

MEASUREMENT SALT CONTENT

The most abundant solutes in seawater are Cl^- , Na^+ , Mg^{2+} , SO_4^{2-} , Ca^{2+} , and K^+ . They are referred to as the major or conservative ions. They constitute over 99.8% of the mass of the solutes dissolved in seawater. The Na and Cl alone account for 86%.

$$= \frac{\text{g of inorganic dissolved ions}}{1\text{Kg seawater}} \times 1000$$

The most accurate and precise salinity measurements are made with an inductive salinometer, which measures the conductivity of a seawater sample.

The conductivity reading is converted to salinity using an empirical equation. The precision of a good inductive Salinometer is $\pm 0.001\%$. Accuracy is insured by calibrating the salinometer on a routine basis against IAPSO (International Association for Physical Sciences of the Ocean) standard sea water, which is the international accepted salinity standard.

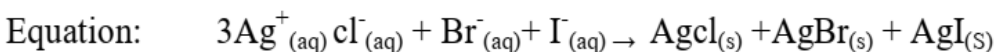
Chlorinity

Because the major ions are present in constant proportions, their concentrations can be used to infer the salinity of seawater. Before the invention of the salinometer, salinity was calculated from the chloride concentration of seawater because of the ease and accuracy with which this measurement can be made.

$$\text{Salinity} = 1.80655 \times \text{Chlorinity}$$

Where chlorinity is defined as the mass in grammes of halides (Expressed as Cl^-) that can be precipitated from 1000g of seawater by Ag^+ .

Chlorinity is determined by titrating a sample of seawater with a standard solution of silver nitrate.



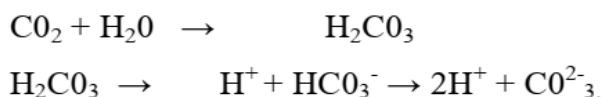
Thus:

$$\text{Chlorinity} = \text{Atomic weight of } \text{Cl}^- \times \text{Moles of } \text{Ag}^+ \text{ required to precipitate halides per } 1\text{Kg seawater} \times 1000$$

DISSOLVED GASES

Nitrogen, carbondioxide and oxygen are the most abundant gases dissolved in sea waters. The solubility of gases is a function of a temperature. And as temperature increases, solubility decreases/reduces. Nitrogen is comparatively inert, and it is therefore not involved in the basic life processes of most organisms.

Carbondioxide and oxygen are metabolically very active and they are therefore the most important dissolved gases in the ocean. Carbon dioxide is abundant in seawater in higher concentration than in the atmosphere. In the sea, the CO₂ concentration is never too low to support plant growth because sea water has unusually large capacity to absorb CO₂ due to the fact that most of the dissolved CO₂ does not remain as a gas, much combines with water to form carbonic acid (H₂CO₃) which is a weak acid. H₂CO₃ normally breaks-down to form H⁺ and a HCO₃⁻ or 2H⁺ and a CO₃²⁻.



The abundance of hydrogen ion in water controls its acidity or alkalinity i.e the pH or the hydrogen ion concentration. The above reaction is reversible. The carbonic acid-bicarbonate-carbonate system in water functions to buffer or limit changes in water pH. If there is excess H⁺ in water, the above reaction proceeds to the left removing the ion from the solution thus preventing the increase acidity. But if it is too low, the reaction will proceed to the right making more ion available (by conversion of carbonic acid to HCO₃⁻, and HCO₃⁻ to CO₃²⁻) and preventing alkalinity.

Oxygen – is one of the most essential elements for marine life. It is necessary for the survival of most organisms except the anaerobic organisms. The abundance or lack of oxygen in sea waters therefore strongly influences the distribution and abundance of most marine organisms. Like in most waters, oxygen is available in sea waters from the (transfer) air/atmosphere and also during photosynthesis by marine organism/plants. These two processes are limited to the surface area of the ocean hence this area is very rich in oxygen. Oxygen replenishment in the deep water near the bottom occurs by very slow diffusion process from the oxygen rich surface layer downward and also by vertical water movements i.e. Upwelling (convection) which mixes surface and bottom waters, as well as, thermocline through water circulation.

The amount oxygen decreases with depth. At intermediate depth, plant and animal respiration as well as bacterial decomposition and organic debris use oxygen as fast as it is replaced thereby creating an oxygen minimum zone. The presence or absence of oxygen minimum zone depends on whether the depth of oxygen respiration exceeds the renewal of oxygen by mixing of surface and deeper waters. The increase in oxygen in depth below the oxygen minimum zone is believed to be due to the influx of oxygen rich water from the polar region into the deeper parts of the ocean.

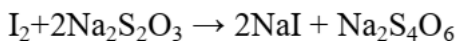
DETERMINATION OF DISSOLVED OXYGEN

It can be determined by

- (i) Oxygen meter (electrical or battery)
- (ii) Titration method (Winkler's method)

In the Winkler's method, concentrated magnesium chloride and alkaline KI are added to the water sample. Both are thoroughly mixed with the water sample under vacuum. A white precipitate of magnesium hydroxide is first formed and some of this is first oxidized into magnesium hydroxide by the DO in the water sample. This magnesium hydroxide which is a brown precipitate settles on the bottom of the specimen bottle (rate of setting depends on the salinity). Concentrated H_2SO_4 is then added, this dissolves the magnesium hydroxide. The magnesium hydroxide liberates iodine from the KI by an oxidation process and is reduced to magnesium oxide. The liberated I_2 takes up excess I^- and forms a complex compound I_3^- .

