4815
3	2.5	2000	3.3501
4	2.2	3000	3.1427
5	1.5	4000	2.595
6	0.5	5000	1.4982
7	0.25	55000	1.0594

Table 1 Attenuation of electromagnetic waves vs. conductivity and depth of sea water.





Graph 1a) Comparison of Attenuation at y-axis vs. depth of sea at x –axis **b)** conductivity at x- axis vs. depth of sea is at y axis.

ISSN 2056-5860

REFRACTION LOSS OF ELECTROMAGNETIC WAVES FROM SURFACE OF SEA TO 5500 M DEPTH OF SEA USING 15 KHz FREQUENCY

It is a Loss occurred when Electromagnetic waves travels from air to water or from water to air , its due to change in the medium **.** It can be affected by salinity, temperature and conductivity of sea water , at surface of sea it is maximum because at surface of sea the salinity, temperature and conductivity of sea water is maximum , while at depth it is minimum**.** We can see its behavior at 15 KHz frequency from surface of sea to depth of 5500 m**.** It can also be affected by frequency of Electromagnetic waves, if the frequency is maximum it will be maximum and **if** the frequency is minimum it will be minimum**.** It can be determined by the following formula**. [8,9]**

Mathematically

Refraction Loss (dB) = -20log7.4586*10^6 $\sqrt{f/\sigma}$ ……………(4)

Suppose if we consider a constant frequency Electromagnetic wave of 15khz in rang of 10 kHz to 30 kHz ,so we can find the attenuation of Electromagnetic wave at 5500 m from equation (4) easily.

Case 1: f = 15 kHz =15*1000 = 15000 Hz depth = 0 m conductivity (σ) = 4 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/4}$ =66.80 dB

Case 2: f = 15 kHz =15*1000 = 15000 Hz depth =1000 m conductivity (σ) = 2.7 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/2.7}$ =65.11 dB

Case 3: f = 15 kHz =15*1000 = 15000 Hz depth =2000 m conductivity (σ) = 2.5 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/2.5}$ =64.76 dB

Case 4: f = 15 kHz = 15*1000 = 15000 Hz depth =3000 m conductivity (σ) = 2.2 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/2.2}$ =64.21 dB

Case 5: f = 15 kHz = 15*1000 = 15000 Hz depth =4000 m conductivity (σ) = 1.5 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/1.5}$ =62.54 dB

Case 6: f = 15 kHz = 15*1000 = 15000 Hz depth =5000 m conductivity (σ) = 0.5 s/m putting in equation (4) the following values

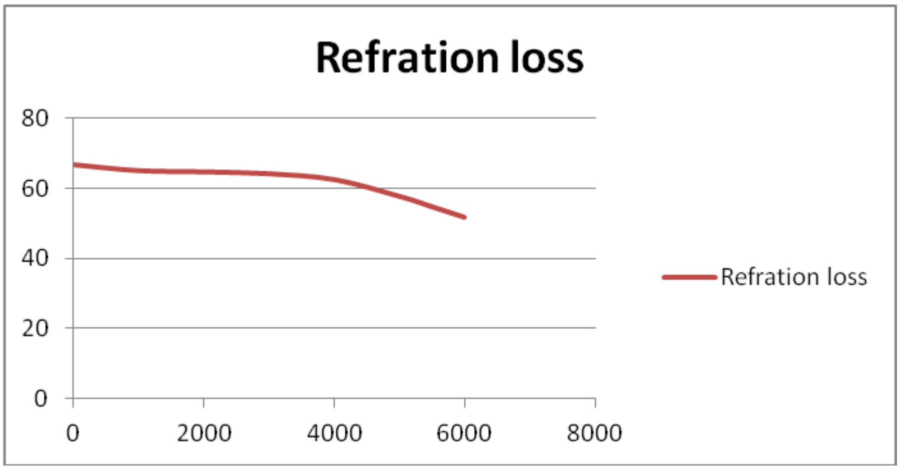
Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/0.5}$ =57.78 dB

Case 7: f = 15 kHz = 15*1000 = 15000 Hz depth =5500 m conductivity (σ) = 0.25 s/m putting in equation (4) the following values

Refraction Loss (dB) = -20log7.4586/10^6 $\sqrt{15000/0.25}$ =54.79 dB

S:no	Conductivity(s/m)	Depth (m)	Refraction loss (dB)
1	4	0	66.80
2	2.7	1000	65.11
3	2.5	2000	64.76
4	2.2	3000	64.21
5	1.5	4000	62.54
6	0.5	5000	57.78
7	0.25	55000	54.79

Table 2 comparison of conductivity , refraction loss and depth of sea at 6000 m depth



Graph 2 Refraction loss is at y –axis vs. depth of sea is at x-axis

The Graph 2 shows refraction loss of electromagnetic waves decrease at depth of 6000 m.

WAVE LENGTH OF ELECTROMAGNETIC WAVES FROM SURFACE OF SEA TO 5500 M DEPTH OF SEA USING 15KHz FREQUENCY

It is the distance between two successive crests of Electromagnetic waves. It is denoted by Greek word λ. It is measured in meters "m".

