

Titanium distribution in a swimming pool – The case for dissolution

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The increased use of titanium dioxide nanoparticles (nano-TiO₂) in consumer products has raised concerns about their possible risk to human and environmental health. The transparent nature and ability to filter both UVA and UVB light has increased the use of nano-TiO₂ by sunscreen manufacturers; recent estimates suggest that 70% of all Ti-containing sunscreens use nano-TiO₂ [1]. Consequently, sunscreens represent a potential source of nano-TiO₂ contamination for aquatic systems. In this work, we report for the first time the occurrence, size distribution and behavior of Ti in a typical swimming pool.

Raw swimming pool water was obtained each week from a local swimming club between May and August, 2009. Samples were fractionated into whole, filtered (< 2 μm), 'nano' (between 1 kDa and 2 μm) and dissolved (< 1 kDa) samples and analyzed for Ti using ICP-MS. Filter backwash and tap water samples were also analyzed for Ti.

The [Ti] in the whole swimming pool water samples ranged between 20 and 60 μg/L and increased throughout the sampling period. [Ti] in tap water samples, however, remained relatively consistent (28 ± 2.4 μg/L), indicating that the increase in [Ti] was due to an external source. The [Ti] in the filter backwash were much higher (301 ± 236 μg/L), suggesting a possible retention of Ti in the sand filter. The vast majority of the [Ti] (between 92 and 98%) was found in the dissolved phase, therefore only a minor fraction of the total [Ti] could be considered nano-TiO₂. Although considered relatively insoluble, our results suggest that dissolution of nano-TiO₂ may be the mechanism most responsible for the observed increase in [Ti]. We will discuss how water chemistry and nano-TiO₂ particle size may enhance dissolution and outline a potential 'filtration-dissolution' scenario that can help explain our results.

[1] Newman *et al* (2009) *J Am Acad Dermatol* **61**, 685-692.

Expansion of Goldschmidt's geochemical classification of the elements to assist in teaching mineralogy, geochemistry, environmental geochemistry, and planetary geochemistry

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Cosmophile and Hydrophile Elements

A recent modification to Goldschmidt's geochemical classification of the elements was the addition of As, Hg, and Pb to the biophile elements [1]. The cosmophile elements are a new group based on the distribution of elements between the earth and solar system. Major cosmophile elements are H, He, Ar, Ne, Kr, and Xe. Minor elements include C and N. The hydrophile elements are determined based on Goldschmidt's ionic potential diagram (soluble cations and soluble complex anions) and by adding soluble inert gases and soluble anions.

Cosmophile	Hydrophile
H, He, Ar, Ne, Kr, Xe	O, H, N, S, Se, Te, F, Cl, Br, I, At, He, Ne, Ar, Kr, Xe, Rn, Li, Cu, Na, Ag, Hg, Au, K, Tl, Rb, Cr, Fr, Mg, Mn, C, Zn, Cd, Sr, Sn, Pb, Ba, Ra, Bi, Ac, B, C, P, As
Minor – C, N	Fe ²⁺ , U ⁶⁺ , Eu ²⁺ , Cr ⁶⁺

Table 1: The Cosmophile and Hydrophile elements.

Teaching Goldschmidt Across the Curriculum

Starting in freshmen geology students are introduced to Goldschmidt's classification of the elements to explain mineral groups, composition of earth's core, crust, biosphere, atmosphere, hydrosphere, and the composition of terrestrial vs. gaseous planets. In mineralogy Goldschmidt's classification of the elements is used as the first principle of substitutions (more important than size and charge) classification of minerals into groups and origin of secondary copper minerals. In geochemistry and environmental geochemistry the enlarged plot of ionic potential enables students to better understand Eh-pH diagrams, origin of mineral deposits, problems of long-term underground storage of radioactive waste, and occurrence in groundwater of As, Rn, Fe²⁺, U⁶⁺, and Cr⁶⁺.

[1] Hollabaugh (2007) In *Concepts and Applications in Environmental Geochemistry* edited by R. Datta, *et al.* Elsevier, Amsterdam, The Netherlands. p. 9-32.