People's Democratic Republic Of Algeria
Ministry OF High Education And Scientific Research
University Cheikh Larbi Tébessi -Tébessa-
INSTITUTE OF MINES
Electromecanical Department

Dissertation

Presented in partial fulfillment of the requirements for the degree of Master+Startup
Master's degree in Electromechanical Engineering
Option: ***Industrial Electromechanics***

Topic

Manufacturing A System Of Water Magnetization For the Prevention Of Scaling And Water Treatment

Presented by:

Ismail Khalfaoui Abderrahmene Gouasmia

Before the jury

Houam Alaa	MCB	President	Université Echahid Cheikh Larbi Tebessi Tébessa
Attia Moussa	MCB	Supervisor	Université Echahid Cheikh Larbi Tebessi Tébessa
Lifa Said	MAA	Examinateur	Université Echahid Cheikh Larbi Tebessi Tébessa
Soudani M saleh	MAA	INAPI Supervisor	Université Echahid Cheikh Larbi Tebessi Tébessa

Graduation Date: 25/06/2023

Manufacturing A System Of Water Magnetization For The Prevention Of Scaling And Water Treatment*

Ismail Khalfaoui & Abderrahmene Gouasmia

smailkhal@gmail.com
abderrahmenegouasmia@gmail.com

ملخص

تتناول هذه الاطروحة معالجة المياه الكهرومغناطيسية كبديل للطرق التقليدية. تقدم مقدمة حول أهمية معالجة المياه وتعرض معالجة المياه الكهرومغناطيسية وتطبيقاتها. تستكشف مراجعة الأدب البحث السابق والنظريات والفوائد المحتملة والقيود. تصف منهجية الدراسة

إعداد التجارب وأساليب تحليل البيانات. تعرض قسم النتائج والتحليل النتائج المتعلقة بتأثير جودة المياه وتناقش الآثار ومجالات البحث المستقبلية. بشكل عام، تقدم نظرة شاملة على معالجة المياه الكهرومغناطيسية وإمكانياتها كطريقة بديلة.

Résumé

Cette dissertation examine le traitement électromagnétique de l'eau comme une alternative aux méthodes conventionnelles. Elle fournit une introduction sur l'importance du traitement de l'eau et présente le traitement électromagnétique de l'eau ainsi que ses applications. La revue de littérature explore les recherches antérieures, les théories et les avantages potentiels ainsi que les limitations. La méthodologie décrit la mise en place expérimentale et les méthodes d'analyse des données. La section des résultats et de l'analyse présente les résultats sur les effets de la qualité de l'eau et discute des implications et des domaines de recherche futurs. Dans l'ensemble, elle offre un aperçu complet du traitement électromagnétique de l'eau et de son potentiel en tant que méthode alternative.

Abstract

This dissertation examines electromagnetic water treatment as an alternative to conventional methods. It provides an introduction to the importance of water treatment and introduces electromagnetic water treatment and its applications. The literature review explores previous research, theories, and potential benefits and limitations. The methodology describes the experimental setup and data analysis methods. The results and analysis section presents findings on water quality effects and discusses implications and future research areas. Overall, it offers a comprehensive overview of electromagnetic water treatment and its potential as an alternative method.

Acknowledgement

I would like to express my deep gratitude and appreciation to everyone who contributed to and supported me throughout my graduation thesis journey. I would like to start by thanking my wonderful family, my mother, brothers, and sisters, for their continuous support and encouragement that gave me the strength to excel.

I would like to thank Dr. Moussa Attia, the excellent supervisor of my thesis, for his guidance and valuable advice. I would also like to thank Dr. Naït Hamoud Mohamed Cherif, the director of Tébessa Business Incubator, for his dedicated work and support.

I would like to extend my heartfelt thanks to Professor Laaraba for his assistance in the patent file and his valuable guidance. I would also like to thank Lilia, the director of Chihab Lab Analysis and Quality, for her support and contribution to the success of this project.

Additionally, I would like to express my gratitude to Gareche Ibtissem for her collaboration and valuable support.

Finally, I would like to thank the entire university for providing a motivating academic environment and opportunities. It has been an unforgettable journey, and I am grateful to everyone who contributed to its success.

Thank you very much!

Contents

List of Tables

List o Figures

Nomenclature

ρ represents net charge inside the surface

∂ is the partial derivative with respect to space-time coordinates

m The mass of the particle

q A particle with charge

ν Velocity

EMTD Electromagnetic Treatment Device

EMTW Electromagnetic Treated Water

ζ potential of colloids

i the imaginary unit $(\sqrt{(-1)})$

ψ The wave function of the particle

γ the Dirac matrices

ε represents permittivity of vacuum

B represents the magnetic field

E represents electric field

J represents current density.

Part I

General introduction

This dissertation examines the electromagnetic treatment of water as an alternative to conventional methods. It provides an introduction to the importance of water treatment and presents electromagnetic water treatment and its applications. The literature review explores previous research, theories, potential benefits, and limitations. The methodology describes the experimental setup and data analysis methods. The results and analysis section presents the findings on the effects of water quality and discusses the implications and areas for future research. Overall, it provides a comprehensive overview of electromagnetic water treatment and its potential as an alternative method.

Electromagnetic water treatment technology has been gaining attention in recent years due to its potential benefits over traditional water treatment methods. This technology utilizes different types of electromagnetic fields, such as static magnetic fields, oscillating magnetic fields, and pulsed electric fields, to treat water.

The theory behind electromagnetic water treatment is based on the idea of magnetization. The electromagnetic field applied to the water causes the charged particles to move, generating a magnetic field that alters the physical and chemical properties of water. The magnetic field affects the water molecules' structure, breaking down large clusters of molecules and increasing the water's ability to dissolve and transport nutrients. This process also reduces the surface tension of the water, which can improve the water's ability to penetrate soils and plants.

The potential benefits of electromagnetic water treatment include the removal of impurities, such as bacteria and viruses, and the reduction of dissolved minerals and other contaminants. This technology can also improve the taste and odor of water and reduce scaling and corrosion in pipes and equipment. Moreover, electromagnetic water treatment does not require the use of chemicals, making it an environmentally friendly and cost-effective solution for water purification.

However, there are some limitations to the use of electromagnetic water treatment. The effectiveness of the technology may depend on water quality, and the equipment required for electromagnetic water treatment can be expensive. Additionally, more research is needed to fully understand the effects of electromagnetic water treatment on human health and the environment.

Overall, electromagnetic water treatment is a promising technology for improving the quality of water. Further research and development are needed to optimize the technology and ensure its safe and effective use in various applications. magnets. [1]

Part II

Chapters

Chapter 1

Introduction And History of Water Magnetization

1.1 Background on the importance of water treatment:

Water treatment is a critical process that plays a significant role in public health, environmental protection, and economic development. In addition to providing safe and clean drinking water, water treatment is necessary for many other applications, including irrigation, aquaculture, food processing, and industrial processes.

The quality of raw water sources, such as rivers, lakes, and groundwater, can vary greatly depending on natural and human-made factors. Natural sources of contamination can include microorganisms, minerals, and organic matter. Human activities, such as agriculture, mining, and industrial processes, can also contribute to water pollution by releasing chemicals and other harmful substances into water bodies. [2]

Water treatment processes typically involve physical, chemical, and biological methods to remove contaminants and impurities from raw water sources. Some of the most common methods used in water treatment include filtration, sedimentation, disinfection, and chemical treatments. [3]

Effective water treatment is crucial for ensuring public health and preventing the spread of waterborne diseases. Inadequate water treatment can lead to the spread of illnesses such as cholera, typhoid fever, and dysentery. Moreover, polluted water can also have long-term impacts on human health, such as causing chronic illnesses and developmental problems.

In addition to public health concerns, water treatment is also essential for protecting the environment and promoting sustainable development. Contaminated water can harm aquatic ecosystems, destroy habitats, and impact biodiversity. Effective water treatment can help reduce the impact of human activities on the environment, promote conservation, and improve the quality of life for both humans and wildlife.

Overall, water treatment is a critical process that is essential for promoting public health, environmental protection, and economic development. The continued development and improvement of water treatment technologies and infrastructure are crucial for ensuring access to safe and clean water for all [4]

1.2 Problem Statement:

Water treatment is essential for public health, environmental protection, and economic development. However, traditional water treatment methods have limitations that can hinder their effectiveness. For example, some methods may not be able to remove certain types of contaminants, such as microplastics, pharmaceuticals, Scaling in water pipes that can clog up and cause another problems and heavy metals. Additionally, some methods can be expensive, energy-intensive, and require extensive maintenance and also It can involve chemical usage of products that can harm humans and animals.

Electromagnetic water treatment is a potential alternative that may help address some of these limitations. Electromagnetic water treatment involves subjecting water to a magnetic or electromagnetic field to alter the physical and chemical properties of water. This alteration can lead to the removal of contaminants, changes in the water's surface tension, and an increase in dissolved oxygen levels.

One of the benefits of electromagnetic water treatment is its ability to remove certain types of contaminants that traditional methods may not be able to remove. For example, studies have shown that electromagnetic treatment can remove heavy metals from water sources. Additionally, electromagnetic water treatment can be more energy-efficient and require less maintenance than traditional methods.

However, electromagnetic water treatment also has its limitations. One of the challenges is the lack of consensus on the optimal field strength and frequency for effective treatment. Additionally, the cost of electromagnetic water treatment systems can be higher than traditional methods, particularly for large-scale applications.

Overall, electromagnetic water treatment shows promise as a potential alternative to traditional water treatment methods. Continued research and development in this area could help improve the effectiveness and efficiency of electromagnetic water treatment systems, leading to more sustainable and accessible water treatment solutions. [5]

1.1.1 Objectives of the Study:

Scientists call ordinary water (dead water), a term that applies to both well and river water. It is water that has lost its activity and vitality from a biological point of view, as a result of a long journey that has lost its energy, activity and vitality, as its molecules have become randomly distributed, also being exposed to condensation, high air pressure . sterile substances, such as chlorine. Therefore, the goal of this project is to treat this water by designing a system for water magnetization which can effectively prevent scaling and save water treatment. The objectives of the study on water treatment with electromagnetic fields are:

1. To investigate the effectiveness of electromagnetic water treatment as a potential alternative to traditional water treatment methods.
2. To examine the theory behind electromagnetic water treatment, including the mechanisms and effects of water magnetization.
3. To explore the different types of electromagnetic fields used in water treatment and their potential benefits and limitations.
4. To determine the effects of electromagnetic treatment on water quality parameters such as pH, dissolved oxygen levels, and surface tension.
5. To compare the efficiency and effectiveness of electromagnetic water treatment with traditional water treatment methods.
6. To identify potential areas for future research in electromagnetic water treatment.
7. To provide insights into the feasibility and practicality of implementing electromagnetic water treatment on a larger scale for public and industrial water supply systems.

1.1.2 Scope of the Study:

The scope of the study includes:

1. The design and development of a system for water magnetization that can prevent scaling and provide water treatment.

2. The evaluation of the effectiveness of the water magnetization system in preventing scaling and providing water treatment.

3. The optimization of the system design based on factors such as flow rate, water quality, and the size and type of equipment being used.

4. The comparison of the cost-effectiveness and sustainability of the water magnetization system to other treatment methods.

5. The assessment of the potential applications and further development of water magnetization technology in the prevention of scaling and water treatment.

6. The study will focus specifically on the application of water magnetization technology in the prevention of scaling and water treatment and will not cover other areas of water treatment or purification.

7. The study will be conducted in a laboratory setting, and the results may need further verification under field conditions.

1.1.3 Overview of traditional water treatment methods and their limitations:

Traditional water treatment methods involve physical, chemical, and biological processes to remove contaminants and impurities from raw water sources. These processes include coagulation, flocculation, sedimentation, filtration, disinfection, and others.

- Coagulation and flocculation: are used to help remove suspended particles and impurities from water by adding chemicals that cause the particles to clump together and settle out. Sedimentation involves allowing the clumped particles to settle to the bottom of a tank or basin, where they can be removed. Filtration involves passing the water through a filter media to remove any remaining suspended particles.

- Sedimentation and Filtration: This involves allowing the water to settle, which causes the impurities to settle at the bottom of the tank, and then filtering the water to remove the remaining impurities.
- Disinfection is the final step in the traditional water treatment process, which involves the addition of chemicals, such as chlorine or ozone, to kill any remaining pathogens in the water. While these methods have been effective in providing safe and clean drinking water, they also have several limitations. [6]

Despite their effectiveness, traditional water treatment methods have some limitations. For example:

- Chemicals used in the treatment process can be expensive and may have adverse environmental impacts.
- Traditional methods are often not effective in removing certain types of impurities, such as heavy metals or certain types of organic compounds.
- Furthermore, traditional water treatment methods are often energy-intensive and require significant infrastructure and maintenance, which can be a challenge in some areas, particularly in developing countries or rural areas with limited resources.

As a result, there is growing interest in exploring alternative water treatment methods, such as electromagnetic water treatment, which may offer a more efficient and sustainable solution to water treatment challenges. [7] [8]

1.2 History of Magnetized water:

Figure 1.1: Whitney Wesley "Pop" Haydn ca. 1885

Pop Haydn (1849-1910), a known associate of Nikola Tesla and Charles P. Steinmetz, made a significant discovery in 1902 regarding the alignment and structuring of water using highly powerful electromagnets. Presently, we continue to employ his methods to create water that is highly energized and easily absorbable, surpassing any other available options.

