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Rapid Portable Water Purification for Disaster Relief: Developing an Emergency Device to Quickly Purify Contaminated Water Sources to Potable Standards

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Abstract: This study checked out the growth and also improvement of a practical, mobile water purification device indicated to quickly convert polluted water into potable requirements, resolving the crucial problem of water scarcity in disaster relief initiatives. By reviewing extensive literary works on different water filtration system techniques as well as their applicability in post-earthquake situations, the research dived right into aspects of water contamination, contaminant identification, materials and methods in water purification, and layout considerations for mobile devices. The findings of the research revealed that the quality of water sources following the earthquake generally satisfied the fundamental standard in Turkey. A simple yet effective water purification device that successfully reduced water turbidity, meeting WHO standards was designed and constructed. This study underscored the importance of complex systems while highlighting need for locally feasible solution that can effectively support disaster victims with clean drinking fluids especially after earthquakes, thereby anchoring future research on development of disaster relief water purification tools within this scope.

Keywords: Water purification, water purification device, disaster relief, portable device, contamination, turbidity reduction, post-earthquake scenarios.

1. Introduction

Water is the source of life. Access to clean drinking water is one of the fundamental human needs, yet it remains a critical challenge in the aftermath of disasters, for example, earthquake. Despite the technological advancements in water purification, there is still a lack of compact and convenient water purification devices, which often cannot be delivered to disaster victims in need when water shortages occur. The repercussions of inadequate access to safe drinking water after disaster are immediate and sever. Victims are at risk of contracting waterborne diseases, which can compound the suffering and increase mortality rates following catastrophic events. Such dire circumstances exacerbate the already devastating conditions of a disaster.

Recognizing this critical need, the core objective of this research is to develop a convenient and portable water purification device that is not only capable of quickly purify contaminated water sources into drinking water that adheres to safety standards, but is also designed with the logistical

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constraints of post-earthquake scenarios in minutes. This seeks to alleviate the difficulty of drinking water shortage for disaster victims by ensuring a reliable supply of purified water.

1.1. Literature Review

In delving into past research, this literature review will mention the water contaminants and pollutants previous scholars found in different situations, critically introduce and analyze the principles of water purification materials and methods that have been employed, and further understand them by comparatively analysis the evaluations and insights from previous scholars, to gain a deeper understanding of the strength and weaknesses inherent in existing methods. Furthermore, an exploration of existing design models for water purification equipment in similar post-disaster settings will be conducted, scrutinizing their applicability. By doing so, this literature review intends to lay the groundwork for the development of an innovative water purification device.

1.1.1. Water Contaminations and Pollutants

Contaminates and pollutants naturally exists in wild or untreated water resources, and after natural disasters, the proportion and quantity of pollutants will be significantly increased. That is, ensuring clean water becomes a key issue. It is necessary to understand the contaminates and pollutants present in the water sources in order to design purification device for earthquake victims.

Wu Fan's study states that typical pollutants found in field water sources includes: (1) Suspended solids, rust, silt, and other particulate matter. (2) Water hardness and harmful heavy metals. (3) Organic compounds, pesticides, insecticides, and industrial solvents, which are hazardous substances. (4) Pathogenic bacteria and viruses: a plethora of microorganisms, including bacteria, viruses, and protozoa such as amoebic cysts. (5) Odors and tastes that are off-putting and indicative of contamination. [6]

Earlier research delineated the distinct characteristics of water source contamination post-floods, highlighting a stark deterioration in water quality, with turbidity, bacterial counts, coliforms, and organic pollution indicators significantly exceeding safe limits, often to levels beyond measurable counts. Additionally, pathogenic enteric bacteria had been detected in various water bodies, compounded by chemical pollution due to industrial and chemical spillages into local waterways. [7]

Previous research has provided valuable information for this work to observe and learn about pollutants in water sources, as well as providing evidence to distinguish newly added pollutants in water samples in post-earthquake scenarios.

1.1.2. Materials and methods

1.1.2.1. Materials and Methods in Water Purification

This theme will explore diverse water purification methods and the fundamental principles that govern them. It will commence with an overview the basic information of the chosen methods, followed by an analysis of the scientific principles behind each technology, providing a foundation for innovation in equipment design. Given the constrained circumstances prevalent in post-earthquake settings, there is a pronounced emphasis on the selection of low-tech, yet highly effective, water purification methods. These methods should not only be effective in purifying water but also feasible for implementation amidst the challenging conditions of disaster-stricken environments.

The traditional water purification technologies commonly used in water purification devices include sedimentation, adsorption filtration, reverse osmosis (membrane technology), distillation, boiling, and ultraviolet sterilization, all of which have advantages and limitations.

Sedimentation (Static Precipitation, Adsorption Precipitation) Method

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Sedimentation method has a simple process that only requires gravity and time, and does not require expensive equipment or chemicals, which is very useful for low resource setting like post-disaster scenario. It could effectively remove particulate matter and suspended solids, significantly improving clarity and removing pollutants attached to the surface of particles. Precipitation is considered the basis and convenience for removing large particles, but it is unable to remove small particles and soluble substances in water (because the solution is homogeneous and stable), such as salt water. [7] Pathogens may also remain in the water. Besides, it may take several hours or days for significant sediment to occur, which raises doubt on whether it could meet the demand for rapid water supply after disasters. That is, sedimentation method is usually not used alone in water purification, but is used in combination with other methods or requires additional disinfection to ensure safe drinking of water. [8]

