World Bulletin of Social Sciences (WBSS)
Available Online at: https://www.scholarexpress.net
Vol. 33, April 2024
ISSN: 2749-361X

CHOOSING THE MOST OPTIMAL WAYS OF WATER DISINFECTION.

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Article history:

Received: 10th January 2024
Accepted: 6th March 2024

Abstract:

Water disinfection is a critical process to ensure the safety of drinking water. Various methods exist for disinfecting water, each with its advantages and disadvantages. This article explores the most optimal ways of water disinfection by conducting a comparative analysis of commonly used methods, including chlorination, UV irradiation, ozonation, and filtration techniques. The research methods involved a comprehensive literature review to evaluate the effectiveness, cost, environmental impact, and feasibility of each method. The results and discussion section presents the comparative analysis, highlighting the strengths and limitations of each disinfection method. Based on this analysis, conclusions are drawn regarding the most optimal ways of water disinfection for different contexts.

Keywords: Water disinfection, chlorination, UV irradiation, ozonation, filtration, comparative analysis.

INTRODUCTION: Access to clean and safe drinking water is essential for public health. However, water sources can be contaminated with various pathogens, including bacteria, viruses, and protozoa, posing significant health risks to consumers. Water disinfection is a crucial step in water treatment processes to eliminate these pathogens and ensure the safety of drinking water. Several methods are employed for water disinfection, each with its advantages and limitations. This article aims to evaluate and compare the most optimal ways of water disinfection, considering factors such as effectiveness, cost, environmental impact, and feasibility [1-3].

In this study, various analytical decision-making methods, including TOPSIS, PROMETHEE, and VIKOR, were employed to identify the most effective treatment alternative for the removal of Triclosan (TCS) from both drinking water and wastewater. To assess the treatment alternatives comprehensively, evaluation criteria were established and weighted using the Analytic Hierarchy Process (AHP) and entropy methods. Subsequently, each decision method was utilized to prioritize the treatment alternatives, leading to the unanimous selection of the adsorption process as the optimal solution for TCS removal across all methodologies [4-5].

While the adsorption process consistently emerged as the top-ranking treatment alternative, it's noteworthy that the remaining options, excluding the best and worst two, exhibited varying priority rankings across all decision methods. This variability can be attributed to the distinct approaches and calculations inherent in each decision method [4,23-25]. Consequently, for a precise alternative ranking amalgamating the results of all methods, the outcomes from each decision method can be aggregated and sorted accordingly. Accordingly, the final priority ranking determined through this integrated approach placed adsorption as the most preferred option, followed by membrane filtration, hybrid processes, advanced oxidation processes, constructed wetlands, conventional treatment processes, biological treatment, and other treatment processes. The notable advantages of adsorption processes include their high removal efficiency, cost-effectiveness, ease of maintenance and operation, as well as accessibility. However, concerns persist regarding the limited application of novel, natural, and biosorbents in full-scale implementations, posing challenges for the modernization of conventional drinking water and wastewater treatment plants [5-8].

In the realm of drinking water treatment, the utilization of disinfection methods has long been recognized as indispensable for controlling microbial pathogens. However, recent decades have unveiled a conundrum between the efficacy of disinfection and the emergence of detrimental disinfection byproducts (DBPs). Commonly employed chemical disinfectants in the water industry, such as free chlorine, chloramines, and ozone, have been found to undergo reactions with various constituents present in natural water, resulting in the formation of DBPs, many of which possess carcinogenic properties. Notably, the literature has documented over 600 distinct DBPs [9-14].

RESEARCH METHODS:

To identify the most optimal ways of water disinfection, a comprehensive literature review was conducted. Peer-reviewed scientific articles, research papers, and reports from reputable organizations were examined to gather information on various disinfection methods, including chlorination, UV irradiation, ozonation, and filtration techniques. The literature review focused on evaluating the effectiveness of each method in disinfecting water, as well as considering factors such as cost, environmental impact, and practical feasibility.

