Effect of nano silica on water quality, health and safety in swimming pools

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Abstract

The purpose of this study has been to review of using nano-silica on the efficiency of water treatment of the swimming pool. The current research was an experimental study and was performed in-vitro and experimentally. At first, a nano-particle, called "Nano-Silica", was prepared in the laboratory and herbal additives such as turmeric, curries, saffron and cinnamon were used to increase its antibacterial property. Then, for performing microbiological tests, the water samples of Urmia University's swimming pool were studied in a multi-stage process, in two parts including water samples before adding the nano-particle and after the addition of the nano-particle. Finally, to study the safety and safety, among the relevant factors, the PH and turbidity were studied in the laboratory again in two parts, including before and after the addition of the nano-particle. The survey results showed that there are averages of 2.0633 and 1.0325 before and after adding the nano-particle, respectively, which is higher (P <0.05). Among the mentioned additives, the curries with 92% and the turmeric with 85% had the most antibacterial properties. But the nano-particle did not adjust the swimming pool water PH up to the optimal level of 7.2. However, it reduced the swimming pool water turbidity significantly. This study showed that by using the nano-silica and adding the herbal additives such as cinnamon and saffron, the swimming pool water treatment has reached to a better quality.

Keywords: quality, health, safety, nano silica, swimming pool.

Introduction

Swimming is a popular sport that takes place in the swimming pools, water parks, hot ponds, lakes, rivers and the sea. Over the past century, the use of modern disinfecting systems of the pools has caused the quality improvement of the water funs and entertainments (1). However, in recent decade, the percentage of disease incidence due to swimming has increased significantly (2). The swimming pool is a suitable location for transmission of infectious and skin diseases. The health and safety of swimming pools can be investigated by considering two aspects of microbial contamination and chemical contaminations. Swimming is an important exercise that should be continued to benefit from its advantages, but the truth is that many countries do not pay enough attention to the health and hygiene of these amusement parks. Believing that the chlorine could destroy all the risky contaminants of these waters is a wrong assumption, and furthermore, even if such matters are being observed, it cannot be ensured that no human excrements and wastes would remain in these waters. All pathogenic microorganisms such as bacteria, viruses, and protozoa and parasite worms exist in the human excrements that can be easily transmitted through these public waters. The waters of swimming pools used by the swimmers are contaminated due to addition of substances from
the swimmers' bodies such as hair, fat, respiratory and digestive systems microbes and other harmful bacteria and waste material in the skin, and since this contamination level is increasing frequently and regularly due to swimming and different people uses of the swimming pools, such places are a very good place for contamination of a lot of people who use the pools' water; extensive studies have shown that the symptoms of respiratory and gastrointestinal systems diseases are more among the swimmers than the non-swimmers. Hence, to prevent such diseases, the health and hygiene standards developed for swimming pools have to be considered. These criteria include the followings depending on their degree of importance: limpidness and clearness of the pool water, temperature, amount of free chlorine and residual amount of microscopic organisms. The entire time that the pool is being used, it should be observed that the water is clear, limpid and clean. The knowledge of disease transmission confirms that some diseases occur due to improper establishment or operation and inappropriate handling of chlorine of the swimming pools and as a result of contact with or swallowing contaminated water, including typhoid, diarrhea, infectious hepatitis and gastrointestinal diseases, conjunctivitis, trachoma, leptospirosis, fungal diseases and skin infections, schistosomiasis and giardiasis, the swimmer's itch, upper-respiratory tract illnesses such as sinus infections, infectious pharyngitis, middle ear infections, recurrent inflammations of mucous covering the eyes, ears and throat (1).