However, it is essential to understand what Magnetized Water truly is and why it holds significance for our well-being.

The impact of magnetic fields on the flow of water has been observed over many years, with patents for magnetically treating water dating back to the 1890s. These early patents revealed that the formation of scale deposits was significantly reduced over extended periods of use. The observed effects suggested that the water exhibited characteristics similar to those of lower mineral content. [9]

1.3 Introduction to electromagnetic water treatment as a potential alternative:

Electromagnetic water treatment is a promising alternative to traditional water treatment methods. It involves subjecting water to various types of electromagnetic fields to change its physical and chemical properties, such as surface tension, pH, and dissolved oxygen levels. The process can help to break down and remove impurities from water, making it safe for consumption.

There are several types of electromagnetic fields used in water treatment, including static magnetic fields, oscillating magnetic fields, and electromagnetic fields. Each type has different effects on water properties and impurity removal.

Research on the effectiveness of electromagnetic water treatment has shown promising results, with studies reporting significant reductions in impurities such as heavy metals, organic compounds, and bacteria. However, there is still a need for further research to optimize the process and understand its potential limitations.

Overall, electromagnetic water treatment holds great promise as a sustainable and efficient alternative to traditional water treatment methods, particularly in areas where resources and infrastructure are limited.

1.3.1 Importance of the Electromagnetic water treatement:

The importance of electromagnetic water treatment lies in its potential as an alternative to traditional water treatment methods. It has been suggested that electromagnetic water treatment could offer a more efficient and sustainable solution to water treatment challenges, particularly in areas with limited resources or infrastructure.

One of the main advantages of electromagnetic water treatment is that it can be applied without the need for chemicals, which can be expensive and have adverse environmental impacts. Additionally, electromagnetic water treatment has the potential to remove impurities that traditional methods may not be able to, such as certain types of organic compounds.

Moreover, electromagnetic water treatment is a relatively energy-efficient process, which can help reduce the overall cost of water treatment. It also has the potential to be implemented on a smaller scale, making it a viable option for rural communities or developing countries with limited resources.

Overall, electromagnetic water treatment is an important area of research and development in the field of water treatment, with potential benefits for both the environment and human health.

1.3.2 Applications:

Electromagnetic water treatment has a wide range of potential applications across various industries, including agriculture, food and beverage production, and water treatment facilities.

In agriculture, electromagnetic water treatment can improve plant growth and crop yield by enhancing soil water retention and reducing salt build-up. In food and beverage production, it can improve the quality and taste of products by removing impurities and contaminants. In water treatment facilities, it can enhance the efficiency and effectiveness of traditional treatment methods by reducing the amount of chemicals required and improving the removal of certain types of contaminants. [10, 11]

Furthermore, electromagnetic water treatment may also have applications in desalination and wastewater treatment, as well as in industrial processes such as cooling towers and boilers. As research into the potential applications of electromagnetic water treatment continues, it is likely that additional uses will be discovered. **We remind of them**:

Water magnetizing device has several economic benefits, including:

1- Cost savings: By improving the quality of water used in industrial processes, the device can reduce the need for using chemical cleaners, salt, and other chemicals commonly used in cleaning, preparation, and production processes.

2- Efficiency improvement: By reducing the amount of minerals and salts in water, the device can increase the efficiency of industrial processes and improve the quality of the final product.

3- Water conservation: The device can convert highly polluted and unused water in production processes into usable water, which helps conserve water and preserve water resources.

4- Increased productivity: By improving the quality of water used in industrial processes, the device can increase productivity and improve process efficiency, leading to increased profitability and improved economic performance for companies.

5- Reduced health costs: By improving the quality of water used in food and beverage industries and others, the device can reduce health costs associated with water-borne diseases and other health problems.

In general, a water magnetizing device can improve the economic, environmental, and health efficiency of industrial, agricultural, and household processes. [12]

A water magnetizer device can provide many industrial benefits, including:

1- Improving water quality: A water magnetizer device can help improve the quality of water used in industrial processes, leading to better quality of the final product.

2- Cost reduction: A water magnetizer device can reduce the use of chemicals used to treat water in industrial processes, leading to cost reduction.

3- Increasing efficiency: A water magnetizer device can increase the efficiency of industrial processes, including chemical and mechanical processes, leading to increased factory productivity.

4- Improving worker health: A water magnetizer device can reduce the harmful chemicals used in the factory, leading to improved worker health and reduced rates of accidents and occupational diseases.

5- Energy saving: A water magnetizer device can help save energy in industrial processes, such as cooling and heating processes, leading to cost reduction and improved energy efficiency.

6- Improving environmental health: A water magnetizer device can reduce water and environmental pollution, leading to improved environmental and community health. [13]

Water treatment is a critical process that plays a significant role in public health, environmental protection, and economic development. In addition to providing safe and clean drinking water, water treatment is necessary for many other applications, including irrigation, aquaculture, food processing, and industrial processes.

The quality of raw water sources, such as rivers, lakes, and groundwater, can vary greatly depending on natural and human-made factors. Natural sources of contamination can include microorganisms, minerals, and organic matter. Human activities, such as agriculture, mining, and industrial processes, can also contribute to water pollution by releasing chemicals and other harmful substances into water bodies. [2]

Water treatment processes typically involve physical, chemical, and biological methods to remove contaminants and impurities from raw water sources. Some of the most common methods used in water treatment include filtration, sedimentation, disinfection, and chemical treatments. [3]

Effective water treatment is crucial for ensuring public health and preventing the spread of waterborne diseases. Inadequate water treatment can lead to the spread of illnesses such as cholera, typhoid fever, and dysentery. Moreover, polluted water can also have long-term impacts on human health, such as causing chronic illnesses and developmental problems.

In addition to public health concerns, water treatment is also essential for protecting the environment and promoting sustainable development. Contaminated water can harm aquatic ecosystems, destroy habitats, and impact biodiversity. Effective water treatment can help reduce the impact of human activities on the environment, promote conservation, and improve the quality of life for both humans and wildlife.

Overall, water treatment is a critical process that is essential for promoting public health, environmental protection, and economic development. The continued development and improvement of water treatment technologies and infrastructure are crucial for ensuring access to safe and clean water for all [4]

A water magnetizer device can be used in agriculture in several ways, including:

1-Improving water quality: A water magnetizer device can improve water quality by reducing mineral and chemical contaminants present in groundwater and irrigation water, resulting in increased efficiency of water use in agriculture.

2-Improving plant growth: A water magnetizer device can improve plant growth by reducing excess salts and chemicals in water and improving soil's ability to retain moisture and nutrients necessary for growth.

3-Increasing crop productivity: A water magnetizer device can improve crop productivity by improving water quality and plant growth.

4-Water conservation: A water magnetizer device can conserve water by improving water use efficiency in agriculture and reducing waste and evaporation.

5-Improving plant health: A water magnetizer device can improve plant health by improving water quality and soil's ability to retain necessary nutrients and water for growth. [14]

A water magnetizer device can be used in many applications in the home, including:

1- Improving water quality: The water magnetizer device can improve the quality of household water by removing impurities, deposits, chlorine, and other organic materials, and reducing lime deposits in pipes and appliances. [11, 15]

2- Improving water taste: The water magnetizer device can improve the taste of water by reducing the chemical substances present in the water and reducing unwanted pollutants and odors.

3- Improving washing efficiency: The water magnetizer device can improve washing efficiency and reduce the use of chemical detergents by reducing water hardness and reducing deposits and lime deposits in the washing machine and pipes.

4- Use in water purification: The water magnetizer device can be used in water purification by removing impurities, germs, and other organic materials present in water.

5- Improving digestive health: The water magnetizer device can improve digestive health by improving the quality of water that is consumed and reducing the levels of mineral salts present in the water. [16]

Chapter 2

Litterature Review

2.1 Overview Of previous researches on Electromagnetic water treatment:

Previous research on electromagnetic water treatment has been conducted in a variety of sectors, including agriculture, food processing, wastewater treatment, aquaculture, and others.

Scale Buildup:

One of the main advantages of EMWT is that it lessens the accumulation of scale in hot water systems. Numerous studies have validated how well EMWT works to reduce scale buildup. In a study on the effect of EMWT on scale accumulation in a hot water system, Xu et al. (2015) found that there was a 41.9% decrease in scale accumulation. In the experiment, tap water was treated using an EMWT device that exposed it to a magnetic field produced by a number of magnets [17]. The heat transfer system, which consists of a copper pipe with a 2 mm inner diameter, was then filled with the treated water. The weight of the copper pipe before and after the scale formation was measured by the researchers. before and after the experiment, and also by both after the experiment and by using X-ray diffraction to examine the scale's crystal structure.

The experiment's findings demonstrated that EMWT was successful in minimizing scale formation in the heat transfer system. After the experiment, the weight of the copper pipe for the water treated with EMWT was less than for the untreated water, indicating that less scale had developed. The scale that was created in the EMWT-treated water had a different crystal structure than the scale that was created in the untreated water, according to the X-ray diffraction analysis. [17]

In conclusion, the study shows that EMWT can be a useful technique for lowering scale formation in heat transfer systems, which can increase the effectiveness and longevity of such systems. can improve the efficiency and longevity of such systems. Likewise, Tufail et al. (2018) found that EMWT can reduce scale buildup in cooling water systems. General Introduction

Here is a study's conclusion that compares (EMWT) to untreated water. Another significant difference was observed inside the outlet steel piping, where the magnetically treated line had a much smaller amount of powder-like coating. In comparison to the plentiful scale from the untreated water, this amount was insignificant. Similar steel pipes are compared in Figure 2.1 EMWT results in less scale buildup, as shown in Picture D.

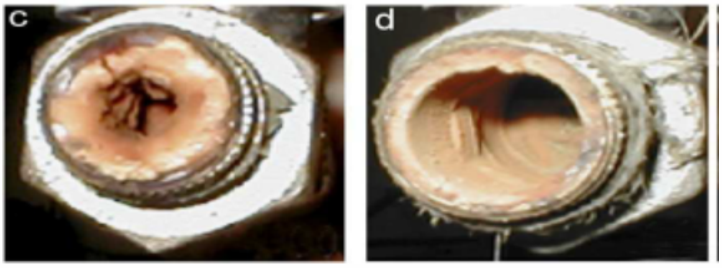


Figure 2.1: Steel pipe without treated water compared to electromagnetic treated water

According to a 1997 article by Quinn et al in the Iron and Steel engineering journal, a 60-inch hot strip mill at a steel plant experienced protracted electrical delays as a result of insufficient motor room cooling caused by lime scale build-up on the heat exchangers. In Format II.1, a heat exchanger without EMTDs is displayed. No mill delays were attributed to motor room cooling failure because of scale buildup six months after the EMTDs were installed. A heat exchanger after one year of use is shown in Figure 2.2, while a heat exchanger after one year of use is shown being washed with a hose . It should be noted that these three heat exchangers are not the same cleaned system, but rather three distinct systems. [18]

Figure 2.2: Electromagnetized watter effects after 1 year

Water Improvement:

In their 2016 study, Esa et al. looked into the impact of electromagnetic water treatment (EMWT) on the standard of drinking water. Groundwater and river water that has been treated were the subjects of the study.

The outcomes demonstrated that the EMWT technology was successful in lowering the bacterial counts in both water sources. The amount of bacteria in the groundwater source was reduced by 99.99%, whereas the amount of bacteria in the treated river water source was reduced by 98.35%.

EMWT was successful in lowering the total dissolved solids (TDS) levels in both water sources, according to the study. The TDS level in the groundwater source was decreased by 44%, whereas the TDS level in the treated river water source was decreased by 22%.

In addition, the researchers noticed a decline in turbidity in both water sources after EMWT. The amount of turbidity in the groundwater source was decreased by 65%, whereas the amount of turbidity in the treated river water source was decreased by 29%. *Similarly*

The effect of electromagnetic water treatment (EMWT) on the flavor and odor of drinking water was assessed in a study by Darwish et al. (2017). In an Egyptian water treatment facility, where EMWT was used as a pre-treatment method before more traditional treatment procedures, researchers conducted a field study. A group of skilled experts used sensory analysis techniques to rate the taste and odor of the treated water.

The outcomes demonstrated that the taste and odor of the treated water significantly improved as a result of the implementation of EMWT. The panelists noted a discernible improvement in the flavor's overall quality and a decline in unfavorable flavors like bitterness and metallic overtones. The panelists also noted a decrease in the strength of offensive odors like musty and earthy odors.

According to the authors, both the decrease in dissolved organic matter and the alteration of the water's physical characteristics, such as surface tension and viscosity, brought about by EMWT, may be responsible for the observed improvement in taste and odor. These findings suggest that by lowering the concentrations of compounds that cause bad tastes and odors, EMWT has the potential to enhance the general quality of drinking water. [19]

Improved cement compressive strength:

Su & Wu (2000) talked about how using magnetic water treatment (MWT) can reduce large water clusters into smaller ones, making it simpler for water to enter the center of cement particles. As a result, hydration improves and strengthens the concrete more effectively. According to Fu & Wang (1994), if magnetized water is kept in a reservoir for longer than 12 hours, its effectiveness may be lost.

According to Wang & Zhao (2008), their research showed that the properties of cement paste and mortar were improved by adding magnetic water. Concrete's compressive strength, pore size distribution, and durability were specifically improved by magnetic treatment.

