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FOREST ECOSYSTEMS

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HYDROLOGY AND WATER RESOURCES

FOREST ECOSYSTEMS

ASSESSMENT OF CHLORINATED WATER IMPACT ON PHYTOPLANKTON

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ABSTRACT

The research of chronicle impact of chlorinated drinking water on phytoplankton was carried out for proving the negative influence of by-products of water chlorinating. For this purpose the river and well water with phytoplankton were chlorinated by different doses of sodium hypochlorite. The content of free residual chlorine was measured and visual observation of the samples was carried out after 90 days. Phytoplankton activity was decreased with sodium hypochlorite dose increasing. It was noticed that more phytoplankton remained in the samples of well water compared to samples of river water. This proves the theory of chlorination by-products increasing with increasing of organic substances concentration in the water. Besides, sodium hypochlorite dose providing the concentration of free residual chlorine under the limit probably does not destroy all pathogenic organisms. Chlorination is still the most common method of drinking water disinfection due to oxidative ability, aftereffect, simplicity of use and high efficiency. But there is a problem of drinking water contamination by chlorination by-products – organochlorine compounds. Many of them have toxic, mutagenic, carcinogenic and teratogenic properties and cumulative effect. This, in turn, significantly increases the risk of various diseases including cancer. There are no appropriate limits in Ukraine for toxic and carcinogenic haloacetic acids as well as for carcinogenic and mutagenic haloacetonitrils.

The aim is to assess the impact of chlorinated water on phytoplankton.

Investigation of toxic impact of water chlorination by-products was carried out by bioindication method. Chlorella and Scenedesmus were used as bioindicators. Long-term impact of chlorinated drinking water on phytoplankton was assessed.

For this purpose the river and well water with phytoplankton were chlorinated by different doses of sodium hypochlorite. The content of free residual chlorine was measured and visual observation of the samples was carried out after 90 days and phytoplankton activity was found to decrease with sodium hypochlorite dose increasing.

Comparing of phytoplankton quantity in samples with river and well water chlorinated by equal doses of sodium hypochlorite was carried out. It was noticed that more phytoplankton remained in the samples of well water compared to samples of river water. This proves the theory of chlorination by-products increasing with increasing of organic substances concentration in the water. Besides, sodium hypochlorite dose providing the concentration of free residual chlorine under the limit probably does not destroy all pathogenic organisms.

Keywords: drinking water, chlorination, phytoplankton, free residual chlorine

INTRODUCTION

Since water is a main factor providing human being, then ensuring water quality must be a priority of every country. This is especially reasonable for water quality by sanitary-hygienic parameters (characterising by disinfection efficiency). Deviation of these parameters can cause dangerous infectious and intestinal diseases. At the same time, the sanitary-chemical parameters can not be ignored as well, since they can also have a negative impact on human health. Increased pollution of natural water bodies and impossibility to provide high quality of drinking water by outdated sewage treatment technologies make health risks very high during water consumption. Despite of existing methods, chlorination is still the most common method of drinking water disinfection due to oxidative ability, post effect, simplicity of use and high efficiency. But there is a problem of drinking water contamination by chlorination by-products – organochlorine compounds (OCC). Many of them have toxic, mutagenic, carcinogenic and teratogenic properties and cumulative effect. This, in turn, as reported in [1], significantly increases the risk of various diseases including cancer. Therefore, above mentioned problem is extremely relevant and requires detailed study and finding of solutions.

