TOXICITY OF NANO TITANIUM DIOXIDE AND INORGANIC MICROPOLLUTANTS TO AQUATIC LIFE

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ABSTRACT

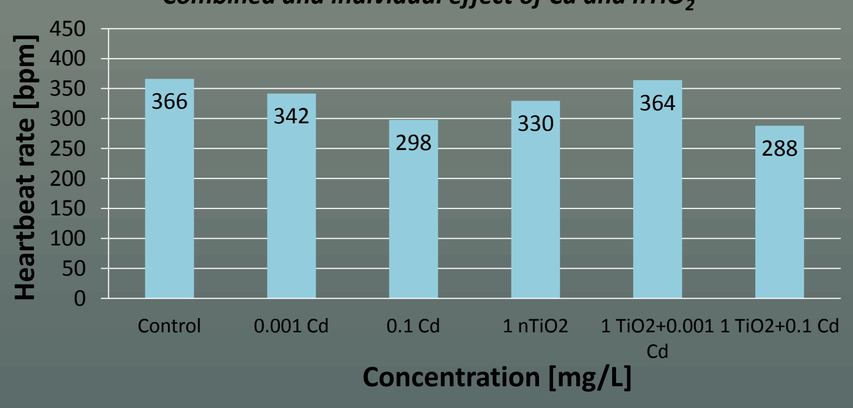
The increasing production and use of manufactured nanoparticles (NPs) have inevitably led to their release into the aquatic environment. As a result of this, a mixture of NPs and other environmental toxicants are present in the environment, thereby posing a threat to aquatic organisms. NPs have a large surface area to volume ratio, suggesting that they are likely to interact with other substances in water. Little literature can be found investigating the potential sinergistic and antagonistic effect of the above mentioned water pollutants.

This study presents the toxicological evaluation of the mixtures of nano TiO_2 and organic and inorganic micropollutants. The total chlorophyll content of *Lemna minor*, and two novel sensitive measurement endpoints – the *Daphnia magna* heartbeat rate and *Tetrahymena pyriformis* phagocytotic activity – were applied to assess the combined effect of nano TiO_2 and several inorganic micropollutants.

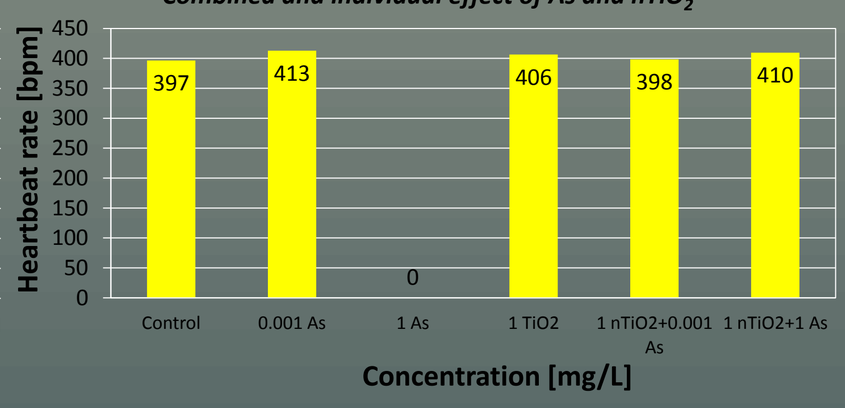
DAPHNIA MAGNA HEARTBEAT RATE

0.001 mg/L Cd resulted in 7% inhibition, but this inhibitory / decreasing effect was reduced to 1% with the combined application of 1 mg/L $nTiO_2$. We have to mention that 1 mg/L $nTiO_2$ resulted in 10% inhibition alone, which was reduced when applied with Cd. 0.001 mg/L. As resulted in 4% acceleration of the heartbeat rate, but this accelerating effect was reduced to 0% with the combined application of 1 mg/L $nTiO_2$. 1 mg/L As resulted in 100% inhibition, all test animals were dead by the end of the 48 h contact time. This value was reduced to almost 0% when it was applied together with 1 mg/L $nTiO_2$. 0.001 mg/L Pb resulted in 5% acceleration of the heartbeat rate, but this accelerating effect was not observable in case of 0.01 mg/L Pb. We have to mention that for this population of *D. magna* 1 mg/L $nTiO_2$ alone had an accelerating effect of 7%, but 0.01 mg/L Pb and 1 mg/L $nTiO_2$ resulted in 7% inhibition compared to control.