(Adsorption) Filtration Method

Adsorption filtration can remove small solid impurities, not only visible solids including fine gravel, but also large molecular substances. Because the molecular arrangement on the filter paper is very tight, it has adsorption effect. Filtering can only remove some solid impurities from water and cannot kill bacteria, other microorganisms, and soluble substances in water. For example, in the case of a mixture of alcohol and water, adsorption filtration cannot achieve a good filtration effect. The best way is to first filter the water and then treat it with chemicals or boil it. [6]

Semi Permeable Membrane Method

A semi permeable membrane is a thin film that only allows certain molecules and ions to diffuse in and out. Generally speaking, semi permeable membranes only allow ions and small molecules to pass through, while biological macromolecules cannot freely pass through semi permeable membranes because the pore size of semi permeable membranes is larger than that of ions and small molecules, but smaller than that of biological macromolecules such as proteins and starch. In daily life, parchment, cellophane, and other materials belong to semi permeable membranes, and common semi permeable membranes include cellulose acetate membranes, polytetrafluoroethylene membranes, etc. The semi permeable membrane filtration method, as the name suggests, utilizes the properties of the semi permeable membrane to remove impurities and bacteria from water, in order to achieve the goal of water purification.

The semi permeable membrane method can isolate bacteria, suspended solids, etc. According to different requirements (mainly substances allowed to pass through other than water molecules), there are various types of semi permeable membranes. This method is currently widely used for seawater desalination. The operational effectiveness of this system depends on many factors, such as fluctuating water pressure, membrane lifespan, and blockage of membrane pores, all of which can affect the quality of effluent. When using the semi permeable membrane method, a large amount of water is required. Generally, 1L of treated water is produced from 10-20L, and the cost is relatively high. [7]

Distillation method

Distillation is a commonly used method for separating and purifying liquid mixtures, as well as for determining the boiling point of liquid compounds.

The single operation of distillation method has the highest relative purification degree, and can basically obtain (pure substance) compound water (if the operation is precise enough). [10] Distilled water used in hospitals is obtained through distillation method, which is generally regarded as pure substance and is the cleanest cleaning method. [7] However, in Wu's research, it was mentioned that the distillation method has the following drawbacks: low efficiency, high consumption of thermal energy, high cost, and inability to remove volatile substances from water. [7] And when the liquid is mixed in water, it cannot be separated, and it must be separated using different boiling points of different liquids. For immiscible liquids with similar boiling points and difficulty in evaporation, it is

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difficult to achieve. It also depends on whether there are low boiling components and their content in water, such as alcohol. If distillation is used, alcohol will come out first, but water will also come out at the same time. The distilled alcohol will contain a small amount of water.

Boiling Method

Boiling is a relatively convenient and simple method that can kill bacteria in water. However, for some chemicals and heavy metals that cannot be removed, even if their content is extremely low, they cannot meet the standards for safe drinking. [7]

UV sterilization method

UV sterilization is an environmentally friendly physical water purification method that can be disinfected without the need for chemicals, avoiding secondary pollution, and is harmless to the environment and humans. It is safe, has low operating costs, simple maintenance, and high efficiency over a wide range. Regardless of water temperature or pH value, stable performance can ensure effectiveness and prevent microbial reproduction in the human body. [7] Ultraviolet technology can effectively kill harmful pathogens such as Escherichia coli and various viruses, improving water quality. However, although UV lamps are becoming increasingly diverse in design, they face challenges: they cannot remove heavy metals or chemicals, dead microorganisms still remain in the water, and they require expensive and complex specific technologies for production. Especially for quartz glass lamps, they cannot be mass-produced, resulting in higher costs. These lamps also experience rapid attenuation of light intensity after several hours of use, reducing their bactericidal ability, and cathode damage can shorten their lifespan. In addition, due to differences in filament and cathode materials, UV lamps cannot use the same ballast as standard fluorescent lamps.

Water Purifier Method

The water purifier is easy to operate and has a good water purification effect. [10] However, the water purifiers sold in the market are designed for urban tap water, and they cannot handle high turbidity and high pollution water, nor can they effectively handle the pollutants that may be produced in post-earthquake water sources, which means that they might not be suitable for post disaster scenarios. In addition, water purifiers that require pressure to pass through, or water purifiers that require a power source, are also not suitable. If a pre filtration device is added to the water purifier, the water purifier with activated carbon and disinfection functions can still be used. [7]

1.1.3. Design Considerations for Portable Purification Devices

This theme will explore the design that affects the portability and efficiency of water purification devices. I will cover topics such as size, weight, and purification capacity, and analyze existing water purification devices as case studies to provide reference and ideas for my design to meet the needs of earthquake victims.

Wu provided an example of a solution-oriented design method for post flood water purification devices. The water purification system involved by Wu is suitable for household scenarios, although it is not completely consistent with my goals, it has high reference value. Wu used local materials and simple construction methods to create this household water purification system. It takes into account the size of the water volume, including simple filtration of layered materials in plastic buckets and more complex sand filtration systems. The use of gravity conveying systems and materials such as charcoal, sand, and fabric for filtration can achieve efficient purification without relying on electricity or complex machinery, making it very suitable for post disaster environments with damaged infrastructure. [6] In addition, integrating disinfection methods such as chlorinated tablets or UV treatment to ensure the elimination of potential pathogenic pathogens in susceptible populations may works as a solution. [7]

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1.2. Summary and Research Gap

This literature review focus on the critical need for clean water in post-earthquake scenarios. It emphasizes the increase in water pollutants such as suspended solids, heavy metals, organic compounds, and pathogens identified by Wu Fan (2022) and Wu Jianying (2010) in different situations. Followed by a review on various water purification methods including sedimentation method, adsorption filtration method, semi permeable membrane filtration method, distillation method, boiling method, ultraviolet sterilization method and water purifier method. Discusses the strengths and limitations of each method in this situation. Furthermore, Wu's (2022) method utilizing local materials and gravity-based water purification system was analyzed, which is a feasible model for creating efficient water purification solutions in environments with damaged infrastructure (post-flood scenarios), providing an inspiring example for this research.