There are many toxic by-products formed during water disinfection by chlorine (sodium hypochlorite, etc.) [2]: trihalomethanes, haloacetic acids, halogenated aldehydes, halogenated ketones, haloacetonitrils, chloropicrin, chlorophenols. They cause chronic impact on humans by oral, inhalation way and through the skin [3]. Some of these organochlorine compounds according to [4,5,6,7] are carcinogenic (they cause cancer of the liver, kidney, thyroid, bladder, breast, esophagus, etc), mutagenic [8,9,10] (break of DNA chains, birth defects such as interventricular septum defects, obstructive urinary tract defects), or teratogenic [11,12,13,14] (premature birth or birth of children with low weight). However the limits are established only for few substances. For example, there are no limits for toxic and carcinogenic haloacetic acids and carcinogenic and mutagenic haloacetonitrils in many countries. Although the World Health Organization and the US Agency for Environmental Protection (USEPA) have established limits [15] for some substances from these groups. Due to the potential toxic effects of chlorination by-products, there is necessity to evaluate their impact on living organisms. Phytoplankton is known to be useful test-object. Therefore, the purpose of this study includes water chlorination by different doses of sodium hypochlorite (NaClO), evaluation of free residual chlorine content in disinfected water, adding phytoplankton to the water disinfected by different sodium hypochlorite doses and conducting visual observation of the phytoplankton changes.

MATERIALS AND METHODS

For well and river water chlorination by different doses of sodium hypochlorite solution (SHS), the mass concentration of active chlorine in SHS was defined. For this purpose, potassium iodide was added to SHS and then solution was titrated by sodium thiosulfate. Also, the necessary SHS quantities were calculated according to relevant instructions for SHS using for drinking water disinfection. After chlorination, free residual chlorine in the investigated samples was measured by method of titrating by methyl orange.

Investigation of toxic impact of water chlorination by-products was carried out by bioindication method. Chlorella and Scenedesmus were used as bioindicators.

11 samples were prepared by mixing equal volume (100 ml) of well and river water disinfected by different SHS doses and phytoplankton solution. The same was done for non-disinfected well, river and tap water. The samples were placed at sunny spot for 90 days.

RESULTS AND DISCUSSIONS

Visual analysis of the investigated samples was conducted after 90 days to evaluate a chronic influence (see Fig. 1–14). The calculated SHS consumption and defined content of free residual chlorine are shown in the Tables 1 and 2.

Table 1. Results of well water research

Sample No.	SHS dose, g/l	NaClO consumption, ml	Volume of titrant (methylorange solution), ml	Free residual chlorine content, mg/l
4	0.49	0.004	1.3	0.28
5	3.7	0.03	15.2	3.3
6	5.57	0.045	21.8	4.7
7	10.0	0.08	34.5	7.5
8	15.0	0.12	42.0	9.1
9	20.0	0.16	63.2	13.7

Table 2. Results of river water research

Sample No.	SHS dose, g/l	NaClO consumption, ml	Volume of titrant (methylorange solution), ml	Free residual chlorine content, mg/l
10	3.7	0.03	1.4	0.3
11	5.57	0.045	2.1	0.46
12	10.14	0.082	13.4	2.9
13	15.0	0.12	34.9	7.57
14	20.0	0.16	40.2	8.7

The results have shown reduce of the phytoplankton activity with SHS doses increasing both for underwater and for river water. Besides, more phytoplankton was found in the samples of well water compared to the samples of river water with the same SHS dose.

This confirms the theory of chlorination by-products increasing while increasing organic substances in the water (river water contains much more organic compounds comparing with well water). Some samples were of special interest. These were samples of usual well water and well water chlorinated by 0.49 g/l of SHS. They both had a gray-white taint of unknown origin (Fig. 1 and 2, samples 2 and 4). One can assume that this is probably pathogenic microflora developed due to the lack or absence of disinfectant. Such phenomenon was not observed in other samples with larger SHS doses. Also, there were yellow-white clusters noticed in the sample of tap water with phytoplankton (Fig. 14, sample 3). That could be precipitated salts – carbonates etc.

The residual chlorine content of 0.3 mg/l is considered as normal according to Ukrainian standard. Therefore, theoretically well water chlorinated by SHS dose of 0.49 g/l and river water chlorinated by SHS dose of 3.7 g/l can be consumed by human without risk. But according to Fig.2 (sample 4) and assumptions mentioned above, the SHS dose of 0.49 g/l do not remove all pathogens and drinking such water can be dangerous to health.