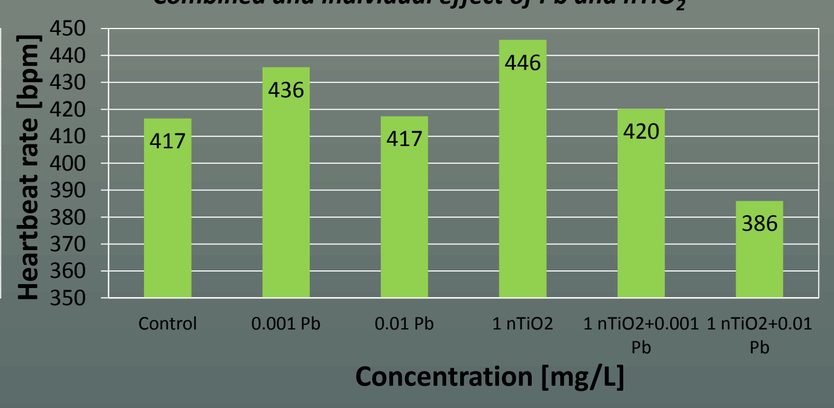
***DAPHNIA MAGNA* HEARTBEAT RATE**
Combined and individual effect of Cd and $nTiO_2$



***DAPHNIA MAGNA* HEARTBEAT RATE**
Combined and individual effect of As and $nTiO_2$

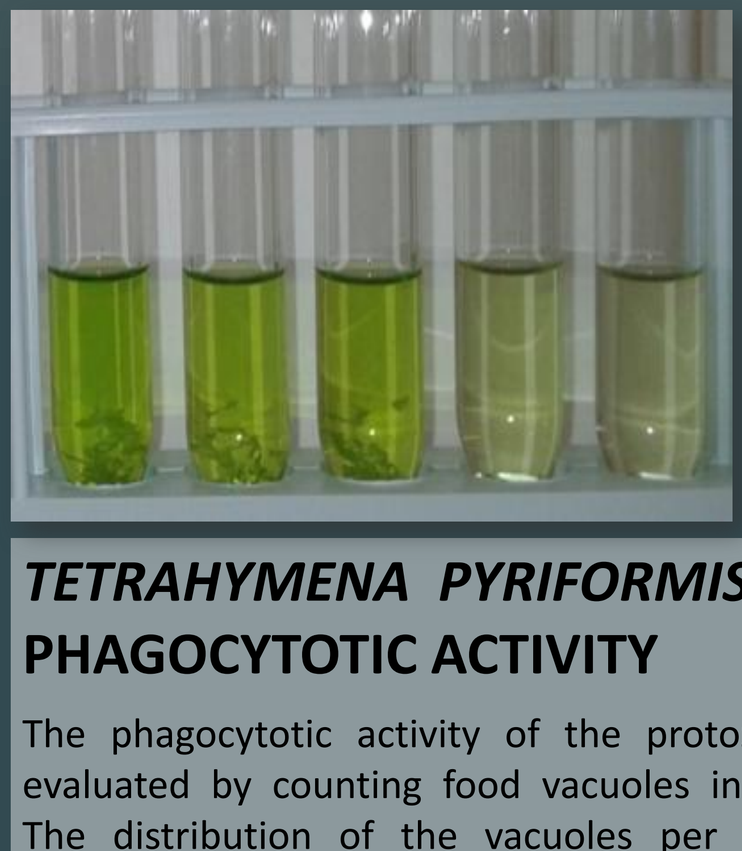


***DAPHNIA MAGNA* HEARTBEAT RATE**
Combined and individual effect of Pb and $nTiO_2$

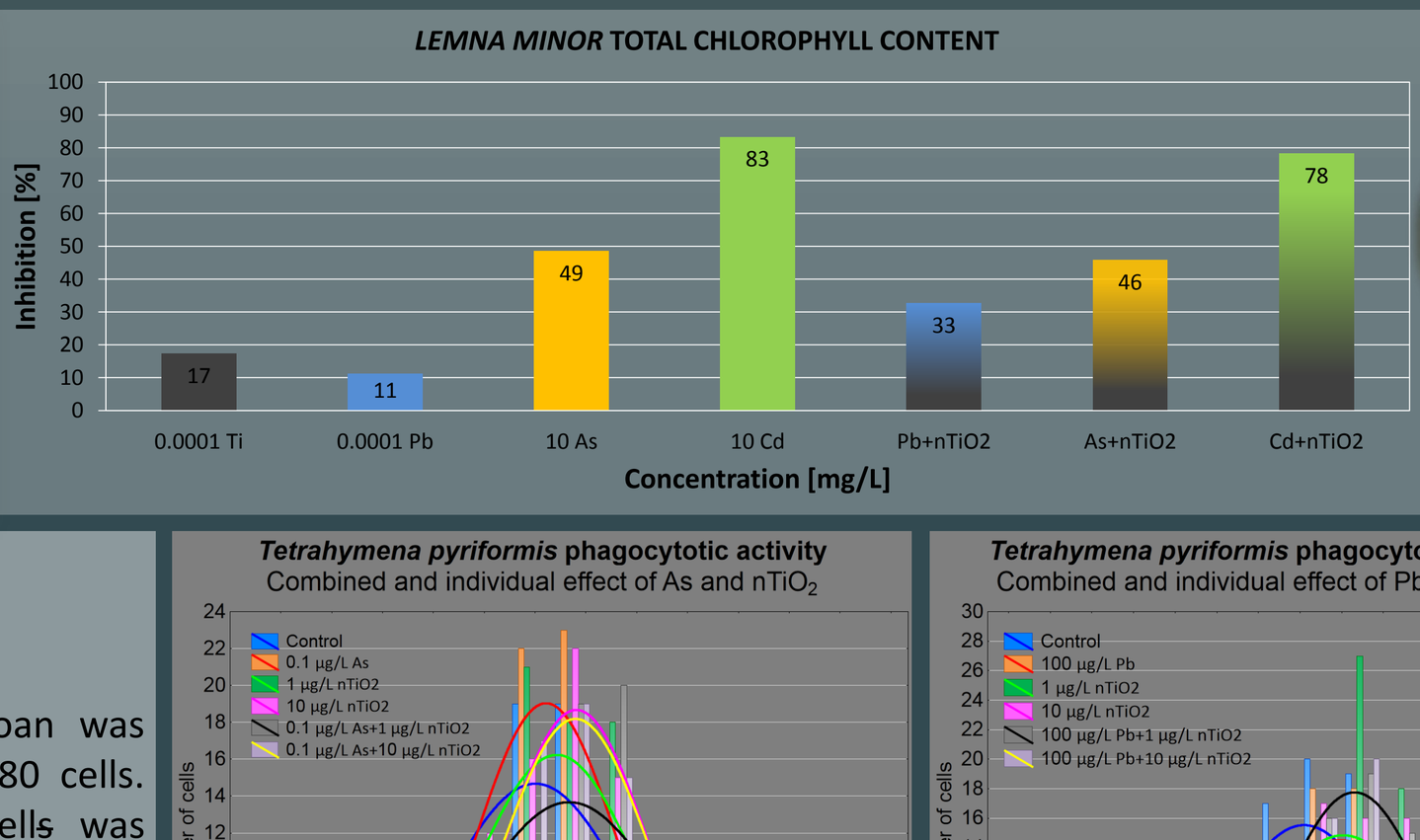


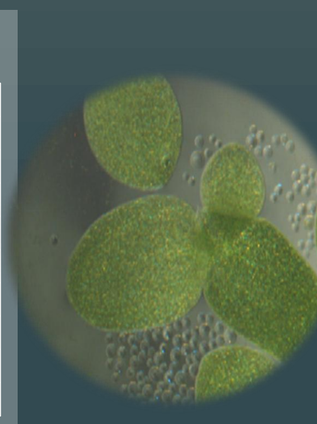
LEMNA MINOR TOTAL CHLOROPHYLL CONTENT

$nTiO_2$ and 0.0001 mg/L Pb resulted in 17% and 11% inhibition, respectively, while 10 mg/L As and 10 mg/L Cd resulted in 49% and 83% inhibition respectively, when applied individually. The combined application did not show any inhibitory effect of As, while the inhibitory effect of Pb increased to 33% from 11% and the inhibitory effect of Cd decreased from 83% to 78%.



