https://doi.org/10.17895/ices.pub.9212

1.

Nomenclature and Units for the Indication of the Content of Constituents of Sea Water.

Report from the Sub-Committee
for the purpose of considering the chemical nomenclature to be used in the publications of the Council.

J. P. Jacobsen, K. Buch, B. Schulz and H. Wattenberg

I. Introduction.

The above-named Sub-Committee was appointed by the Council in 1934. It has collaborated with various scientists all over the world and presented a preliminary report[1]) on its work in 1936.

In accordance with a resolution[2]) of the Council the question of the chemical nomenclature and units to be used in oceanography was proposed for consideration at the General Assembly of l'Association d'Océanographie Physique at Edinburgh in 1936. This Association accordingly recommended a scheme[3]) for the nomenclature and the units to be used in chemical oceanography and has further resolved to undertake the publication of instructions for converting the results from one unit to the other and eventually of tables for such conversions.

The scheme adopted by the Association does not differ to any material extent from that proposed in the preliminary report of the Committee in 1936. Further this preliminary report was amended at the Council Meeting in 1937[4]), in order to bring it more closely into accord with the scheme adopted by the Association. Complete agreement on the manner of indicating the content of constituents of sea water has, however, not been obtained and some objections have been made to the establishment of an absolutely definite scheme. According to a resolution[5]) of the Council the Committee set up for the purpose of considering the chemical nomenclature and the units to be used in the publications of the Council therefore continues in being for the purpose of deciding upon questions that may be raised in this connection.

[1]) Rapp. et Proc.-Verb. du Conseil, Vol. C, 2ième partie, page 90, 1936.
[2]) Rapp. et Proc.-Verb. du Conseil, Vol. C, 1ère partie, page 33, 1936.
[3]) Proc.-Verb. de l'Association No. 2, page 58, 1937.
[4]) Rapp. et Proc.-Verb., Vol. CV, I, page 31, 1937.
[5]) ibid, page 31.

In the elaboration of the following scheme some designations are considered which have been introduced by committees existing in the various countries for the standardization of units to be used in science and technical work. This is for instance the case with the units val and Torr for one equivalent of an element or chemical compound and for the pressure of a column of mercury of the height 1 mm. at 0° at a locality where the acceleration is $980{\cdot}665\ \frac{\text{cm.}}{\text{s}^2.}$ The unit val is adopted as the standard unit in Germany and is proposed in Denmark. The unit Torr is adopted as the standard unit in Finland and Germany.

II. General View on Units.

A general view on units and designations principally comprising those upon which are based the following indications, is stated below. Several of the abbreviations for units which are given in brackets are used later in this report.

Mass Units.

1 ton (t.) or megagram (Mg.) = 10^3 kilograms (kg.) = 10^6 grams (g.).

1 gram (g.) = 10^3 milligrams (mg.) = 10^6 mygrams (μg.) = 10^9 nanograms (ng.).

One gram-atom of an element is defined by means of the atomic weight of the element. If the atomic weight is A, one gram-atom means A grams of the element. 1 gram-atom (g.-atom) = 10^3 milligram-atoms (mg.-atom) = 10^6 mygram-atoms (μg.-atom) = 10^9 nanogram-atoms (ng.-atom).

One equivalent of a substance is that amount of the substance which — according to the chemical processes in question — is equivalent to 1 g.-atom of hydrogen.

One equivalent (val) = 10^3 milliequivalents (millival).

The unit equivalent is used also for indicating an amount of several substances involved in the same way in a chemical process. One equivalent of a sum of the halogen-ions Cl′, Br′ and J′ is for instance that amount of the ions which — according to the processes:—

$$Cl' + Ag^{\cdot} \rightarrow Ag\ Cl$$
$$Br' + Ag^{\cdot} \rightarrow Ag\ Br$$
$$J' + Ag^{\cdot} \rightarrow Ag\ J$$
$$Ag + H^{\cdot} \rightarrow Ag^{\cdot} + H$$

is equivalent to 1 g.-atom of silver.

In such a case the ratios of the amounts of the different substances to one another are irrelevant and an indicated amount of equivalents has no relation to the mass of the substances in question but only to the mass of a single substance. According to the chemical processes given above this substance may be silver or hydrogen.

Ordinarily the halogen-ions in an amount of sea water are indicated as a mass of chlorine, found equivalent to an amount of silver, that again being equivalent to the halogen-ions.