Figure 1. Sample 2 (well water with phytoplankton)

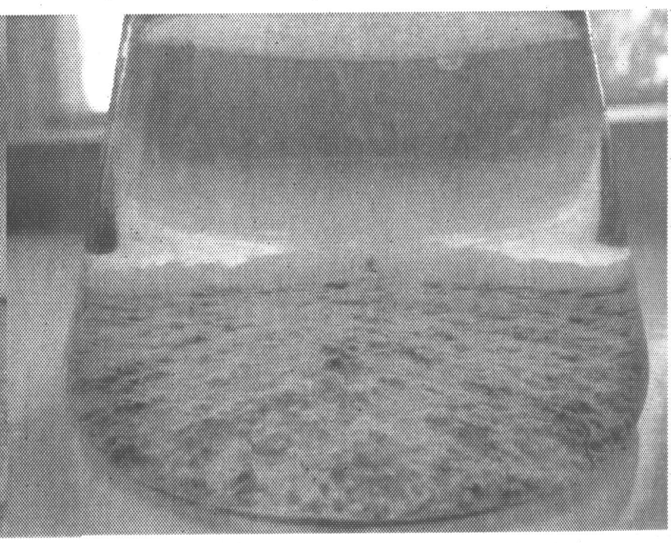

Figure 2. Sample 4 (well water with phytoplankton and SHS dose of 0.49 g/l)

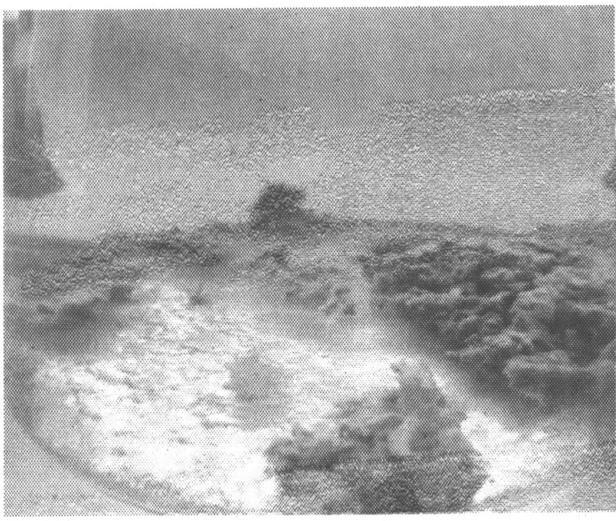

Figure 3. Sample 5 (well water with phytoplankton and SHS dose of 3.7 g/l)

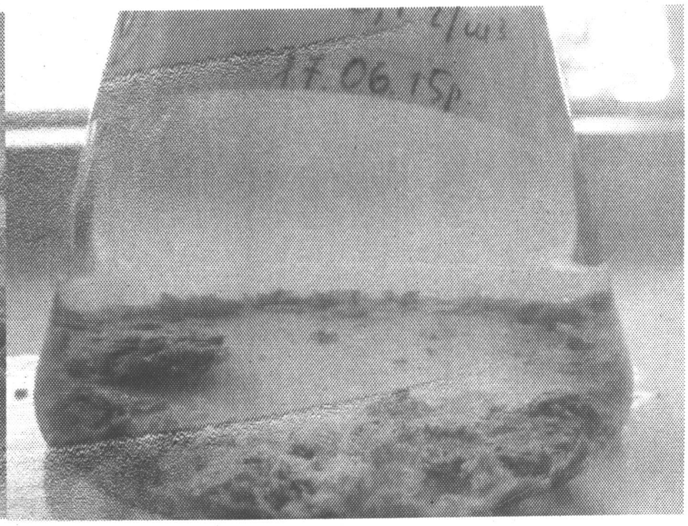

Figure 4. Sample 10 (river water with phytoplankton and SHS dose of 3.7 g/l)