The chlorine in the swimming pools water intensifies the risk of involving asthma and allergies. The chlorine in the swimming pools water triggers the asthma and chest wheezing in children and can aggravate the risk of asthma and allergies involvement (3). The results of a new research in the Lovine University of Brussels show that swimming in the pools that are disinfected with chlorine will put children at the risk of asthma and a variety of allergies involvement. It was shown in this study that children and adolescents that swim more than 1,000 hours in these pools, whether indoor or open, more than eight times are at risk for asthma. While swimming in pools that are disinfected with copper- silver method is in no danger. The researchers in Belgium have analyzed the data of 190000 teenagers with the age ranging 13 to 14 years old in 21 countries (4). These adolescents were asked to explain their respiratory problems, hay fever and allergic eczema. In this study, the researchers found the prevalence of asthma and chest wheezing in small and large towns, in which the density of indoor pools was high. So that, the prevalence of asthma and chest wheezing increased per one unit of indoor pool as 2.73% and 3.39%, respectively. It was seen in the study that the prevalence of such problems was more in West Europe than East Europe, which indicated the more number of pools in the western part of the continent (5). The presence of chlorine in pool water has had a very important effect on the occurrence percentage of allergic diseases in the studied group. The nitrogen tri-chloride was known as the increasing causes of asthma prevalence of in the indoor pools. The nitrogen tri-chloride is an irritating gaseous substance that can easily enter the lungs. This chemical, also called tri-chloramines, is released when the chlorinated water react with urine, sweat or other organic materials of the swimmers' bodies. However, if chlorine is used in an appropriate amount and properly for this purpose, it will be safe and effective, but since, a tremendous amount of chlorine is often used for water disinfection or the indoor pools space, it causes irritability in the body's organs that are in contact with air and water of the swimming pool environment, and as a result, the permanent swimmers are prone to allergies and asthma (6).

As chlorine react with the bacterial and other organisms' proteins and destroy them, it can also react with skin proteins. This reaction causes the horned layer of cells or stratum corneum cells lose their cohesion and thus lose their effectiveness. This is the basis of damage to skin caused by chlorine. People who have a dry and sensitive skin involve rubefaction, dryness and itching of the body in more severe cases due to effects of contact with chlorinated water. The chlorine in the pool water, especially if it is high (especially in susceptible individuals) can cause stimulation, itching, irritation and inflammation of the eyes. The allergy symptoms show them as redness, irritation, itching and pimples under eyelids. The prone people should use swimming goggles that water cannot penetrate into them. The chlorine also can cause hair loss (6). The colored hairs are very sensitive to chlorine and lose their color by chlorine exposure. Inhaling chlorine from pool water in the long term damages the lungs (especially in patients with respiratory irritations and asthma). If the chlorine concentration would not be controlled properly, it can cause even bronchitis in the long term. Chlorine gas has a sharp and nasty smell, and is yellowish to green. The applications and uses of chlorine in the industry is so many and include: production of bleaching powders, paper and textile industries, the disinfectant substance in order to disinfect drinking water, swimming pools and wastes, preparation of chlorinated organic and mineral compounds and metal chloride combinations, production of solvents and pesticides, polymers, and the coolant or cooler materials (7). Chlorine gas is a strong stimulant of skin mucosa and respiratory system. This gas combines with the body moisture and produces an acid and is considered as a suffocating substance,
since it causes severe contraction of the laryngeal muscles and its mucosa swelling (6). It has been attempted in this study to find an alternative for chlorine and its derivatives using the updated world technologies, which would be healthier and safer from the health and safety standpoint and more costly compared to chlorine (8). The purpose of this study was to study the impact of nano-silica on water efficiency safety and of swimming pool. The following objectives were considered as the research specific objectives:
1. To determine the effect of using nano-silica on the increase of swimming pool water safety
2. To determine the effect of using nano-silica on the improvement of swimming pool water health conditions

Methodology
This study was an experimental research type and has been performed experimentally (Nanochemistry laboratory materials and equipment). At first, the nano-silica was prepared and synthesized; then, the nano-particle was tested to measure other variables listed in the hypotheses, and finally, the comparison with samples collected from the pool was done. In this study, the quite herbal materials such as turmeric, curry powder, cinnamon and saffron were used to increase the antibacterial properties of the silica nanoparticles by applying adsorption technique. Some amount of these spices was solved in alcohol and was passed through the filter paper. Then, the silica nanoparticles were added to it and was slowly stirred and mixed for 24 hours at environment temperature. Microbiological tests were performed in the laboratory in two steps, including before and after adding the nano-silica. A spectrophotometer device was used for measuring the turbidity and PH.