One equivalent of base means an amount of one or more bases that — according to the process of neutralization — is equivalent to an amount of acid containing 1 g.-atom of dissociated or dissociable hydrogen.

One grammolecule of a chemical compound is defined by means of the molecule-number for the compound. If the molecule-number is M, 1 grammolecule means M grams of the compound.

1 grammolecule (mol) = 10^3 milligrammolecules (millimol).

The Temperature Scale.

The Celsius Scale is used with the Kelvin Scale as base. For temperatures between 0° and 100° this scale differs by less than 0·001° from the hydrogen thermometer scale.

Pressure Units.

As basic unit for pressure is used the "physical atmosphere" defined as the pressure of a 76 cm. high column of mercury of temperature 0° at a locality where the acceleration is 980·665 cm./s^2 (about 45° N. Lat.).

1 physical atmosphere (Atm.) = 760 Torr
= 1·0133 bar (b) = 1·0133 × 10^3 millibar (mb)
= 1·0133 × 10^6 dyn/cm.^{2}.

The unit bar quoted above is that principally used in meteorology. In physics and chemistry the pressure 1 dyn/cm.^{2} is commonly designated as 1 bar.

Volume Units.

The basic unit for volume is the true litre, i. e. the volume of 1 kg. distilled water at 4°.

1 kilolitre (kl.) = 10^3 litres (l.) = 10^6 millilitres (ml.).

Conditions to be stated when indicating the volume of an amount of gas.

The temperature and the pressure are to be stated.

The volume of an amount of gas is given preferably for the temperature 0° and for the pressure 1 Atm. These conditions are designated as "normal temperature and pressure" (NTP).

Special interest is attached to the volume at NTP of one grammolecule of a gas. This volume is designated as the molecular volume.

Conditions to be stated when indicating the volume of an amount of sea water.

A sample of sea water, arbitrarily chosen in the sea, may in several respects be characterized with sufficient accuracy by means of three variables, namely, the pressure, the temperature and the content of one or more of the major constituents.

The following considerations on sea water in this report are always applied to sea water that has been taken out of the sea and subjected to the pressure of the air only. The pressure may then be taken with a sufficient accuracy as constant and equal to 1 Atm. Salinity as defined by M. KNUDSEN[6]) has been chosen as representative for the content of one or more of the major constituents. The density and its derivates may then be taken as dependent on the temperature and the salinity only.

The volume of an amount of sea water depends upon its density and that in turn depends upon its temperature and salinity. Therefore an indication of a volume of sea water is to be followed by an indication of the density or by indications of the temperature and the salinity. On account of the fact that the salinity may be taken as a characteristic constant for a sea water sample under consideration the latter procedure is chosen; for a volume of sea water of known salinity, the temperature only is to be stated.

III. Expressions and Units for Common Use.

In the following section a list is presented of the symbols, expressions, units etc. that are to be commonly used in the indication of the content of the various constituents of sea water. The following remarks are made with regard to putting the list into effect.

[6]) See Hydrographical Tables edited by MARTIN KNUDSEN, Copenhagen 1901. That the salinity and not the chlorinity has been chosen as a characteristic of the sea water is in accordance with a resolution of the International Council for the Exploration of the Sea. (See Rapp. et Proc.-Verb., Vol. XCIV, page 33. Copenhague 1935).

All indications of the content of constituents of sea water apply — in the absence of any other statement — to sea water without any suspended matter.

The special indications of the hydrogen-ion concentration and the pressure of carbon dioxide in the air in equilibrium with the free carbon dioxide in the sea water are inserted in the list but are disregarded in the remarks below on the manner of indicating the units for the content of the constituents.

A constituent may be present in sea water as a free dissolved substance or in combination with other substances and (or) with electric charges of ions. According to the fact that the analytical method of determining the amount of a constituent in a given amount of sea water consists in the comparison of masses, the indication of the amount of a constituent applies to the amount of an element or to the mass of a group of elements. This also holds good if the amount of a gaseous constituent is given in millilitres at NTP as the density of the gas at NTP is always known.

The symbols etc. expressing the constituents are chosen in such a way that in them a reference is made to the element or to the group of elements used for indicating the amount of the constituents. If a constituent is contained in more than one form in sea water and the amounts of the constituent in its different forms are to be distinguished from one another, different expressions are used for the different forms of the constituent.