In the aftermath of earthquakes, the conditions for water purification are limited by the environment and available resources. The selection of methods for post disaster water purification in such scenarios must be tailored and simple. Priority should be given to low technology methods that can fulfill basic needs for purification: convenient, effective, safe, and reliably. Low technology methods should be used to meet the minimum water demand. Each method mentioned discussed previously possesses distinct strengths and limitations. There may be potential in combine several water purification methods that are conductive to post-earthquake situations to synergize their benefits and mitigate their drawbacks.

A significant gap identified in the current research is the lack of information or specific data on pollutants found in water sources after earthquake, which is crucial to the research. To address this gap, it is important to conduct water quality assessments for the water sample taken from post-earthquake areas.

The water purification device plan to design should not only filter out basic pollutants, heavy metal substances, and pathogens like existing water purification devices, but also tackle the unique contaminants resulting from earthquake disasters. It should aim to improve the water purification efficiency and minimize the device size. Moreover, the complexity, technical demands, and resource limitations inherent in post-disaster settings must be considered. The goal is to select straightforward technologies that do not compromise on water quality, therefore ensuring the devised purification unit is user-friendly. The key to innovation lies in creating a water purification device that balances purification effectiveness with operational simplicity, potentially by integrating multiple techniques to maximize their collective strengths while minimizing their individual weaknesses.

1.3. Research Questions

By studying, summarizing, and analyzing the above content, this research attempt to answer three research questions that are crucial to my research:

1. What kind of pollutant and contaminants will be caused to water sources in the post-earthquake area? What means/methods can effectively remove them?
2. How to apply a single or (combined) multiple water purification methods to design a water purification device? How to screen for functionality and properties?
3. How to design a device that is more convenient and portable while ensuring the quality and efficiency of water purification, in order to meet the purpose of post disaster material donations and truly put them into the use of disaster victims?

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2. Methodology

2.1. Approach

The major methodology employed in this research is the pragmatism's problem-solving orientation to every day realities and its commitment towards practical outcomes. It begins by identifying what people require most within their communities, aiming for a positive impact by focusing on alleviating tangible hardships, in this case, providing potable water for disaster victims in post-earthquake scenarios. Through this approach, various types of investigations can be carried out to design and build a portable, efficient purification device that matches the needs of disaster victims.

This approach embodies how flexible or adaptable pragmatism could be, since it always aims not just to come up with solutions but workable ones and never tied down single truth or approach. Therefore, both quantitative and qualitative analysis will be used in this research. On the qualitative side, insights will be gathered and synthesized from previous publications related to post-disaster water contamination issues and purification methods suited for resource-limited environments. On the quantitative side, water quality assessments of samples from simulated post-earthquake disaster sites to identify target pollutants and contaminant levels for remediation will be carried.

2.2. Procedure

2.2.1. Research on Literatures

The initial phase involves a holistic review of existing literature concerning post-disaster water contamination issues and purification methods suitable for resource-limited environments. This step aims to identify gaps in current research and formulate pertinent research questions to guide the study, as well as to gain inspiration for the index of water quality testing and the subsequent device design.

2.2.2. Water Quality Testing

Following the literature review, water quality assessments are conducted on samples collected from the selected locations in earthquake-affecting areas in Türkiye. These test aim to identify target pollutants and contaminant levels, providing crucial insights for designing effective purification devices.

2.2.2.1. Materials and Participants

2.2.2.1.1. Sampling Plan for Collecting Source Water Samples

In order to obtain water samples for this research, a detailed sampling plan that focused on earthquake-affected areas in Türkiye was developed. The plan aimed to ensure representation from diverse locations and water sources within the earthquake-impacted regions. 16 water samples were collected from distinct locations with varying degrees of damage; these water samples included a range of water types: tap water, drinking water, and groundwater, since they represent different environmental settings across affected districts.

2.2.2.1.2. Materials

In accordance with our sampling plan, we utilized specific materials to collect and document each water sample comprehensively. In attaining this goal, we employed 100ml water collection bags, ensuring the same volume of water collected for each sample. Markers were used to record essential information such as the sampling location, time of collection, and the type of water source.

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2.2.2.2. Source Water Samples Collected

The following is a detailed list of the water samples collected from various locations within earthquake-affected areas in Türkiye, adhering to the sampling plan:

Figure 1: Water Sample Collection in Earthquake-Affected Areas of Türkiye

Tap water from Arsian Hotel, Kahramanmaraş (collected on August 1, 2023)
Tap water from disaster victim's Home, Goksun (collected on August 2, 2023)
Tap water from the container settlement Melikgazi (formerly China Village), Kahramanmaraş (collected on August 2, 2023)
Spring water from the earthquake-stricken area (collected on August 2, 2023)
Groundwater from disaster victim's Home, Goksun (collected on August 2, 2023)
Tap water from Container Settlement, Adiyaman (collected on August 3, 2023)
Tap water from Gas Station, Adiyaman (collected on August 3, 2023)
Tap water from disaster victim's Home, Osmaniye (collected on August 3, 2023)
Tap water from disaster victim's Home, Nurdagi (collected on August 4, 2023)
Tap water from Container Settlement, Hatay (collected on August 4, 2023)
Tap water from Hassa Gas Station, Hatay (collected on August 4, 2023)
Tap water from disaster victim's Home, Tekir (collected on August 5, 2023)
Tap water from Cappadocia Hotel (collected on August 7, 2023)
Tap water from Hotel, Antakya (collected on August 8, 2023)
Tap water from Aegean Coast Hotel (collected on August 13, 2023)
Tap water from Hagia Sophia Hotel, Istanbul (collected on August 14, 2023)

