WATERPROTECTIVE ZONES (WZ) AS A COMPLEX OPTION FOR MINIMIZING OF NON-POINT WATER POLLUTION FROM LAND-BASED SOURCES

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Land-based sources water contamination and, as a result, the toxic, bacteriological and radioisotope parameters of water bodies (WB) (rivers and other water courses, natural and manmade lakes, ponds etc.) with enclosed coastal seas in the most of East Europe river basins, including Ukraine, testify the crisis environmental situation and incapability of vital waterenvironmental systems for natural selfregulation. For such conditions, except traditional environment protection (EP) measures, such as available technical and technological solutions, special place belongs to complex EP step - creation of waterprotective zones (WZ) along WB (modificated term analogous to "shelter belts" and so on), as a relatively simple and effective option for WB environmental state improvement, especially taking into account the prevention from large square (non-point) impacts on water pollution (by agricultural areas surface and subsurface runoff, waterreception from contaminated, primary radioactive, drainage basins into river network etc.). The definition of such consequences, their correct assessment and adequate actions for the curbing of regional and local environment danger impacts (from point and, especially, square sources of water contamination) are enough difficult because of objective and subjective reasons, among which is the lack of recent methodology, including computerized support, for the waterprotective zone establishment.

That's why, corresponding with the worldwide experience on creation of special environmental status areas, in the Ukrainian Environmental Center (EC) 'SIC WEMOW' are formulated the attributes of WZ and watersides, bases and practical computerized procedures (with algorithmic schemes, models and so on) for their organization and regime management according, among others, to the preliminary accomplishments (Samoylenko,1989,1993). In this way, **waterprotective zone (WZ) of water body (object) (WB)** is defined as the contact zone between water mass and shore (bank), where is established the special regime of resource use and economic activity connected with EP (first of all water & shoreprotective) measures which ensure the necessary level of natural-technical & sanitary (i.e. environmental) conditions both in WZ and WB on the whole, firstly by minimizing of water pollution from land-based sources. **Waterside (WS)** is WZ WB part with the most intensive development of environmental-unfavourable processes during water/shore interaction, where is established the severe regime (restriction right up to total prohibition) of economic activity and resource use.

The criteria of WZ/WS creation and distinguishment in different physical-geographical conditions of river basins can be determined with the help of elaborated models and schemes (Samoylenko,1993) by the characteristics of undesirable (environmental-dangerous) geological-engineering, hydrogeological, hydromorpholithodynamics and the rest processes as pollution agents. Optimum WZ establishment components (with corresponding software products), proposed by EC 'SIC WEMOW' and based on theses of the stochastic environmental hydrology (Samoylenko,1993), include: (a) WZ complex environmental regionalization (or substructuralization) (Samoylenko,1993); (b) WZ planning (as the functional zones distinguishment) with typical WZ schemes elaboration (Samoylenko & Tavrov, 1996) for reconstruction of land & aquatory towards creation of controllable environmental-technical shore

systems in WZ (Samoylenko,1993); (c) monitoring of environmental state and natural processes in WZ during their exploitation (Samoylenko,1996) for the pollution minimizing.

WZ regionalization

The waterprotective zones regionalization is supported by determination of WZ as complicated dynamic environmental-technical system *WZ* (or simply '*WZ* ecosystem', '*WZ*' or 'ecosystem' with its lower case subecosystems) which is defined by characteristics (non-normalized values) or parameters (normalized values, called 'environmental parameters' of *WZ* or 'e-parameters') consisted from the random function presentation for the waterenvironmental state (status) sign-sets (hydrological, hydrochemical, hydromorpholithodynamics, ecotoxicological, hydrobiological, radioecological, hydrogeological data series and some other sets) with lowering during modelling from characteristic and parameter sets (the highest level) up to components and elements (more lower data levels) using revealed peculiarities of ecosystem temporal-spatial structure and corresponding computerized field databases, as well replenished from monitoring networks. The *WZ* dynamics (*WZ* parameter indignation, i.e. fluctuations etc., caused human impacts) is simulated as an independent combination of *WZ* characteristics or e-parameters random functions (processes or fields). Noted modelling options provide the complex probability four-dimensional environmental regionalization (or region distribution) as distinguishment of homogenous parts of WZ for the ecological-economic fixing of paying WZ/WB natural resources utilization under WZ planning.

Strictly under region (and zone, including length/depth/height parameters along the whole waterline) distribution, we understand the spatial-temporal distinguishment (both in WZ and *WZ* ecosystem) of different level environmental-technical compartments (ETC of WZ, viz. subecosystems, subcomplexes etc. as lower range regions in principal WZ zone compartments, such as shallow water subzone, waterside as subzone, shore or bank subzone, biological hypersubecosystem) in which interaction processes between atmosphere, hydrosphere, lithosphere, biosphere and human impact on ecosystems have the adequate nature.