The following and their subdivisions are used as the commonly adopted units for the amounts of constituents:—

1 g. of a constituent
1 g.-atom of a relevant element
1 val of a constituent or of a sum of constituents
1 mol of a constituent
1 ml. of a gaseous constituent at NTP

The following are used as the commonly adopted units for amounts of sea water of known salinity:—

1 kg. of sea water
1 l. of sea water at 20°

The unit for the content of a constituent is designated as a fraction, the numerator indicating a unit for the amount of the constituent and the denominator a unit for the amount of sea water. The substances and the conditions applying should in reality be stated in such a fraction. The unit for the content of phosphate-phosphorus in sea water of known salinity could for instance be written:—

$$\frac{\text{mg.-atom of phosphate-phosphorus}}{\text{l. of sea water at } 20^\circ}$$

and the unit for the content of oxygen for instance:—

$$\frac{\text{ml. of oxygen at NTP}}{\text{l. of sea water at } 20^\circ}$$

The substance to be stated in the numerator is given, however, by the symbol, or expression, for the constituent, and the substance to be stated in the denominator is always sea water. The indications of the substances in the units are therefore not inserted in the following list but are to be understood. The condition that a volume (ml.) of a gas is valid for the gas at NTP is stated in the relevant units. The expression "l. of sea water at 20°" is represented by the symbol L_{20}.

The units mentioned above as examples are therefore stated as follows:—

for the content of phosphate-phosphorus as: $\frac{\text{mg.-atom}}{L_{20}}$

and

for the content of oxygen as: $\frac{\text{ml. at NTP}}{L_{20}}$

In a case when g. is used as the unit for the amount of the constituent and kg. as the unit for the amount of sea water, the unit for the content of the constituent could have been written $\frac{\text{g.}}{\text{kg.}}$. In the following list this symbol is replaced by ‰.

It is to be remembered that the temperature 20° in the expression "l. of sea water at 20°" only serves as a definition of the amount of sea water. If the amount of a constituent varies with the temperature of the sea water — as for instance the free carbon-dioxide — the amount of the constituent is to be given for the relevant temperature of the sea water, which may be other than 20°.

In connection with the constituents mentioned in the following list some of the international atomic weights of 1937 and values for the molecular-volumes of the gases in question are given. The atomic weights and the values of the molecular-volumes for the gases are to be used by conversion computations.

IV. List of Symbols etc. of various Constituents of Sea Water and of the Units for the Indication of their Content.

Alternatives which may be employed if special usage or convenience makes it desirable are marked with an asterisk (*).

Chlorinity —
to be expressed as: Cl
Unit: ‰

The chlorinity means the amount of chlorine, indicated in grams, which — by means of "standard water" of standardized chlorinity — may be found as equivalent to the amount of the halogens, chlorine bromine and iodine contained as free or associated halogen-ions in 1 kg. of sea water.

The chlorinity may be determined — as has usually been done — by a volumetric titration with silver nitrate. If this method is used "KNUDSEN's Hydrographical Tables" may be used for a direct computation of the chlorinity.
Atomic weight: Cl = 35·457.

Salinity —
to be expressed as: S
Unit: ‰
The salinity S is defined by the chlorinity Cl by means of the formula $S = 0{\cdot}030 + 1{\cdot}8050\ Cl$. Thus the salinity comprises the "oceanic salts" only and the formula is to be used only for chlorinities higher than 1 ‰.

Content of Sulphate —
to be expressed as: SO_4
Unit: ‰
The content of sulphate means the amount of SO_4, indicated in grams, contained as free or associated sulphate-ions in 1 kg. of sea water.
Atomic weights: S = 32·06, O = 16·000.

Content of Magnesium —
to be expressed as: Mg
Unit: ‰
The content of magnesium means the amount of magnesium, indicated in grams, contained as free or associated magnesium ions in 1 kg. of sea water.
Atomic weight: Mg = 24·32.

Content of Calcium —
to be expressed as: Ca
Unit: ‰
The content of calcium means the amount of calcium, indicated in grams, contained as free or associated calcium-ions in 1 kg. of sea water.
Atomic weight: Ca = 40·08.

Content of Free Oxygen —
to be expressed as: O_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$
The content of oxygen means the amount of oxygen, indicated in ml. at NTP, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: O = 16·000
Molecular volume of O_2 = 22·393 litre.

*Content of Free Oxygen —
to be expressed as: O_2
Unit: $\frac{\text{mg.-atom}}{L_{20}}$
The content of oxygen means the amount of oxygen, indicated in mg.-atoms, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: O = 16·000
Molecular volume of O_2 = 22·393 litre.