RESULTS AND DISCUSSION:

Chlorination: Chlorination is one of the most commonly used methods for water disinfection. It involves adding chlorine or chlorine compounds to water to kill or inactivate pathogens. Chlorination is highly effective against a wide range of microorganisms and has a residual disinfectant effect, providing ongoing protection against recontamination. However, chlorination can produce harmful disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAAs), which are carcinogenic and pose health risks. Additionally, chlorination may not effectively eliminate certain pathogens such as Cryptosporidium.

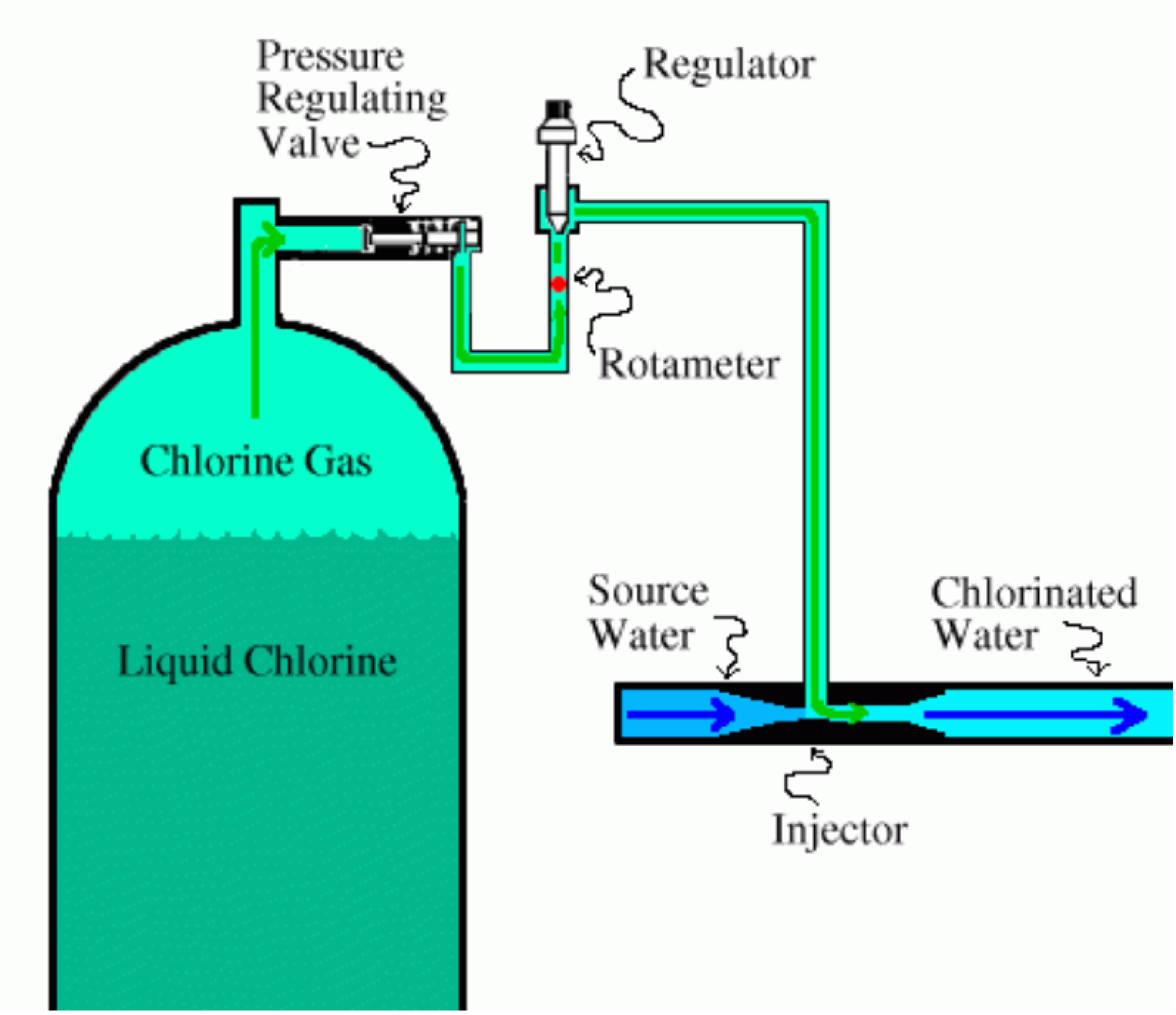

Fig. 1. Chlorination

Water chlorination is the process of adding chlorine (Cl_2) or hypochlorite to water. This method is used to kill certain bacteria and other microbes in water. In particular, chlorination is used to prevent the spread of waterborne diseases such as cholera, dysentery, and typhoid [16-19].

One of the primary advantages of chlorination is its effectiveness in destroying a broad spectrum of microorganisms, providing a reliable barrier against waterborne pathogens. Chlorine compounds, such as chlorine gas (Cl_2), sodium hypochlorite ($NaClO$), and calcium hypochlorite ($Ca(ClO)_2$), are commonly employed for this purpose. These compounds work by

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Available Online at: https://www.scholarexpress.net
Vol. 33, April 2024
ISSN: 2749-361X

oxidizing and disrupting the cellular structures of microorganisms, rendering them inactive and unable to cause infections.

Furthermore, chlorination offers residual disinfection, meaning that a certain level of chlorine remains in the water distribution system to provide ongoing protection against microbial regrowth and recontamination. This residual disinfection is crucial for maintaining water quality throughout the distribution network and ensuring that consumers receive safe drinking water at their taps.

