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ACTUAL PROBLEMS, POSSIBILITIES AND TRENDS IN DRINKING WATER TESTING

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Abstract

Water is the fundamental life source that sustains all beings on Earth, and the driving force of the development of mankind. Perhaps due to the high degree of development and industrialization, drinkingwater of good quality and quantity becomes less and less accessible. A largeamount of pollutants are found in water recources, coming from agriculture, industry and households. Some of these are endocrine disruptive, mutagenic or carcinogenic. Disinfection-byproducts are poorly studied pollutants of drinkingwater. Based on literature, the number of compounds formed during drinking water treatment is estimated to be over 200. Since more and more pollutans are explored, monitoring of water quality becomes more and more important. Effects of chemicals can hardly be assessed on the basis of chemical test, thus biological tests come into view. These tests are carried out according to international guidelines so results are highly comparable. To get a complex picture, experiments should be conducted on different trophic levels. As a new trend, model ecosystems and biomagnification field studies become famous again. Interestingly, food chain models are neglected, however could serve valuable information on the potential ecosystem effects of previously unknown compounds. The goal of this work is to present the actual problems, possibilities and trends in drinking water testing.
Keywords: drinking water, toxicology, zebrafish

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Az ivóvíz tesztelésének aktuális problémái, lehetőségei és trendjei

Összefoglalás

A víz a földi lét alapja, az emberiség fejlődésének mozgatórugója. Talán pont a nagy mértékű fejlődésnek, iparosodásnak köszönhetően egyre nehezebb megfelelő minőségű és mennyiségű ivóvízhez jutni. Számos, a mezőgazdaságból, az iparból és a háztartásokból származó szennyezőanyag található meg ivóvíz bázisunkban. Egy részükről bebizonyosodott, hogy hormonrendszert zavaró, mutagén vagy éppen karcinogén hatásúak. Az ivóvízben található, napjainkban még kevéssé vizsgált szennyezők a víztisztítási melléktermékek. Ezen vegyületek az ivóvíz fertőtlenítése során keletkeznek, egyes publikációk kettőszáz felettire becsülik a számukat. Mivel egyre több szennyező létére derül fény, ezért egyre fontosabbá válik a vizek minőségének ellenőrzése. Csupán kémiai vizsgálatokkal nem lehet felmérni az egyes vegyületek hatását, így egyre jobban előtérbe kerülnek a biológiai tesztek. Ezeket nemzetközi irányelvek alapján végzik

a laboratóriumok, így az eredmények jól összehasonlíthatóak. Hogy komplex képet kapjunk, a lehető legtöbb trofikus szinten szükséges vizsgálódni. Legújabb trendként újra előtérbe kerülnek a modell ökoszisztémák, a terepi biomagnifikációs vizsgálatok. Érdekes azonban, hogy a laboratóriumban modellezett táplálékláncok tanulmányozása háttérbe szorult, pedig ezekkel a vizsgálatokkal értékes információkhoz juthatnánk az eddig ismeretlen vegyületek ökoszisztémára gyakorolt esetleges hatásairól. A munkám célja, hogy bemutassam a ivóvízzel kapcsolatos aktuális problémákat, valamint a vizsgálati lehetőségeket, trendeket.
Kulcsszavak: ivóvíz, toxikológia, zebradánió

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Concept and importance of drinking water in the development of mankind

Drinking water is water for human consumption meeting the prescriptions about the quality requirements and control order of potable water. Water is not just the basis of the life on Earth, but it is also the driving force of the development of mankind. It is more and more difficult to provide enough food of good quality to the increasing population of our planet. To produce large volumes of food farmers have to implement industry-like agriculture methods, which require lots of water. Unfortunately these activities also imply high degree of water contamination affecting the water bases as well.

The quantity of water is Earth is estimated to 1.4 billion cubic kilometers, but only 0,003% of it can be used as drinking water or for sanitation, agricultural and industrial purposes. In case the population increases in the current rate, by 2030 the water might be not enough to sustain mankind. A FAO survey showed that the branch of economy requiring most of the water is agriculture. The production of each kilogram of grain requires 1000-3000 liters of water. The potable water consumption per capita is not merely the direct consumption as 2-5000 liters of water are needed to produce the daily food requirement of one person.

Problems of the developing and developed countries

The distribution of the water resources is not even. There are regions, where the water is almost wasted, while in other areas tens of thousands of people die every day due to the lack of water. In the developing countries hunger is a major problem as they cannot produce enough food due to the lack of water. Many diseases (malaria, typhoid, salmonella, hepatitis, *E. coli* infection) take their victims in these countries because of the absence of adequate sanitation and clean drinking water.

Developed countries face totally different problems. Here the water reserves are available, but due to the high degree of industrialization they get contaminated. Besides the pollutants emitted by the industry and agriculture there are also other contaminants, detergents, chemicals, drug residues reaching the waters. In order to remove these materials and to prevent the water-borne diseases the waste waters of the settlements are subject to different water-cleaning procedures. Although these procedures are modern, still they are not suitable for example for removing many endocrine disrupters. EDC compounds offset the natural balance of the hormones in the living organisms, affect reproduction and ontogenesis and acting as analogues of natural hormones they result in numerous adverse biological effects (such as distortion, development disorders) (*Bakos et al.* 2013).

Nowadays more and more attention is paid in toxicology to the compounds forming during the disinfection of drinking water.