A rough estimate of the DO content in the sample can be made by noting the depth of colour of the I_2 at this stage. The liberated I_2 is titrated with $Na_2S_2O_3$ using a starch solution indicator. The end point is blue colour. The amount of DO is equivalent to the quantity of $Na_2S_2O_3$ titrated to reach the end point.



Also at any given temperature, pressure and salinity DO can be deduced:

$$CS = \frac{475}{33.5} + t$$

CS = Solubility of oxygen (mg/l)

t = temperature ($^{\circ}C$).

°c	CS (mg/l)	°c	CS (mg/l)
0	14.18	25	8.12
1	13.7	26	7.98
20	8.88	27	7.85
21	8.72	28	7.72
22	8.56	29	7.69
23	8.41	30	7.48
24	8.26	31	7.37

$$\text{General DO} = \frac{C_s + P}{100}$$

P = % saturation of oxygen in the water

Cs = Solubility of O₂ of any given temperature.

DISSOLVED ORGANIC NUTRIENTS

Most important dissolved organic nutrient in sea water are nitrogen and phosphorus. They are chemically combined in organic compounds and eventually oxidized to nitrate and phosphate. They are known as the fertilizers of the sea. Their sources are from excreta of animals, dead remain of plants and animals which drop to the bottom and decomposed by bacteria. These and other amounts of nutrients are usually utilized during photosynthesis by plant at or near the surface of the water. This, therefore, depletes the surface water nutrient and increases their concentration in deeper water. This mixing of surface and bottom waters are very vital for their distribution.

Other dissolved organic compounds in seawater include organic carbon, CHOs, proteins, amino acids, organic acids and vitamins. Generally dissolved organic matter/nutrient is present in seawater in moderately small and usually variable amount of between 0-6mg/l.

TEMPERATURE

This is the relative measure of the condition caused by heat energy. In the world's ocean, temperature ranges from -2°c (bottom, near the Antarctic) to 30°c (equatorial regions). However, at the lower limits, ice usually forms. The surface of the ocean is heated by:

- i. Radiation from the sky and sun

- ii. Conduction of heat from atmosphere
- iii. Condensation of water (vapour).

The surface is cooled by:

- i. Back radiation from the sea surface to the atmosphere
- ii. Back conduction of heat to the atmosphere
- iii. Evaporation.

The surface temperature of the ocean is closely related to the latitude and season of the year. Usually more heat for unit area is received at the equator just as more heat is received in dry season and summer. In the sea, temperatures do not vary throughout the year like on land. There is, however, an important seasonal fluctuation of surface water temperature in the ocean. This is known to vary with ocean currents, prevailing winds, and these variations occur most in the middle latitudes.

The change of temperature with depth depends on four (4) factors:

- i. Variation in the amount of heat absorbed
- ii. Effect of heat conduction
- iii. Lateral displacement of water by current.
- iv. Vertical motion of water.

In most seas, there is thermal stratification. In the mid and low latitude, the temperature profile with depth consists of 3 layers:

1. A warm, well mixed (uniform) layer probably up to 500m, depth where temperature is virtually similar to the surface.
2. A transition layer below the surface called the thermo chine. This is a region where there a rapid decrease in temperature from that in the surface layer above. It can be from about 500m - 1000m depth.
- iv. Deep layer of cold water with relatively homogeneous water temperature. It is usually below 100m and temperature slowly decreases towards the bottom.

The water in the region has its origin in the high latitudes.

Thermocline is usually about in polar regions since in these regions, most of the ocean surface is covered by ice in winter and solar radiation is usually low in summer. In the tropics, the thermocline may be very close to the surface (at times 20-50m depth). So all areas with strong seasonal warming have a temporary seasonal thermocline in the surface area. Off

Nigerian coast there is a minor thermocline during the period of high temperature. This usually disappears during the harmattan and rain when the water is cool.

The relationship between air temperature and sea temperature is responsible for Seafog formation. Seafog are formed when warm damp air passes over a cold sea surface. The air is then cooled below its dew point and fog is formed. Seafog can also occur with strong winds which are not dependent on daily heating and cooling. This occurs when there is a diurnal variation in seawater temperatures. Seafog occur monthly in spring and early summer when air passing off the land may be warmer while the sea is still very cold. Fogs are most common in high latitude, very rare in the tropics and do not often occur in the Mediterranean region.

Dew point is the temperature at which a given parcel of air must be cooled at constant pressure and constant water vapor content in order for saturation to occur. When this temperature is below 0°C it is sometimes called frost point i.e. the highest temperatures at which atmospheric moisture will sublimate in form of a frost of a cooled polished surface.