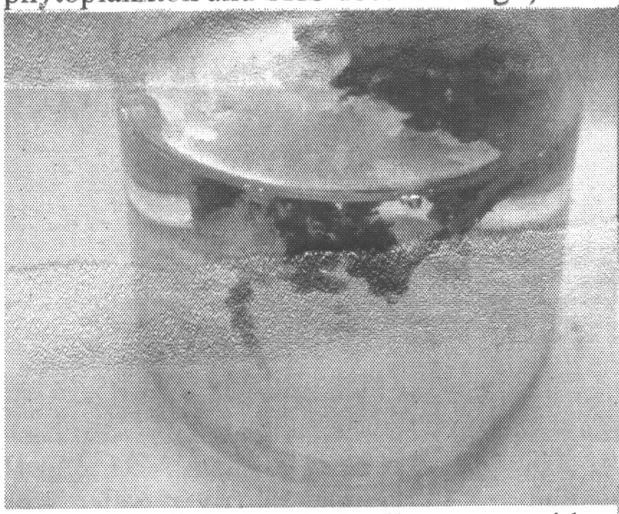

Figure 5. Sample 6 (well water with phytoplankton and SHS dose of 5.57 g/l)

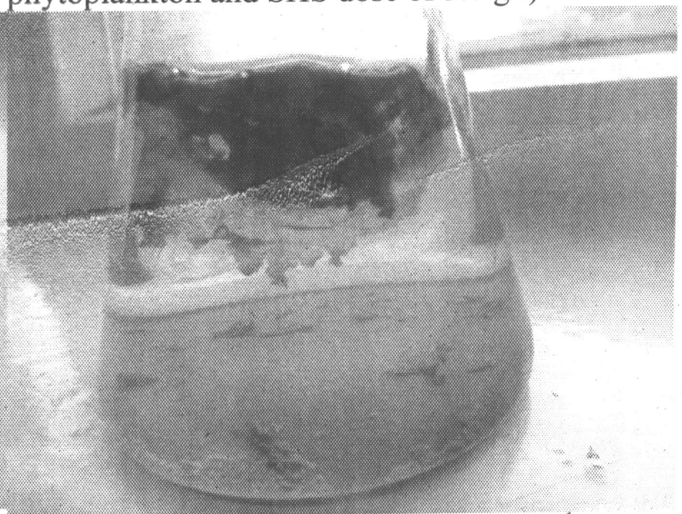

Figure 6. Sample 11 (river water with phytoplankton and SHS dose of 5.57 g/l)

Figure 7. Sample 7 (well water with phytoplankton and SHS dose of 10.0 g/l)

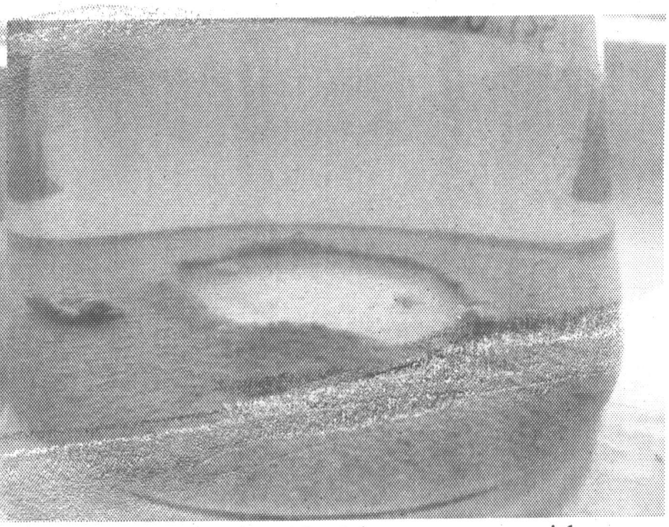

Figure 8. Sample 12 (river water with phytoplankton and SHS dose of 10.14 g/l)

