DYNAMICS OF OXYGEN EXCHANGES THROUGH THE SEA SURFACE

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SUMMARY

The oxygen echange between the sea and atmosphere was examined under calm surface conditions with temperature varying from 14-24°C. It was also examined under mixing conditions with temperature varying from 17-28°C. Chlorinity was ranged from 20 to 21,03 ‰. Seawater was deoxygenated by nitrogen introduction and oxygenated by oxygen introduction. Oxygen was measured by Winkler's method. We have got better insigh into the oxygen exchange rate velocity.

RESUME

On a expérimentésur l'échange de l'oxygèn dans les eaux de la mer, dans des conditions de l'eau calme, pour l'intervalle de la temperature de 14-24°C, ainsi que dans des conditions de l'eau turbulente, pur l'intervaile de la température de 17-28°C, l'intervalle de la chlorinité ayant été de 20-21,03‰. L'eau de la mére est déoxidé par l'introduction de l'azote et puis oxidés par l'introduction de l'oxygene. Le méasurement de l'oxygene est fait par la méthode de Winkler. Ainsi-a-t-on obtenu quelques caractérsitiques de vitesse de l'echange de l'oxygene.

Rapp. Comm. int. Mer Médit., **24**, 3 (1977).

INTRODUCTION

The oxygen fluctuations mechanisms has not been fully explor yet, because it is affected by series of factors: echange of oxygen betwen the sea and atmosphere, in situ processes (photosynthetic oxygen production and its consumption by marine plants and animals respirations, including bacteria, too), composition of the atmosphere, partial pressure of gas in solution, gas solubility in seawater, advection and diffusion processes. It is particularly difficult to determine the exchange velocity because a number of biologi al processes affect this gas so that its concentration rapidly varies.

Surface oxygen concentrations above 100% are frequently accounted for by the in situ photo synthetic oxygen production. Here we have tried to bring out some more information on this processes. We have been particularly interested in examining the condition under which oxygen enters the sea and those under which it leaves it. To examine this we have experimented with the seawater undersaturated with oxygen and with the oversaturated one.

METHODS

There were chosen the basins with seawater of constant salinity, temperature and partial pressure and with turbulence varying. The experimental conditions were subjected to changes within the limits of oceanographic regimes. It is to be pointed out that experiment was carried out under the assumption that the oxygen fluctuations originating in biological production had no effect on the velocity of oxygen exchange thorugh the surface film.

RESULTS AND DISCUSSION

The extreme experimental conditions were applied. The outgoing transport was effectuated under the conditions of oxygen oversaturated seawater (481-491%) with values considerably above the upper limits of saturations in the sea. The low oxygen content of 21-42% illustrated the conditions in the sea layers with so called "old water".

The oxygen exhange rate velocity through the sea surface has its theoretical definition according to equations by Redfield (1948):

$$dQ/dt = E.S. (P-p)$$

where dQ/dt (10^3 ml/m^2 · hour) is the exhange velocity, S (m^2) air-sea interface (P-p) atm the difference between the partial pressure in the sea and that in the atmosphere.

The oxygen exchange process is determined by the diffusion velocity. It is limited to the thin surface layer of the liquid phase and bottom layer of the gaseous phase (amosphere). The direction of oxygen depends on the difference in partial pressure of gas in solution and in the gaseous phase. Transport velocity is proportional to the magnitude of this difference and of the interface ot two phases. (Hutchinson, G., 1957).

For the practical purposes we can assume that the composition of atmosphere is constant except for the considerable variations in the water vapour pressure. Accordingly, oxygen partial pressure at the sea surface may be considered the specific function of atmospheric oxygen when corrected for the water vapour content. Meanwhile, we can with certainty that the air at the sea surface is saturated with water vapur what results in that partial air pressure (O_2) becomes the function of only atmospheric pressure and temperature and water salinity (Hutchinson G., 1957). The difference between air and sea oxygen pressure is determined by the formula:

$$P-p = P (c_o - c_x)/c_o$$

where P is atmospheric pressure, $p = P \cdot c_x/c_o$ (Henry's law). c_o oxygen content of seawater in equilibrium with 1 atmosphere of wet air, c_x oxygen content in the seawater sample analyses. To calculate c_o there were extrapolated the values from the oxygen concentration tables (S.A. Truesdale et al.) for the experimental conditions. Also the nomogram was constructed by the help of values for certain temperature and chlorinity of sea water the oxygen content c_x was known.

Positive values of P-p expression indicate the transport of oxygen from the sea to the atmosphere.

Besides observations made of individual analytical data related to experimental conditions various temperatures, water movement or tranquility, oxygen saturation rate, we also compared the results obtained.

CONCLUSIONS

1. a) Velocity of molecular out going transport (under calm conditions) is 5.4 times as great as molecular ingoing transport within the limits of oxygen concentration between 466% (initial concentration of O_2 molecular outgoint transport) to 44% (initial concentration of O_2 molecular ingoing transport).

b) Velocity of turbulent out goint transport (under mixing) exceedes the turbulent inorganic transport for 1.9 times, within the concentrations limits 23-451%.

2. By the temperature decrease velocity of oxygen exhange through sea surface increases. When the temperature is 7^{o} lower, molecular exchange velocity rises to 255%. Temperature decrease of 3.95^{o}C causes molecular outgoing transport to increase to 216.5%.

22. Mladinić G. - Dynamics of Oxygen exchanges through the sea surface.

Discussion

Elder D.L. (IAEA, Monaco) : It seems to me that your conclusion that exchange of oxygen through the sea surface increases with decrease in temperature is the opposite of what predicted inherently. How do you rationalize this observation ?

Mladinić G. : At temperature lower than 3.95°C the concentrations was higher than 50%. This of course in the experimental conditions used.