Concrete and mortar were combined with magnetic water and granulated blast-furnace slag in Su & Wu's (2000) experiments. According to their research, mixing mortar samples with magnetic water increased their compressive strength by 9–20% compared to mixing them with tap water. Concrete prepared with magnetic water had a 10–23% higher compressive strength than samples made with tap water. The study also found that magnetic water improved the fluidity of mortar, the slump, and the degree of concrete hydration.

Results obtained by Weilin et al. (1992) showed that the strength of cement was significantly increased by magnetic treatment of the cement slurry. According to the study, the compressive strength, bending strength, and bonding strength of magnetized cement all increased by 54%, 39%, and 20% respectively. Following magnetization, the cement slurry's initial and final set times also decreased by 39% and 31%, respectively. [20]

Agricultural Benefits:

According to Bogatin et al.'s (1999) analysis, the main effects of magnetized water were an increase in crystallization centers and a change in the free gas content. According to Bogatin et al. (1999), an increase in CO2 and H+ levels in alkaline soils is comparable to the addition of fertilizer. In wet soil, CO_2 and H_2CO_3 combine to transform refractory carbonates into soluble bicarbonates. Bicarbonates exchange the Na of the charge. The exchange reaction results in the removal of Na from the cation exchange complex into the soil, improving the properties of alkaline soils and accelerating leaching. They made the following notes when they used magnetic water to irrigate crops:

- Increased cumulative yield per unit plot
- Extended crop season (growth, ripening, fruit-bearing); improved vegetative deployment.
- Improved fruit quality; size, shape, texture, sugar level, greener leaves.
- Larger fruit
- Improved growth uniformity; vitality
- Cleaner piping, reduced scale deposition in piping and drip heads

Some of the tests that are made and proven to be true:

- ***Field Test 2.1 Dairy farm on Kibbutz Gva***

Cows on treated water yielded more milk, with the same percentage fat. Lactation period, non-productive days and veterinary conditions were better. Impregnation was better.

- ***Field Test 2.2 Calves on Kibbutz Gvat***

Week old calves on magnetic water grew 12% faster than the control group. 3 month old calves showed increased weight gains compared to controlled groups. Their meat contained 30-40 less kg fat at 10 to 12 months.

- ***Field Test 2.3 Sheep farm ut Givat Zayad***

Sheep were cultivated for milk, meat and wool. All three factors showed a considerable increase in yield after drinking magnetic water.

- ***Field Test 2.4 Geese on farm Hayogev***

Magnetic pre-treatment of gosling's water resulted in improved performance: increased daily weight gains, generally improved health and a greater economic return to the farmer.

- ***Field Test 2.5 Turkeys at Nahalal Weight increases***:

Increase in percentage of layers, longer laying period, improvement infertility. [21] [22]

By comparing the germination rates of seeds treated with tap water, filtered water, North / South pole magnetically treated tap water, South pole treated tap water, and North pole treated tap water, Pederson (2005) conducted an intriguing experiment for AQUATOMIC MTDs.

The germination rates of the magnetized waters were 100%, compared to 85% and 15% for the untreated filtered water and tap water, respectively.

The seedlings grew the quickest with treated water from the South Pole, but their stems could not support their leaves. The seedlings had an average height of 14.13 cm. The North Pole-treated water produced a seedling that grew more slowly and could support its leaves. These seedlings were 11.95 cm in height on average. The water that had been treated at the North and South Pole produced the best results, with a healthy seedling growing an average of 12.28 cm. Some of the experiment's results are shown in Figure 2.3. [23]

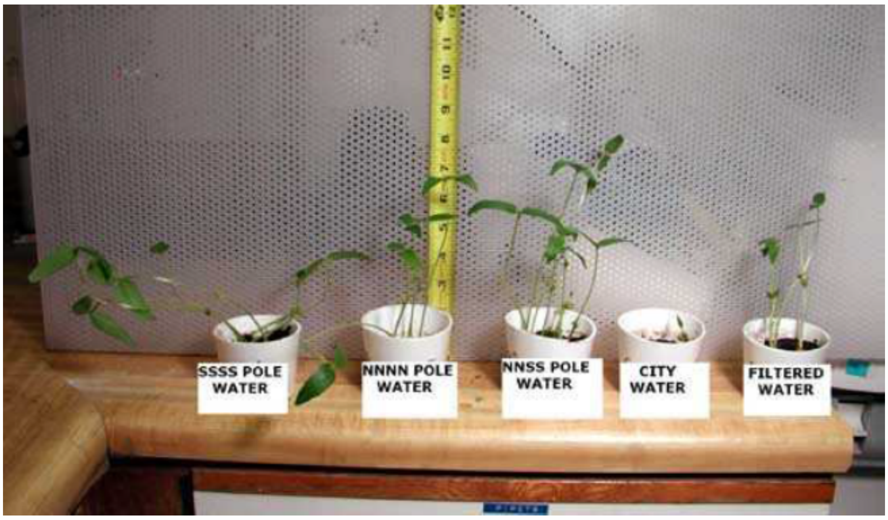


Figure 2.3: Seedling germination and growth rates varied depending on orientation of magnets

2.2 Discussion Of The Theory Behind Electromagnetic Water Treatment:

2.2.1 Current theories of water Magnetisations:

Numerous contradictory theories have been put forth because the underlying principle of this phenomenon is still not fully understood.

According to Brower (2005), magnetic systems purify water by exposing it to a multi-pole, multi-polarity magnetic field. As a result of the dipolar movements of the water and dissolved solids molecules, the crystal form is split into thin layers and the ions align along a single magnetic axis at the time of crystallization. Then, a significantly higher number of nuclei are produced as a result of the magnetic field. Because of the excess similar charge, the solids precipitate as much smaller crystals that tend to stay apart. Currently, the calcium carbonate powder is available in sludge form and is easily maintained as it will not stick to elements and piping.

According to the The Department of Energy's Federal Technology alert (1998) , the general operating principle for the magnetic technology is a result of the physics of interaction between a magnetic field and a moving electric charge. When ions pass through the magnetic field, a Lorentz force is exerted on each ion which is in the opposite direction of each other. The redirection of the particles tends to increase the frequency with which ions of opposite charge collide and combine to form a mineral. A journal article from Quinn (1997) explains the molecular makeup of water and its polarity. A molecule of water consists of one atom of oxygen and two atoms of hydrogen, H2O. The covalent bond that holds each hydrogen atom to the oxygen atom results from a pair of electrons being shared.

Here's a figure that shows the molecule of water [15, 24]

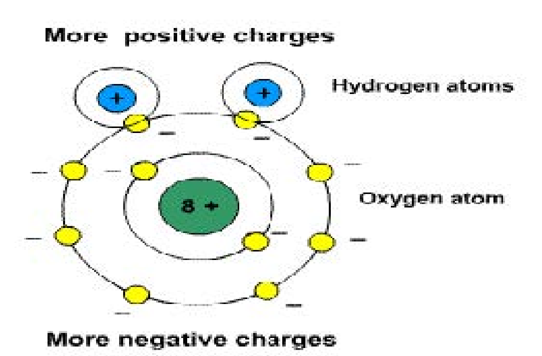


Figure 2.4: Water molecule H_2O

According to Quinn (1997), the polar molecules attain different orientation under the influence of a magnetic field. The stronger the magnetic field, the greater the numberof dipoles pointing in the direction of the field. The unusual properties of water can be attributed to extensive hydrogen bonding between its molecules. It has been suggested that the molecules could form clusters as illustrated in Figure 2.5(a) .According to Su & Wu, 2002, these associations and disassociations of water molecules are in thermodynamic equilibrium. In general, each cluster contains about 100 water molecules at room temperature as shown in Figure 2.5(c). In a magnetic field, magnetic force can break apart water clusters into single molecules or smaller ones as shown in Figure 2.5(b).Therefore, the activity of water is improved. It should be noted that theories of water clusters are just that, theories and have not been proven yet, according to Lower (2009). [11]

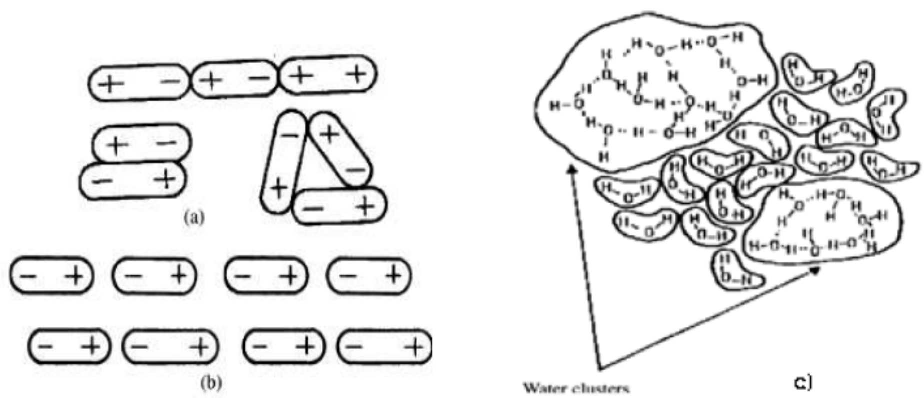


Figure 2.5: Water molecules. Dipole Effect of magnetic field on water molecules

2.2.2 The theory of Electromagnetization:

The phenomenon known as electromagnetism is concerned with the interaction of an electric field and a magnetic field. Moving charges in a system create a magnetic field, while stationary charges create an electric field. The wave moves at the speed of light and the electric and magnetic fields are always perpendicular to one another. Using Maxwell's equations, Scottish mathematician and scientist James Clerk Maxwell established the relationship between electricity and magnetism for the first time. Existing laws of electricity and magnetism like Newton's Law, Faraday's Law, Kelvin's Law, and Ampere Law were all brought together by Maxwell's four differential equations.

Before learning Maxwell's Equations, we need to learn 3 Mathematical operations which are basic entities of the equations. The Del operator refers to the partial differentiation of a function. We represent it as ∇ (Nabla). Grad f gives the gradient of a function i.e. grad f = ∇f, which means the partial differentiation of a function with respect to x, y and z-axis in a 3 – dimensional domain. The gradient is a vector quantity. The Divergence operator of a vector quantity gives us a scalar entity, which represents the rate at which the density exits a given range of space. [8] [25]

It is represented as div v = ∇.v. The Curl represents the rotation of a vector in a three-dimensional field. It is denoted by Curl v = ∇ x v.

The 4 basic Maxwell's Equations are as follows:

Gauss Law:

The first law states that the electric flux which forms across a closed surface is proportional to the charge enclosed.

$$\nabla E = \frac{\rho}{\varepsilon_0} \tag{2.1}$$

Gauss Magnetism Law:

The second law states that the magnetic flux induced across a closed surface is zero

$$\nabla . B = 0 \tag{2.2}$$

Maxwell-Farady equation:

The third law states that the magnetic fields which vary with time lead to an electric field.

$$\nabla \times E = -\frac{\partial B}{\partial t} \tag{2.3}$$

Ampere Circuital Law:

The fourth law states that that time-varying Electric fields or steady currents lead to a magnetic field.

$$\nabla \times B = \mu_0 \left(J + \varepsilon_0 \frac{\partial E}{\partial t} \right) \tag{2.4}$$

ρ: represents net charge inside the surface

ε_0: represents permittivity of vacuum

B: represents the magnetic field,

E: represents electric field

J: represents current density.

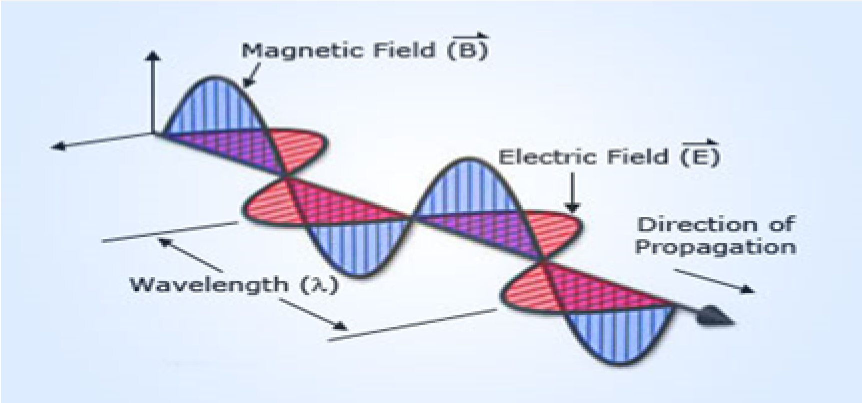


Figure 2.6: Magnetic field wave

Hence, as shown by the above equations, it is proved that a varying electric field leads to a magnetic field and a varying Magnetic field leads to an electric field. The solution of Maxwell's equations is a three-dimensional equation which represents a wave travelling at the speed of light. The electromagnetic energy waves carry energy through empty space and this energy is used for a variety of applications such as Remote sensing techniques, Radio waves, Ultraviolet (UV) rays and many more. [26]