Despite its effectiveness, chlorination does have some drawbacks. One notable concern is the formation of disinfection byproducts (DBPs) when chlorine reacts with organic matter present in water. These DBPs, including trihalomethanes (THMs) and haloacetic acids (HAAs), have been associated with potential health risks, including cancer and reproductive effects. To mitigate DBP formation, water treatment plants may employ strategies such as optimizing chlorine dosage, using alternative disinfectants, or implementing additional treatment steps such as activated carbon filtration.

UV Irradiation (Bactericidal light treatment of water): UV irradiation is a chemical-free method of water disinfection that involves exposing water to ultraviolet light to destroy the DNA of microorganisms, preventing them from reproducing. UV irradiation is highly effective against bacteria, viruses, and protozoa and does not produce harmful by-products. However, UV irradiation requires electricity to operate, and the effectiveness of the process can be influenced by factors such as water turbidity and organic matter content. Additionally, UV irradiation does not provide residual disinfection, so additional measures may be needed to prevent recontamination.

Bacteria in water can also be neutralized by treating water with ultraviolet rays. For this, water is treated with rays with a wavelength of 2200-2800 A°, which have a bactericidal effect. 1 A° is equal to 10-10 meters. Disinfection is carried out in special devices. Water must be clear to use bactericidal irradiation. Mercury-quartz or argon-mercury lamps are used as a bactericidal light source for water disinfection. In this case, the clear water as a thin layer is exposed to bactericidal light while passing around the lamp and is neutralized. Of course, the coefficient of light resistance of different bacteria is different. This is taken into account in calculations using the coefficient of resistance.

