REVIEW ARTICLE

Drinking Water Treatment System And The Challenges Faced by Developing Countries

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ABSTRACT

This review examines how developing countries cope with the provision of clean and potable water, and the challenges they face. The findings demonstrate that physical techniques including sedimentation, filtration, slow sand filtration, coagulation, and flocculation, as well as disinfection methods like chlorination, are increasingly used in developing nations to treat drinking water. Other key renewable technologies used in developing countries have been developed, including as arsenic removal technologies using cutting-edge solid-phase materials and hybrid filtering processes, and sun disinfection. The absence of natural water sources is the biggest problem facing emerging nations, and flooding brought on by environmental pollution makes clean water sources vulnerable to contamination and difficult to treat. In several countries, it has been reported that even though good water treatment is available, people often have difficulty accessing water sources that have been provided because lack of pipelines reaching remote areas.
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INTRODUCTION

Natural resources like water are crucial for human survival. In the last century, freshwater use has increased six-fold globally and at a rate of about 1% per year since the 1980s. Future water treatment and supply issues are anticipated as a result of rising water usage. Environmental degradation and pollution are a result of industrialization, agricultural production, and urban life. This has a negative impact on water bodies (rivers and oceans), which are essential for life, and will indirectly harm human health (1,2).

Many people around the world did not have access to basic sanitation and drinking water until recently. About 783 million people continued to use inadequate sources of drinking water because lacked improved sources of drinking water, and 2.5 billion people continued to use inappropriate sanitation facilities or defecate in the open, according to data compiled by the WHO on Water Supply and Sanitation (3). According to estimates, women (64%) and girls (8%) spend billions of hours annually gathering water from uncontrolled water sources in many underdeveloped nations (4). Hygiene practices in impoverished nations are frequently impacted by the inconsistent supply of adequate and safe drinking water. Lack of access to safe drinking water can cause adolescents' deaths in the majority of developing nations (5-11). Drinking water distribution in developing nations continues to face significant maintenance challenges, particularly in suburban regions (12,13).

Safe, affordable, and easily accessible water sources are important for human health. But in recent decades, a billion or so people in developing nations have been without a reliable source of clean water. It is estimated that humans need approximately 7.5 liters of water per day to support life, especially for drinking, preparing food, and personal hygiene (14). Most water is for agricultural and ecosystem needs, and even in rich countries, water consumption far exceeds this number (15).

Based on previous reports, it is known that there are several different technologies that can improve water quality. Five are the most promising: filtration with ceramic filters; chlorination with better storage in vessels; solar disinfection in clear bottles; thermal disinfection (pasteurization) in solar cookers or reflectors; and combined systems using chemical flocculation and

chlorination (16). In Malaysia, the implementation of water treatment technology has started by conducting research and development of water treatment methods and carried out either through the private sector or the government. In short, the method used by Malaysia has also been successfully developed by Canada, Japan and Australia (17).

This article provide data on various types of treatment that have been carried out, such as chlorination, combined chlorination and flocculation, filtration, combined filtration and biosolids, combined filtration and chlorination, innovative solid materials, solar disinfectants, innovative technologies, and nanotechnologies. This article will also investigate the obstacles that developing countries have in achieving a sustainable supply of clean water in their regions by exhibiting previously published facts and data.

METHOD

To assess the direction of drinking water treatment development and the difficulties faced in developing nations, a number of databases have been created and collated. Some keywords used were "drinking water treatment", "challenges", and "developing countries". The discussion was carried out in depth by looking at all the existing data and then dividing it based on treatment techniques by displaying supporting literature on each treatment carried out. The challenge variables found are discussed in one paragraph by displaying all the results of the challenges from previous studies. More details can be found in the Discussion section.