Mathematically

$$\lambda = 1/f \text{ ....(5)}$$

The wave length of Electromagnetic waves also affected from salinity , temperature and conductivity of sea water if the salinity, temperature and conductivity is high the wave length will be minimum and vice versa. it can also be affected by frequency of electromagnetic waves . **[8,9].**

$$\text{Wave Length (m)} = 1000\sqrt{10/\sigma f} \quad \text{.......................................} \quad (6)$$

Case 1: f = 15 kHz =15*1000 = 15000 Hz depth = 0 m conductivity (σ) = 4 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/4*15000} = 12.90 \text{ m}$$

Case 2: f = 15 kHz =15*1000 = 15000 Hz depth = 1000 m conductivity (σ) = 2.7 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/2.7*15000} = 15.71 \text{ m}$$

Case 3: f = 15 kHz =15*1000 = 15000 Hz depth = 2000 m conductivity (σ) = 2.5 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/2.5*15000} = 16.32 \text{ m}$$

Case 4: f = 15 kHz =15*1000 = 15000 Hz depth = 3000 m conductivity (σ) = 2.2 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/2.2*15000} = 17.40 \text{ m}$$

Case 5: f = 15 kHz =15*1000 = 15000 Hz depth = 4000 m conductivity (σ) = 1.5 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/1.5*15000} = 21.08 \text{ m}$$

Case 6: f = 15 kHz =15*1000 = 15000 Hz depth = 5000 m conductivity (σ) = 0.5 s/m putting in equation (6) the following values

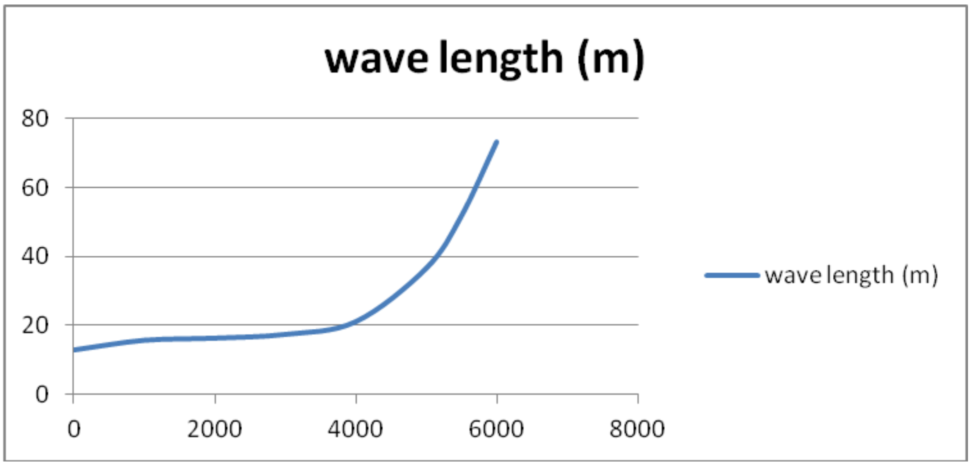
$$\text{Wave Length (m)} = 1000\sqrt{10/0.5*15000} = 36.51 \text{ m}$$

Case 7: f = 15 kHz =15*1000 = 15000 Hz depth = 5500 m conductivity (σ) = 0.25 s/m putting in equation (6) the following values

$$\text{Wave Length (m)} = 1000\sqrt{10/0.25*15000} = 51.63 \text{ m}$$

S:no	Conductivity(s/m)	Depth (m)	Wave length (m)
1	4	0	12.90
2	2.7	1000	15.71
3	2.5	2000	16.32
4	2.2	3000	17.40
5	1.5	4000	21.08
6	0.5	5000	36.51
7	0.25	55000	51.63

Table 3 Comparison of conductivity, depth of sea of 6000 m and wave length of electromagnetic waves



Graph 3 Wave length at y –axis and depth of sea is at x-axis

The graph 3 shows that wave length of Electromagnetic waves increases with depth of sea water.

ISSN 2056-5860

CONCLUSION REMARKS

We noted that conductivity of sea water decreases with depth of sea and increases at surface of sea the reason is that at surface of sea the inorganic compounds are in abundant form while at depth of sea the inorganic compounds are in insufficient forms. The conductivity of sea water affects the refraction loss , attenuation and wave length of Electromagnetic waves. The Refraction loss and attenuation of electromagnetic waves decreases at depth of sea water while increase at surface of sea water due to changeable behavior of inorganic compounds. The Conductivity also affects the wave length of electromagnetic waves at surface of sea it is decreases, while at depth of sea it is increases its also due to changeable behavior of inorganic compounds.

FUTURE WORK:

We can improve our results if we have real time data for more than 5500 m on National Oceanic and Atmospheric Administration (USA).

ACKNOWLEDGEMENT

This research work is supported by Changchun University of science and technology Jilin china.

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