Toxicologic classification of pool water quality in relation to selected pollutant fractions present in washings samples

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Pollutions in pool water

- Impurities of different molecular weight and size: suspensions, particles with a size of over 45 µm, particles with a size of 30 µm, nanoparticles around 955 nm.
- Urine, sweat, cosmetics ingredients, pharmaceuticals, etc.,
- Residues of coagulants and disinfectants,
- Disinfection by-products.

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Pollutions in pool water

- It is estimated that up to 30% of organic pollutants are washed out during the filtration process, getting into the purified water feeding the basin.
- Most of the disinfectant by-products present in the pool water environment are characterized by molecular weight below 1000 g/mol.
- Increased ability to penetrate by-products of disinfection into the organisms of pool users.

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Aim of the research

- The determine the fractional share of organic pollutants in pool water samples taken from the systems of various purposes (toddler's pool, swimming pool, hot tub).
- The evaluation of the physicochemical and toxicological quality of raw washings (collected after pressure filters rinsing), fraction <200 kDa, <30 kDa and <300 Da has been presented.
- Separation of selected fractions was carried out with the participation of a multistage pressure membrane system using ultra- and nanofiltration.
- The physicochemical analysis based on the selected parameters—TOC concentration, dissolved organic carbon (DOC) and total carbon (TC).
- The toxicological classification of isolated fractions was also prepared using the percentage of toxicity effects obtained in commercial bioassays—Microtox® and Artoxkit M.

Methods

Subject of study

- The subject of the study was the washings collected independently of the three water purification cycles— a children's pool, swimming pool and hot tub.
- An integral element of the analyzed systems are multilayer pressure filters (quartz sand with different granulation) with an activated carbon layer.

Fig. 1. The multilayer pressure filters

Methods

Fractionation of pollutants in a multi-stage system

- Flat ultra- and nanofiltration membranes from Osmonics Inc. (USA), differing in the scope of the separation, the so-called molecular weight cut-off (MWCO) and the type of membrane-forming material were used for the fractionation of pollutants in the washings.
- The membranes were placed in a steel filter cell with a volume of $3.80 \cdot 10^{-4} m^3$, where the active filtration surface of the membrane is $38.5 \cdot 10^{-4}\ m^2$. The filtrations were conducted in a one-way system (*dead-end*).

Fig. 2. The steel filter cell for membrane filtration

Methods

Fractionation of pollutants in a multi-stage system

- The fractionation processes were carried out in UF I – UF II – NF multistage systems, according to the scheme shown in Figure 3.
- The feed for the first stage of filtration was made up of raw washings. The permeate obtained after UF I was used as the feed for UF II. The permeate after the second stage of ultrafiltration was used as a feed in the nanofiltration process.
- As part of the presented work, the focus was only on the physicochemical quality and toxicity classification of protected samples of raw washings and permeates.

