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# New Permittivity Measurement from Surface of Sea to 5500 m Depth of Sea using Sea Water Real Time Data from National Oceanic and Atmospheric Administration (USA)

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**Abstract**

In this paper we used modified version of Ellison and his colleagues model 1998 for Permittivity measurements of sea water , in past this model is used as a reference model for permittivity measurements of sea water .The only demerit of this model is that it used Debye model interpolation function" ε (t,s,v) " on 3 GHz fixed frequency and used unchanged salinity concentration of sea water ,which is not feasible in practical because salinity of sea water varies with each depth of sea due to changeable inorganic compounds concentrations like, Potassium nitrate ,sodium chlorides, and magnesium sulfate concentrations .The Ellison and his colleagues model 1998 are also not used for permittivity measurement at depth of sea water ,it used data as a supposition, practical or real time data is not used in it. In this paper we bring some changes to Ellison and his colleagues model 1998 and used Debye model interpolation function " ε (t,s,v) " on 2-40 GHz frequency and used varying salinity and Temperature from National centers for environmental information ,which is mostly called National oceanic and atmospheric administration (USA).which comprises of real time data in form of temperature and salinity from surface of sea to depth of 5500 m . We used Mat lab as a simulation tool to find the permittivity of sea water from surface of sea to depth of 5500 m.

***Keywords:*** salinity; Temperature; conductivity; inorganic compounds; permittivity.

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## 1. Introduction

In earlier period for permittivity measurement, most of models was presented by scientist but there data was not a real time data, they used data as an assumption , which is not possible because at every longitude ,latitude, and depth of the sea ,the water parameters varies. National centers for environmental information, where the real time data are available at each latitude, longitude and at every depth of sea, the real time data is salinity concentration, temperature of sea at different depth, and pressures of sea. The permittivity of sea water is dependent on temperature, salinity concentration and conductivity of sea water.

## 2. Sea water and in organic compound

Sea water is a water from sea or ocean, it consist of dissolved salts (inorganic compounds) and organic compounds .The freezing point and density of sea water depends upon on salt concentration The Permittivity of sea water is a function of salinity ,temperature and conductivity .The salinity ,temperature and conductivity are directly proportional to each other and these three parameters of sea water depends on inorganic compounds concentration of sea water. At surface of sea the inorganic compounds are maximum, so the salinity concentration , conductivity and temperature of sea is high ,which affects the permittivity of sea water. At depth of sea the inorganic compounds are minimum ,so the temperature , salinity ,conductivity and permittivity is low .Sea water and inorganic compounds concentration are shown in In Figure 1, Figure 2 and in Figure 3.

**Figure 1:** Sea water

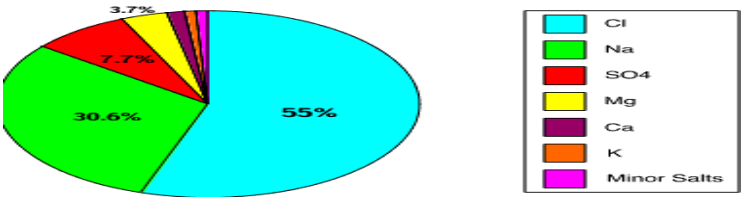



**Figure 2:** inorganic compound of sea concentration.

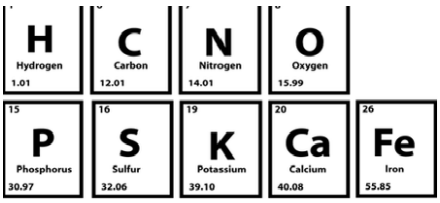



**Figure 3:** inorganic compound periodic table positions

Figure 2 and Figure 3 shows the percentages of inorganic compounds in sea water and their division in periodic table.

## 3. Factors affecting Permittivity of sea water

### *3.1. Salinity*

It shows the concentration of salts dissolved in sea water. The sea water comprises of different salts concentration but the rich concentration of salt is sodium chlorides. The other salts which also dissolved in sea water is Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) and magnesium sulfate ($Mgso_{4)}$. The average salinity of sea water is 35% parts per thousand ( ppt), it means that in 100 grams of water the salts concentration is 35 grams. Chlorinity means that the concentration of chlorine ions dissolved in sea water. Salinity came into being to sea water, when globe or earth was forming, Volcanoes remit different types of salts and chemicals .The other resource of sea water salinity is rain, the rain bathe the salty mountains and lands to sea. If the temperature is high the concentration of inorganic compounds Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_{4)}$ and sodium chlorides is also high for example at the surface of sea water the temperature is high, so the salinity concentration is also high ,if the temperature is low mostly at the bottom of sea water ,the inorganic compounds concentration is low ,which affects the salinity concentration to be low [1,2].