Providing good quality drinking water free from harmful contaminants/pollutants has become a vital, strategic task all over the world and in our country too. The water purification processes currently used (chlorine, chlorine dioxide, ozone or UV treatment) are aimed primarily at killing the bacteria in the water and in addition a variety of filtration techniques seek to reduce the chemical contamination.

The oxidizing disinfectants can interact also with inorganic materials in the drinking water therefore the result of these chemical interventions, besides the obvious benefits of the disinfection, can be the formation of many organic compounds (by-products of water purification), which might have harmful, mainly mutagenic (*Sujbert et al.* 1993) and carcinogenic impacts (*Bull et al.* 1995).

Importance of and possibilities to check harmful materials present in the drinking water

In order to safeguard human health and the environment laboratory tests become more and more important. This is the safest way to map up the effects of certain compounds or environmental samples. In order to obtain a complex picture about the impact of a compound it is important to have information about as many species as possible, from the lower living beings up to the vertebrates.

The toxicity tests of the various substances are usually performed in the laboratories based on internationally accepted regulations, standards or guidelines. In most of the cases the OECD guidelines are applied. They contain the regulations relating the conduct of studies as well as the method of determining the parameters needed for the evaluation of the tests.

From the elements of the ecosystem, the testing usually starts with the bacteria tests, for example with the Ames-test (OECD 471), which is used for the detection of genotoxicity, but toxicity tests are made on *Aliivibrio fischerii* too. This latter test organism shows the toxicity of the tested substance through the reduction of its bioluminescence (*Thouand,* 2011). The lower plants are represented by algae, where the growth inhibition test of unicellular algae (OECD 201) is widely used. The effect of the compounds on macrophytic aquatic plants is tested on duckweed species *(Lemna sp.*) in accordance with OECD 221 standard. As to the animals, tests made on lower crabs are essential as these tiny organisms serve as food for the higher vertebral consumers, fishes. The most commonly used tests are also recorded in the OECD standard (i.e. OECD 202), which describes the tests of the acute immobilization and reproduction parameters of the *Daphnia magna*.

The above mentioned acute test draws a picture about the impact of the tested materials or environmental samples on the lower living beings and the researcher can move on to the testing on vertebral organisms.

Fish as ideal model in the water toxicity tests

Fish as a taxonomy group represents the only vertebral group, which lives exclusively in water therefore they are indispensible part of the integrated toxicological tests (*Spitsbergen and Kent,* 2003). It is now recognized on an international level (EU regulation 233/1996) that fish is one of the most suitable aquatic organizations for the examination of environmental pollution.

Acute and chronic toxicological tests performed on fishes are widely used animal tests for the examination of the effects of different chemical substances on vertebrates.

A popular model-animal of the biological research performed on aquatic organisms is a tiny team-fish, zebrafish (*Denio rerio*) (*Engeszer et al.* 2007), which is well known from the fishbowl. These fishes have many features, which makes them outstanding from the other animal species used as models. They have short generation intervals, high quantity of brood can be obtained from them, the development of embryos takes place *ex utero,* and it can be followed easily through the transparent eggshell (*Lieschke and Currie,* 2007). They are widely used for development biological and genetic (*Eisen,* 1996; *Grunwald and Eisen*, 2002), gerontological, (*Gerhard and Cheng,* 2002), tumor-biological (*Lieschke and Currie*, 2007), behavior-biological, (*Engeszer et al.* 2007; *Spence and Smith,* 2005), toxicological (*Ankley and Johnson,* 2004; *Hill et al.* 2005, *Rácz et al.* 2012), morphometric (*Staszny et al.* 2013) and immune-biological examinations (*Csenki et al*. 2010).

Of course, OECD standards are connected to tests performed on fish as well. These tests are: acute toxicity test (OECD 203), test on poisoning in an early age (OECD 210), and the short-term effect test made on the embryo (OECD 212).

Possibilities of using complex testing systems

To make a complex picture about the effects of the different compounds it is not enough to examine only individual elements of the food chain. Laboratory ecosystem models were created in order to monitor the changes taking place in nature. Their use was widespread in the 1970-80’s mainly for examining pesticides, drugs and drug residues. (*Metcalf et al.* 1973 a,b; *Coats et al.* 1976 ; *Lutnicka et al.* 1999). Maybe due to the development of the computer aided modeling, nowadays the use of the highly complex, multi-trophic-level laboratory models is loosing its importance.

Since many compounds (heavy metals, pesticides, etc.) can accumulate in the food chain, the development of test systems which can model this process seems to be appropriate. The essence of the food chain models is that the first element and then sequentially the species located on the next steps of the chain are treated by the pollutant (*Pickhardt et al.* 2005; *Ferard et al.* 1981). The first element present in the aquatic food chains as the primary producer is alga. The next level, the lower crabs are fed with the treated algae and then the crabs serve as food for the fish. In each step, the counter-measuring of the tested substance by analytical methods is essential. Presently the use of this method is not popular in the research, but in my opinion it should be re-introduced again, as in the case of many substances it is not clear if they can reach the to top of the food chain (that is: people) through the different elements of the chain.

As a summary one can state that the monitoring of the drinking water is extremely important since everybody drinks it every day, therefore people can be subject for long term to the contaminants possibly present in the water. In our days research sees the potable water not only as a substance. It rather examines the effects of more and more compounds detected in the drinking water on the different groups of living beings. This is indispensible if we want to protect our health and also the health of the generations to come.

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