The bactericidal device calculation is based on the determination of the bactericidal irradiation power.

$$F_b = \frac{[(Q \cdot \alpha \cdot k \cdot \lg \cdot (P/P_0))]}{1563{,}444 \cdot \eta \cdot \eta_0}, \quad \text{wt}$$

In this,
Q-calculated water consumption, m3/h,
α- absorption coefficient of irradiated water, cm -1
k - for colorless groundwater ((0.1-0.15cm -1
lg - for cooled surface water ((0.3 cm -1
k-bacteria resistance coefficient, usually k=2500μm.vt. s/cm2 is acceptable.
Pn, Po-water coli index before and after irradiation. UzDSt 950. According to 2000 Po>3
ηn- coefficient of use of bactericidal light depending on the type of device
η0 is the useful work coefficient of bactericidal radiation η0=0.9

Knowing the irradiance requirement of the bactericide, the power generated by one lamp and the number of lamps required can be found.

$$n = \frac{F_h}{F_l}$$

Fl=35-50 is the power produced by one lamp
Advantages of bactericidal irradiation over chlorination:
1. Relative simplicity of operation
2. No need to add or remove reagents
3. The taste of water is not spoiled. Decontamination of water using bactericidal rays does not cost more than chlorination.

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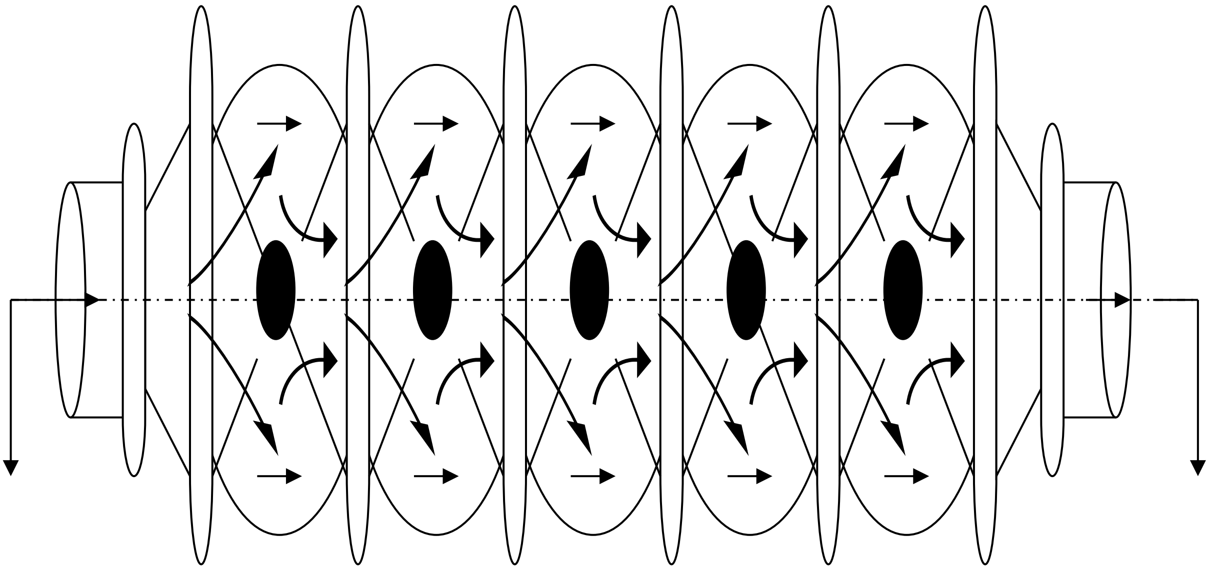

