REGULARITIES OF DISPERSE-PHASE DISTRIBUTION OF ORGANIC ECOTOXICANTS IN THE WATER OF THE WORLD'S RIVER SYSTEMS

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It was analyzed the results of determining the disperse-phase distribution of organic ecotoxicants: organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in the water of various river systems. The parameters of water quality in these river systems differ significantly. Despite this, the following regularity has been established for all researched river systems: the higher the hydrophobicity coefficient of the organic ecotoxicant log $K_{o/w}$, the smaller its water-soluble part.

Relevant dependences have been established according to own and literature data and their statistical processing has been carried out. Figures 1, 2, 3 show examples of such dependencies for OCPs, PCBs, and PAHs, respectively. Statistical data processing was performed using Pearson's correlation analysis by the Statistical Package for Social Sciences version 19. The values of the correlation coefficient (r) and the probability criterion (p) were calculated. It is known that the correlation is considered significant if $p < 0.05$. For aqueous systems presented in fig. 1, no clear reliable correlation between the water-soluble part of OCPs and log $K_{o/w}$ has been established. The correlation coefficients in these cases are low. This is due to the fact that the group of OCPs includes compounds of different chemical nature, as well as the characteristics of these aquatic systems.

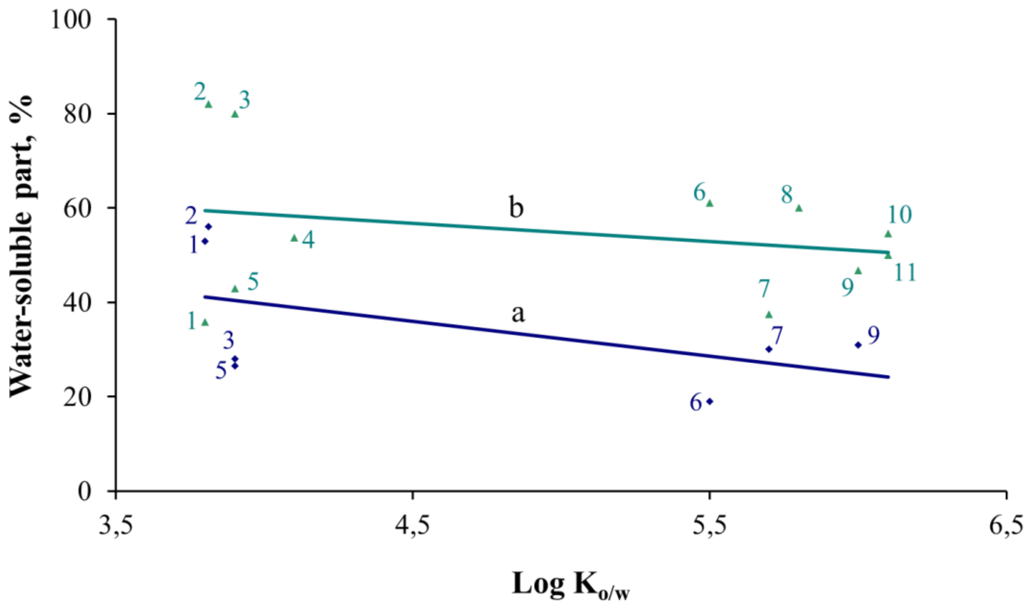

Fig. 1. Dependence of the average value of water-soluble part of individual OCPs on their hydrophobicity coefficient log $K_{o/w}$ in the waters of the Dnieper (a) [1], r = -0.532, p = 0.2191, and the estuary of the Daliao (b) [2], r = -0.262, p = 0.4371. The names of OCPs are indicated by numerals: 1 − γ-HCH; 2 − α-HCH; 3 − β-HCH; 4 − σ-HCH; 5 – heptachlor; 6 − 4,4'-DDD; 7 − 4,4'-DDE; 8 − 2,4'-DDE; 9 − 4,4'-DDT; 10 − 2,4′-DDT; 11 − 2,4'-DDD.