2.3 Mechanisms and Effects of Water Magnetization:

The properties of water and their changes under the action of a magnetic field were gathered by the spectrum techniques of infrared, Raman, visible, ultraviolet and X-ray lights, which may give an insight into molecular and atomic structures of water. It was found that some properties of water were changed, and a lot of new and strange phenomena were discovered after magnetization. Magnetized water really has magnetism, which has been verified by a peak shift of X-ray diffraction of magnetized water + Fe_3O_4 hybrid relative to that of pure water + Fe_3O_4 hybrid, that is a saturation and memory effect. The properties of infrared and ultraviolet absorptions, Raman scattering and X-ray diffraction of magnetized water were greatly changed relative to those of pure water; their strengths of peaks were all increased, the frequencies of some peaks did also shift, and some new peaks, for example, at 5198, 8050 and 9340 cm^{-1}, occurred at 25°C after water was magnetized. In the meanwhile, the magnetized effects of water are related to the magnetized time, the intensity of an externally applied magnetic field, and the temperature of water, but they are not a linear relationship. The study also showed a lot of new and unusual properties of magnetized water, for example, the six peaks in 3000–3800 cm^{-1} in infrared absorption, the exponential increase of ultraviolet absorption of wave with the decreasing wavelength of light of 200–300 nm, the frequency-shifts of peaks, a strange irreversible effect in the increasing and decreasing processes, as well as a stronger peak of absorption occurring at 50°C, 70°C and 80°C, the existence of many models of motion from 85°C to 95°C in 8000–10000 cm−1 [13, 27]

Group of approaches	Colloidal	Ionic	Water
Impact object	Colloidal particles including ferromagnetic	Ions that are present in water	Water molecules
Mechanisms	The surface properties of such particles changes and they act as crystallization centers under the magnetic field influence. This group explains the anti-scale effect.	Under the influence of a magnetic field , polarization and deformation of ions occur, which are accompanied by their hydration decrease, which affects the course of physicochemical processes in aqueous systems.	This group combines ideas about the possible influence of a magnetic field on the water structure. This influence, on the one hand, can cause changes in the aggregation of water mole-cules, and on the other hand, etc

Table 2.1: Classification of the hypotheses of the EMWT mechanism

Liquid water is affected by magnetic fields , and such fields can assist its purification. Water is diamagnetic and may be levitated in very high magnetic fields (10 T), compared with Earth's magnetic field of 50 μT . Lower but still powerful magnetic fields (0.2 T) have been shown, in simulations, to increase the number of monomer water molecules but, rather surprisingly, they increase the tetrahedrality at the same time. Other studies show that an increase in cluster size in liquid water is caused by a magnetic field . In contrast, the friction coefficient of water in thin films has been shown to reduce in a magnetic field (0.16-0.53 T), indicating a possible reduction in hydrogen bond strength . The air-water surface is macroscopically deformed by a magnetic field (the "Moses Effect") . Magnetic fields of ∼0.5 T, or more, cause dips in the surface with depths of 10 -104 μm. Such processing is reported to help descale metal surfaces, improve cement hydration, change the ζ potential of colloids, accelerate the growth of plants irrigated with such water, enhance calcium efflux through biomembranes and influence the structure of model liposomes . The effect has a 'memory' effect of minutes to hours after the treatment; orders of magnitude longer than expected from water's normal relaxation processes (ps - ns). This is thought due to the formation of reactive oxygen species during treatment. electromagnetic fields that attempt to reorient the water molecules should necessitate the breakage of some hydrogen bonds; for example he increased hydration ability of water in electromagnetic fields has been shown by the dissociation of an enzyme dimer (electric eel acetylcholinesterase), leading to gel formation due to the microwave radiation from a mobile phone [28]. The resultant aqueous restructuring caused by such processes may be kinetically stable. The solubility properties of the water will change in the presence of such fields and may result in the concentration of dissolved gases and hydrophobic molecules at surfaces followed by reaction (for example, due to reactive singlet oxygen ($1O_2$) or free radical formation such as OH·) or phase changes (for example, the formation of flattish surface nanocavities, termed nanobubbles). It is also possible that these processes may result in the production of low concentrations of hydrogen peroxide isimilarly to mechanical vibrations:

$$3O_2 + H = HO_2 \tag{2.5}$$

$$HO_2 + H = H_2O_2 \tag{2.6}$$

$$HO_2 + HO_2 = H_2O_2 + 1O2 \tag{2.7}$$

Such changes can result in effects lasting for a considerable time, giving rise to claims for 'memory' effects. One of the curious facts concerning reports of the effects of magnets and electromagnetic radiation on the properties of water is the long lifetime these effects seem to have. However, this should not be so surprising as it can take several days for the effects, of the addition of salts to water, to finally stop oscillating and several months where such solutions are still changing. Also, there is evidence that water structuring in undisturbed deaerated pure water increases over a day or two , changes in dilute ethanol solution occur over days, and changes in homeopathic preparations occur over hundreds of days. a Also, clathrates may persist metastably in water, water restructuring after infrared radiation may persist for more than a day , and water photoluminescence (possibly due to impurities at gas/liquid interfaces) may change over days . In addition to the breakage of hydrogen bonds, electromagnetic fields may perturb in the gas/liquid interface and produce reactive oxygen species . Changes in hydrogen bonding may affect carbon dioxide hydration resulting in pH changes. [29]

Thus the role of dissolved gas in water chemistry is likely to be more critical than commonly realized; particularly as the formation of nanobubbles (that is, nanocavities) containing just a few hundred or less molecules of gas, the stability of larger bubbles (≈ 300 nm diameter) detected by light scattering and nanobubble coating of hydrophobic surfaces have all been described. Reinforcement of this view comes from the effect of magnetized water on ceramic manufacture and out-gassing experiments that result in the loss of magnetic and electromagnetic effects or photoluminescent effects . Gas accumulating at hydrophobic surfaces promotes the hydrophobic effect and low-density water formation. The accumulated gas molecules at such hydrophobic surfaces become supersaturating when electromagnetic effects disrupt this surface low-density water. An interesting (and possibly related) 'memory of water' phenomenon is the effect of water, previously exposed to weak electromagnetic signals, on the distinctive patterns and handedness of colonies of certain bacteria. Here, the water retains the effect for at least 20 minutes after exposure to the field. [30]

It has been proposed that extremely weak (40 nT) alternating magnetic fields combined with a weak (40 μT) static magnetic fields affect living systems by shifting molecules between coherent (clusters involving stronger hydrogen bonds, e.g., ES) and incoherent (clusters involving weaker hydrogen bonds, e.g., CS) domains. Extremely low-frequency electromagnetic fields (ELF-EMF) have significant and lasting effects on liquid water. Using a weak field, adjusted to give a magnetic field of 45 μT, on glutamic acid solutions causes changes in the pH shifting towards the de-protonated species . Using just water, FTIR-ATR spectroscopy (see below left) showed that the lower energy part of the stretching absorption band (≈ 3250 cm−1), which is related to the coherent fully-hydrogen-bonded population, decreases . Stronger ELF-EMF fields (≈ 0.15 T) were applied to water, and its relative permittivity (dielectric constant) was measured and compared with that of untreated water (see below right). It was found that the relative permittivity (dielectric constant) of the ELF-EMF field-treated water was 3.7% higher than the control over the frequency range of 1-10 GHz, which may indicate a higher molecular polarization in the treated water. [31]

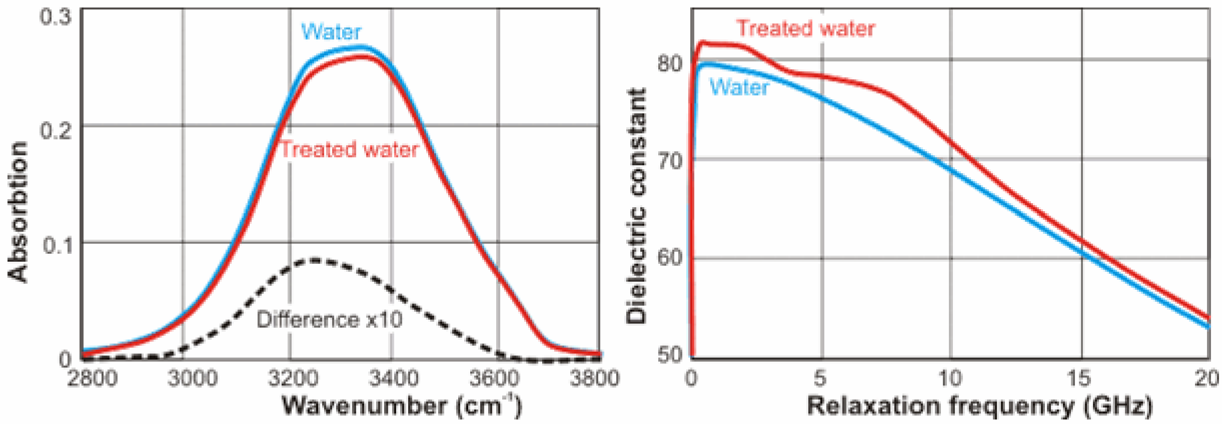


Figure 2.7: Effects of Electromagnetic field on Water.

2.3.1 The difference between magnetic and electromagnetic field in water treatment:

Magnetic water treatment and electromagnetic water treatment are both methods of altering the physical and chemical properties of water, but they use different types of fields to achieve their goals

Magnetic water treatment involves the use of a magnetic field to change the physical properties of water. The magnetic field is created by passing water through a magnetic field generator or a set of magnets. The magnetic field causes the mineral ions in the water to form clusters, which can reduce the buildup of scale and mineral deposits in pipes, water heaters, and other equipment. This is because the mineral clusters are less likely to adhere to surfaces and are more easily removed by flowing water. However, the effectiveness of magnetic water treatment is still a subject of debate, and studies have produced conflicting results. [32, 33]

Electromagnetic water treatment, on the other hand, involves the use of an electromagnetic field to alter both the physical and chemical properties of water. Electromagnetic water treatment devices typically use a combination of magnetic and electric fields to treat the water. The electromagnetic field can break up mineral clusters and reduce the formation of scale, as well as change the chemical composition of the water to improve its quality. For example, the electromagnetic field can change the oxidation state of certain ions, making them more easily removable by filtration or precipitation.

The key difference between magnetic water treatment and electromagnetic water treatment is that the latter can produce a more comprehensive treatment effect. By using both magnetic and electric fields, electromagnetic water treatment can alter both the physical and chemical properties of the water. Additionally, electromagnetic water treatment devices can be designed to produce specific treatment effects depending on the needs of the application. For example, some electromagnetic water treatment devices are designed to target specific contaminants or pathogens, while others are designed to reduce corrosion in metal pipes.

In summary, while both magnetic water treatment and electromagnetic water treatment are methods of altering the properties of water, electromagnetic water treatment offers a more comprehensive treatment effect and greater flexibility in targeting specific water quality issues. [34]

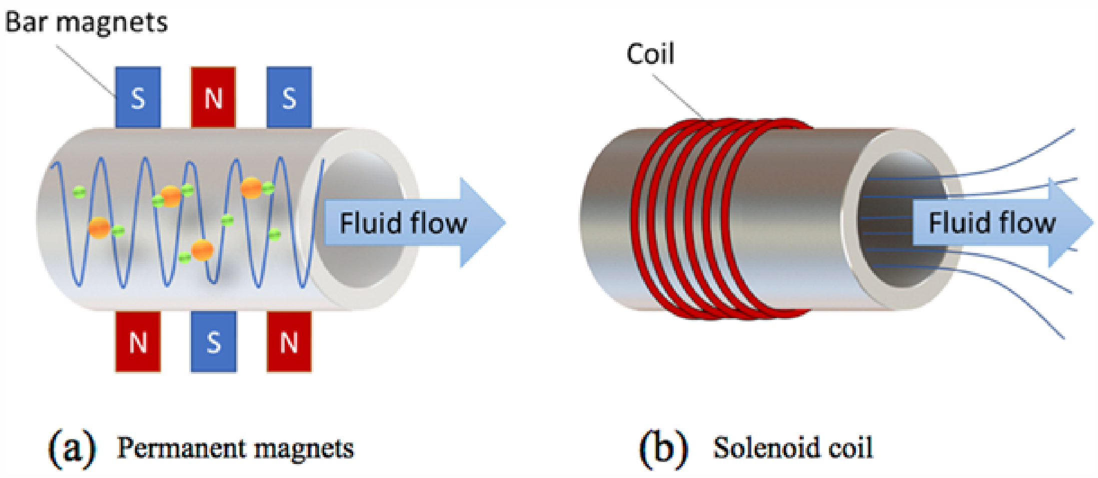


Figure 2.8: The difference between Permanent magnet and Electromagnetic coils

We can also see the effects of permanent magnet's field and Electromagnetic field on the water on this study:

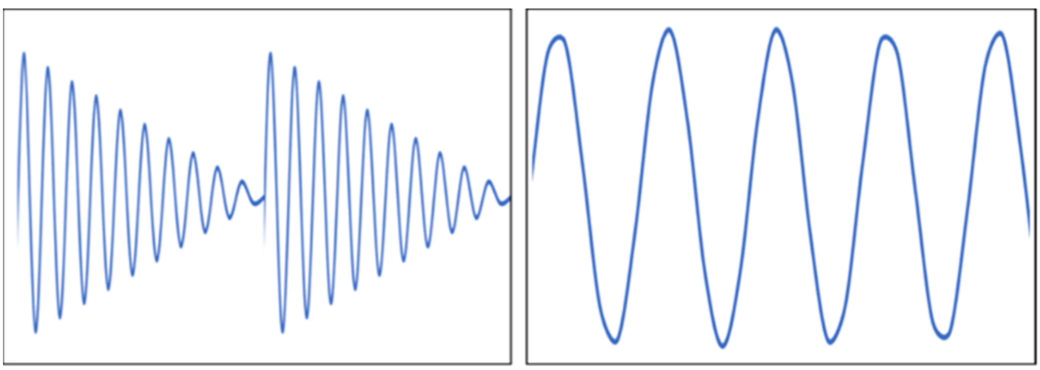


Figure 2.9: Schematic representations of waveforms for two pulsed EMF devices.