Fig. 2. a) OV-AXK bactericidal device with PRK-7 lamp

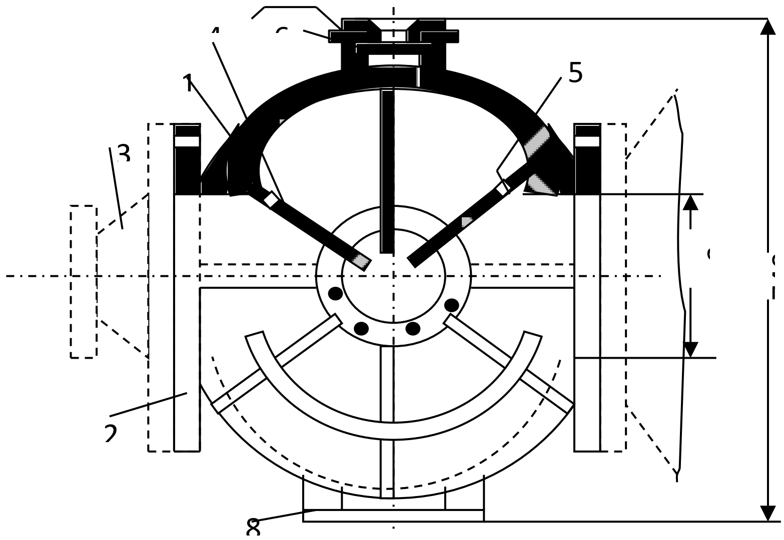

Figure 3. OV-AXK bactericide with PRK-7 lamp water disinfection chamber of the device

1 – body, 2 – flange, 3 – transition from the pipe to the device, 4 – barriers, 5 – a hole, 6 – a hole with a cover, 7 – a device for monitoring the operation of the lamp from above, 8 – tightly closed cover [20-23].

Ozonation: Ozonation is a process that involves injecting ozone gas into water to disinfect it. Ozone is a powerful oxidizing agent that effectively kills bacteria, viruses, and other pathogens. Ozonation does not produce harmful by-products and can effectively remove taste and odor compounds from water. However, ozonation can be expensive to implement and requires careful monitoring and control to ensure proper dosage and contact time. Additionally, ozone is unstable and must be generated on-site, which can increase operational complexity.

Azonation of water, i.e. passing air containing triatomic oxygen (O3) through the water layer, can also be used for water disinfection.

The amount of azon for underground water is 0.75-3 mg/l., for settled surface water is 1-3 mg/l. A water azan device is used to obtain azan. In this case, azan is obtained by introducing a "quiet" electric charge into the dried and cooled air.

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The advantage of water purification is that it does not spoil the taste of water. Azonation is used against water discoloration and odor.

Filtration Techniques: Filtration techniques such as membrane filtration, sand filtration, and activated carbon filtration are commonly used for water treatment and can effectively remove pathogens, suspended solids, and other contaminants from water. Filtration can be combined with other disinfection methods to provide multiple barriers against contamination. However, filtration alone may not be sufficient to achieve complete disinfection, especially against smaller microorganisms such as viruses. Additionally, filtration systems require regular maintenance and replacement of filter media to ensure proper functioning.

Comparative Analysis: Each disinfection method has its advantages and limitations, making them suitable for different applications depending on factors such as water quality, treatment goals, and operational constraints. Chlorination is widely used for its effectiveness and residual disinfection, but concerns about DBPs and microbial resistance have led to increased interest in alternative methods such as UV irradiation and ozonation. UV irradiation offers a chemical-free approach with no harmful by-products, making it suitable for applications where chemical disinfectants are undesirable. Ozonation provides effective disinfection and can improve water quality, but it is more costly and complex to implement compared to chlorination or UV irradiation. Filtration techniques are often used in conjunction with other disinfection methods to provide multiple barriers against contamination, but they may not be sufficient on their own for complete disinfection.

CONCLUSION: In conclusion, the treatment and use of wastewater offer a sustainable solution to address water scarcity in regions with limited water resources. Effective wastewater treatment technologies, coupled with appropriate reuse practices, can significantly contribute to the conservation of existing basins and the overall resilience of water systems. However, challenges such as regulatory frameworks and public perception must be carefully addressed to ensure the success of these initiatives. Based on the analyzes in the article, it is necessary to increase the efficiency of cleaning in order to get out of the water shortage situation. This comparative analysis sheds light on the diverse water treatment technologies employed in Korea and Uzbekistan. While Korea showcases cutting-edge solutions, Uzbekistan's context-driven approaches highlight the importance of considering local conditions. By sharing experiences and collaborating on research and development, these nations can contribute to a global dialogue on sustainable water management, addressing current challenges and building a foundation for future advancements in water treatment technologies.

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