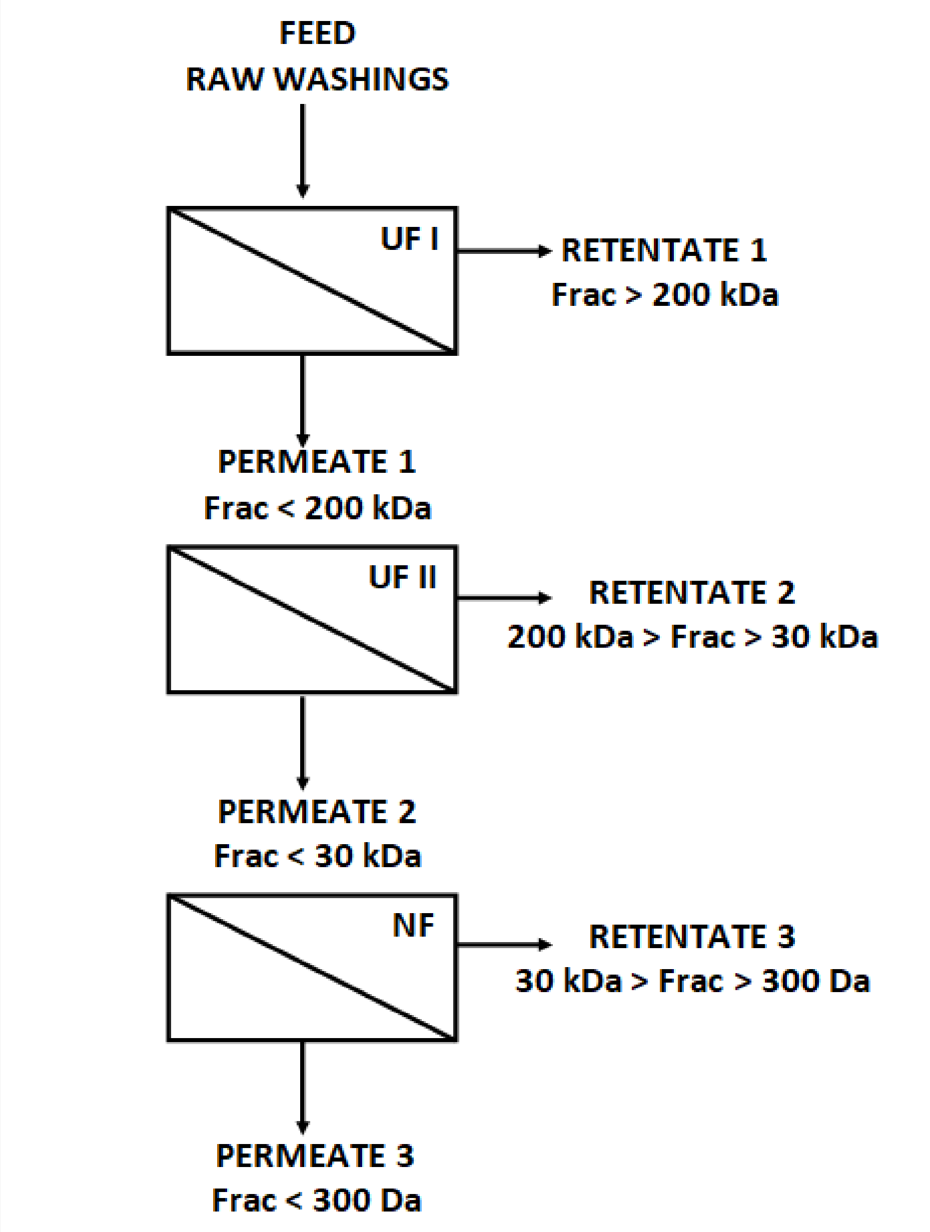

Fig. 3. The fractionation processes in multistage systems

Methods

Analysis of the physicochemical quality of the separated pollutant fractions

- The values of selected physicochemical parameters were analyzed in the morning hours, in the washings secured in the previous evening. The concentrations of TC, organic carbon (TOC) and dissolved carbon (DOC) were determined in the samples of washings and/or permeate (after 0.45 µm filtration, PVDF syringe filter) using a TOC—L series analyzer using catalytic oxidation by combustion at 680°C (Shimadzu).

Fig. 4. Analyzer TOC-L (Shimadzu)

Methods

Classification of toxicity of the obtained pollutants fractions

- Toxicity analysis using the Microtox® test was carried out according to the MicrotoxOmni Screening Test procedure in the Microtox Model 500 (Tigret) analyzer. The toxicity effect was determined as the percentage of bacterial bioluminescence inhibition E,%.
- At the same time, the toxicity of the samples was assessed based on *Artemia salina* crustaceans larvae mortality test. A toxicity effect E,% was calculated for each sample of washings, permeate and control sample constituting brine solution for crustaceans breeding.
- The system based on the determination of the so-called PE, is used for the purpose of toxicity classification. The analyzed value is the average of both bioassays (for the second measurement: 15 min for the Microtox® test and 48 h for the Artoxkit M).

Tab. 1. Toxicity classification system

PE	Class	Toxicity
≤ 20%	I	No acute hazard
20 ≤ PE ≤ 50%	II	Slight acute hazard
50 ≤ PE < 100%	III	Acute hazard
PE = 100%[1]	IV	High acute hazard

[1] At least in one bioassay.

