

Applied PUBLIC water supply hydrobiology: A brief review. Problems of the drinking water systems in the Czech Republic.

Aplikovaná vodárenská hydrobiologie: stručný přehled. Problematika rozvodů s pitnou vodou v České republice.

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Abstract

Surface waters affected by eutrophication produce more biomass and enable development of organisms which are difficult to remove during the water treatment technology. The increasing numbers of organisms in treated water cause the problems during the treatment process, namely in coagulation and filtration stages. The quality of water has to be controlled and monitored by drinking water suppliers during all stages of the treatment process beginning at the water source until the end of distribution systems. The knowledge of ecological requirements of individual organisms for water quality evaluation, and the impact on biological stability of drinking water is used for evaluation of control points in the water treatment process. The critical points that should be monitored during the water treatment process and further distribution of water are presented in this paper.

Introduction

The problems of eutrophic reservoirs, the formation of biofilms in pipelines, the secondary development of organisms in storage tanks etc. are solved in many European countries, for example, in Belgium, France, the Slovak

Republic, Spain, Latvia. The monitoring of raw water sources, treatment process and the distribution system (hazardous pathogens, point sources of microbial pollution, modelling of the treatment with the intervention of microorganisms, study of the distribution system and presence of microorganisms; RIBAS 2003) are the main problems to be solved. Studies on cyanobacteria ecology in water bodies seem to be very important to limit the cyanotoxins concentration in drinking water (SCHMIDT & RUSEVA 2003). The study on biofilm formation and biological stability of drinking water are very important measures to prevent drinking water quality deterioration during water distribution. Biofilm, presented by thin film of slime-forming bacteria, micromycetes and microscopic protozoa, has considerable negative influence on hygienic quality, organoleptic and corrosive properties of distributed drinking water (JUHNA & KLAVINS 2003).

The quality of water has to be controlled and monitored by drinking water suppliers during all stages of the treatment process from the water sources to the end of distribution systems. This principle, i.e., to study the whole water supply system from the catchments to the consumer, is one of the key points of Water Safety Plans included in the new WHO Drinking Water Quality Guidelines (currently in draft version) and in the WEKNOW Microbiological Quality Position Paper in the Quality management part. The processes of the monitoring and control of water quality are presented step by step in this paper.

The majority of drinking water sources in the Czech Republic are the surface waters (about 74% of them are the reservoirs and about 26% are the streams). Surface waters affected by eutrophication produce more biomass and enable the development of organisms which are difficult to remove by current water treatment technology. The increasing numbers of organisms in treated water cause the problems in coagulation and filtration stages (filter clogging, penetration of filter mass, shortening of filter cycle). Hardly removable microorganisms penetrate to drinking water and become the nutritive substrate for secondary development of other microorganisms.

Hydrobiological analysis

Hydrobiological investigation of water samples is based on microscopic analysis and determination of microscopic image; the presence and the quantity of microorganisms per 1 ml of water is investigated (the Czech standard No. 75 7712). The analysis according to this standard is based on the concentration of organisms by centrifugation of defined volume of water sample (10 ml) and quantification and determination of microorganisms in counting chamber of the Cyrus type (AMBROŽOVÁ 2003).

Critical control points in the drinking water treatment process

The knowledge of the ecological requirements of individual organisms for evaluation of water quality, water treatment processes and impact on biological stability of drinking water is used for evaluation of control points in the water treatment process. The occurrence of living organisms in drinking water indicates: improper water treatment process, failure of water sanitation, urgency of mechanical removal of biofilms and sludges, improper construction and materials. Tripton (abioseston) indicates air-borne contamination in the storage tanks, the penetration of particles through the technological units and also can serve as substratum for the growth of micromycetes and other heterotrophic organisms.

The critical points within the drinking water process are: water basins (1), water treatment plants (2), water storage tanks and accumulations (3), distribution systems and pipelines (4).

(1) Water basin (or conduit). The characteristics of organisms (numbers, species composition, size) in the whole water column should be controlled with respect to the presence of hardly removable organisms (i.e. phototactic and phototrophic colored flagellates, small centric and penate diatoms), that are seldom removed by the coagulant flocks and therefore, these organisms can easily pass through the filters into treated water (SLÁDEČKOVÁ 1997). The sampling along the vertical profile of the water body based on temperature and oxygen stratification is recommended.

