

INDIVIDUAL AND COMBINED EFFECT OF NICKEL AND COPPER SALTS ON THE INITIAL ONTOGENETIC STAGES OF *RUMEX AQUATICUS* (POLYGONACEAE)

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SUMMARY

The problem of combined effects of toxic substances on living organisms is of great interest to the modern science. Ecological and biochemical mechanisms of adaptation of aquatic ecosystems and aquatic life to the effects of heavy metals have not been studied enough. There were no studies on the combined effects of heavy metals on the initial ontogenetic stages of aquatic plants. Therefore, the aim of the study was to determine the individual and combined toxic effect of nickel and copper on *Rumex aquaticus* L. seed germination and initial seedling development. Seeds were germinated in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ solutions in concentrations of 1, 10, 25, 50, 100, 250 mg/l. The lag-time, germination period and laboratory germination were determined. At the end of the experiment 10 seedlings from each experimental variant where the seeds have sprouted, were measured for the length of the primary root, the hypocotyls, cotyledons, number of secondary roots and width of the cotyledons.

The effect of nickel and copper sulfate toxicity on the germination of the studied species was manifested in decrease of laboratory germination and increase of germination period. Changes in the last parameter demonstrated inhibition of seed germination in initial stages during swelling. Individual and combined toxic action of the Cu and Ni salts terminate germination at concentrations exceeding: 50 mg/l for Cu^{2+} , 100 mg/l for Ni^{2+} and $\text{Cu}^{2+} + \text{Ni}^{2+}$.

R. aquaticus seedling development was observed under treatment with 1–50 mg/l solutions. Data on the basic morphometric parameters revealed a significant reduction in the length of the primary root and changes in the size of hypocotyls and cotyledons. The combined effect of Cu and Ni salts on the seedlings shows the change in their interaction: at higher concentrations the independent action is replaced by the increased combined toxic effect, with further weakening of individual toxicity of one element under the influence of another.

It was confirmed that overall combined toxic action of heavy metals could not be represented as the expected sum of the effects, if each chemical acts independently. The patterns of combined action of different heavy metals require further studies.

Key words: *Rumex aquaticus*, heavy metals, nickel and copper sulfate, seed germination, development of seedlings.