2.2.2.3. Determining test content

The tests index is determined based on the standards set by authorized organizations, which includes the World Health Organization (WHO) drinking water quality standard and the Sanitary Standard for Drinking Water (GB5749-2006). The two standards mentioned index such as:

a) Heavy metal ions: Test the content of arsenic, cadmium, chromium, lead, iron, manganese, mercury, selenium and other metal.
b) Fluoride and nitrate: Determine the content of fluoride and nitrate in water and compare the standard limits.
c) Microbial contamination: Assess the presence of E. coli groups and other pathogens.
d) Organic contaminants: Detect possible pesticides, insecticides and industrial solvents.
e) Physical pollution: Observe the suspended solids and silt in the water.
f) Taste and odor: Sensory detection to ensure no odor. (WHO, 2022) (GB/T5749, 2022)

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Due to the limited sample size of 100 ml, it was finally decided to focus on testing for the main metal ions (arsenic, cadmium, chromium, lead, iron, manganese, mercury, selenium), fluoride, and nitrate in the water samples as they are most relevant to human health.

2.2.2.4. Carrying the Water Quality Test

The water samples are sent to the Ecology Center for testing. The testing process takes about half a month to complete.

2.2.3. Device Design

The prototype of the water purification device will be made base on the findings from the water quality test. In this case, the design would potentially be based on a combination of simple methods such as sedimentation and filtration which are efficient despite its low-tech requirements. The system should also ensure that it is portable while increasing its ability for purifying more water. Moreover, it needs to meet the expectation of removing the contaminants that can come as a result of an earthquake after analyzing them during the water quality test meant for this specific disaster.

2.2.4. Development of prototypes

At this stage, various materials including plastic, wood, fabric and activated carbon, will be required for the construction of the functional prototype of water purification device.

3. Results and discussion

This section will demonstrate the water quality test results for water samples taken from earthquake-affected areas in Türkiye. The data will be presented visually through charts and graphs to provide a clearer comparison between the results and the standards set by WHO (World Health Organization) and GB5749-2006 "Sanitary standard for drinking water" used for data analysis. Each visual representation is accompanied by brief descriptions facilitate deeper understanding, especially in connection with findings about overall implications of water quality within the earthquake-affected areas of Türkiye.

3.1. Raw Data

Table 1: Water quality test results

Test Item		Fluoride	Nitrate (as N)	Arsenic	Cadiium	Chromium	Lead	Iron	Manganese	Mercury	Selenium
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Limit Value/Guidehne Value	GB/T 5749-2022	1.00	10	0.01	0.005	/	0.01	0.3	0.1	0.001	0.01
	WHO 2022	1.50	50(as NO^3)	0.01	0.003	0.05	0.01	0.3	0.08	0.006	0.04
1	Maraç	0.26	4.72	0.00079	<0.00006	0.0371	0.00048	0.0035	0.00010	<0.00007	0.0008
2	Melikgazi Konteyner Kent	0.19	0.54	0.0006	<0.00006	0.0006	0.00990	0.0044	0.00029	<0.00007	0.0006
3	Moutain Spring Water	0.08	0.84	0.00015	<0.00006	0.0004	0.00012	0.0037	<0.00006	<0.00007	<0.0001
4	GOKSUN Tap Water	0.14	0.97	0.00074	<0.00006	0.0003	0.00043	0.0046	<0.00006	<0.00007	0.0002
5	GOKSUN Under Ground Water	0.12	0.26	0.00021	<0.00006	<0.0001	<0.00007	0.0067	<0.00006	<0.00007	0.0002
6	Adiya Tap Water	0.12	2.13	0.00076	<0.00006	0.0010	0.00107	0.0040	<0.00006	<0.00007	0.0003
7	Adiya Gas Station	0.10	2.15	0.00033	<0.00006	0.0019	0.00061	0.0048	<0.00006	<0.00007	0.0002
8	Nandagi	0.30	3.75	0.00039	<0.00006	0.0015	0.00199	0.0043	0.00080	<0.00007	0.0002
9	Osmaniye	0.25	22.85	0.00117	<0.00006	0.0307	0.00015	0.0043	<0.00006	<0.00007	0.0006
10	Hatay Gas Station	0.22	1.23	0.00061	<0.00006	0.0006	<0.00007	0.0047	0.00013	<0.00007	0.0004
11	Hatay Settle Site	0.07	0.73	0.00011	<0.00006	0.0015	<0.00007	0.0028	0.00008	<0.00007	0.0003
12	Tekilk	0.17	1.37	0.00011	<0.00006	0.0004	<0.00007	0.0040	0.00010	<0.00007	<0.0001
13	Calidochia Tap Water	0.38	5.97	0.00594	<0.00006	0.0003	0.00035	0.0025	<0.00006	<0.00007	0.0002
14	Antalya	0.33	6.5	0.00224	<0.00006	0.0026	<0.00007	0.0063	0.00449	<0.00007	0.0003
15	Aegean Sea	1.04	14.11	0.01360	<0.00006	0.0009	0.00097	0.0073	0.00141	<0.00007	0.0059
16	Istanbul	0.28	0.34	0.00061	<0.00006	0.0003	<0.00007	0.0032	0.00022	<0.00007	0.0002