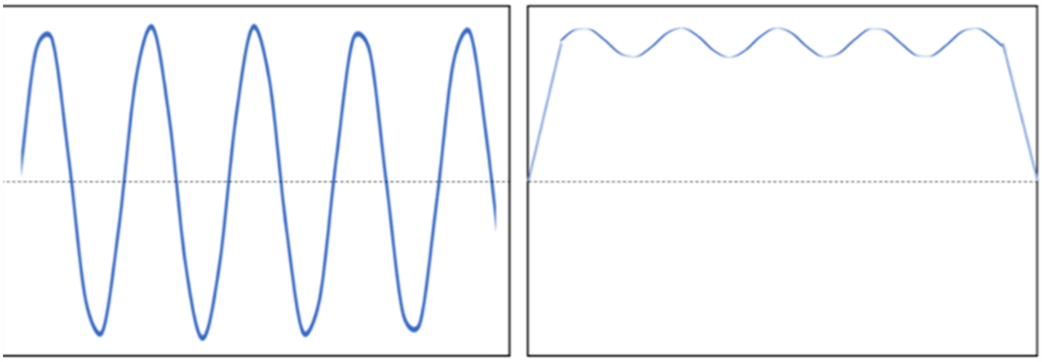


Figure 2.10: Schematic representations of waveforms for inverted and non-inverted pairs of permanent magnets

Two commercial EMF devices with comparable frequencies of ∼100 kHz but quite different waveforms have been used to study the scale of CaCO3 under the influence of the pulsed Noticing that exposure to the EMF from the device with less homogeneous waveform (Fig. 3a) can improve the quantity of CaCO3 microcrystals. Gabrielli et al.1 built a customized EMF device with permanent magnets to treat scaling waters, and utilized an ion selective electrode to measure the remaining ionic calcium. The permanent magnets of the EMF device had two configurations: inverted and non-inverted, and the corresponding waveforms are presented in Fig. 3b. The inverted configuration had a less homogeneous waveform than non-inverted one, resulting in the nucleation delay for 5–12 times. Stojakovic et al. examined the effect of different EMF waveforms generated with a home-made device on deposit formation in installations with a geothermal water. By applying the saw-tooth and sinusoidal function, the total amount of deposit in the pipe decreased from 2.07 grams (g) without EMF to 0.23 g and 0.30 g, respectively. [35]

2.3.2 Review of the different types of electromagnetic fields used in water treatment:

Electromagnetic field processing technology utilizes electromagnetic fields to improve water quality by removing suspended solid, gas, and chemical particles in water. This technology works by exposing water to variable electromagnetic fields that generate electrical currents in the water. These currents produce electromagnetic forces and frequency interferences in the water, which help to improve water quality.

There are several types of electromagnetic fields used in electromagnetic field processing technology, which differ in terms of the strength and frequency of the electromagnetic field used. Among the types used are:

2.3.2.1 Electromagnetic Radiation (EMR):

EMR refers to the range of electromagnetic waves, including radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. In water treatment, specific types of EMR, such as ultraviolet (UV) radiation and gamma radiation, are used to disinfect water. UV radiation at certain wavelengths can effectively kill bacteria, viruses, and other microorganisms by damaging their DNA. Gamma radiation, on the other hand, can also eliminate microorganisms and is sometimes used in industrial water treatment processes. [19, 36]

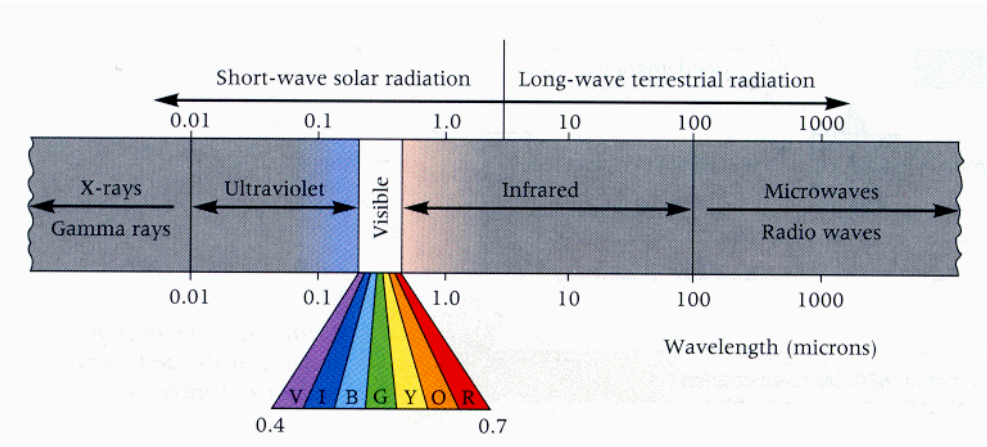


Figure 2.11: The effect of a constant electromagnetic field on water

2.3.2.2 Electromagnetic field wave:

Used to improve water quality, reduce pollutants and bacteria, and have positive effects on plants and animals.

Research suggests that the electromagnetic wave field can affect water in different ways. Exposing water to certain electromagnetic waves can change some of its physical and chemical properties, such as acidity, electrical conductivity and the ability to undergo electrolysis, so that the electromagnetic wave field can help improve water quality and reduce chemical and biological pollution in it. Exposure to an electromagnetic wave field can increase the speed of movement of mineral and organic molecules in water, thereby increasing the effectiveness of filtration and purification processes. Some studies have shown an improvement in water quality after exposure to specific electromagnetic wave fields.

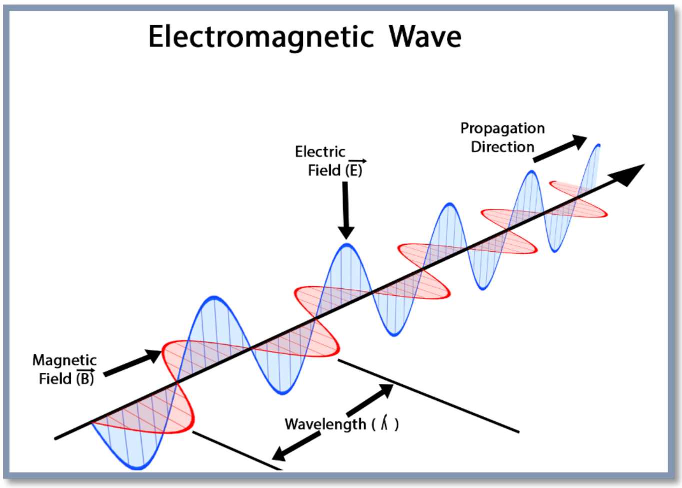


Figure 2.12: Electromagnetic waves

Radiations refers to the phenomenon of electromagnetic waves, which are produced by the interaction of electric and magnetic fields. These waves propagate through space, with their direction of movement perpendicular to the fields that give rise to them. [37] [38]

2.3.2.3 Electrostatic Field:

The electrostatic field is used to attract solid particles, organic matter, and salts to the electrical poles in water.

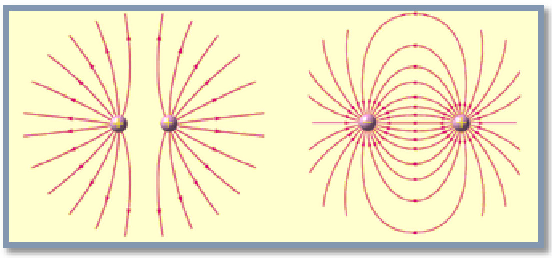
In the electrostatic field, static electric charges are formed and they affect the electric charges in particles, attracting them to the poles. This leads to the

The electrostatic field is used to attract solid particles, organic matter, and salts to the electrical poles in water.

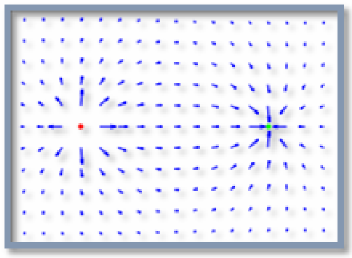
In the electrostatic field, static electric charges are formed and they affect the electric charges in particles, attracting them to the poles. This leads to the deposition of particles and solid materials in the bottom of tanks and

improves the chemical quality of water. There is not a lot of research on the effects of the electrostatic field on water. However, some suggest that exposing water to an electrostatic field can move solid and organic impurities in

the water and make them easier to settle and purify. It is also possible that exposure to an electrostatic field can change some of the physical properties of water, such as surface tension and electrical conductivity. However, the effect of the electrostatic field on water has not been sufficiently studied to determine the precise effects of this impact. [30, 31]



(a) Electric field lines around two particles with the same charges (left) and opposite charges (right).



(b) Illustration of the electric field vectors (in blue) between a positive charge (in red) and a negative charge (in green).

Figure 2.13: Effect of the electrostatic field

2.3.2.4 Electrodynamic Field:

The electrodynamic field is used to move water and reduce the deposition of particles and pollutants in it. An electric current is created in the electrodynamic field cell, and the water moves in a rotational manner, leading to the concentration of suspended particles and materials in the medium. This movement helps to increase the efficiency of removing solid and suspended materials from water.

The dynamic field is an electromagnetic field that changes periodically and is usually produced by an electric current that is periodically varied. These types of electromagnetic fields can affect water in different ways. It is known that exposure to the dynamic field can increase the speed of particle movement in water, leading to increased efficiency in filtration and purification processes. This may improve water quality.

Scientific studies have also shown other effects of the dynamic field on water, including changes in ion concentration and water conductivity. It is also possible that exposure to the dynamic field may lead to changes in the properties of solid surfaces and organic materials present in water, but these effects have not been studied sufficiently yet.

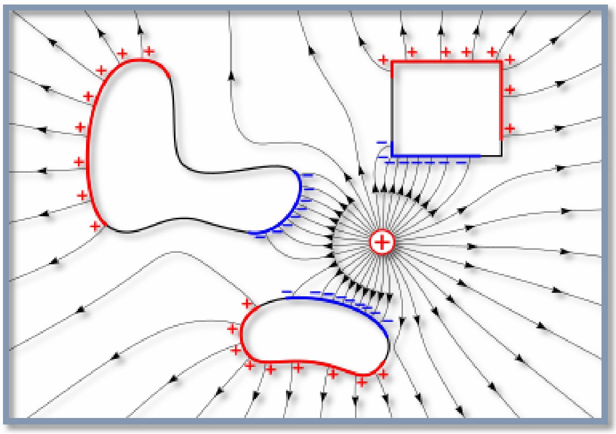


Figure 2.14: The electric field (lines with arrows) of a charge (+) induces surface. charges (red and blue areas) on metal objects due to electrostatic induction.

> Electromagnetic field processing technology is one of the modern and effective technologies used to improve water quality and remove suspended pollutants and particles. It can be efficiently used in water treatment plants to improve the quality of treated water, making it suitable for human and agricultural use. [1, 9]

2.3.3 Principles of Magnetic Fields and Evaluating the Impact of Electromagnetic Fields on Water Properties:

The motion of electric charges generates magnetic fields. These fields can interact with other magnetic fields to produce a range of effects. The strength of a magnetic field is measured in teslas (T), and its polarity indicates the direction of the field.

When water is exposed to a magnetic field, it can undergo various changes in its properties. One of the most common effects is a modification in the surface tension of the water. Surface tension is the property of water that enables it to form droplets and allows insects to walk on its surface. A magnetic field can alter the orientation of water molecules, which can, in turn, affect the surface tension of the water. . Another effect of magnetic fields on water is a change in its pH. The pH of water measures its acidity or basicity, determined by the concentration of hydrogen ions (H+) in the water. A magnetic field can cause a shift in the concentration of H+ ions, leading to a change in the water's pH.

Additionally, magnetic fields can affect the dissolved oxygen levels in water, which are crucial for aquatic life and measured in milligrams per liter (mg/L). A magnetic field can alter the solubility of oxygen in the water, ultimately affecting the dissolved oxygen levels.

In conclusion, the impact of electromagnetic fields on water properties, such as surface tension, pH, and dissolved oxygen levels, can be significant. Understanding these effects is crucial for various applications, from water treatment to environmental monitoring and management. By comprehending the impact of magnetic fields on water, we can better protect and preserve our natural resources. [18] [35]

2.3.3.1 Principles of magnetic fields:

One of the four basic forces of nature, electromagnetism has a fundamental component called magnetic fields. Electric charges move, creating magnetic fields, which may interact with other magnetic fields to generate a variety of effects.

According to the density of magnetic field lines in space, the intensity of a magnetic field The polarity of the magnetic field—which can be either north or south—indicates the magnetic field's direction.

There are a number of basic rules that regulate how magnetic fields behave, including:

1. Moving electric charges generate magnetic fields. Any time an electric charge moves, a magnetic field is produced.

2. Magnetic fields can be attracted to or repelled from. While two magnetic fields with different polarities will attract one another, those with the same polarity will repel one another.

3. Magnetic fields and electric charges may interact to create a force. The Lorentz force is a physical force that an electric charge experiences when it travels through a magnetic field. This force is perpendicular to both the magnetic field's and the charge's motion directions.

