Combined method of UV treatment and ozonation during water disinfection in swimming pools

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Abstract

Operation of pools requires a complex of measures for filtering and disinfection of water. The technology of complex water disinfection in swimming pools is proposed with the help of UV radiation and with the use of ozone formed by short-wave UV radiation of lamps. The study of the effectiveness of bactericidal decontamination of water using the installation was carried out in a pool of 80 m^3. This installation provides a dose of irradiation of water not less than 250 J/m^2 and additional ozonation with an amount of ozone of approximately 0,1 g/m^3 of water. In order to ensure circulation of water, at least 5 times the exchange, two sets of capacity of 10 m^3/h were installed per day. At additional ozonation, the microbiological number does not exceed 25 CFU/cm^3. Additional ozonation (with a dose of 0,1 g/m^3) using the UV technology of disinfection of water provides the necessary bacteriological purity of water in small pools, while the residual concentration of ozone in water does not exceed 0,015 mg/l.

Introduction

Construction of swimming pools is an integral part of social infrastructure development programs for cities. The use of swimming pools becomes a norm and indicator of a healthy lifestyle for a large part of the population. But along with the healing effects there is a possibility of harmful influence of water in the pool on the human body, in particular the irritating effect of chemical impurities in water on the skin and mucous membranes, intoxication with the ingestion of harmful substances in the respiratory tract and accidental ingestion of water in the gastrointestinal tract. There is also the probability of infection with diseases of an infectious nature that can be transmitted through the water of swimming pools and swimming.

The purpose of this study is to investigate the effectiveness of bactericidal water purification systems for pools of small volumes using ozone and UV irradiation of water.

Operation of pools requires a complex of measures for filtering and disinfection of water. The application of technologies that do not lead to the formation in the process of decontamination of toxic compounds, while completely destroying pathogenic microflora and do not affect human health is an important at water disinfection. Microbiological indicators of water should ensure the impossibility of transmission of various infectious diseases through water.

The combined methods are the most widely used now: UV irradiation in combination with chlorination and UV irradiation combined with ozonation.

Therefore, the purpose of this study is to investigate the effectiveness of bactericidal water purification systems for pools of small volumes using ozone and UV irradiation of water.

One of the aims was to study the possibility of bactericidal decontamination of water in the pools with the complex effect of UV irradiation and ozone without the use of an additional ozonizer, and using ozone formed due to short-wave UV radiation of the lamps. The method of ultraviolet disinfection is widely used in various fields of human activity when irradiating surfaces, water disinfection, etc.

At present, there are more than a hundred different water disinfection's products in swimming pools, including:

• trihalomethanes - chloroform, bromoform, bromodichloromethane, etc.

• nitrosoamines, which are formed as a result of the entry of toxins with a high level of nitrogen (brought by swimsuits into the pool water). N-nitrosamines are very toxic compounds that cause a mutagenic and carcinogenic effect even at low concentrations. Their permissible concentration is 7,10-5 mg/l (data from the national standard for drinking water quality in the USA);

• bromine and iodine-containing products, chloramines, which are formed during the process of water chlorination. They have a stronger cytotoxic and mutagenic effect than chlorine. Some compounds have a carcinogenic effect.

An oxidation process is used to reduce the concentration and neutralization of the formed toxic products, which leads to the complete or partial destruction of contaminants molecules. Existing oxidation technologies are based on the use of OH radicals.

The chlorination is the most common method of water disinfection until now. But, its use is reduced due to lack of effectiveness to enteroviruses and protozoa, the formation of hazardous by-products, as well as the negative impact on the mucous membranes and respiratory tract.

Ozone can be used as a disinfectant an alternative to chlorine. Ozone not only has a bactericidal effect on the pathogenic microflora, but is also capable of destroying many of the chemicals compounds presented in water which leads to eliminate tastes and odors. As known, ozone easily decomposes with the formation of atomic oxygen which is one of the most powerful oxidants. Atomic oxygen destroys bacteria, spores, viruses, and organic substances dissolved in water. This property allows using the ozone not only for disinfection, but also for water deodorizing. The disinfecting effect of ozone is about 15–20 times greater than the chlorine action, and about 300–600 times stronger in relation to spore forms of bacteria.

Ozonation for disinfecting water in swimming pools is widely used in the USA, France, Japan, Finland, and Germany. Primary ozonation in small doses (1,5-2,0 mg/l) in combination with other technologies, including UV disinfection, is most commonly used method. UV-irradiation of water does not create by-products. Its dose can be selected in such to ensure epidemiological safety, both with respect to bacteria and viruses. Also, it was established that UV radiation effects on viruses stronger than chlorine.

