Supplementary Material

As regards relationships to obtain the density of seawater, and therefore its *S*A, that of the silicate concentration is better documented than those of most other relevant constituents. However, it should be noted that there are still many other contributing elements to the density that are poorly documented and/or poorly understood.Le Menn *et al*. (2019) has identified some of these elements which are described below.

*Dissolved organic materials*

This is usually assessed as the concentration of coloured dissolved organic matter (CDOM). CDOM is the result of the degradation of organic matter in coastal waters, the photosynthetic activity of macro-alga, and the interactions between microbes, bacteria and phytoplankton. It is composed essentially of humic and fulvic acids. CDOM is found in all the oceans in varying concentrations. For example, the Black Sea is characterized by a very high CDOM content: 2 to 6.6 mg l−1. The North Atlantic subpolar gyre, observed in wintertime, also shows high CDOM concentrations: 1.4 to 2.5 mg l−1.

*Bacteria*

Bacteria are found everywhere in the world’s oceans. Of these, Nitrococcus and other similar species replenish nitrate (NO3-) in the ocean through the oxidation of nitrite (NO2-), simultaneously fixing carbon dioxide (CO2) for growth. Nitrogen is needed to make proteins and nucleic acids, and its most abundant and stable form is nitrate. Bacteria can vary in size between 1 and 10 *μ*m, and their numbers are usually a function of the oxygen concentration. There are between five to ten million different kinds of bacteria in the oceans. Sogin *et al*. (2006) found 6.4 x 104 cells/ml of seawater in the Labrador Sea at a depth of 1400 m and a temperature of 3.5 °C. The weight of a well-known bacterium Escherichia coli is 10-12 g. If filtered before a measurement with a densimeter, this would lead to an error of 6.4 x 10-4 g l−1 for Labrador Sea seawater. But, according to Sogin *et al*.**,** the number of bacteria should be superior to 105 for surface waters. The error would then be 1 x 10-3 g l−1.

*Chlorofluorocarbons (CFCs) or polycyclic aromatic hydrocarbons (PAHs)*

These result from anthropic activities, and can be found in seawater in trace concentrations. They come from petrol combustion, mineral oils or fuels, and are composed of naphthalene, acenaphthene, phenanthrene, chrysene, pyrene or anthracene molecules. Depending on the proximity to the contaminating sources, the concentrations of PAHs can vary from 0 to a few micrograms per liter or milligrams per liter. CFCs, which were once profusely used in refrigerants and aerosols, are absorbed and transported by the oceans. Due to their persistence in seawater, they can be used to date water masses and study the oceanic circulation. Similarly, in the deep ocean, hydrogen sulphide can also be found, especially in the vicinity of natural hydro-thermal springs.

*Suspended particulate matter (SPM)*

This is constituted by organic (plankton and other micro-organisms) and mineral particles placed in suspension by waves and storms, and thereafter carried by the currents: alluvium, clay, inorganic matter, and aerosols of different kinds. It is generally admitted that SPM concentrations can be between 0.5 mg l−1 and 4 mg l−1 in the oceans, 4 mg l−1 to 100 mg l−1 in some coastal waters and 100 mg l−1 to several g l−1 in estuaries. Le Menn and Pacaud (2017) outlined that density measurements are sensible to SPM and the threshold to keep the uncertainty under 4 g m−3 is close to the the typical SPM concentrations found in the open oceans.They have also shown thatSPM decreases the measured conductivity and increases the measured density, thereby increasing the systematic error between *S*Pand *S*A, even at low concentrations.

*Microplastics*

These come from a variety of sources: degradation of plastic debris, beauty products containing plastic microbeads, tyre wear (60% in Danish waters), synthetic textiles from washing machine residues, etc. In the Mediterranean Sea, “*waves and sea surface currents ought to transport microplastics away from the Tyrrhenian Sea. Therefore, the bottom plastic flux in this basin should be one of the lowest: 1.5 to 7 g km−2 day−1, compared to a regional maximum of 70 g km−2 day−1 elsewhere*”, according to Kane *et al.* (2020). According to Lebreton *et al*. (2018), subtropical waters between California and Hawaii can contain as much as 2.33 kg km−2 of microplastics.

*Microbes*

Microbes drive most ecosystems and are modulated by viruses that impact their lifespan, gene flow, and metabolic outputs, according to Gregory *et al*. (2019) who established a 12-fold expanded global ocean DNA virome dataset of 195,728 viral populations. It has been estimated that each litre of seawater can contain about 100 billion virus particles. Virus populations appear to be distributed in five meta-communities, or ecological zones: the Arctic, the Antarctic, beyond 2000 metres depth, in the depth range of 150 to 1000 metres and in the upper 150 m in temperate/tropical waters. Viral diversity does not depend on the latitude. The size of a virus is between 10 and 400 nm, and its weight can vary from 1 x 10-17 g to 5 x 10-15 g. Therefore, their presence or absence can cause density changes between 1 *μ*g l-1 and 5 x 10-4 g l−1.

**References:**

Gregory, A.C., Zayed, A. A., Conceicao-Neto, N., Temperton, B., Bolduc, B., Alberti, A., Ardyna, M., Arkhipova, K., Carmichael, M., Cruaud, C., Dimier, C., Domınguez-Huerta, G., Ferland, J., Kandels, S., Liu, Y., Marec, C., Pesant, S., Picheral, M., Pisarev, S., Poulain, J., Tremblay, J-E., Vik, D., Tara Oceans Coordinators, Babin, M., Bowler, C., Culley, A. I. , de Vargas, C., Dutilh, B. E., Iudicone, D., Karp-Boss, L., Roux, S., Sunagawa, S., Wincker, P., and Sullivan, M. B., (2019). Marine DNA Viral Macro- and Microdiversity from Pole to Pole. Cell 177, 1–15 May 16 2019, Elsevier Inc.. https://doi.org/10.1016/j.cell.2019.03.040

Kane, I. A., Clare, M. A., Miramontes, E., Wogelius, R., Rothwell, J. J., Garreau, P., Pohl, F., (2020). Seafloor microplastic hotspots controlled by deep-sea circulation. Science 10.1126/science.aba5899. [DOI: 10.1126/science.aba5899](https://doi.org/10.1126/science.aba5899)

LeBreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A., Noble, K., Debeljak, P., Maral, H., Schoeneich-Argent, R., Brambini, R., & Reisser, J., (2018). Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Nature Scientific Reports, 8:4666. <https://doi.org/10.1038/s41598-018-22939-w>

Le Menn, M., Pacaud, L., (2017). Effect of sediments on seawater conductivity and density assessments. Journal of Water Resources and Ocean Sciences, 6, 2, 23-24. <https://doi:10.11648/j.wros.20170602.11>

Le Menn, M., Albo, P. A. G., Lago, S., Romeo, R. and Sparasci, F., (2019). The absolute salinity of seawater and its measurands. Metrologia, 56, 1. <https://doi.org/10.1088/1681-7575/aaea92>

Sogin, M. L., Morrison, H. G., Huber, J. A., Welch, D. M., Huse, S. M., Neal, P. R., Arrieta, J. M. and Herndl, G. J., (2006). Microbial diversity in the deep sea and the underexplored “rare biosphere”. PNAS, 103, 32. <https://doi.org/10.1073/pnas.0605127103>.