The correlations presented in fig. 2 and 3 are clear and reliable except for the Pearl River. The correlations for the rivers Dnieper and Elba practically coincided. This is due to the fact that these river systems are flat with the normal and calm flow and are close to each other for the water quality parameters. Thus, they are characterized by approximately the same values of chemical oxygen demand (COD) and biological oxygen demand (BOD). Values of COD (permanganate) and BOD for the rivers Dnieper and Elba were 10.95, 15.0 and 4.35, 4.8 mgO_2/dm^3, respectively. This indicates a fairly high content of organic compounds in the water of these rivers.

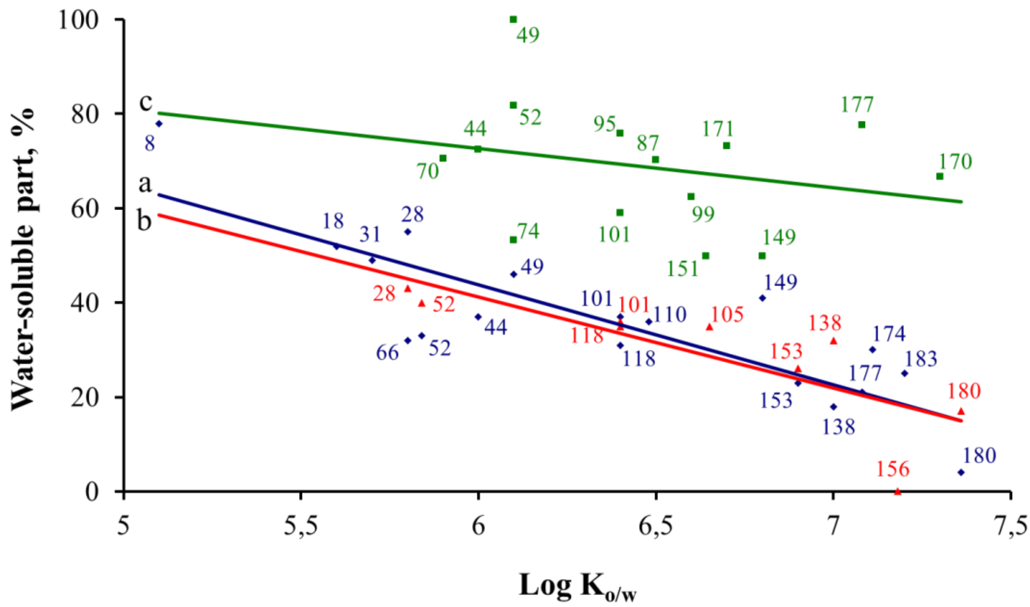

Fig. 2. Dependence of the average value of the water-soluble part of individual PCBs on their hydrophobicity coefficient log $K_{o/w}$ in the waters of the Dnieper (a) [1], r = -0.846, p = 0.00001, Elbe (b) [3], r = -0.799, p = 0.0099, and the estuary of the Pearl River (c) [4], r = -0.255, p = 0.3798. The numerals indicate the numbers of PCB congeners.

The obtained results indicate that the hydrophobicity coefficient of a compound is an important parameter by which its disperse-phase distribution can be estimated. For most cases, significant reliable correlations were found, characterized by high coefficients r, which were in the range from -0.6674 to -0.9847, and the probability criterion was done: $p < 0.05$. For the Dnieper and Elbe rivers, the results were almost identical, due to the similar physicochemical characteristics of these water systems. In addition to the hydrophobicity coefficient, the disperse-phase distribution of organic ecotoxicants is influenced by a number of parameters of the aqueous system itself. It is impossible to predict the impact of each factor at this stage of the study. Therefore, these dependences are not the usual predicted trends, but are established experimentally scientific facts for each analyzed water system according to the statistical processing of the experimental results.