### *3.2. salinity vs permittivity of sea water Matlab simulation results*

In Figure 3.2 a) b) shows that real and imaginary parts of permittivity is mostly constant from zero to 28 ppt but jumped to maximum permittivity at 30 ppt,at this point energy stored by a medium and energy lost in the medium is maximum , the permittivity is a function of salinity concentration. In Figure 3.2 a),b) the mean permittivity real and imaginary parts from 0 to 28 shows that we moving from depth of sea to surface of sea and the real imaginary parts of permittivity increases linearly as shown in Figure 3.2 a),b) from 0 to10 ppt the real and imaginary parts are at minimum values ,while from 10 to 20 ppt, there is a slight change in real and imaginary part of permittivity, the reason is that the inorganic compounds concentration of Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_{4)}$ and sodium chlorides are changed and its in abundant form as compared to 0 to 10 ppt of salinity concentration, while from 20 to 30 ppt of salinity concentration is very high and showed the surface of sea at this point the real and imaginary part of permittivity is high as shown in Figure 3.2 a), b).

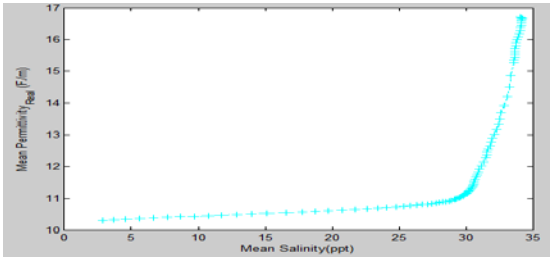



**Figure 3.2 a:** mean salinity vs Mean permittivity real

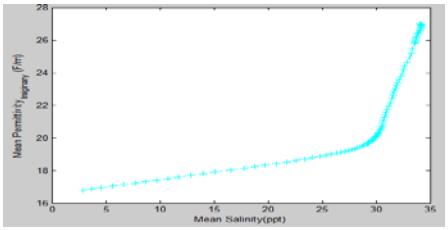



**Figure 3.2 b:** mean salinity vs Mean permittivity imaginary

### *3.3. Temperature of sea vs permittivity of sea water and Mat lab simulation results*

It is a parameter demonstrates a material coldness or hotness. It is calculated in SI unit Celsius, denoted by ($c^o$). It is mostly in the range of -2 to 30($c^o$).The temperature of sea water is function of salinity concentration and conductivity of sea water .At the surface of sea water the temperature is maximum ,so the salinity concentration is also maximum due to inorganic compounds like Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_4$) and sodium chlorides in plentiful form at the surface of sea ,which increases the conductivity at surface of sea water, because conductivity is a function of temperature and salinity , the temperature also affects the permittivity of sea water which is maximum at surface of sea, while at depth of sea water the salinity and conductivity decreases which decreases permittivity. In Figure 3.3 a) and b) its show a linear relationship both parts of permittivity real and imaginary vary linearly with temperature , from 0 to 8 ($c^o$) the real and imaginary parts of permittivity is at minimum value, it means it is the depth of sea water ,and at depth the temperature of sea is low and we already discussed the concentration of inorganic compounds is also minimum due to deficiency of Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_4$) and sodium chlorides, while from 8 to 14 ($c^o$) the real and imaginary parts of permittivity increases, and we moving from depth of sea to surface of sea. At this point the salinity concentration is high due to inorganic compounds Magnesium chloride, Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_4$) and sodium chlorides are in abundant forms [3].