Results
The reliability test results showed that the research tool had a good reliability (Cronbach's alpha equal to 0.9). The results of research hypotheses testing are shown in the Table 1. The first hypothesis has investigated the impact of nano-silica on the efficiency increase of water treatment in swimming pool. The average total amount, standard deviation and the t level have been obtained respectively as 12.1474, 1.51618 and 9.471. In the second hypothesis that the impact of using nano-silica on reducing the chemical contaminations of the swimming pool water has been studied, the total average amount, standard deviation and the t level have been obtained respectively as 1.2650, 2.29249 and 1.104. The third hypothesis that has studied the use of nano-silica impact on reducing the physical contaminations of the swimming pool water, the total averages values have been measured as following: in water sample without chlorine: 1571; in d sample (cinnamon): 1691; in k sample (curries): 1730; in zm1 sample (saffron): 2676; and in zm2 sample (turmeric):1611. The standard deviations were respectively as: 37573, 38156, 38751, 37705 and 3900.

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<th>Hypothesis</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Conclusion</th>
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<td>1-The use of nano-silica on the increase of swimming pool water safety</td>
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<td>.37573</td>
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| 2-The use of nano-silica on the improvement of swimming pool water health conditions | Before adding the nanoparticle | 2.0633 | 16781.63679 |
| | After adding the nanoparticle | 1.4000 | 1145.64392 |
| | | 26.6667 | 46.18802 |
| | | 40.0000 | 69.28203 |
| | | 6.4367 | 871.56201 |
The last hypothesis has reviewed the impact of using nano-silica on the reduction of microbiological contaminations of the swimming pool water. The total average in the swimming pool water samples before adding the nano-silica was 2.0633. After addition the nanoparticle, the total average values in the D, K, ZM1 and ZM2 samples became respectively as: 40.0000, 26.6667, 1.4000, and 6.4367. The standard deviation in the pure sample has been as 16781.63679 and in the test samples as 1145.64392, 46.18802, 69.28203 and 871.56201, respectively.

Discussion
This study was performed to review the effect of nano-silica on the reduction of physical contaminations of the swimming pool water. These contaminations include insoluble impurities and colloidal materials entered by the swimmers and from the surrounding environment into the pool water, and cause the water turbidity. Based on the t test used, the t values in D, k, zm1 and zm2 samples were more than the t value in pure water, which is equivalent to 5.928, and the degree of freedom was 200, and the obtained t values in all groups was greater than the significance level. Thus, the significance level of the table was smaller than the error (P <0.05), and this is the reason of the hypothesis significance level. Accordingly, we come to the result that the impact of physical contamination on reducing the physical contaminations of the swimming pool water is positive. Regarding the same subject, Jennifer Lynn has used the nano-titanium to remove the sunscreens particles from the swimming pool and has come to the conclusion that this nano-particle is able to remove 100% of the particles (9).

In continue, the effect of using nano-silica on the reduction of microbiological contaminations of the swimming pool was evaluated; the t test was used, and the average before adding the nanoparticles was equal to 2.0633 and after adding was equal to 1.0325, which is larger. Thus, the significance level of the table was smaller than error (P <0.05), which is the reason for the hypothesis meaningfulness. Comparing the table data, we conclude that using the nano-silica is effective on reducing the microbiological contaminations of the swimming pool. This hypothesis is confirmed by 95% confidence and is stronger than other variables. Accidentally, Osman San has studied the antimicrobial properties of Borosilicate glass powder with a spherical shape in his research and concluded that with adding silver oxide to nano-silicate, the antibacterial properties of the powder has had a significant increase (10). F. Barzegar also in a similar study has used the nano-titanium to reduce the Staphylococcus aureus and E. coli bacteria; the bacteria growth has shown a reduction of 5.6% in the presence of nano-titanium with 1.5% concentrations (9).

Conclusions
Acceptable results were not obtained in this study regarding PH reduction. Also, we found no research in regard to using nano-silica to adjust PH. However, the results showed in general that the use of nano-silica will significantly increase the swimming pool water quality with 95% reliability. Also, we have achieved acceptable results in regard to reduction of physical and microbiological contaminations. Using herbal additives in different combinations of nanoparticles can be used in future research and by other researchers.

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