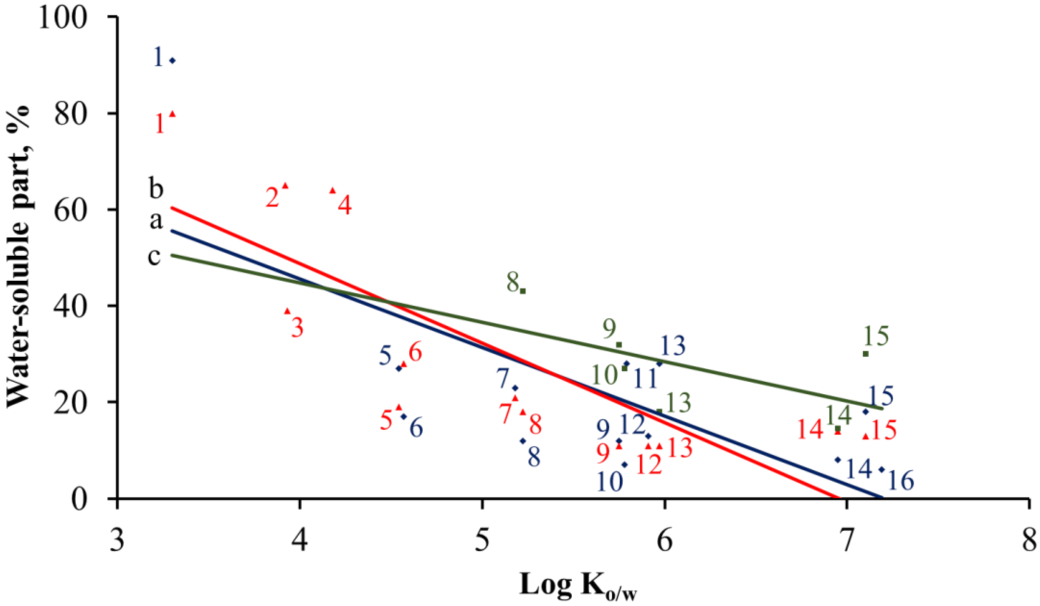

Fig. 3. Dependence of the average value of the water-soluble part of individual PAHs on their hydrophobicity coefficient log log $K_{o/w}$ in the waters of the Dnieper (a) [1], r = -0.714, p = 0.0061, Elbe (b) [3], r = -0.810, p = 0.0008, and Tiber (c) [5], r = -0.593, p = 0.2149. The names of PAHs are indicated by numerals: 1 – naphthalene, 2 – acenaphthene, 3 – acenaphthylene, 4 – fluorene, 5 – anthracene, 6 – phenanthrene, 7 – pyrene, 8 – fluoranthene, 9 – benzo(b)fluoranthene, 10 – benzo(k)fluoranthene, 11 – chrysene, 12 – benzo(a)anthracene, 13 – benzo(a)pyrene, 14 – indeno(1,2,3-cd)pyrene, 15 – benzo(g,h,i)perylene, 16 – dibenzo(a,h)anthracene.

References:

1. Milyukin M.V., Gorban M.V. Concentrations and regularities of disperse-phase distribution of organochlorine pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons in natural water. *Mediterranean Journal of Chemistry*. 2021, 11 (1), P. 32–42.
2. Tan L., He M., Men B., Lin C. Distribution and sources of organochlorine pesticides in water and sediments from Daliao River Estuary of Liaodong Bay, Bohai Sea (China). Estuarine, Coastal and Shelf Science. 2009, 84, P. 119–127.
3. Heemken O.P., Stachel B., Theobald N., Wenclawiak B.W. Temporal variability of organic micropollutants in suspended particulate matter of the River Elbe at Hamburg and the River Mulde at Dessau, Germany. Arch. Environ. Contam. Toxicol. 2000, 38, P. 11–31.
4. Wurl O., Obbard J.P., Lam P.K.S. Distribution of organochlorines in the dissolved and suspended phase of the sea-surface microlayer and seawater in Hong Kong, China. Marine Pollution Bulletin. 2006, 52, P. 768–777.
5. Patrolecco L., Ademollo N., Capri S., Pagnotta R. et al. Occurrence of priority hazardous PAHs in water, suspended particulate matter, sediment and common eels (Anguilla anguilla) in the urban stretch of the River Tiber (Italy). Chemosphere. 2010, 81, P. 1386–1392.