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Results

The samples taken from the children's pool circuit

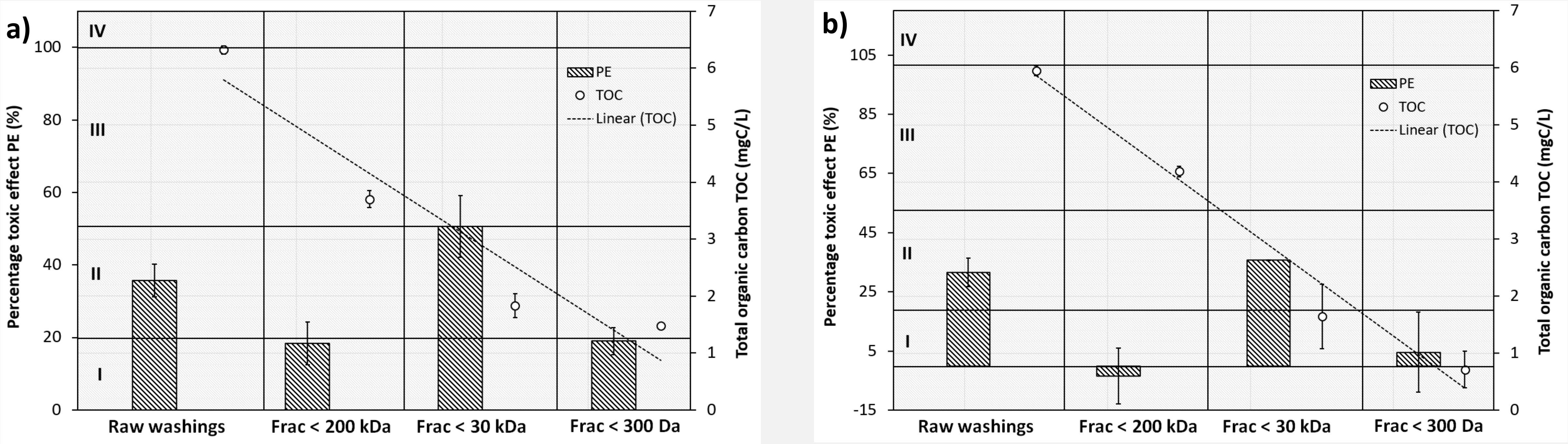

Fig. 5. Values of TOC and PE in raw washings and separated fractions, samples were taken from: (a) toddler's pool—sampling 1; (b) toddler's pool—sampling 2.