RESULTS AND DISCUSSION

Water Treatments in developing countries

The creation of ecologically safe water is the top goal for water treatment in developing nations. Waterborne infections are a significant global issue, particularly in tropical nations with inadequate water supply (18). While not ignoring the water's chemical and physical qualities, emphasis should be made on the treatment's biological effectiveness. The two processing systems include a centralized processing system and point-of-use treatment system. Some of the treatment practices carried out in developing countries during this decade are as follows:

Chlorination

Beginning in the 1900s, cities across the United States and Europe began to add chlorine to purify public water supplies. In developing nations, It is common practice to package a sodium hypochlorite solution with usage instructions for source water purification. For clear water, the user puts one capful of the solution to a typical storage container. After shaking the bottle, the consumer waits 30 minutes before consuming. Because it doesn't leave a deposit in the water, chlorination is used in developing nations (19,20). The existence of a high organic component, which might result in the development of disinfection byproducts that are thought to be carcinogenic, is one of the main difficulties with chlorination. The strategy for implementing chlorine application in several countries is carried out on a national and sub-national scale through social marketing campaigns. In Indonesia, liquid chlorine is distributed through private parties led by manufacturing companies. Something similar happened in countries such as Laos, Ecuador, Nepal and Haiti (21).

Chlorination and flocculation

The majority of the time, flocculation and chlorination processes are combined in hybrid water-treatment systems. A little sachet containing powdered calcium hypochlorite and ferrous sulfate (a flocculant) is an illustration of integrated technology. This method's commercial design is referred to as Pu-R. In order to use Pu-R, the user must first open the sachet and pour the liquid inside into an open bucket that may hold up to 10 liters of water. The water's solids settled to the bottom of the bucket after being agitated for 5 minutes. Pu-R technique oftenly used by developing nation such as Brazil, Uzbekistan, and guatemala (19,20). The user has to wait 20 minutes for the microorganisms to stop being active after filtering the water through a cotton cloth into a different vessel. This technique has been demonstrated to successfully eliminate viruses, bacteria and protozoa even in extremely murky environments (22,23). Because flocculation can remove organic materials from water, it is possible to prevent the production of disinfectant byproducts through chlorination and flocculation.

Filtration

For basic filtration, porous rocks and other organic materials are used, and water has been purified for hundreds of years by removing visible pollutants. Filters are desirable alternatives for treatment at the household level (24,25). To effectively remove pollutants from filter media, a number of interconnected removal processes have been used. As part of this elimination process, deposition on the media, adsorption, absorption, biological action, and filtering are all included (26). For water filtration, there are numerous readily accessible porous materials and affordable alternatives. Filtration methods are often straightforward and simple to operate, and the filter media has a long service life. Filter back flushing and the lack of disinfection residual effects are two maintenance-related downsides of filtration. In order to minimize organic matter, an intriguing membrane hybrid device that combines a thin layer of biomass biosand and a trickling filter has been published in literature (27,28).

Filtration and biosolids

Utilizing biosolids, a more sophisticated filtration technique was created. A slow sand filter that can be used in a domestic setting is the biosand filter (BSF). The

bioactive layer that forms atop the sand when water travels over the filter allows pathogens in the water to be eliminated. When more water flows through the filter, the plate guard stops the water film from being disrupted. It has been demonstrated in the literature that BSF is highly effective at eradicating bacteria and protozoa from water (29,30). Interesting studies using sand filters to remove arsenic from water when there is iron present have been published in Nigerian literature. The filter eliminates arsenic via co-oxidation with Fe(II) and adsorption or co-precipitation with Fe(III) produced on the surface (31,32). The possibility for biofouling to accumulate on the filter surface is one issue with prolonged filter use (33).

Filtration and chlorination

Additionally common are combinations of filtration and chlorination systems (34). In order to solve the drawback of slow sand and ceramic filters' inability to eradicate pathogenic germs from water, a hybrid filter-chlorination technology is employed (35).

Innovative solid materials

Arsenic (As) and its metalloids can be removed from drinking water using metal adsorption phases such as iron oxide coated sand, ferrihydrite red mud, activated alumina, TiO_2, $FePO_4$ (amorphous), MnO_2, MnO_2 charged resins, natural zeolites (such as clinoptilolite), iron oxides, and iron-charged chelating resins (36). This technique involves the electrostatic adsorption of negatively charged virions onto positively charged iron oxide-coated sand particles (37,38).