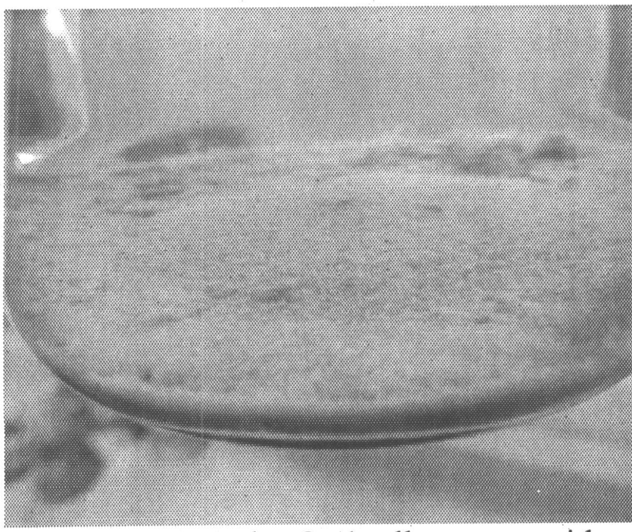

Figure 9. Sample 8 (well water with phytoplankton and SHS dose of 15 g/l)

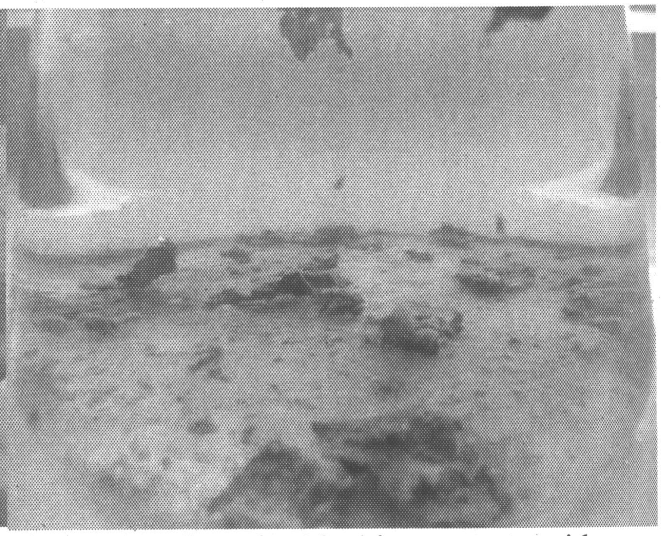

Figure 10. Sample 13 (river water with phytoplankton and SHS dose of 15 g/l)

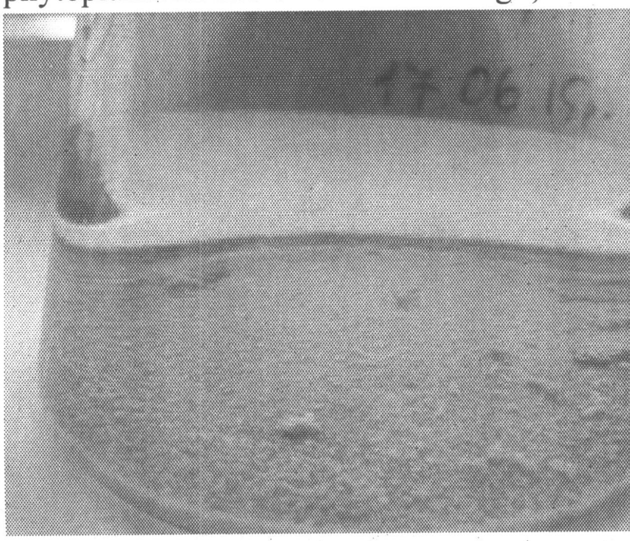

Figure 11. Sample 9 (well water with phytoplankton and SHS dose of 20 g/l)