Content of Free Nitrogen —
to be expressed as: N_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$
The content of free nitrogen means the amount of nitrogen, indicated in ml. at NTP, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008
Molecular volume of N_2 = 22·401 litre.

*Content of Free Nitrogen —
to be expressed as: N_2
Unit: $\frac{\text{mg.-atom at NTP}}{L_{20}}$
The content of free nitrogen means the amount of nitrogen, indicated in mg.-atoms, contained as free absorbed gas in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008
Molecular volume of N_2 = 22·401 litre.

Content of Hydrogen Sulphide —
to be expressed as: H_2S
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$
The content of hydrogen sulphide means the amount of gaseous hydrogen sulphide, indicated in ml. at NTP, containing the same amount of sulphur as the free absorbed hydrogen sulphide and the free or associated ions of sulphides and bisulphides in an amount of sea water that at 20° has the volume 1 litre.
Atomic weights: H = 1·008, S = 32·06
Molecular volume of H_2S = 22·14 litre.

*Content of Hydrogen Sulphide —
to be expressed as: Sulphide-S
Unit: $\frac{\text{mg.-atom}}{L_{20}}$
The content of hydrogen sulphide means the amount of sulphur, indicated in mg.-atoms, contained in the free absorbed hydrogen sulphide and in the free or associated ions of sulphides and bisulphides in an amount of sea water that at 20° has the volume 1 litre.
Atomic weights: H = 1·008, S = 32·06
Molecular volume of H_2S = 22·14 litre.

Total Content of Carbon Dioxide —
to be expressed as: Total content of CO_2
Unit: $\frac{\text{ml. at NTP}}{L_{20}}$
The total content of carbon dioxide means the amount of gaseous carbon dioxide, indicated in ml. at NTP, containing the same amount of carbon as the free absorbed carbon dioxide and the free or associated ions of carbonates and bicarbonates in an

amount of sea water that at 20° has the volume 1 litre.

Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

*Total Content of Carbon Dioxide — to be expressed as: Total Carbon-Dioxide-C

Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The total content of carbon dioxide means the amount of carbon, indicated in mg.-atoms, contained in the free absorbed carbon dioxide and in the free or associated ions of carbonates and bicarbonates in an amount of sea water that at 20° has the volume 1 litre.

Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

Content of Free Carbon Dioxide — to be expressed as: Free CO_2

Unit: $\frac{\text{ml. at NTP}}{L_{20}}$

The content of free carbon dioxide means the amount of gaseous carbon dioxide, indicated in ml. at NTP, that is equal to the total content of CO_2 (see above) minus the amount of gaseous carbon dioxide, indicated in ml. at NTP, containing the same amount of carbon as the free or associated ions of carbonates and bicarbonates in an amount of sea water that at 20° has the volume 1 litre.

Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

*Content of Free Carbon Dioxide — to be expressed as: Free Carbon-Dioxide-C

Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of free carbon dioxide means the total carbon-dioxide-C (see above) minus the amount of carbon, indicated in mg.-atoms, contained in the free or associated ions of carbonates and bicarbonates in an amount of sea water that at 20° has the volume 1 litre.

Atomic weights: C = 12·00, O = 16·000
Molecular volume of CO_2 = 22·260 litre.

Pressure of Carbon Dioxide — to be expressed as: P_{CO_2}

Unit: 10^{-4} Atm.

The pressure of carbon dioxide means the partial pressure of carbon dioxide that must be present in air of the pressure 1 Atm. being in contact with the sea water, when the exchange of carbon dioxide between the air and the sea water is in equilibrium at an equal temperature of the sea water and the air.

Hydrogen-ion concentration — to be expressed as: pH_t

Unit: See below.

The hydrogon-ion concentration of sea water at a temperature t is termed pH_t when the determination has been made on a basis of the conventional constants of S. P. L. Sørensen. For the activity of the hydrogen ions the designation paH_t may be used (see K. Buch: Ueber das Kohlensäuresystem im Meerwasser, Rapp. et Proc.-Verb., Vol. LXXIX, p. 20, and K. Buch: Die kolorimetrische Bestimmung der Wasserstoffionenkoncentration im Seewasser, Rapp. et Proc.-Verb., Vol. CIII, p. 27).

In publishing results it is to be stated if corrections are added for salt error and temperature effects and, if so, what corrections are used.

