Systematic Approach to Global Water Treatment

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Introduction

Bacterial, chemical, and radioactive contaminants threaten water quality and safety to people around the world. People around the world have specific water situations and are in need of tailor made solutions. The goal of this project is to develop water treatment technology that can be used by groups ranging from companies to non-profit organizations and can bridge the gap between water problem and solution. We envision a user-friendly website that can suggest unique treatment methods to the user based on their available resources.

To begin the framework of our project, we gathered information about all possible water contaminants, researched the water treatment process, found sources about water quality regulations to add to our database, and developed a website to prescribe treatment methods.

Objectives

1. Perform a comprehensive literature review to create a database of possible contaminants and characteristics of water hazardous to human health
2. Continue building a database for treatment methods for each type of contaminant
3. Develop website that will provide universal treatment information
   a. Must be user-friendly
   b. Must provide instructions for how to use the treatment
   c. Must provide the amount and type of treatment

Database

To address the plethora of pollutants, each contaminant was categorized by chemical, microbial, and radiological. Topics of occurrences, safe limits, detection and treatment methods were gathered for each category.

Name	Occurrence	Safe amount	Detection limit	Treatment
Arsenic	Found widely in the Earth's crust, fish/shellfish, 1-2 ug/L but reaches to 12 mg/L	0.01 mg/L	0.1 ug/L (ICP-MS), 2 ug/L hydride generation AAS or flame AAS	typical conventional treatments (coagulation)
Fluoride	groundwater but typically does not exceed 10 mg/L with highest being 2800 mg/L	1.5 mg/L	0.01 mg/L be ion chromatography, 0.1 by ion-selective electrodes or through colorimetric method (sulfo phenyl azo dihydroxy naphthalene disulfonic acid)	activated alumina

Figure 1. Example of Database for Chemical Contaminants

Website

The first iteration, a MATLAB app, was designed to prescribe treatment based on the detected contaminant. The user will input the type of disinfectant they plan to use, the concentration of that disinfectant they have, and the amount of water that needs to be purified. A sample design for chlorine disinfection of water contaminated with E.coli is shown:

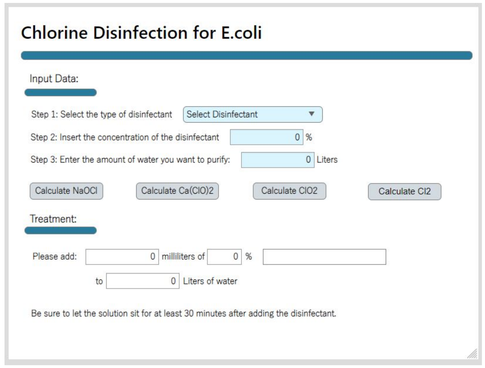

Figure 2. MATLAB App for Chlorine Disinfection

This app will calculate the amount of chlorine treatment necessary to add to the given amount of water to be purified. However, MATLAB is not widely accessible to the public, so an alternative approach was to create a website.

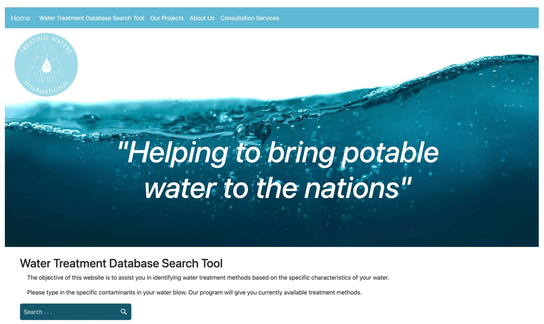

Figure 3. Website — User Interface

The website comprises two primary components: the user interface and the database. The user interface is a search tool displayed on the website, as shown in Figure 3. The database stores data obtained from the spreadsheet mentioned in the database section, which compiles information on contaminants gathered from WHO and EPA resources. Users can input a contaminant, and the tool will retrieve relevant information, such as treatment methods, from the database, ensuring a convenient user experience.

Search results:

Contaminants	Treatment	Background	Occurance	Safe Amount	Danger Level	Source	Page Number
Aldicarb	GAC or ozonation	Systemic pesticide used to control nematodes, insects, and mites. Extremely soluable in water	In as a Contaminant in groundwater (near application areas)	0.01 mg/L	less toxic	WHO (2022): Guidelines for Drinking Water Quality	331

Figure 4. Example Search Result of Aldicarb

Water Treatment Process

Step 1

Contact Biola University consultation group with any questions via water treatment website. Consultation group will give you further instructions

Step 2

Determine contaminants in the water sample by first using simpler/cheaper testing techniques like test strips. The slew of things to test are influenced by the region's water regulations

Step 3

With the known contaminants, take a water sample to the laboratory for further detailed testing

Step 4

Use website to determine the appropriate treatment

Step 5

Treat water according to directions provided with feedback from the consultation group

Figure 5. Timeline Steps For Treatment Process

Research

For our database, in addition to using governmental documents and literature review, we will also update it with our experimental findings from the chemistry research side. For example, our research group analyzes different ways to treat excessive fluoride in water. In our database, we would add methods of how fluoride is currently being treated (i.e. activated alumina) and how we are modifying the adsorbents to increase adsorption capacity. Our research group has tested the effectiveness of using activated carbon and aluminum hydroxide as well as zeolites with titanium sulfate to treat fluoride.
This project is truly a multidisciplinary one that involves computer programming, chemistry and engineering.

Future Work

The future of this project includes continuing to compile a comprehensive database of all contaminants, research different detection methods, research different treatment methods, and complete website features.

Compiling the database includes researching microbial resistances to specific treatment methods, accounting for physical properties of water, and looking into different water regulations by area.

Ultimately, the long-term goal of this project is to have a comprehensive list of all possible contaminants, a complete database providing drinking regulations and treatment methods, and a user-friendly website that can readily search this database and instantaneously prescribe treatment.

Resources

- MATLAB, MATLAB App Designer
- World Health Organization (WHO)
- Environmental Protection Agency (EPA)
- United States Geological Survey (USGS)
- Engineers Without Borders (EWB)

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