(2) Water treatment plants. The quality of surface water for water treatment plants, the characteristics of water in coagulation tanks, in the filtration units and the filtered water should be assessed. Some attributes of coagulant flocks (i.e. size, shape, density, presence of organisms in flocks) should be observed in the sedimentation tanks. Generally, the acicular diatoms (i.e. genus *Nitzschia*), the actively moving organisms or filamentous algae and some cyanobacteria are hardly bound into flocks and afterwards penetrate into the filters, treated water and contaminate the distribution systems. The penetration of coagulant flocks through the filters into treated water indicates the quality of the filtration process (bed loading, a phase of ripening, sufficiency to wash filter).

(3) Water storage tanks and accumulations. The protection of windows against insects intrusion is very important (the possibility of egg-laying). The development and propagation of photosynthetic organisms (i.e. cyanobacteria and green algae) and the peeling plaster falling to the surface of accumulated water are very often registered in these facilities. The presence of ciliates indicates the insufficient water sanitation. Presence of hardly removable organisms (some diatom species, chrysophytes, etc.) in distributed water indicates their penetration through the filters. Starch grains, plant residues, pollen grains, gramineous remains, bird feathers, spores of micromycetes of *Alternaria solani* species, hyphae of micromycetes, etc. are the indicators of air-borne contamination. The presence of organisms forming biofilms on the walls of technological units indicates the insufficient mechanical cleaning of these

facilities. The presence of phototrophic organisms indicates the negative influence of light irradiation. The monitoring of the reservoirs during the process of cleaning is recommended: both water samples and scum samples from the walls. In case that insect chitin is found there is a great probability of imagos presence.

(4) Distribution systems and pipelines. Zero live organisms and limited number of all organisms in drinking water are required by the Czech Directive No. 252/2004. Many samples of drinking water do not meet these requirements – the results of hydrobiological analyses exceed these limits. The presence of achromatic flagellates indicates insufficient water sanitation. Iron bacteria indicate increased content of iron substances in water. The biological stability of drinking water should be controlled using the exposed special slides (the biofilm is formed on their surface and could be analysed).

Conclusions

From the biological point of view we are interested not only in the bioeston (according to the Czech standard No. 75 7712), but in the character of particles of abioeston as well (the Czech standard No. 75 7713). Both mentioned parameters are very important indicators of drinking water quality. If the live organisms are found in drinking water, further information is needed, i.e. type of organism, taxonomy, origin, classification of hardly removable groups of microorganisms. How the microscopic image can inform us? The indication value based on organisms types is presented in Table 1.

Table 1: Indication value of organisms found in water treatment system

Type of organism	Indication
Bacteria of genus <i>Sphaerotilus</i> and achromatic flagellates	The pollution from the surroundings
Sulphur bacteria	The presence of sulphate, anaerobic conditions
Iron bacteria	The increased concentration of iron forms
Yeasts, hyphae of micromycetes, fungi spores e.g. <i>Alternaria solani</i>	The air-borne contamination
Proliferous mycelium	The presence of organic matter or the leakage from the surroundings
Helminths, rotifers and crustaceans	The air-borne contamination, a leakage of the eggs through the filters, insufficient water treatment technology, insufficient hygienic sanitation

The particles of abioeston are very significant. Verbal description is recommended in case the value of abioeston is greater than 1 %, more information about character, composition and possible origin). Main types of

abioseston in raw, treated and drinking waters are: corrosion products, iron and manganese precipitations, detritus, plant residues (fibres, cellulose, frustules of diatoms), pollen grains, starch grains, micromycetes hyphae, fungi spores (e.g. *Alternaria solani*), animal remains (setae of oligochaet worms, filter ribs of crustaceans, envelopes of rotifers, remains of chitin), feathers, etc. (AMBROŽOVÁ 1999, 2001, AMBROŽOVÁ et al. 2003).

It is possible to prevent the formation of buckles and biofilms on walls of a storage tanks by periodic hydrobiological control (SLÁDEČKOVÁ & MATULOVÁ 1997). The water quality in a storage tanks depends also on their maintenance, e.g., to prevent the plaster falling on water surface, the use of antifungal surface coatings (prevention the growth of fungi on walls), the use of ceramics surface of reservoir walls, dark conditions (no windows or blue sheets) in all technological units, the prevention of dust fall out, the selection of suitable air condition, etc.

Recommendations

The study of the whole distribution network (so called “hydrobiological audit”) is based on the monitoring and evaluation of raw water quality, technological units in the water treatment plants (the treatment process) and treated and drinking water quality in storage tanks, reservoirs, accumulations and distribution systems respectively.

Usage of hydrobiological analyses is very important. Microscopic analyses help the water designers, builders, water managers, technologists and water supply companies to understand the sources and consequences of eutrophication, and both raw and drinking water pollution. These methods can provide rapid results and reliable data for the selection of appropriate preventive measures or ecologically sustainable remedial actions.

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