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# ON AN APPROXIMATE EVALUATION OF THE MASS FLOW RATE OF SUBMARINE SPRINGS

*SUMMARY*

*The paper deals with the proposal for an approximate evaluation of the mass flow rate of a submarine spring. Under the assumption of a complete mixing between marine and spring waters, the spring flow rate can be evaluated on the base of concentration measurements.*
*The proposed relationship needs to be experimentally verified.*

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As it is well known, the outflow from a submarine spring opening is essentially due to the density difference between the outflowing water and the surrounding salt water.

The discontinuity of flow speed through the interface separating the outflowing jet and the surrounding marine water accelerates the salt water and mixes the two kinds of water because of viscous interactions. Therefore, the apparent flow rate of the jet increases as a result of such a drag action.

If a complete mixing between marine and spring water can be assumed, the steady mass conservation equation can be written as follows (Fig. 1):

$$Q_o \cdot \rho_o + \Delta Q \cdot \rho_s = (Q_o + \Delta Q)\, \rho_h \qquad (1)$$

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being

$Q_o$ = flow rate outflowing from the opening
$\Delta Q$ = salt water induced flow rate
$\rho_o$ = spring water density
$\rho_s$ = salt water density
$\rho_h$ = density of the jet at $z = h$.

Moreover, being density correlated with salinity (‰) [1, 2], (equation 1) becomes

$$Q_o S_o + \Delta Q \cdot S_s = (Q_o + \Delta Q) S_h \tag{2}$$

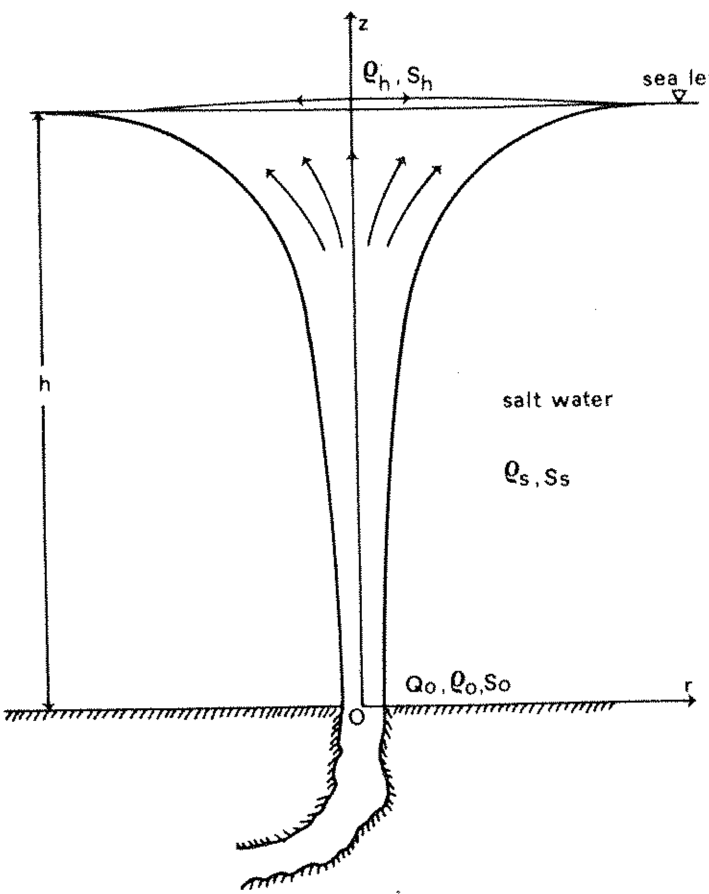


Fig. 1 - Idealized sketch of the outflow from a submarine spring.

From 2) we can obtain

$$\frac{\Delta Q}{Q_o} = \frac{S_h - S_o}{S_s - S_h} = \beta$$

$$\text{i.e. } \Delta Q = \beta \cdot Q_o$$

If an additional flow rate q of a tracer solution with concentration $K_l$ is introduced inside the mouth of opening (and in such a manner that the tracer solution is uniformly distributed over its crossectional area at the sea bottom), the resulting concentration $K_h$ at the level $z = h$ of the ascending spring water column can be expressed in terms of $K_l$ as follows:

$$q\,K_l = (Q_o + \beta \cdot Q_o + q)\,K_h$$

Because $q \ll (Q_o + \beta \cdot Q_o)$, it follows

$$Q_o = \frac{q\,K_l}{(1 + \beta)\,k_h} \tag{3}$$

Such a relationship allows to evalute the spring flow rate by means of concentration measurements.

Of course the equation 3) needs experimental validation which is beyond the aim of the present proposal.

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