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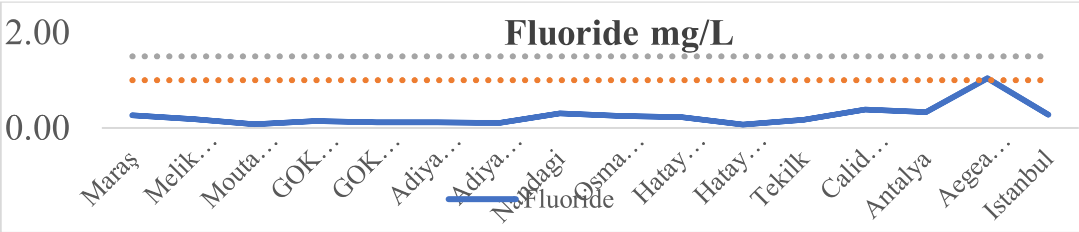
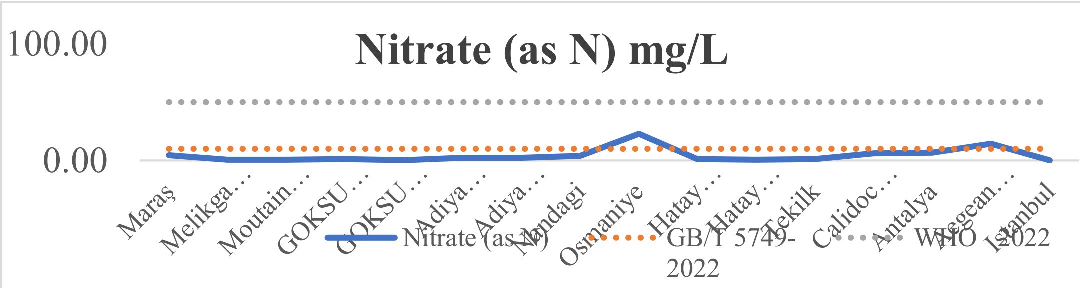
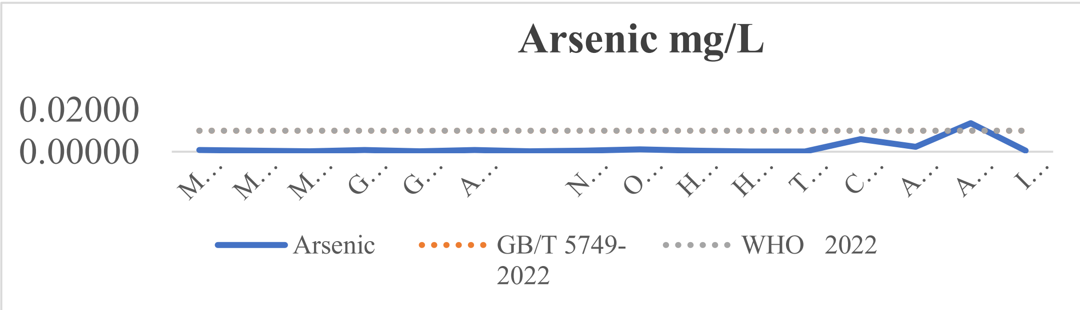
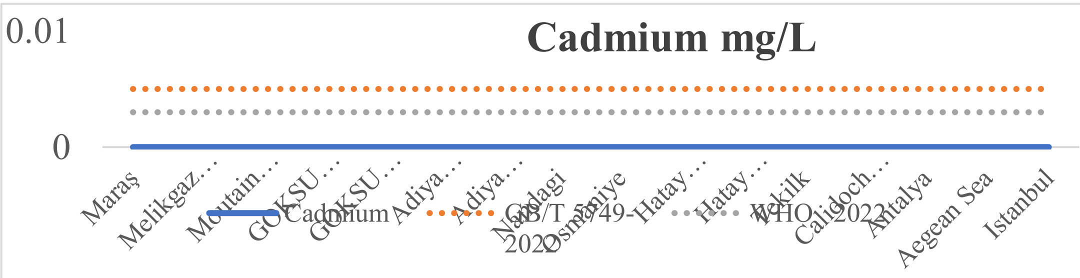
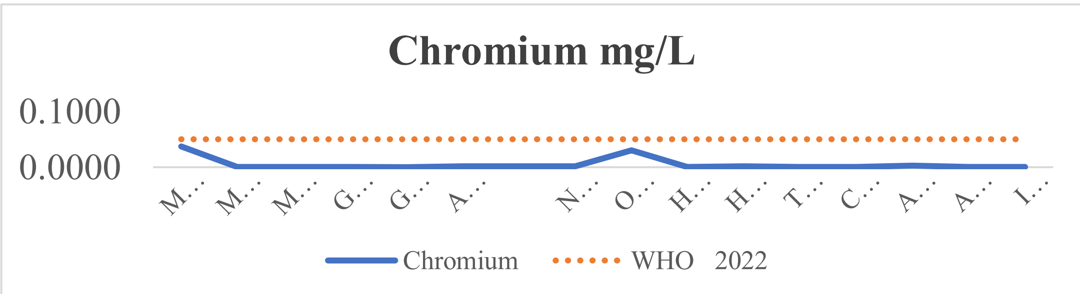
3.2. Comparison through Visuals