4. Electric currents can be produced by magnetic fields. A magnetic field can cause an electric current to flow through a nearby conductor when its direction or intensity changes.

5. Some materials have the ability to shield magnetic fields. Magnetic fields can be blocked or redirected by some substances, such as iron. grasp the behavior of magnetic fields requires a grasp of these concepts. [39] [25]

2.3.3.2 Examination of the effects of electromagnetic fields on water properties, including surface tension, pH,scaling, and dissolved oxygen levels:

Electromagnetic fields (EMFs) have been found to affect several water properties, including surface tension, pH, scaling, and dissolved oxygen levels.

Surface Tension: Several studies have found that exposure to EMFs can cause changes in the surface tension of water. EMFs can cause both an increase and a decrease in surface tension, depending on the frequency and intensity of the field. The exact mechanism behind this effect is still not fully understood but is thought to be related to changes in the orientation of water molecules.

pH: EMFs have also been found to have an effect on the pH of water. Exposure to EMFs can cause both an increase and a decrease in pH, depending on the frequency and intensity of the field. The mechanism by which EMFs affect pH is not well understood but may be related to changes in the solubility of carbon dioxide in water.

Scaling: EMFs have been proposed as a potential method for preventing or reducing scaling in water systems. Several studies have investigated the effects of magnetic fields on scaling and found that they can reduce the amount of mineral buildup on surfaces. However, the effectiveness of this method is still debated, and more research is needed to determine the optimal frequency and intensity of the field.

Dissolved Oxygen Levels: EMFs have also been found to affect the dissolved oxygen levels in water. Exposure to EMFs can cause both an increase and a decrease in dissolved oxygen levels, depending on the frequency and intensity of the field. The mechanism behind this effect is not well understood but may be related to changes in the solubility of oxygen in water.

Overall, the effects of EMFs on water properties are complex and can depend on several factors, including the frequency, intensity, and duration of exposure. While EMFs have shown promise in reducing scaling and other issues in water systems, more research is needed to fully understand their effects and to develop optimal methods for their use. [35]

2.4 Mathematical Models and Equations :

The method of treating water with an electromagnetic field involves exposing water to a strong magnetic field or an electromagnetic field. This process is believed to change the structure of water molecules, resulting in improved water quality and a range of potential health benefits.

There are several models and mathematical equations used to describe the effects of an electromagnetic field on water. Here are a few examples:

2.4.1 Lorentz Force Law:

This law explains the force that an electromagnetic field applies to a charged particle. It is frequently used to describe how ions travel through water when an electromagnetic field is present.

A fundamental property of electromagnetism known as the Lorentz Force property defines the force that a charged particle encounters when travelling through an electromagnetic field.

The Dutch scientist Hendrik Lorentz, who developed the concept in the late 19th century, is honored with the law's name.

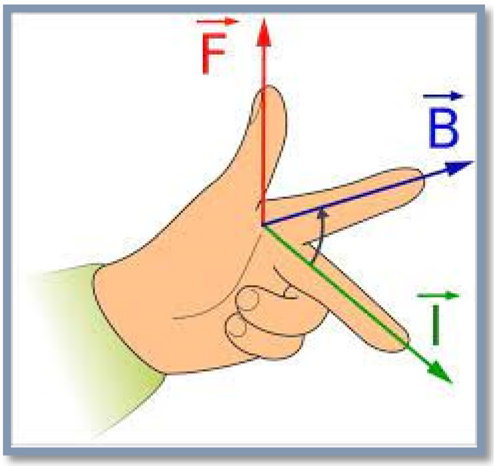


Figure 2.15: Fleming's Hand rule

According to the law, when a charged particle—like an ion—moves through an electromagnetic field, it encounters a force that is perpendicular to both the direction of the magnetic field and its velocity vector. In a magnetic field B, a particle with charge q and velocity v experiences the Lorentz force, which is represented mathematically by:

$$F = q\,(v \times B) \tag{2.8}$$

where x stands for the cross product of two vectors.

The Lorentz force law may be used to explain the movement of ions in the treated water under the effect of the electromagnetic field. The ions in the water will encounter a force when they are exposed to the field, which will drive them to flow in a specific direction. Surface tension, conductivity, and pH levels of the water can all alter as a result of this movement. [13, 32]

2.4.2 Maxwell's Equations:

These equations describe the behavior of electromagnetic fields and their interactions with charged particles. They are used to model the effects of electromagnetic fields on water molecules. Maxwell's Equations are a set of four partial differential equations that describe the behavior of electromagnetic fields and their interactions with charged particles. They were first formulated by James Clerk Maxwell in the 19th century and represent one of the most important achievements of classical physics. [11] [39]The equations are:

1. **Gauss's Law for Electric Fields**: According to Gauss's law, the net outflow of the electric field through a closed surface is proportional to the enclosed charge, including bound charge resulting from material polarization. A static electric field points away from positive charges and towards negative charges. The permittivity of open space serves as the proportion's coefficient. [13, 40]

2. **Gauss's Law for Magnetic Fields:** According to Gauss's law of magnetism, magnetic monopoles, which are analogous to electric charges, do not exist independently as north or south magnetic poles.Instead, a dipole is thought to be responsible for a material's magnetic field, and a closed surface has no effect on the magnetic field's net outflow. Loops of current or unbreakable pairs of equal and opposite "magnetic charges" can both serve as representations for magnetic dipoles. The magnetic field is a solenoidal vector field, and the total magnetic flux across a Gaussian surface is exactly zero. [30]

2.4.3 Faraday's Law of Electromagnetic Induction:

According to the Maxwell-Faraday interpretation of Faraday's law of induction, the curl of an electric field is equivalent to a time-varying magnetic field.[3] In integral form, it asserts that the rate of change of the magnetic flux through the enclosed surface equals the work per unit charge needed to transport a charge around a closed loop.

Numerous electric generators work on the idea of electromagnetic induction. For instance, a revolving bar magnet produces a fluctuating magnetic field that induces an electric field in a neighboring wire.

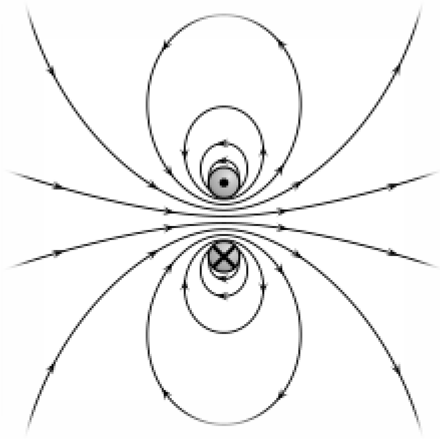


Figure 2.16: Magnetic fieldlines scheme

Gauss's rule for magnetism states that magnetic field lines never start or stop and instead form loops or go on forever, as seen in this illustration of the magnetic field caused by a ring of current.

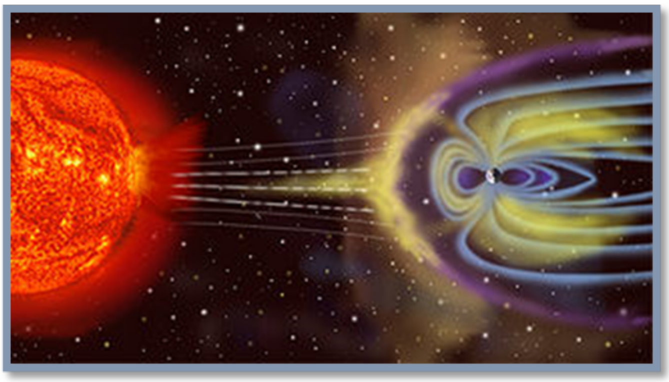


Figure 2.17: Illustration of the interaction between the Sun and Earth's magnetosphere

During a geomagnetic storm, an increase in the flow of charged particles causes a temporary change in the Earth's magnetic field. This produces electric fields in the atmosphere, which in turn causes surges in electrical power networks. It's not scaled.

- **Ampere's Law with Maxwell's Correction**:

According to Ampère's original law, magnetic fields and electric current are related. They also relate to shifting electric fields, which Maxwell referred to as displacement current,

according to Maxwell's addition. According to the integral form, every enclosing curve has a magnetic field that is proportional to the electric and displacement currents.

The importance of Maxwell's amendment to Ampère's law stems from the fact that static fields require a correction to Ampère's and Gauss' original laws. As a result, it foretells the occurrence of a rotating magnetic field in

conjunction with a fluctuating electric field.Self-sustaining electromagnetic waves that can travel over empty space are another effect.

The computed speed for electromagnetic waves matches the speed of light, which may be expected from tests on charges and currents.. One type of electromagnetic radiation is light, which also includes X-rays, radio waves, and

other types. The ideas of electromagnetism and optics were unified in 1861 when Maxwell realized the relationship between electromagnetic waves and light. [41]

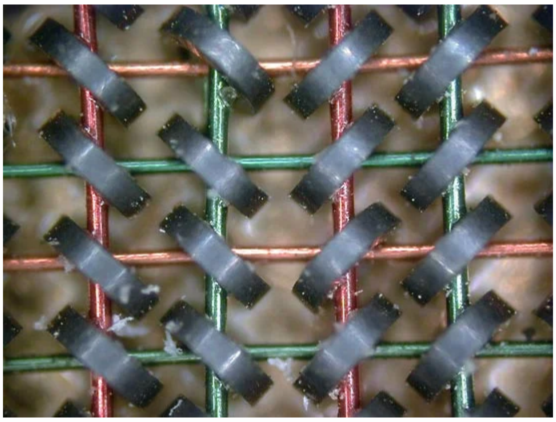


Figure 2.18: Magnetic-core storage Memory

Ampère's law is used in magnetic-core memory, which was developed in 1954. One piece of data is stored in each core.

By defining the behavior of the fields in the presence of charged particles, Maxwell's Equations are used to describe the effects of electromagnetic fields on water molecules. An electromagnetic field causes electric currents to flow through water when it comes into contact with it, and these currents in turn cause the water molecules to vibrate and move in reaction to the field. The structure and characteristics of the water may alter as a result of this movement, which may affect the water's capacity to carry and dissolve chemicals. [42]

- **Quantum Electrodynamic Theory:**

While QED is primarily used to describe the behavior of subatomic particles, it is sometimes used to explain the effects of electromagnetic fields on the structure of water molecules. According to some theories, water molecules can form networks or clusters under the influence of an electromagnetic field. These structures may be stabilized by the exchange of virtual photons between the water molecules, which can result in changes to the properties of the water, such as its surface tension, viscosity, and ability to dissolve substances. However, it should be noted that the application of QED to the study of water is still a topic of ongoing research, and its potential applications in water treatment and other fields are still being explored.

It is occasionally used to explain how electromagnetic fields affect the structure of water molecules, even though QED is typically used to describe the behavior of subatomic particles. A network or cluster of water molecules may develop under the influence of an electromagnetic field, according to certain ideas. The exchange of virtual photons between the water molecules may maintain these structures and alter the characteristics of the water, including its surface tension, viscosity, and capacity to dissolve things. It should be emphasized that QED's potential uses in water treatment and other sectors are still being investigated, and research on its use in the study of water is currently underway. [43]

The behavior of fermions, such as electrons, in the presence of an electromagnetic field is described by the Dirac equation, a relativistic wave equation. In mathematics, it may be expressed as:

$$(i\gamma^{\mu}\partial_{\mu} - m)\psi = 0 \tag{2.9}$$

i : the imaginary unit $(\sqrt{(-1)})$.

ψ: The wave function of the particle

γ^{μ}: are the Dirac matrices

∂_{μ} is the partial derivative with respect to space-time coordinates

m: is the mass of the particle

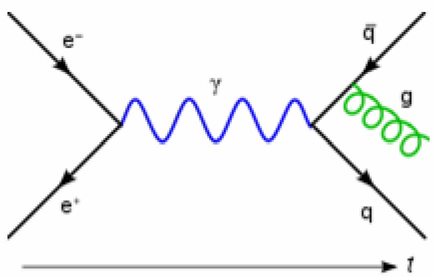


Figure 2.19: Feynman diagram elements

- **Vortex Theory:** According to the vortex hypothesis, when an electromagnetic field is present, water molecules can organize into coherent shapes or vortices that have unique characteristics and improve the water's quality. The circulation and transportation of nutrients and other materials are expected to be greatly aided by these vortices, which are supposed to resemble the formations seen in natural water bodies like rivers and seas.

The vortex hypothesis states that an electromagnetic field can cause the water molecules to rotate, which can result in the development of vortices. It is thought that these vortices have a stable structure and can survive without the electromagnetic field.

Additionally, additional molecules like dissolved gases and minerals can be drawn to and organized by the vortices, changing the water's physical characteristics. Viktor Schauberger, an Austrian forester and naturalist who investigated the characteristics of water and its interactions with the environment, is one of the primary proponents of the vortex hypothesis. According to Schauberger, the health and vitality of the ecosystems that are sustained by natural water bodies may be attributed to the vortex patterns that can be found there. The vortex hypothesis has drawn criticism for having ill-defined mathematical equations and for lacking a solid scientific foundation. However, some academics are still investigating the characteristics of water vortex formations and their possible uses in industries like water treatment and agriculture. [44] [45]

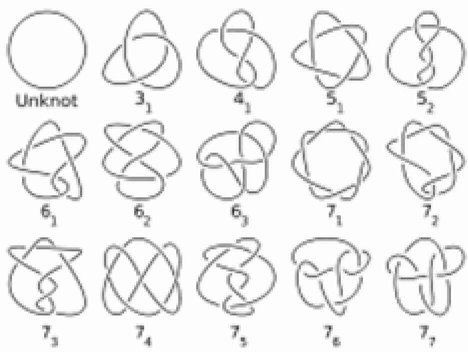


Figure 2.20: The knots with up to 7 crossings.