Solar disinfectant

In developing nations, using sunlight to sanitize water has a lot of potential. The technique that is frequently utilized is called the solar disinfection technique. (SODIS). The water used for oral rehydration solutions (39) was first cleaned using the solar disinfection method (SODIS). Low-turbidity water is poured into a plastic soda bottle that may hold between 0.3 and 2.0 liters, and it is then shaken to provide oxygen. The bottles are placed outside in the sun for six hours and in the clouds for two days (40). Numerous investigations have demonstrated the ability of the SODIS approach to inactivate cryptosporidium, giardia (41), and viruses as well as bacteria. In the literature, there are several developments utilizing UV light (42-45). The affordability of ultraviolet light technology is one of its key benefits but designing the device to best capture ultraviolet light is one of the issues. UV ray intensity can be impacted by seasonal influences. Small amounts and a lengthy treatment process can be problematic. Before treating the water with UV light, it is advised to flocculate or filter the water if it has a high level of turbidity.

Innovative technologies and nanotechnologies

Photocatalysts based on nanocatalysts, such as the Titanium dioxide catalyst, degrade substances like microbes, pesticides, dyes, crude oil, and organic acids by using UV radiation from sunshine. TiO_2 that has been weakened by ultraviolet radiation is being used in pilot projects for drinking water filtration in impoverished nations (46). Another nanotechnology is now being developed in various emerging countries (47,48).

Challenges

The lack of natural water sources in some locations is one of the problems with treating drinking water in developing nations. Flooding can also cause silting of streams, which can lead to various problems. On some occasions, drought is commonly exacerbated by climate change in underdeveloped countries (49,50). Poor treatment of water resources and inadequate access to water sources are other issues that need to be addressed (51). It is necessary to address the issue of affordable water and the difficulties associated with funding water treatment facilities in underdeveloped nations (52)(53). Sobsey, (24) reported that a lack of public education contributed to a lack of awareness regarding appropriate water storage.

An integrated strategy is required to maintain safe and inexpensive drinking water in emerging nations. In addition to treating water resources directly, effective solid waste and wastewater treatment can help raise drinking water quality by removing sources of pollution (54,55). There is still an engaging discussion on the number of drinking water treatment systems operated by private firms in underdeveloped nations (55). The issues of recycled drinking water and water conservation have been debated in developed nations and can also be used in under developed nations. Regarding maintenance and monitoring, it is crucial to examine both large- and small-scale technologies (56,57). It is important to consider the energy requirements utilized during continuous treatment in addition to the technical treatment of clean water. The majority of developing nations are situated in regions of the world with the worst droughts, as well as seasonal variations in rainfall and evaporation that cause droughts at particular times (58).

Everyone has the right to clean drinking water, including women and children (52). The World Health Organization cautions that without taking into account the socio-cultural aspects of the community, as well as without good conduct, motivation, education, and community participation, the introduction of water treatment technology is unlikely to be successful or sustainable (59), it is crucial to create and spread clean water technology for poor nations. This is backed by (60) who stated that in order to ensure the sustainability of clean water sources, the treatment performance framework around drinking water must be maintained (60).

Numerous water sources are exploited for various purposes, which puts a tremendous strain on the

resource and its treatment (61). The carrying capacity of people and an increase in the number of people using clean water cannot be isolated from this (62). To stop the spread of waterborne diseases, developing nations need to enact legislation and audit risk treatment on water conservation (63-68). Future studies on waterborne illnesses will continue (69).

CONCLUSION

The findings show that physical methods for treating drinking water, such as filtration, sedimentation, coagulation and flocculation, and disinfection methods like chlorination, are increasingly adopted in developing countries. Other key methods, such as hybrid filtration, solar disinfection, and arsenic removal employing state-of-the-art solid-phase materials, have also been shown to be renewable technology employed in developing countries. The absence of natural water supplies is the biggest problem faced by developing nations. In addition, flooding bringing environmental pollution leaves clean water sources vulnerable to contamination, making treatment difficult. Additionally, it is worth noting that despite the availability of good water treatment, many people frequently struggle to access the water sources that have been supplied because there aren't any pipes reaching rural places. The primary cause of this issue is inadequate infrastructure and water treatment facilities. The conclusion is that while developing nations have made a variety of efforts to treat drinking water, the are still a number of obstacles that need to be solved in order for them to efficiently offer clean water.

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