The method of ultraviolet disinfection of water is one of the physical, reagentless methods. These methods have a number of significant advantages over chemical reagent method, most of which is the lack of changes in the composition and organoleptic properties (smell, taste). In cases of overdose the chemical reagent method also may have some negative effects.

Bactericidal effect of ultraviolet radiation acts on the wavelength range of 205-315 nm which leads to photochemical damage of DNA. Changes in the DNA of microorganisms accumulate and lead to a slowdown in their breeding and subsequent extinction in the first and subsequent generations. The most effective impact energy of UV radiation from germicidal perspective occurs at a wavelength of 253,7 nm.

Thus, the presented method of disinfection is quite effective, but it has one major drawback, which consist of the absence of radiation aftereffect.

Method

For the implementation of UV technology of water disinfection in pools of small volumes (up to 50-100 m^3) with the use of ozone, which is formed due to shortwave radiation from lamps, we have developed the design of the installation presented in Fig. 1.

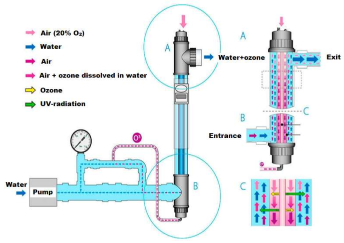

Figure 1 Design of the installation for water UV-disinfection in swimming pools with using ozone.

The installation includes a cylindrical chamber with an inside diameter of 90 mm and a length of 950 mm, in which the UV lamp placed in the quartz cover is located along the chamber axis. The diameter of the lamp is 19 mm, the diameter of the cover is 30 mm, and the thickness of the wall is 1,2 mm. Such a design allows an effective passage of the UV-flux, through the water circulating inside the chamber. Ozone which formed in the air space between the lamp and the walls of the quartz cover is fed into the water using an ejector. The volume of air passing through the chamber is 240-250 l/h.

This installation provides a dose of water irradiation not less than 250 J/m^2 and additional ozonation with an amount of ozone of approximately 0,1 g/m^3 of water. The residual concentration of ozone entering the pool after UV irradiation does not exceed 0,015 mg/l (with a norm not more than 0,02 mg/l).

The study of the effectiveness of bactericidal decontamination of water using the installation of described design was carried out in a pool with a volume of 80 m^3.

Two installations of capacity of 10 m^3/h each equipped with lamps of type ZW80D19Y and ZW80D19W were used in order to ensure water circulation at least 5 times per day. Characteristics of the lamp are presented in table 1.

Table 1 Characteristics of quartz glass lamps capacity of 80 W

Type of lamp	P, W	Distance UV radiation 1 m, W/cm²
ZW80D19Y (ozone)	80	240-270
ZW80D19W (without ozone)		

Results

The results of bacteriological studies of water in the pool under different operating modes of installation are summarized in table 2.

Table 2 The results of bacteriological studies of water in the pool

Parameter	Limit value (Method)	Research results			
		Initial water indicators	UV irradiation without ozone (after 4 days)	With water ozonation 1 and 2 days after complex ozone and UV radiation	
Number of colonies at 37°C	100/ml (EN ISO 6222)	5	125	18	7
Coliforms	0/100 ml (EN ISO 9308-1)	-	1300	750	-
Enterococcus	0/100 ml (EN ISO 7899-2)	-	-	-	-
E.coli	0/100 ml (EN ISO 9308-1)	-	-	-	-

Bacteriological tests of water in the pool showed that the ultraviolet decontamination without ozonation does not meet the requirements [DsanPin 2.2.4-171-10] of the number of colonies CFU/cm^3. At additional ozonation does not exceed 25 CFU/cm^3. However, combined action of ozonation (with concentration of azone of 0,1 g/m^3) and the UV-disinfection technology can provide the necessary bacteriological purity of water in small pools.

Conclusions

An installation for the combined disinfection of water in swimming pools by means of UV irradiation and using ozone formed by low-pressure discharge lamps has been proposed and investigated.

The following parameters have been found effective for the required level of disinfection: a) productivity of a UV installation an exposure dose of 250 J/m^2 is 10 m^3 of water per hour; b) productivity of the ozone generation is 1,0 g/h, which provides an ozonation dose of 0,1 g/m^3.

The required bacteriological purity of water has been provided by two installations with a total circulation capacity of 20 m^3 per hour for a pool with a water volume of 80 m^3. The concentration of ozone in water fed to the pool after irradiation did not exceed 0,015 mg/l.

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