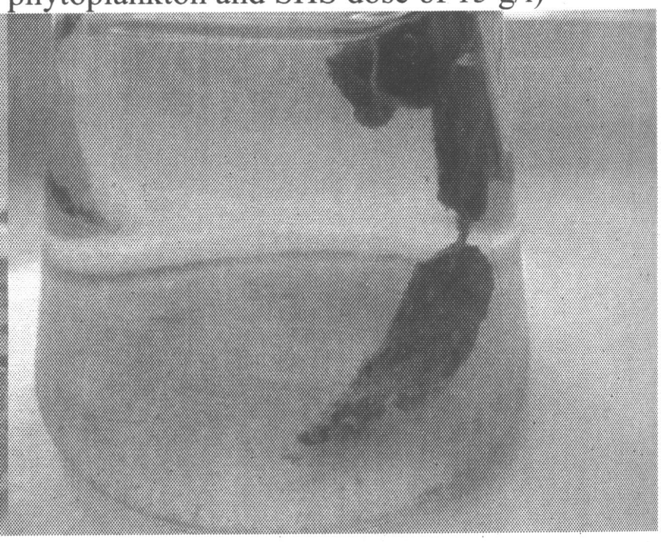

Figure 12. Sample 14 (river water with phytoplankton and SHS dose of 20 g/l)

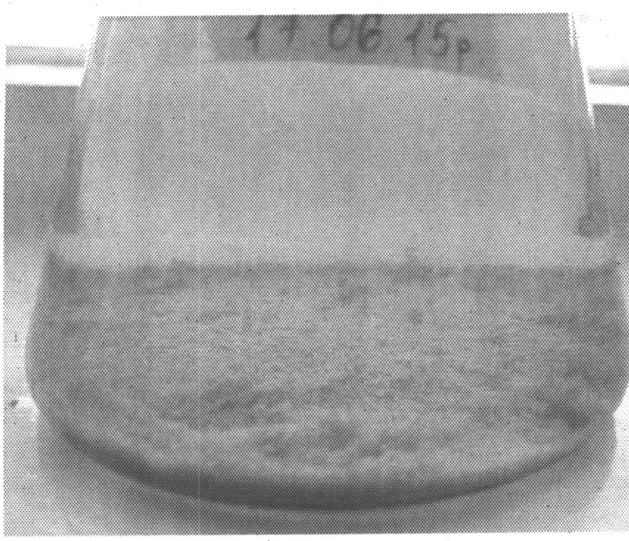

Figure 13. Sample 1 (distilled water with phytoplankton)

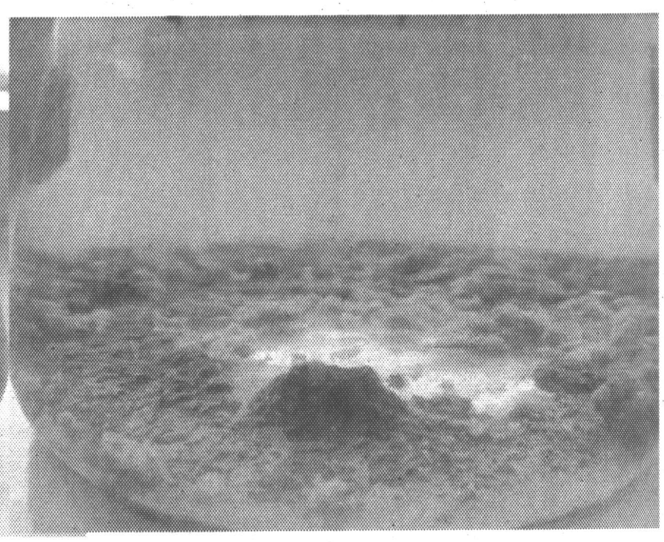

Figure 14. Sample 3 (tap water with phytoplankton)

CONCLUSION

Investigation of the chronic impact (during 90 days) of chlorinated well and river water on phytoplankton and comparing with control samples (without disinfection), resulted in next assumptions. Chlorinated water, in particular by-products of chlorination, indeed affect the phytoplankton activity according to following trends. Increasing SHS doses causes reduction of phytoplankton amount at the end of experiment. Besides, the fact that more phytoplankton was found in the samples of well water compared to the samples of river water with the same SHS dose confirms the theory of chlorination by-products increasing while increasing organic substances in the water. It was also experimentally studied that SHS dose of 0.49 g/l providing free residual chlorine content in the normal range does not remove all pathogens. Therefore, the main objective of water disinfection can not be achieved in this case.

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