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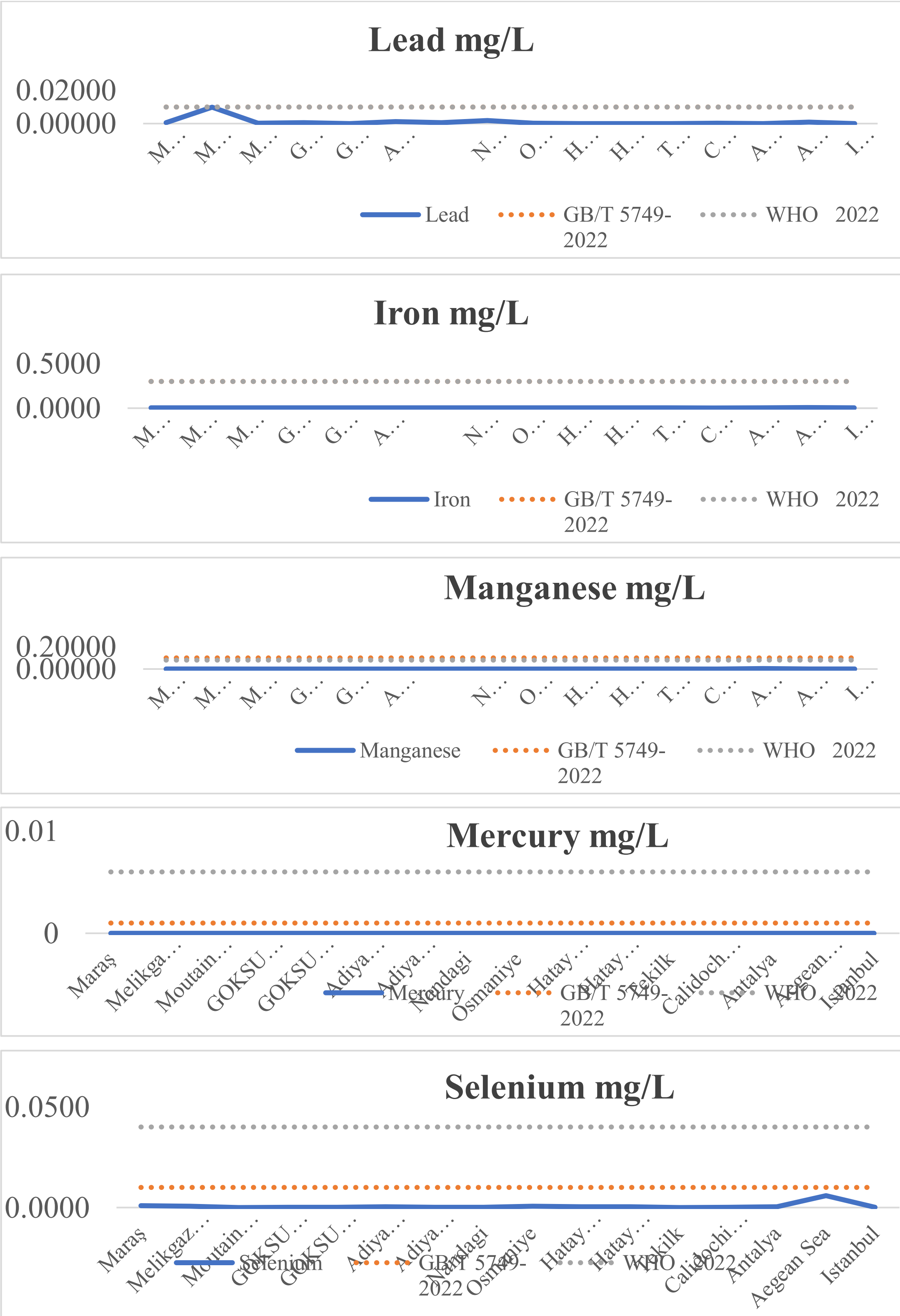

Figure 2: Separately water quality test results

The chloride content of 15 water samples fell within the limits of both standards. Samples from the Aegean Coast were slightly above the GB/T5749 standard but still within the WHO range ($1.0 < 1.04 < 1.5$). The nitrate content of 14 samples was within both standards, with samples from Osmaniye

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and Aegean Coast slightly exceeding the GB/T5749 standard but remaining within the WHO range ($10 < 22.85 < 50$ and $10 < 14.11 < 50$). The arsenic content of all 15 samples was within both standards, though Aegean Coast samples were slightly above both GB/T5749 and WHO standards ($0.01360 > 0.01$), with no significant impact on water quality. Cadmium, chromium, lead, iron, manganese, mercury, and selenium content in all 16 samples met both standards.

3.3. Discussion

It is claimed that the quality of water in Türkiye after earthquakes remains satisfactory. This argument is made on the basis of conformity of post-earthquake water quality in Türkiye to set benchmarks for drinking water quality by relevant bodies such as WHO and Sanitary Standard for Drinking Water (GB5749-2006). We have carried out thorough assessments on the quality of water by testing and analyzing samples collected from areas affected by earthquakes in Türkiye, and it turned out that most of the parameters in the tested water samples meet the standards of WHO and GB/T5749. Although a few places have slightly higher amounts of chloride ions as well as nitrates than required by WHO, however these quantities still assure safety when it comes to overall wellbeing. Furthermore, even though arsenic levels found in some water samples from Aegean coast exceed what has been stipulated by World Health Organization, their significance towards affecting general water integrity is almost insignificant.

3.4. Design and Construction of Water Purification Device

3.4.1. Determine the design direction

It is evident from the water quality test that the samples under consideration meet the fundamental standards and do not raise any significant pollution issues. However, during the on-site visits in Turkey as well as consultations with the disaster victims and community members affected by this catastrophe; it became apparent that there the ground waters and rivers adjacent to them which happen to be their primary sources of drinking water was highly turbid. Two options face victims of such an emergency where there is high turbidity in water bodies; either they expose themselves to diseases that are spread through muddy or refrain from using such water for drinking despite the fact that there are no enough supplies guaranteeing safe consumption levels.