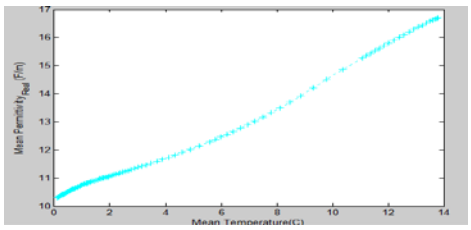


**Figure 3.3 a:** Mean permittivity real vs mean Temperature

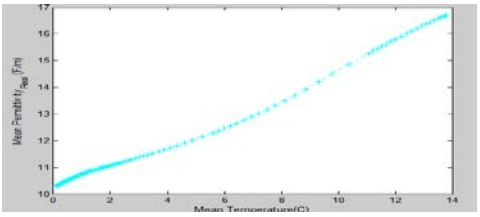


**Figure 3.3 b:** Mean permittivity imaginary vs mean Temperature

### *3.4. Conductivity of sea water vs permittivity of sea water*

In electrical engineering conductivity is the capability of material to allow electric current, it is inverse to resistivity of material or substance ,while water conductivity means the ability of water to allow electric current. It is calculated in Siemens per meter (s/m). the conductivity of sea water changes according to climate of sea water, in coldness the conductivity of sea water is 2 s/m and 8 s/m in summer weather . The standard 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

. Mathematically conductivity

$$\sigma(s,t) = w(t) + y(t)\, s \qquad (1)$$

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

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

Where “w” and “y” are coefficients [4, 5].

### *3.4. Conductivity of sea water vs permittivity of sea water and Mat lab simulation results*

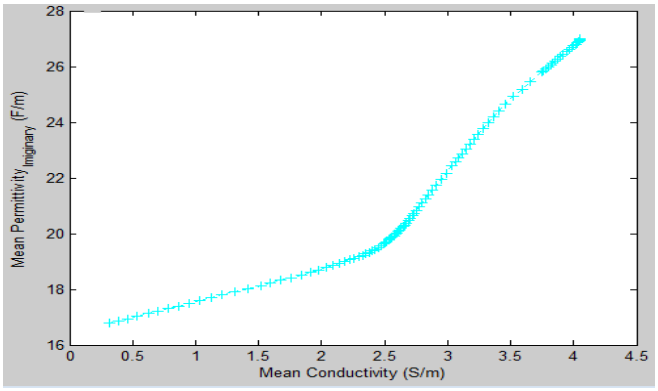
The real and imaginary part of permittivity increases linearly with mean conductivity as shown in Figure 3.4 a), b) from 0 to 2.5 s/m conductivity, the real and imaginary part of permittivity is less due less amount of salinity concentration and minimum temperature of sea water and it shows the depth of sea water , while from 2.5 to 4.5 s/m conductivity of sea water ,the real and imaginary parts of permittivity is too high due to abundant amount of salinity concentration like Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_{4)}$ and sodium chlorides, and the sea water temperature is also high ,at this point and it showed the surface of sea.

### *3.5. Permittivity of sea water at 5500m depth of sea and Mat lab simulation results*

The permittivity is the ability of a substance or material to store electrical energy in electric field, its measured in farad per meter (F/m). Mathematically

$$\varepsilon = \varepsilon_r \varepsilon_o \qquad (2)$$

where “$\varepsilon_r$” is the relative permittivity of the material and” $\varepsilon_o$” is the vacuum permittivity $\varepsilon_o$ =8.85*10^-12 F/m. In this paper we used Debye model to find the permittivity of sea water at 5500 m depth of sea for 2 to 40 GHz frequency and at varying salinity concentration, in past Debye model is used only at 3GHz and at fixed salinity which s not possible in practical because at every depth the salinity concentration and temperature ranges changes.