Results

The samples of washings collected from the swimming pool system

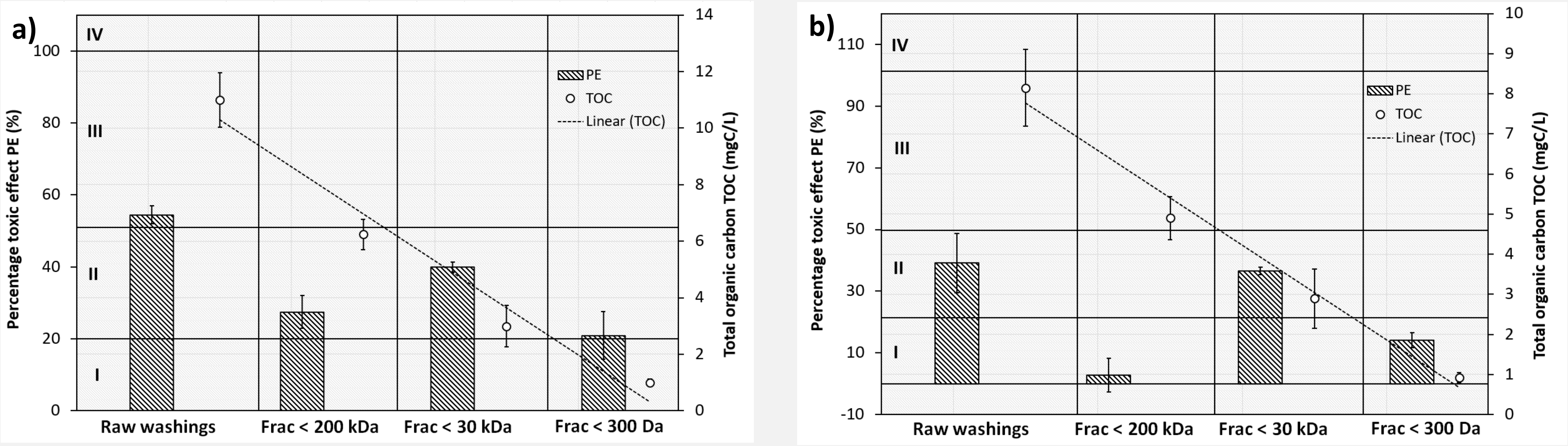

Fig. 6. Values of TOC and PE in raw washings and separated fractions, samples were taken from: (a) swimming pool—sampling 1; (b) swimming pool—sampling 2.

Results

The samples of washings from the hot tube system

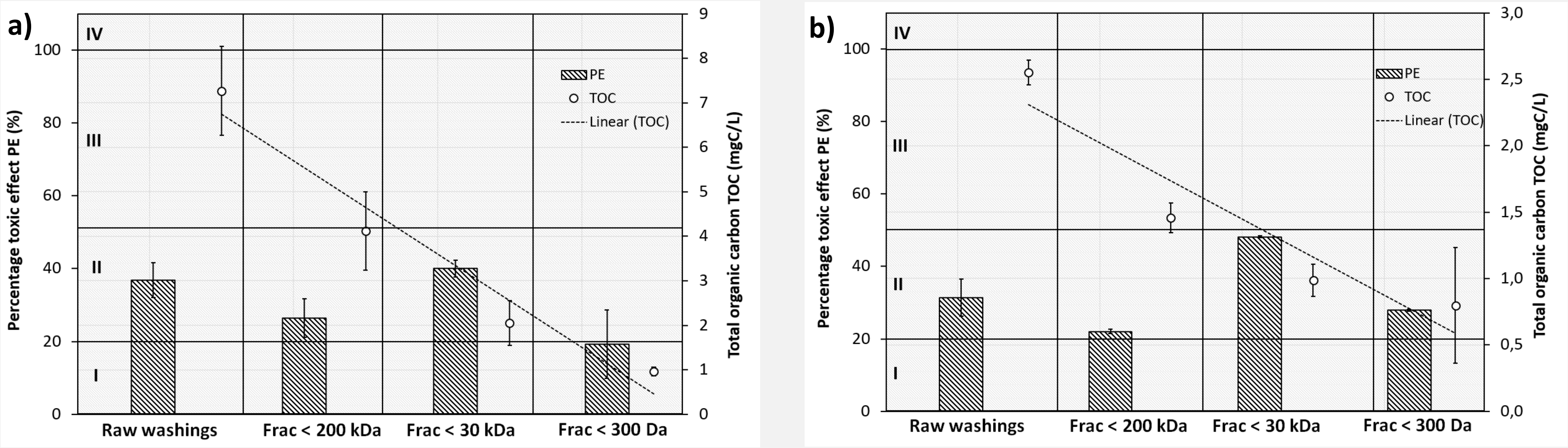

Fig. 7. Values of TOC and PE in raw washings and separated fractions, samples taken from: (a) hot tub—sampling 1; (b) hot tub—sampling 2.

Conclusions

- The use of a multistage membrane system allowed for the extended physicochemical and toxicological analysis of pool water quality.
- The presented study showed a significant share of the organic pollutants fraction with a molar weight below 300 Da in the examined washings. The quality of washings (the value of selected physicochemical parameters) varied depending on the purpose of the basin from which the samples were taken.
- There was a clear reduction in the concentration of organic pollutants along with the subsequent processes.
- The highest toxicity in the samples tested was observed for fractions below 30 kDa. In addition, none of the samples were classified as highly toxic to test organisms.
- There was no correlation between the concentration of TOC and the percentage of toxic effect.
- Screening toxicity tests can be a signal of the quality of environmental samples, including swimming pool water. However, analyzes of this type require the extension of additional test organisms or observations of a larger number of morphological parameters of these organisms.

Thank you for your attention!

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