Chapter 3

Methodology

3.1 Introduction

This chapter aims to present the methodology employed in the development and evaluation of an electromagnetic water treatment device. The device under investigation harnesses the power of electromagnetic fields to alter the physicochemical properties of water, with the ultimate goal of enhancing its quality. In order to ascertain the effectiveness of this device, a comprehensive analysis will be conducted in the laboratory, employing various parameters and indicators to assess its performance.

The primary objective of this study is to establish the efficacy of the electromagnetic water treatment device in terms of its ability to remove or reduce contaminants and reduce scaling, improve water clarity, and enhance overall water quality. The methodology outlined herein will serve as a roadmap to systematically investigate the device's operation, optimize its parameters, and validate its performance using rigorous laboratory testing procedures.

To accomplish these objectives, the following sections will be presented in this chapter. First, a detailed description of the electromagnetic water treatment device will be provided, elucidating its design, construction, and operational principles. Subsequently, the laboratory experimental setup will be explained, highlighting the key instruments, equipment, and protocols employed in the analysis. This will be followed by a comprehensive overview of the selected water quality parameters that will be evaluated during the testing process.

In addition to the technical aspects of the methodology, a critical review of the relevant literature on electromagnetic water treatment will be included. This review will provide a theoretical foundation for the experimental investigation, ensuring that the research aligns with existing knowledge and contributes to the advancement of the field.

By implementing a systematic and rigorous approach, this research aims to bridge the gap between theoretical understanding and practical application of electromagnetic water treatment. The findings of this study will not only provide valuable insights into the performance and efficacy of the proposed device but also contribute to the broader body of knowledge in water treatment methodologies.

Ultimately, the successful validation of the electromagnetic water treatment device's performance through laboratory analysis will pave the way for future research and potential implementation in real-world scenarios.

3.2 Design of EMTD (Electromagnetic water treatment device):

An electromagnetic water softener device is designed to reduce the amount of hard minerals in water by using an electromagnetic field thus reducing scale. The device is typically installed near the water source and has two coils, one wrapped around the incoming water pipe and another wrapped around an outgoing pipe

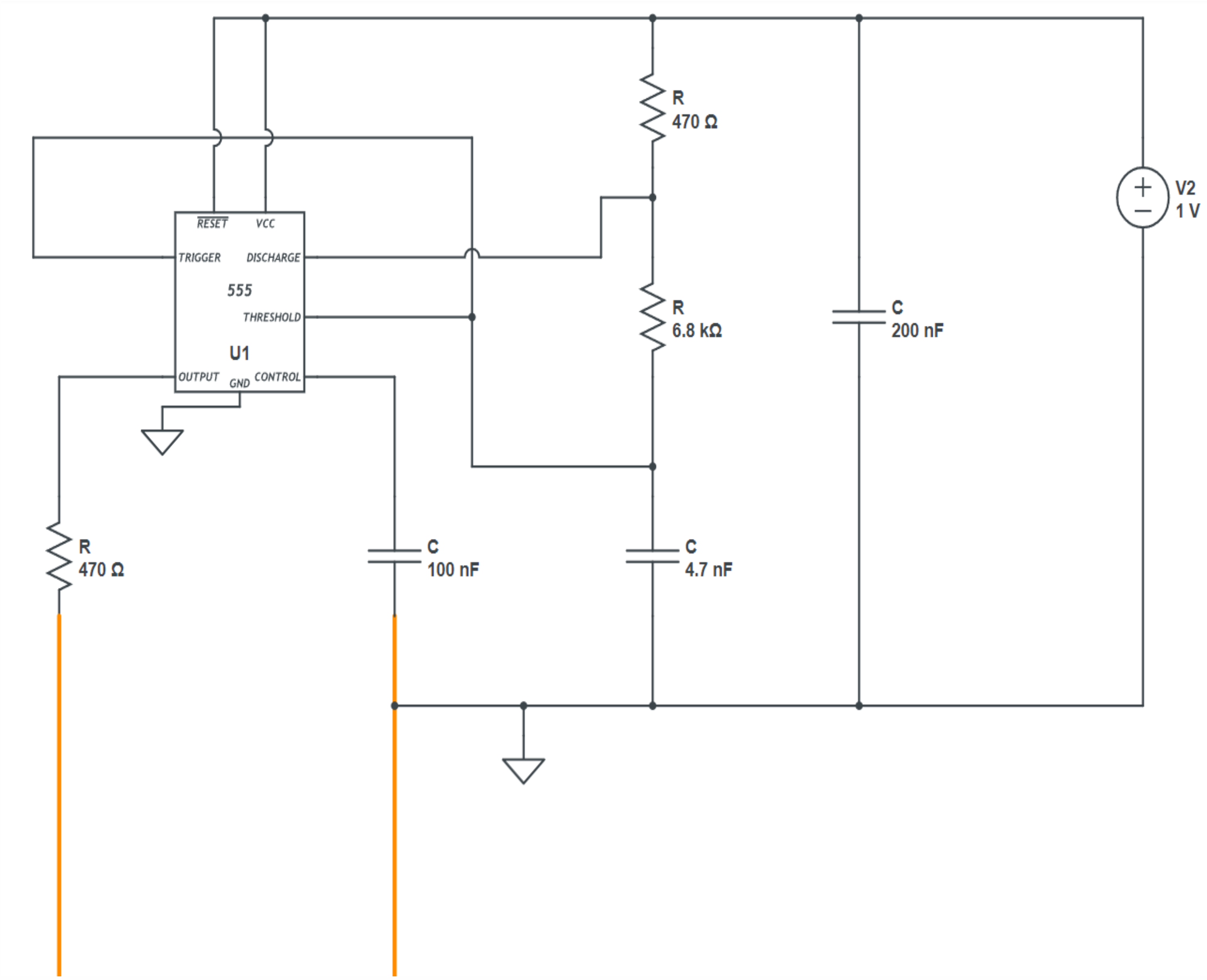


Figure 3.1: Electromagnetic water Treatment device circuit

3.2.1 Technical specifications:

The device is characterized by an electromagnetic technology that allows it to improve the quality of the water and its efficiency in various uses, and this is due to the real results obtained in several scientific journals, including the Journal under the number:208727048, as well as the analyzes that we have carried out.

Magnetic Power	0.2 Gauss, can be adjusted according to customer requirements.
Frequency	702 Hz, can be adjusted according to customer requirements.
Size and Weight	30*10*3 cm, 500 grams.
Power Supply	The device can be operated using a power outlet or requires a 12-volt battery for power.
Construction Materials	Plastic, firewood. Additional Features: Durability, ease of use.

Table 3.1: Spécifications techniques

3.2.2 Circuit Description:

In this circuit, the values of C1, C2, C3, and R1 and R3 set the frequency and duty cycle of the astable multivibrator circuit, and R2 and C2 act as a feedback network to stabilize the oscillation. The CV pin is connected to C2 to provide voltage control of the oscillator frequency. R1 and R3 are connected in parallel to the DIS pin to prevent the NE555 from resetting when the voltage at the CV pin is changed.

When power is applied to the circuit, the NE555 will begin oscillating at a frequency determined by the values of C1, C2, and R1 and R3. This will cause a fluctuating magnetic field to be generated by the copper wire coils. The frequency of the magnetic field can be adjusted by changing the resistors or adding and improving the circuit.

Using LTspice simulator A standard NE555 timer is used to form an astable oscillator. Its free running frequency is about 15kHz with component values shown. Power supply can be from 9 to 15 Volts, the output voltage at Pin3 will swing to the full supply voltage. The diagram below shows a typical transient waveform in LTspice. The reciprocal of the time difference indicates the frequency. Although no switch is shown current drain is about 5mA.

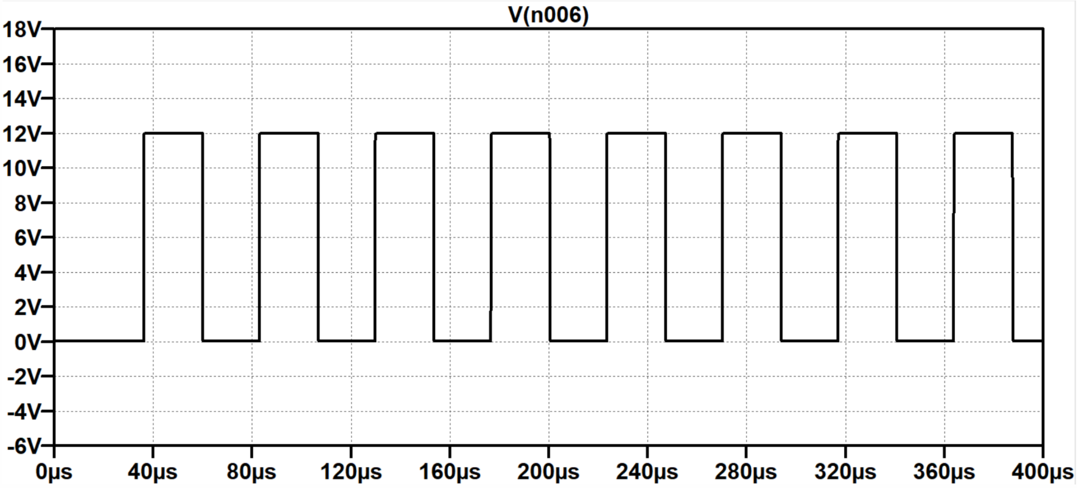


Figure 3.2: Voltage graph simulated by LTspice software

3.3 Testing change in properties of water:

3.3.1 pH and Dissolved Oxygen:

Tap water and water from a local reservoir were tested for their pH and DO values. Before passing the samples through the EMTD solenoid coils, pH and DO values were recorded for each sample. The water samples were then passed through the EMTD, as seen in Figure 3.3, and then tested with a pH meter and a DO meter.

The samples were magnetically stirred at a low velocity while the data was collected to keep the sample thoroughly mixed.

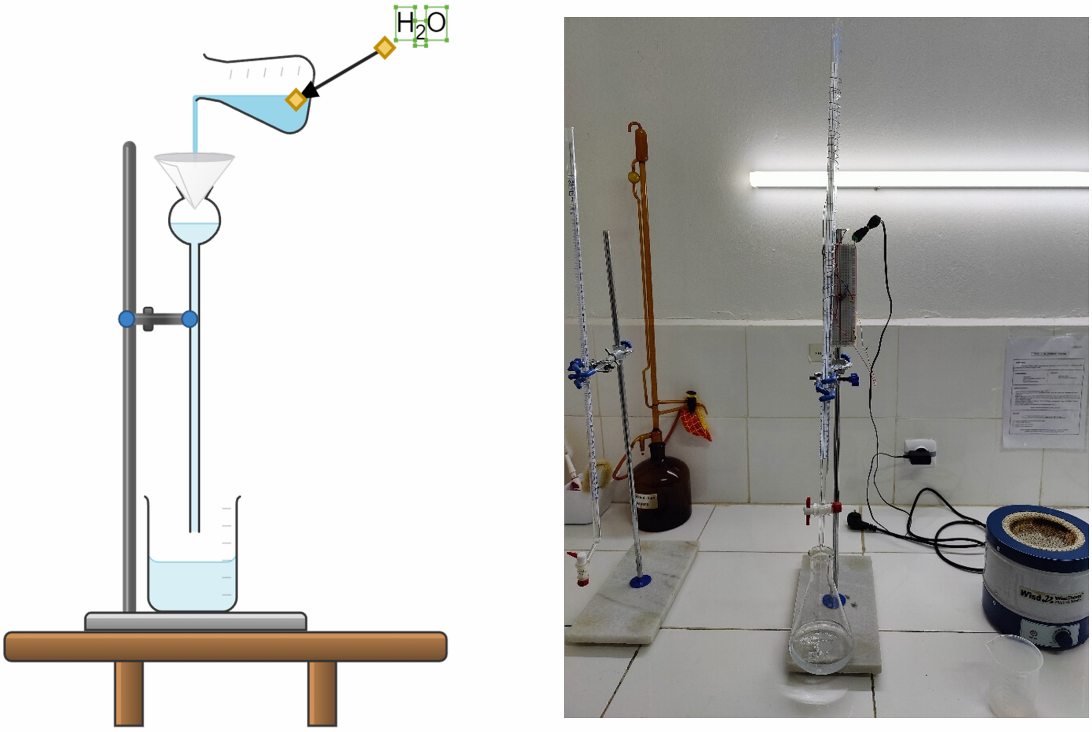


Figure 3.3: EMTD Coils wrapped around the Burette

Each water sample was tested at 1x pass through the EMTD, 2x and 5x to evaluate whether successive passes altered the sample's properties. The non-magnetic samples were also passed through the funnel without the Device attached so the only difference in the water's treatment was the absence of EMTD. After initial readings had been taken, the solutions were rapidly stirred for 2 minutes by the magnet stirrer to induce a vortex and introduce more oxygen into the solution. The DO was tested again after the sample was mixed.