Therefore, this study aims to design a device that is targeted to decreased the turbidity of water that can be constructed locally in earthquake-affected areas, so that proactive responds could be made towards solving this problem by making the water people collected clearer though using the device. This gadget will use locally available materials so that it can be able to effectively remove silt from these areas mentioned above which have been affected greatly by disasters caused due to heavy rains and flooding. The main reason why simplicity was a key factor when devising such a device was because something that could be done within the shortest time possible without much hassle on the part of victims who already had enough on their plate already is crucial. It is thus important to introduce such measures promptly before help comes officially so as to provide immediate relief for people who are still living under such conditions even now. By doing this early enough before relief supplies come officially then they can minimize the problem of high turbidity water, thereby saving many lives as well as ensuring quick recovery among them all in general through obtaining potable water. This approach not only guarantees timely assistance but also enhances overall health aspects within communities affected by disasters.

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3.4.2. Design and Construction

3.4.2.1. Materials

1. Empty mineral water bottles
2. Rocks
3. Sand (coarse sand and fine sand)
4. Wood shavings
5. Charcoal
6. Gauze
7. Scissors (or knives)

The materials and tools required for constructing the water purification device are accessible to disaster victims through various means. Empty mineral water bottles, a crucial component of the device, can be easily obtained as they are commonly found in households or can be acquired from local stores and roadside vendors. Rocks, sand, wood shavings, and charcoal, essential for filtration purposes, are readily available in the natural environment and can be collected from surroundings or post-disaster sites. Additionally, gauze, used for filtering impurities, is either found in many households for medical use or can be purchased from nearby stores. Alternatively, traditional clothing items like Kaftan and Turban, known for their permeability and porosity similar to gauze, can be sourced from local communities. Lastly, scissors, the only tool required for assembly, are commonly found in households or can be easily procured from stores, or could be replaced by any sharp item that can cut fabric.

3.4.2.2. Structure

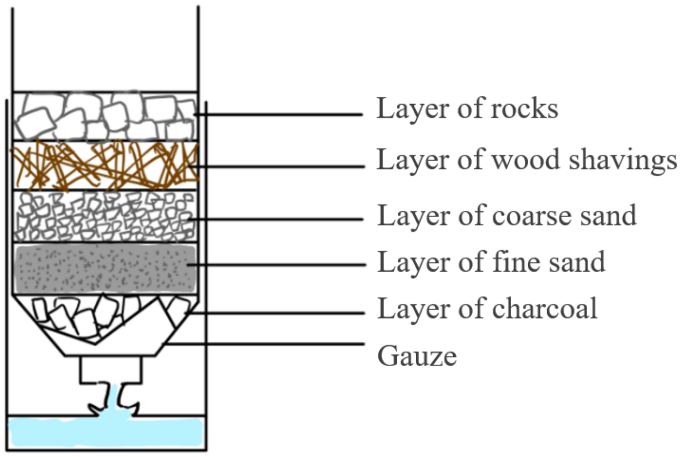

Figure 3: Schematic diagram of the portable water purification device

The device used to purify water is made up of various components arranged in a modified mineral water bottle. A mineral water bottle is cut in half as part of its structure, which uses every part to create a filter system. The bottom half serves as a container for collecting purified water; on the other hand, the top half (which is inverted) acts as the main body of the filter device that fits into the bottom part. Also, the bottle cap has been altered so that it allows for water flow through filtration layers containing different natural materials like rocks, wood shavings, coarse sand, fine sand, and charcoal. These items are placed in layers within an inverted bottle top until they achieve the desired filtration.

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3.4.2.3. Principles

3.4.2.3.1. Rocks

The large gaps between rocks are used as a barrier that traps large particles and impurities. When the fluid passes through this stage, more solid materials and sediments will be eliminated from it because they could not pass due to their big sizes

Wood Shavings: Organic matter or small particles stick to hydrophilic fibers found in wood shavings thus effected natural filtration where smaller contaminants are removed purifying water further

3.4.2.3.2. Coarse Sand

The porosity of coarse sand is employed in capturing minute contaminants and particles. The sand does this by filtering out finer dirt that was not trapped by rocks or wood shavings during their process

3.4.3.2.3. Fine Sand

Tiny suspended impurities and particles are stuck on finer sand particles providing an extra layer which ensure every little dirt is gotten rid while water passes through the equipment.

3.4.2.3.4. Charcoal

Known for its microporosity and active sites, charcoal can effectively absorb organic pollutants as well as odor causing substances from the water. This layer greatly enhances the taste and smell of the filtered water making it safe for consumption.

3.4.2.4. Gauze

Act as the final filtration stage, captures any remaining tiny particles, such as fine sand, letting only the clean, purified water pass through and collect in the bottom part of the bottle.