The WZ regionalization research procedure foresees the following quantity/quality criteria and model parameters integration and application: (a) landscape peculiarities of WZ and adjoined drainage basin; WB bed morphology & morphometry; hydrological and hydromorpholithodynamics regularities; (b) geological-geomorphologic and hydrogeological coastal zone peculiarities; hydro- and geochemical, toxic and radioisotope water & shore conditions and the intensity of contamination compounds (organic, mineral, radioisotope etc.) entering to water bodies, including surface and subsurface runoff; (c) WZ subecosystems self-regulation & self-purifying (from pollution) abilities; sediment genesis types; (d) WB exploitation regime, area and causes of pollution entering to WB from waterside, the existing structure of EP complexes in WZ and some other regularities.

WZ planning and monitoring

The WZ planning intends the multipurpose functional region/zone distinguishment with typical WZ schemes elaboration, based on environmental WZ regionalization results, for the optimum WZ structure selection, according to the required level of WZ environmental conditions, for the reconstruction of WZ land & aquatory. The planning foresees: (a) ecological-economic criteria WZ natural resources tarification, as resources quantity and quality definition for paying resource utilization (PRU), and regulations set up (environment use structure, limits etc.); (b) substantiation of technologies for WZ resources reservation under EP priority towards PRU

establishment with payment for the: resources reproduction, resources withdrawal and for PRU regulations infringements (including all *WZ* ecosystem resources kinds); (c) selection of typical WZ reconstruction schemes which permit the environmental secure disposition, functioning and interaction inside WZ for industrial, rural, urban, transport, recreation, reserved and other zones and their subelements. WZ reconstruction must be directed to the creation (with constructive and technological solutions, such as erosionprotective, antiflood, shoreprotective, water meliorative, pollutionpreventive and other measures) of controllable environmental-technical shore (bank) systems (CSS). CSS are regarded as transformed WZ ETC inside which the interaction between water body and its coastal zone is mostly controlled and negative consequences of such interaction are sufficiently limited or excluded; (d) design and implementation of WZ natural processes monitoring as information & simulation system (with adequate physical network) for observation, estimation and prediction of environmental conditions in WZ/WB in order to EP decisions support and for WB contamination sources identification.

Monitoring estimation & prediction simulation modelling serves for the definition of *WZ* ecosystem long- and short-term changes and sustainability. The sustainability is identified as a combination of the directly stability (WZ compartments temporal phase development stability plus observed ecological parameters stability) and the reliability (the *WZ* ecosystem ability to fulfil the positive social-economic, firstly EP, functions) with regarding to the synergetic environmental pollution agents effect and environmental risk assessment (cost/benefit) criteria. The sustainability level of *WZ* ecosystem (SL_{wz}) can be defined as the superposition function of the following elements:

$$SL_{wz} = \mathrm{f}(D_{wz} ; R_{st} ; R_{wz} ; SR_{wz} ; E_{wz})$$

where D_{wz} is the *WZ* ecosystem dimension; R_{st} is the stability index of constructive and technological EP solutions under WZ reconstruction; R_{wz} is the index of economic activity restriction; SR_{wz} is WZ regulation (self-regulation) processes index; E_{wz} is the index of WZ creation effectiveness, which determined both by the achieved waterprotective extent (pollution limitation etc.) and the level of rational WZ land & aquatory use (as a portion of maximum possible level of WZ exploitation under conditions of EP functions non-disturbance).

Computerized results

The elaborated general algorithmic scheme for computer modelling of river basin water body waterprotective zones establishment includes: (1) definition of WZ compartments, *WZ* ecosystem types and *WZ* parameters; (2) assessment of WZ formation, its compartments ability for self-regulation & self-purifying, actual and potential ecosystem social-economic functions (SEF);(3) determination of needful WZ compartments SEF (including the ability for their fulfillment) and SEF connection with the general WZ regime; (4) assessment of the restriction level for undesirable processes in WZ (WS) according to the WZ functional planning; (5) definition of the main processes and agents which don't permit for WZ and its compartments to fulfil the needful SEF; (6) foundation of procedures for monitoring and support of the WZ sustainable functioning; (7) determination of measures for WZ reconstruction, including steps for WZ compartment transformation into controllable shore (bank) systems; (8) integral assessment of WZ (*WZ* ecosystem) environmental state (conditions) and the tendencies of this state changes under the waterenvironment protection measures implementation.

The gained methodology, procedures and software products can be implemented for any plain river basin with enclosed coastal sea in order to improve their waterenvironmental conditions and to prevent the freshwater and marine contamination from land-based (firstly agricultural) sources.