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THE WATER SELF-PURIFICATION CAPACITY IN THE PRESENCE OF VITAMIN B₁₂

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Introduction

Vitamin B₁₂, also known as Cobalamin (Cbl), is a water-soluble vitamin B and a vital nutrient with significant implications for biological processes *in vivo* and water quality. Vitamin B₁₂ functions as a cofactor in the synthesis of DNA, the metabolism of fatty acids and amino acids, and the production of red blood cells. It is the most abundant cobalt compound *in vivo*, and a deficiency of vitamin B₁₂ can lead to severe and sometimes irreversible complications. The concentration of vitamin B₁₂ in natural waters varies significantly due to many factors and typically ranges from 10⁻¹⁴ to 10⁻¹¹ M. The main sources of vitamin B₁₂ in natural waters include microbial production (by some aquatic bacteria and archaea), decomposition of organic matter, and contributions from running water, as well as industrial and household water.

Understanding the variation in concentrations and transformations of vitamin B₁₂ is essential for assessing water quality and maintaining ecological balance in natural waters. Adequate levels of vitamin B₁₂ support the health of aquatic ecosystems, but deficiencies or excesses can affect the species' growth and development, potentially disrupting trophic chains, biogeochemical cycles, and the self-purification capacity of aquatic ecosystems. Based on this, the aim of this work is to evaluate the self-purification capacity of aquatic systems in the presence of vitamin B₁₂.

Materials and methods

To estimate the self-purification capacity of aquatic systems in the presence of vitamin B₁₂, the kinetic parameters of inhibition capacity and OH radical concentration were used. The PNDMA (4-nitroso-N,N-dimethylaniline dye) trap method was employed to determine these parameters.

To isolate and identify the mechanisms of vitamin B₁₂ transformation and its role in radical self-purification processes in aquatic systems, research was conducted under laboratory conditions using the following model systems: *B₁₂-PNDMA-H₂O-hv*; *B₁₂-H₂O-H₂O₂-PNDMA-hv*; and *B₁₂-H₂O-H₂O₂-Cu(II)-hv*.

Solutions were prepared using double distilled water at pH 6.0–6.9, under temperature-controlled conditions at 25 °C with continuous stirring. The solutions were maintained under aerobic conditions to create modeling conditions as close as possible to those in natural aquatic systems. Samples were irradiated using the Oriel Model 9119X (SS) Solar Simulator.

Results and conclusions

The results obtained for the inhibition capacity and OH radical concentrations in both systems are shown in Figure 1 (A and B).

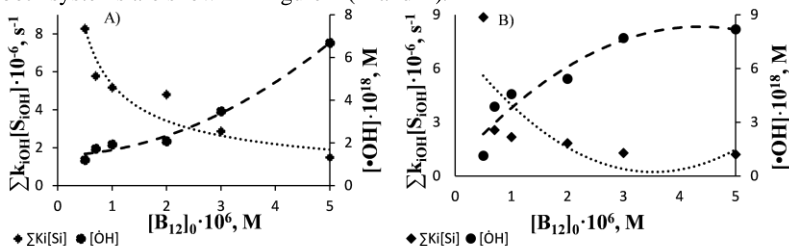


Figure 1. The inhibition capacity and OH radicals concentration versus B_{12} initial concentration added, in the systems: A) B_{12} - H_2O_2 -PNDMA- $h\nu$, B) B_{12} - H_2O_2 -Cu(II)-PNDMA- $h\nu$. Experimental conditions: $[PNDMA]_0 = 2 \cdot 10^{-5}$ M, $[H_2O_2]_0 = 1 \cdot 10^{-2}$ M, $[Cu(II)]_0 = const = 2 \cdot 10^{-6}$ M, $pH = 6.2$, $t = 25$ °C

From the results presented in Figure 1A, it is clear that increasing the concentration of vitamin B₁₂ in the system leads to a decrease in inhibition capacity values and an increase in OH radical concentrations within the same order of magnitude. But also, the inhibition capacity values are on the order of 10⁶ s⁻¹, and the OH radical concentrations are on the order of 10⁻¹⁸ M, which are characteristic of polluted and highly polluted waters. In the system with added Cu(II) ions (Figure 1B), the same legality is observed, but the inhibition capacity decreases more markedly, and the OH radical concentrations increase, being 1.2 to 2 times higher than in their absence. It was found that, on one hand, vitamin B₁₂ acts as a reducing agent, leading to the consumption of oxidative equivalents and its oxidation. High inhibition capacity values and low OH radical concentrations confirmed this. On the other hand, under irradiation, vitamin B₁₂ can also act as a sensitizer. It actively absorbs photons in the UV and visible range, transitions to an excited state, and then transfers the electronic excitation energy to dissolved oxygen in water, forming active species such as singlet oxygen and superoxide radical anion. In the upper layers of natural waters, where sunlight penetrates, vitamin B₁₂ will primarily convert to hydroxocobalamin, the most stable form of cobalamin. The obtained results, confirm that under natural aquatic system conditions, vitamin B₁₂ does not disturb radical self-purification capacity. Given its complex transformation mechanisms and very low concentrations, it can be stated that in natural waters, the concentrations of vitamin B₁₂ will not decrease significantly due to photochemical and chemical processes.

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