Excess base (titration alkalinity) — to be expressed as: Alk

Unit: $\frac{\text{millival}}{L_{20}}$

Excess base or titration alkalinity means the amount of base, indicated in millival, that is equivalent to the surplus of the ions of bases in relation to the ions of strong acids — hydrohalic acids, sulphuric acid, nitric acid and the first dissociation step of phosphoric acid — contained in an amount of sea water that at 20° has the volume 1 litre.

For determination of the excess base the method of expelling the total amount of carbon dioxide of sea water by means of hydrochloric acid and titration of the surplus of acid by sodiumhydroxide with brom cresol purple as indicator may be used.

Content of Borate — to be expressed as: Borate-B

Unit: $\frac{\text{mg.-atom}}{L_{20}}$

The content of borate means the amount of boron, indicated in mg.-atoms, contained in free or associated borate-ions, in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: B = 10·82.

Content of Phosphate — to be expressed as: Phosphate-P

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of phosphate means the amount of phosphorus, indicated in μg.-atoms, contained in free or associated phosphate-ions in an amount of sea water that at 20° has the volume 1 litre.

The proceeding in estimating the content of phosphate — including the correction, if any, for salt error — is to be stated in connection with the results.

Atomic weight: P = 31·02.

Content of Dissolved Organic Compounds of Phosphorus — to be expressed as: Dissolved-Organic-P

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of dissolved organic compounds of phosphorus means the amount of phosphorus, indicated in μg.-atoms, contained as dissolved organic compounds of phosphorus in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: P = 31·02.

Remark: The amount of phosphorus, indicated in μg.-atoms, contained in the plankton in an amount of sea water that at 20° has the volume 1 litre is to be expressed as Plankton-P. The total amount of phosphorus, indicated in μg.-atoms, contained in an amount of sea water that at 20° has the volume 1 litre and has not been freed from plankton is to be expressed as: "Phosphate-P + Dissolved-organic-P + Plankton-P + Phosphorus contained in inanimate suspended matter of organic and inorganic origin (detritus)".

Content of Nitrate —
to be expressed as: Nitrate-N

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of nitrate means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated nitrate-ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008.

Content of Nitrite —
to be expressed as: Nitrite-N

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of nitrite means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated nitrite-ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008.

Content of Ammonia —
to be expressed as: Ammonia-N

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of ammonia means the amount of nitrogen, indicated in μg.-atoms, contained as free or associated ammonia in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008.

Content of Albuminoid Nitrogen —
to be expressed as: Albuminoid-N

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of albuminoid nitrogen means the amount of nitrogen, indicated in μg.-atoms, contained in the albuminoid compounds in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008.

Content of Organic Nitrogen —
to be expressed as: Organic-N

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of organic nitrogen means the amount of nitrogen, indicated in μg-atoms, contained in organic compounds in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: N = 14·008.

Content of Silicate —
to be expressed as: Silicate-Si

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of silicate means the amount of silicon, indicated in μg.-atoms, contained in free or associated silicate-ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: Si = 28·06.

Content of Arsenate —
to be expressed as: Arsenate-As

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of arsenate means the amount of arsenic, indicated in μg.-atoms, contained as free or associated arsenate ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: As = 74·91.

Content of Arsenite —
to be expressed as: Arsenite-As

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of arsenite means the amount of arsenic, indicated in μg.-atoms, contained as free or associated arsenite ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: As = 74·91.

Content of Iron —
to be expressed as: Fe

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of iron means the amount of iron, indicated in μg.-atoms, contained as free or associated ferro- and ferri-ions in an amount of sea water that at 20° has the volume 1 litre.
Atomic weight: Fe = 55·84.

Content of Manganese —
to be expressed as: Mn

Unit: $\frac{\mu\text{g.-atom}}{L_{20}}$

The content of manganese means the amount of manganese, indicated in μg.-atoms, contained as free or associated mangano- and mangani-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: Mn = 54·93.

Content of Copper —

to be expressed as: Cu

$$\text{Unit: } \frac{\mu\text{g.-atom}}{L_{20}}$$

The content of copper means the amount of copper, indicated in μg.-atoms, contained as free or associated cupri-ions in an amount of sea water that at 20° has the volume 1 litre.

Atomic weight: Cu = 63·57.

Content of radio-active substances. — The symbols etc. expressing the different radio-active substances are to be chosen in accordance with the common usage in physics. As unit is to be used $^0/_{00}$, i.e. grams of the radio-active substance per kilogram of sea water.