DIAGNOSIS OF SCALE AND GRADIENT OF MARINE ENVIRONMENT POLLUTION

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The diagnosis of scale and gradient of water environment pollution plays an important role in the assessment of surface water and marine water areas, as it helps determine the contribution of local processes to the pollution of water environment and identify main ways of pollutants inflow and transfer.

This research describes the methods for diagnosis of scale and gradient of the water environment pollution developed in the Caspian Marine Scientific Research Center. These methods are applied for the assessment of state of water bodies of the Lower Volga and the Caspian Sea, including the areas of search, prospecting and development of oil and gas deposits.

To assess the contribution of local processes into the pollution of any water area the posts for water sampling for chemical analysis should be evenly distributed (the number of water sampling posts should be at least 15).

Local processes are revealed in statistical data distribution. The distribution becomes uneven in points where these processes occur. In case of asymmetric distribution the mean value and the median do not coincide and this difference increases as the asymmetry grows. So to estimate the contribution of local processes into the water environment pollution (hereinafter named $\mathbf{E_S}$ and measured in %) we have offered the following formula:

$$E_S = (C_{cp} - Me)\times 100\ ,$$

where $\mathbf{C_{cp}}$ is the average concentration and **Me** is the median.

It should be noted that E_S can take both positive and negative values. It means that local processes can be displayed by both enrichment and depletion of the water environment with pollutants. In our opinion, the median can be considered as geochemical background concentration of a pollutant ($\mathbf{C_f}$), as the median is a robust characteristic of statistical distribution and it best characterizes the pollution of a water body (or its part) from external sources.

The following is important for the interpretation of obtained results: local processes can be of anthropogenic origin (discharges of pollutants into water or, vice versa, dilution of polluted water with clean water) and of natural origin (self-purification, or the release of temporarily inactive pollutants into the water). The presence of sources discharging polluted or treated water within the water body (or its part) points to anthropogenic nature of local processes. Otherwise natural origin of local processes is concerned.

The diagnosis of water pollution gradient is designed to determine main ways of pollutants inflow and transfer within a water body or a separate sector of a water area. The gradient can characterize pollutant distribution in physical or parametric space.

Working with physical space, the researcher randomly determines the direction (azimuth), along which the gradient is measured, and the reference point (maps indicating sampling posts should be used). Next the researcher places a virtual rectangle, which long axis is perpendicular to the selected direction. The rectangle should cover 5-7 observation posts which are closest to the reference point (the number of covered posts can vary but should be at least 3). Then the rectangle which we will further call "roller" starts moving along the selected direction. Every step it covers 1-3 posts in front and leaves 1-3 posts behind. The process continues until the "roller" arrives to its destination point.

At the following stage we calculate the average concentration of a pollutant for every stage at observation posts covered by the "roller", which will further be called $\mathbf{X_i}$. We offer two ways to implement quantitative assessment of pollutant gradient in physical space. The first way implies making the graph of $\mathbf{X_i}$ series and the linear trend for this graph. The numeric index of gradient is assumed as "a" coefficient in the trend formula (y = ax+b). In the second technique this index is assumed as coefficient "k", calculated with help of the formula:

$$k = X_n / X_1 ,$$

where $\mathbf{X_1}$ is the average concentration in the reference point and $\mathbf{X_n}$ is the average concentration in the destination point of a selected direction.

At the final stage similar calculations are made for the second time for the directions obtained by the turn of azimuth by 45 or 90 degrees and further on until it returns to the initial direction. The calculations result in the series of coefficients "a" a/or "k".

The obtained results can be easily interpreted, as the maximal value "a" or minimal value "k" denote the route of pollutant transfer along the area of the water body (or its part). The beginning of this route points to the quarter where the advection of pollutant occurs.

The pollutant gradient in parametric space is more easily calculated. To do this, the series of pollutant concentration values ($\mathbf{C_i}$) is ranged by a selected parameter (**Q**) in ascending manner. Next, mean values of X_i are calculated for C_i ranged by Q series, using the window which width is determined by the researcher (it commonly comprises 5-7 values of C_i series).

To implement quantitative assessment of the pollutant gradient in parametric space we use the same two ways as for the gradient in physical space, i.e. for the series of of sliding mean values X_i coefficients «**a'**» and/or «**k'**» are calculated.

The interpretation of obtained results depends on Q parameter. For example, to carry out research in the mixing zone of riverine and marine water we use salinity as Q. In this case the gradient of pollutant concentration in salinity space makes it possible to determine riverine or marine origin of pollution. The former corresponds to $k < 1$, and the latter - to $k > 1$.

In conclusion we should note that correlation analysis can be used for the assessment of the pollutant gradient in parametric space. Positive correlation between the concentration of a pollutant and any other parameter corresponds to $k > 1$, and negative correlation corresponds to $k < 1$. But our technique can be used if correlation analysis is complicated for any reason (small amount of data, non-linearity and etc.).