Fog: this is a visible aggregate of minute droplets suspended in the atmosphere in the earth surface → result of condensation.

Seawater is slightly compressible and this leads to an increase in temperature of water when it is compressed adiabatically (i.e., without exchange of heat). Thus at great depths, the measured temperature may be found to increase with depth. The adiabatic effect of increasing pressure leads to temperature increase of the order of 0.1°C for 1000m.

Potential temperature is defined as the temperature a water sample would have if it were brought adiabatically to the sea surface.

DETERMINATION OF TEMPERATURE

Temperature of sea water at different depths is generally determined “in-situ”. It is usually done with contact thermometer of various types. There are (1) the fluid thermometer – includes Hg type (for surface water) thermometer. It can be done in a scoop bucket or also in water.

To obtain the temperature of selected depths of the ocean, (2) the tipping thermometer is used. It is usually attached to a suitable water bottle (3). Also the bathythermograph is used

to record continuous temperature as a function of depths. It is accurate up to about 270m depth after which it is relatively inaccurate. (4). Metal resistance thermometer; metals are said to have the ability to increase their electrical resistance when they are heated. The most popular metal with this characteristic is platinum. (5). Thermistors: this also operates on the principles that certain semi-conductors can react with heat by showing a strong fall for a resistance. These thermistors are also described as heat conductors and they are very sensitive. Thermistors can be used alongside with recording thermometer for the measurement of surface water temperature both in anchor as well as moving ship. It can continuously measure and record total water temperature or temperature stratification of surface water.

DENSITY

This is referred to as mass per volume. In the seas, it ranges from $1.02 - 1.07\text{g/cm}^3$, it is usually controlled by salinity, $T^{\circ}\text{C}$, pressure or depth. Generally it increase with increase in salinity, increase in pressure or depth, and decreases with increase $T^{\circ}\text{C}$. so colder, deeper, more saline water is usually the densest water.

However, increase in density with decreasing temperature continues only to 4°C below which density decreases with increase in temperature thus, continuous cooling below 4°C causes the density of water to decrease until the freezing point (0°C) is reached. At this point water is turned into ice, there is a sharp decrease in density, and the ice formed floats. This proficient of ice floating is of great advantage of living organisms that are heavier than water. Without this unique temperature/density relationship, the ice formed would sink and water bodies would freeze from bottom making life difficult and almost impossible.

LIGHT

Although very small amounts of water appear to be transparent, the ocean absorbs most of the solar radiation incident at the surface within several tens and metres from the surface. It is this absorption of solar energy that supplies most of the energy input to the ocean and that limits most of the primary production to the upper layers of the sea. The average energy input to the sea by solar radiation is about 10^4 times that input by the wind or tides.

The spectrum (distribution of energy as a function of wavelength or frequency) of solar radiation that reaches the sea surface covers the spectral range from 290 to 3000nm

($1\text{nm} = 10^{-9}\text{m}$) in wavelength, of which the range 350 to 750nm is visible. The energy has a peak near 480nm (blue-green) by nearly half the energy is in the infra-red. Some of the light is reflected at the sea surface (only a few % for angles of incidence less than 45° from normal) and the rest enters the sea to be refracted, and alternated by scattering and absorption; the latter is the ultimate fate of most of the light.

Clear sea water is most transparent to blue green portion of the light spectrum and is least transparent to the red portion. Hence blue light penetrates sea water more deeply than red light. Hence, blue light penetrates sea water more deeply than red light. Even in the clearest tropical waters, almost all the red light is absorbed in the first 10m whereas the blue light penetrates up to 100m. The blue colour common to most clear Open Ocean is due to the greater penetration, and eventual back scattering of blue light.

SOUND IN THE SEA

Sound is mechanical radiation, a propagating pressure disturbance, and the ocean is an excellent medium for propagating acoustic waves. The speed, C , at which sound waves propagate is given as $C^2 = (k\rho)^{-1}$ where k is the adiabatic compressibility of the water, which like ρ is a function of salinity, temperature and pressure. The speed increases with increasing salinity, temperature or pressure (depth). Since the speed of sound varies significantly in the ocean, sound undergoes refraction. The concept of an acoustic ray, analogous to a light ray, is used and Snell's law, which relates the angle of incidence and the angle of refraction to the ratio of wave propagation speeds, can be applied. In the thermocline the effect of temperature dominates and the speed of sound decreases with depth, and sound rays tend to 'bend' (refract) downward. In relatively uniform water below 2000m, the pressure effect dominates and sound speed increases with depth and the rays tend to "bend" back upward. Thus the sound energy tends to be trapped in a 'sound channel' and is propagated extremely well over great distances.

Acoustic radiation, like electromagnetic radiation (e.g. light) is attenuated by absorption and scattering. In absorption, the radiation interacts with the water molecules and the dissolved ions in sea water and is irreversibly altered and the energy transformed into heat, or chemical potential energy. Scattering is any random process by which the direction of radiation is changed without any other alteration. Absorption and scattering decrease the

intensity of sound exponentially with distance. This is very useful for the detection of the limits of the sea water (the bottom) and objects within it e.g fish.