***LEMNA MINOR* TOTAL CHLOROPHYLL CONTENT**

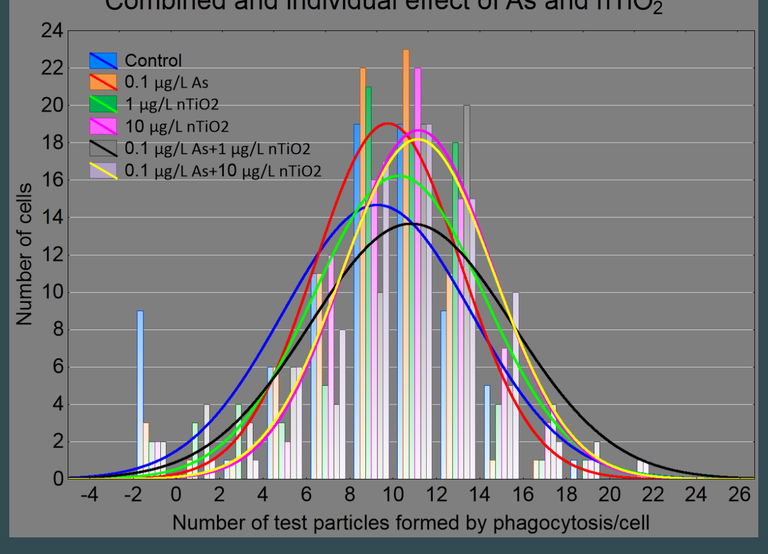




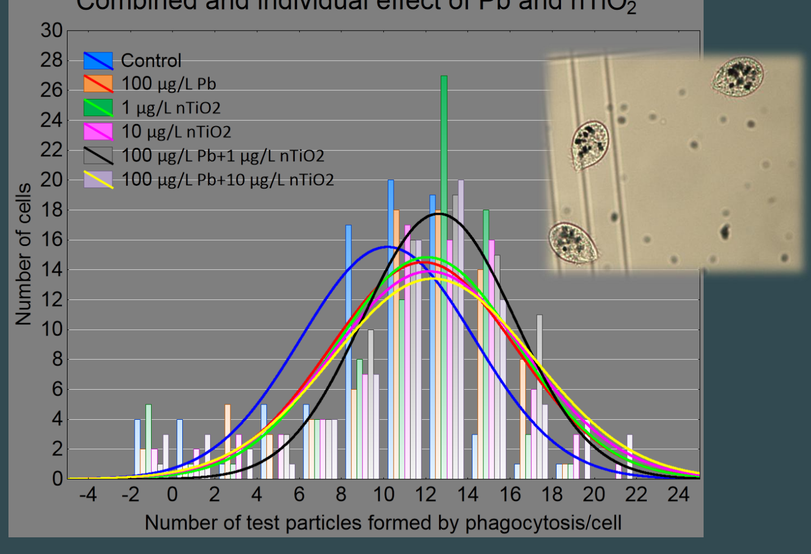
TETRAHYMENA PYRIFORMIS PHAGOCYTOTIC ACTIVITY

The phagocytotic activity of the protozoan was evaluated by counting food vacuoles in 80 cells. The distribution of the vacuoles per cells was determined and characterized with the median, geometric mean and variance values. The inhibitory effect of the combined application of 0.1 µg/L As and 10 µg/L $nTiO_2$ reveal differences compared to their individual application. The co-exposure of Pb and $nTiO_2$ shows differences in variance of phagocytotic activity compared to their individual application.

***Tetrahymena pyriformis* phagocytotic activity**
Combined and individual effect of As and $nTiO_2$



***Tetrahymena pyriformis* phagocytotic activity**
Combined and individual effect of Pb and $nTiO_2$



sample	*Control*	*0.1 µg/L As*	*1 µg/L TiO_2*	*10 µg/L TiO_2*	*0.1 µg/L As+ 1 µg/L TiO_2*	*0.1 µg/L As+ 1 µg/L TiO_2*
geometric mean	10.0	9.7	9.6	11.1	9.8	10.4
median	10.0	10.0	11.0	11.0	11.5	11.0
variance	18.7	11.1	15.3	11.5	21.5	12.2

sample	*Control*	*100 µg/L Pb*	*1 µg/L TiO_2*	*10 µg/L TiO_2*	*100 µg/L Pb+1 µg/L TiO_2*	*100 µg/L Pb+1 µg/L TiO_2*
geometric mean	9.8	11.1	12.2	11.4	12.2	11.8
median	11.0	13.0	13.0	13.0	13.5	13.0
variance	16.7	19.1	18.3	20.8	12.8	22.4

DISCUSSION

The combined toxic effect of Cd, As and Pb with $nTiO_2$ was determined based on the total chlorophyll content of *Lemna minor*, the *Daphnia magna* heartbeat rate and *Tetrahymena pyriformis* phagocytotic activity tests. In some cases synergistic or antagonistic effects can be observed. The toxic effect of As and Cd on *D. magna* was reduced by applying these heavy metals together with $nTiO_2$, while in case of *L. minor* test organism $nTiO_2$ could not reduce the toxic effect. The inhibitory effect of Pb increased to 33% from 11% when testing with *L. minor* test organism. The concentration of $nTiO_2$ in the test solution highly affects the combined toxic effect. Our results suggest that NPs may influence the bioavailability, fate, and toxicity of a toxicant to aquatic biota. Thus, interactions between the toxicant and organisms are of particular concern for the environmental risk assessment of contaminants. The exact mechanisms need to be further discussed.

ACKNOWLEDGEMENT

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