In conclusion, when these various stages are combined together, they form an effective means through which different sized materials may be removed thus leaving behind clean safe drinking water

3.4.2.5. Construction Procedure

1. Prepare the Bottle: Cut an empty mineral water bottle in half using scissors or a small knife. Make sure your cut is neat and straight. Keep both halves because they are all necessary for the construction. The lower one will serve as a tank where filtered water should be collected after purification.
2. Modify the Cap of the Bottle: Take the cap off the upper part of the bottle and puncture a small hole in its center with a sharp object like scissors. By so doing, you will enable filtered water pass through while retaining filtering materials inside the bottle. Place a piece of gauze over the mouth (beneath this cap). The gauze should be big enough to cover the entire opening. Screw back the modified lid onto the neck of this container so that it holds the gauze tightly in position. This ensure that no particles from the filtering layers will pass through along clear water.
3. Add the Filtering Layers: With an upside-down position of the top half; start filling up this part with filtering substances until about two thirds full or more depending on desired purity levels (the more the layers, the cleaner the water). Begin from near the mouth of the bottle going upwards as follows:

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1) First Layer-Charcoal Layer: divide the charcoal into small pieces, then put a layer of them above the gauze covered opening directly.
2) Second Layer-Fine Sand Layer - on top of the charcoal layer, add fine sand. The diameter of the fine sand should be approximately less than 0.25mm, preferably up to 0.1mm
3) Third Layer-Coarse Sand Layer: after putting fine sand then place coarse sand above it. The diameter of the fine sand is about 0.5mm or more, but not too large.
4) Fourth Layer-Wood Shavings Layer: Break wood or bark with hands or cut with scissors into as small pieces as possible, then place it above the coarse sand layer.
5) Fifth Layer-Rocks Layer: lastly arrange rocks on topmost part.

4. Setting Up the Device: Slide the filled inverted top half of the bottle into the bottom half carefully. Make sure it fits tightly and stands on its own. Check if layers are uniformly spread out and well-arranged so that filtering process can be optimized.
5. Using the Device: To use this device simply pour contaminated water in the upper side of the bottle which has been inverted. Water will then be passing through each layer of filtration and getting purified step by step downwards. Clean filtered drinking water collects at the lower part ready for use.

3.4.3. Turbidity reduction efficiency

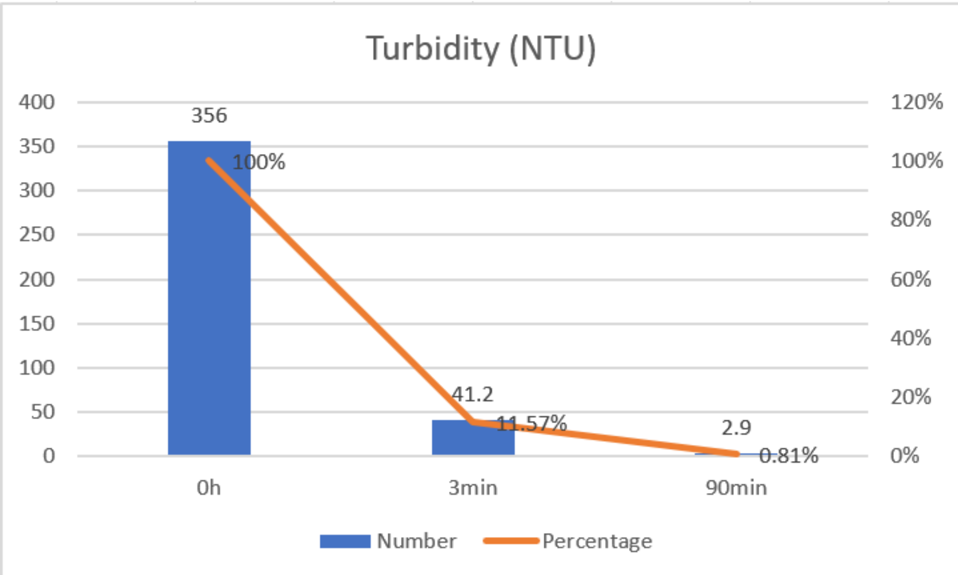

Figure 4: Turbidity reduction efficiency

A Hach turbidimeter is used to ascertain the water's turbidity levels before and after it passed through the water purification device. As shown in the graph, initially, the turbidity was recorded at a high of 356 NTU. However, after filtering for 90 minutes, this figure dropped significantly to 2.9 NTU, corresponding to a 99.19% decrease.

At 2.9 NTU, the final reading conforms to the World Health Organization's (WHO) acceptable standard for drinking water, which is less than 5 NTU. To make it potable for drinking purposes, the best course of action would be boiling since this would further reduce any remaining particles thus lowering the figure even more during this process. It should be noted that if done correctly there should hardly be any single suspension visible dissolved solids. It will help achieve maximum clarity thereby ensuring safety.

4. Conclusion

To conclude, the research reveals that following an earthquake, the water quality in Turkey generally adheres to the standards set by the World Health Organization (WHO) and the Sanitary Standard for Drinking Water (GB5749-2006). Most of the tested samples had contaminant levels well within acceptable limits, indicating that despite being challenged by an earthquake, the quality of water has remained good.

Moreover, the water purification devise designed is very convenient and effective. It is possible to construct it with readily available materials and put it together rapidly. Our trials indicate that this machine can reduce water turbidity greatly; within 90 minutes only 2.9 NTU from 356 NTUs was recorded which meets potability standards according to WHO and can further be enhanced through boiling. Therefore, it provides a workable way of getting clean drinking water in areas affected by disasters.

4.1. Reflections and Future Improvements

However, there are some areas which can be done better in future studies. One limitation was that our study only used 100 ml as a sample size which might not adequately represent how bad things are with different volumes of water throughout all affected regions. Henceforth more comprehensive assessments should be carried out by taking larger amounts from more sites for examination purposes. Additionally, one may think about setting up multi-stage filtration systems comprising advanced media such as activated carbon among others or maybe even employing UV treatment in combination with them thereby enhancing overall purification efficiency. In the end, seek input from local communities about how easy or hard they think the device is to use and whether or not it actually works. This will help make a disaster water purifier that can be depended on more by designing it in a way that suits them best.

Conclusively, these improvements would serve to heighten the efficacy as well efficiency levels of the water treatment gadget hence making it a more dependable answer for clean drinking water in areas affected by calamities.

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