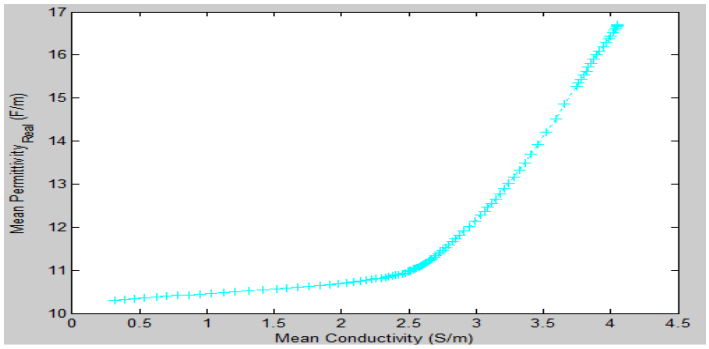




**Figure 3.4 a,b:** mean conductivity vs mean permittivity Imaginary.

Debye model

$$\varepsilon(t,s,v) = \varepsilon_{\infty} + \varepsilon_{o} - \varepsilon_{\infty} / 1\text{-}j2\pi\tau v + j\,\sigma / 2\pi v\,\varepsilon^{*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where "ε (t,s,v) " is the interpolation function , "$\varepsilon_{o(t,s)}$" , "$\varepsilon_{\infty(t,s)}$" are static and frequency dielectric constants "τ(t,s)" is the relaxation time in seconds, it depends on molecule size if the molecules size is larger the relaxation time would be higher and if the molecules size is small relaxation time will be minimum , and depends on temperature and salinity concentration, and "$\varepsilon^{*}$ " is permittivity of vacuums $\varepsilon^{*}$ = 8.85*10^-12 F/m.. It depends mostly on temperature and are not affected from electric filed.where "σ " is the ionic conductivity in s/m." v" is the angular frequency in rad/sec [5,6,7].

### *6.1. Mat lab simulation results of permittivity*

We use mat lab as a simulation tool to find the permittivity of sea water at 5500 m depth of sea using real time data. In Figure 3.5 a),b) the permittivity real and imaginary parts decreases at the depth of sea water , while the permittivity is maximum at the surface of sea .So we concluded that at the surface of sea the salinity concentration due to inorganic compounds is high, and temperature of sea water and conductivity is also high that why the permittivity is too high, in case if we moving from surface of sea to depth of sea the salinity concentration , the temperature of sea water and the conductivity of sea water decreases due to insufficient inorganic compounds like Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_{4)}$ and sodium chlorides ,which affects the real and imaginary parts of permittivity of sea water.

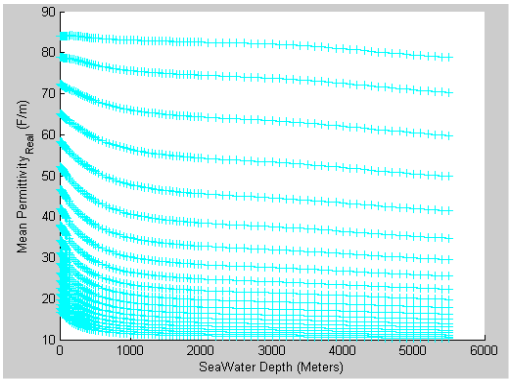



**Figure 3.5 a:** Mean permittivity real vs sea water depth

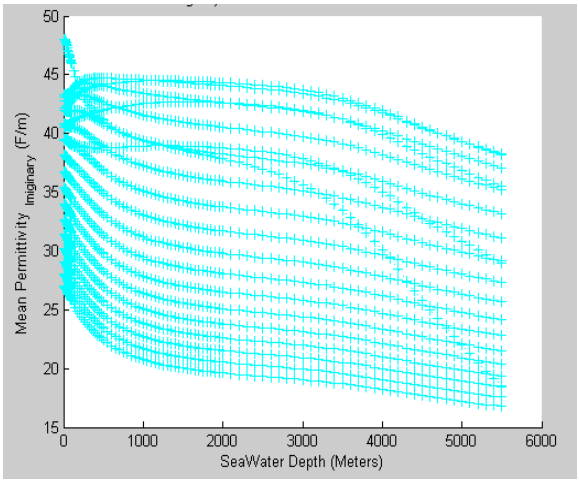



**Figure 3.5 b:** Mean permittivity imaginary vs sea water Depth.

**Table1:** comparison of permittivity with different parameters of sea water.

| S:no | Depth of sea(m) | Freq 2-40 GHz | Salinity ppt | Temperature($c^o$) | Conductivity s/m | Permittivity F/m |
|---|---|---|---|---|---|---|
| 1 | Surface | same | maximum | maximum | maximum | maximum |
| 2 | depth | same | minimum | minimum | minimum | minimum |

## 7. Conclusion Remarks

As we concluded that permittivity is affected from surface of sea to 5500 m depth of sea ,due to salinity concentration like Potassium nitrate ($KNO_3$), sodium bicarbonate ($NAHCO_3$) , magnesium sulfate ($Mgso_{4)}$ and sodium chlorides, temperature of sea , conductivity of sea water .we notice if the salinity concentration is high ,

temperature and conductivity is also high , which increase the permittivity of sea water, and if the salinity concentration is low , temperature , and conductivity will be low as a result permittivity of sea water will be low.

## 8. Future work

For future work we can improve our results if we have real time data of sea for more than 5500 m depth of sea. We can also improve radar image resolution by permittivity of sea water. Sea water radar images are affected from permittivity of sea water.

## Acknowledgement

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