3.4 Testing Changes in Water Properties (Magnesium, Calcium, Hardness and Chloride):

3.4.1 How scale forms:

Scaling occurs when dissolved minerals, such as calcium, magnesium, and other impurities in the water, precipitate and solidify on the inner surfaces of the tubes over time. The exact process of scale formation can vary depending on the specific minerals present in the water and the temperature and pressure conditions. However, the general steps involved in scale formation are as follows:

1. Precipitation: When the concentration of dissolved minerals in the water exceeds their solubility limit, they can no longer remain in a dissolved state. This leads to their precipitation or crystallization as solid particles.

2. Nucleation: The precipitated minerals form tiny nuclei or seed crystals on the inner surfaces of the tubes. These nuclei provide a surface for further mineral deposition.

3. Crystal Growth: Once the nuclei form, the dissolved minerals in the water continue to deposit on these surfaces, causing the crystals to grow larger. The crystals may have different shapes and structures depending on the specific mineral composition

4. Aggregation: As the crystals grow, they may merge or aggregate with nearby crystals, forming a more solid and compact scale layer.

Factors such as temperature, pressure, pH levels, and the mineral content of the water can influence the rate and extent of scale formation. Higher temperatures and lower flow rates can promote scale formation by accelerating mineral precipitation and reducing the ability of water to hold dissolved minerals. Scale deposits can cause various problems, including reduced flow rates, increased energy consumption, and decreased efficiency in heat exchange systems. To mitigate scaling, methods such as chemical treatment, water softening, mechanical descaling, and regular maintenance are often employed, depending on the specific circumstances and scale severity.

3.4.2 Laboratory analyses:

To determine the level of calcium and magnesium, Hardness and Chloride in the treated water and non-treated one, a chemical analysis was done:

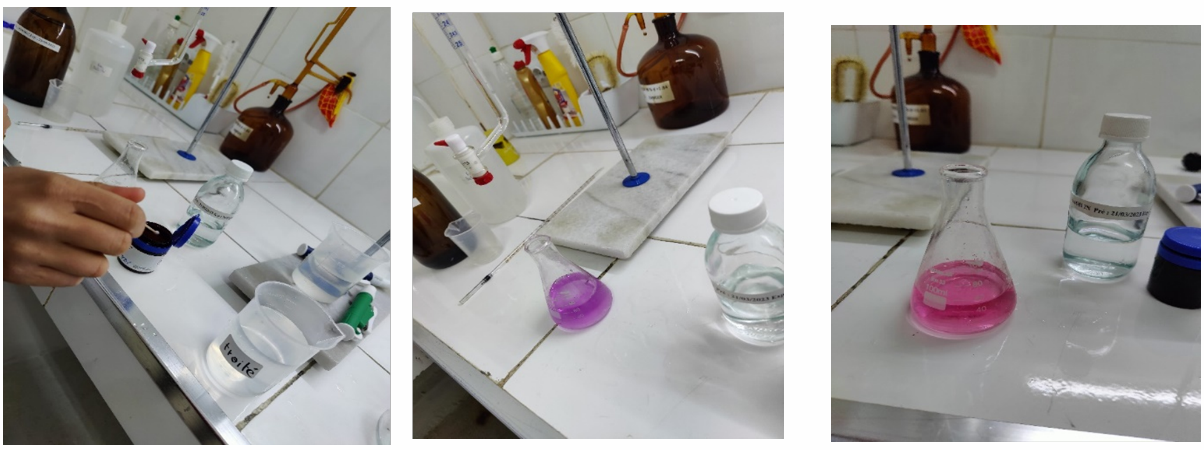


Figure 3.4: Illustrations of Laboratory work

- Collecting a representative water sample that has been treated using the electromagnetic device.
- Equipment and Reagents: The necessary equipment and reagents for the hardness test. This typically includes a titration setup, a burette, an Erlenmeyer flask, a pH indicator (e.g., Eriochrome Black T), and titrants (e.g., ethylenediaminetetraacetic acid (EDTA 3.72g) solution).
- Calibration: Calibrating the pH indicator using standard solutions to ensure accuracy.
- Sample Preparation: a 50ml of water was filtered to ensure that there are no left particles to have some accurate calculations.
- Titration preparation: We Added a few drops of the pH indicator (Eriochrome Black T) to the water sample in the Erlenmeyer flask. The indicator produced a color change in the presence of calcium and magnesium ions.
- Titration Procedure: Filling the burette with the EDTA 3.72g solution (titrant) for the Hardness test and 2mL NaOH (2N) + Solution of Murexide Powder for the Calcium test.
- Slowly adding the EDTA 3.72g solution drop by drop into the water sample while swirling the flask. The solution chelated with the calcium and magnesium ions in the water, causing the color to change.

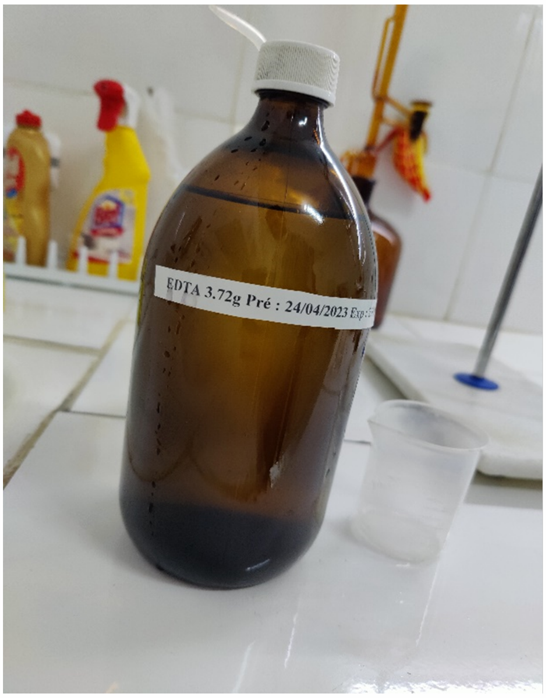


Figure 3.5: Solution preparation

- Endpoint Determination: The color change of the solution indicates the endpoint of the titration. The indicator changed from blue to pink or purple when the calcium and magnesium ions have been completely complexed by the EDTA 3.72g.

- Titration Calculation: By noting the volume of EDTA 3.72g and NaOH (2N) solution used for the titration. The volume required is proportional to the concentration of calcium and magnesium ions in the water sample.

- Calculate the chloride in water using the same methods above with solution of AGN03 0.1N, 25mL of treated and non-treated water and 6 drops of the yellow potassium chromate.

Figure 3.6: Chloride prepared solutions

Results and calculation were done and the levels of calcium, Magnesium, Hardness and Chloride were obtained on different samples of water.

3.5 Testing TDS and Water Conductivity:

Total Dissolved Solids (TDS): refers to the collective concentration of inorganic and organic substances that are dissolved in water. These substances can include minerals, salts, metals, ions, organic compounds, and other dissolved particles. TDS is typically expressed in milligrams per liter (mg/L) or parts per million (ppm) and represents the mass of dissolved solids per unit volume of water.

TDS can originate from various sources, such as natural geological formations, industrial processes, agricultural activities, and water treatment practices. Common constituents of TDS include calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, nitrate, and organic matter.

The measurement of TDS provides an indication of the overall quality and mineral content of water. High TDS levels may affect the taste, appearance, and suitability of water for specific purposes. In certain applications, such as drinking water, irrigation, aquaculture, and industrial processes, TDS levels are important factors to consider and can be regulated by relevant standards and guidelines.

TDS can be measured using various methods, including conductivity measurements, gravimetric analysis, and laboratory instruments such as TDS meters. Conductivity is commonly used as an indirect measure of TDS because dissolved ions in water contribute to its electrical conductivity. By measuring the conductivity of water, an estimation of the TDS level can be obtained. However, it is important to note that conductivity measurements do not provide information about the specific types or concentrations of individual dissolved substances within the TDS.

- **Procedure:**

Preparing a neuteral solution to calibrate the sensor and the device that has been used is

RCYAGO 5 in 1 TDS/EC/PH/Salinity/Temperature Meter

Pouring 50mL of Electromagnetic treated water and 50mL of non-treated water and then using the device that is connected with the computer and collecting data.

Figure 3.7: RCYAGO 5 in 1 TDS/EC/PH/Salinity/Temperature Meter

Water conductivity : the ability of water to conduct an electrical current. It is a measure of the water's ability to transmit electrical charges through the presence of dissolved ions or other conductive substances.

Pure water, in its natural state, is a poor conductor of electricity because it has a low concentration of ions. However, when water contains dissolved substances such as salts, minerals, or other ionic compounds, it becomes more conductive due to the presence of charged particles (ions) that can carry the electric current. Conductivity is typically reported in units of siemens per meter (S/m) or microsiemens per centimeter (µS/cm). Higher conductivity values indicate a higher concentration of dissolved ions or other conductive substances in the water. Water conductivity is influenced by several factors, including:

1. Dissolved ion concentration: The more ions present in the water, the higher the conductivity.

2. Temperature: Conductivity generally increases with higher temperatures due to enhanced ion mobility.

3. Dissolved solids: Water with a higher concentration of dissolved solids, such as salts, will have higher conductivity. Taking a sample of 50ml of Treated and non-treated water and using a device to calculate the parameters and using a logger in the computer that draws readings.

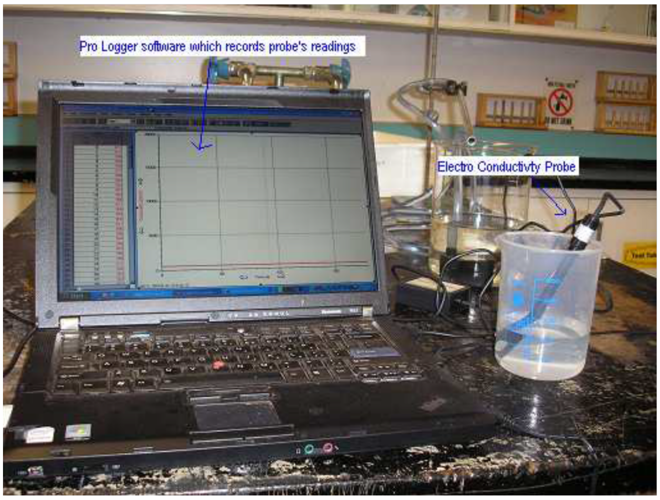


Figure 3.8: Logger Pro software with Electro conductivity probe.

3.6 Results and discussions:

3.6.1 Results on pH test:

The first test compared tap water passed through the device with EMTD 1x, tap water passed through the device with MTD 5x, with water speed flow of v=0.18m/s at C=20°, tap water passed through the device without Treatment of the device and. The results can be seen in the Figure 3.9 below:

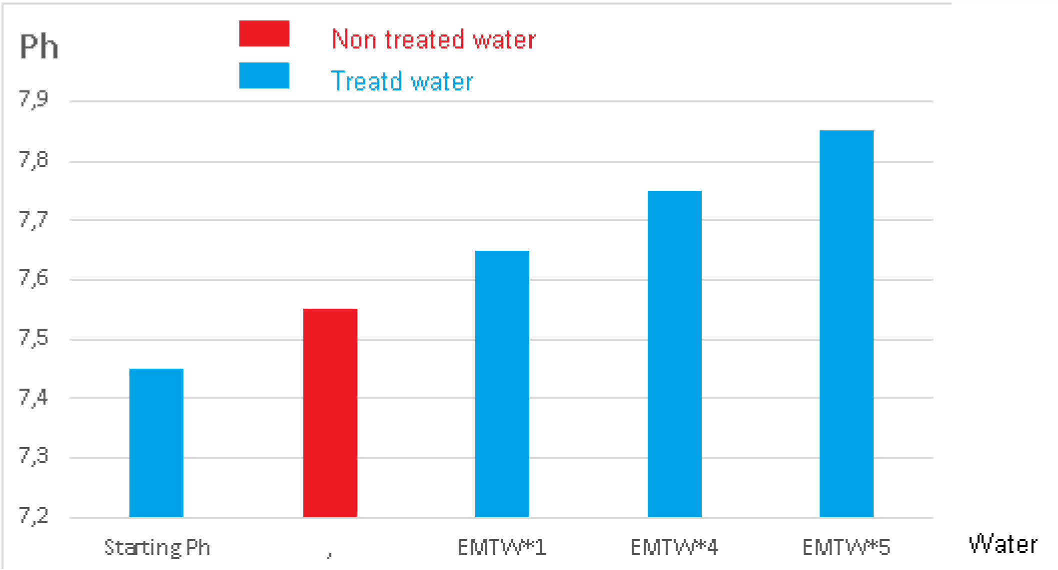


Figure 3.9: Comparison of pH values passed through EMTD

The diagram shows a line graph with the x-axis representing the number of electromagnetic field treatments applied to the water, and the y-axis representing the pH value of the water. The graph begins with one treatment and progresses to five treatments.

At the start, with only one treatment, the pH value of the water is relatively increasing, indicating acidity. As the number of treatments increases to three, four, and five, the pH value steadily rises after each treatment. This trend suggests that the electromagnetic field treatments are causing the pH of the water to increase over time.

However, as the number of treatments continues to increase, the graph shows that the pH value eventually stabilizes at 7.85. This value is considered neutral, indicating a balanced acidity-alkalinity level in the water. The stabilization of the pH at 7.85 suggests that the electromagnetic field treatments have reached a point of equilibrium, where further treatments do not significantly alter the pH of the water.

This stabilization indicates that the water has reached a state of balance in terms of its acidity-alkalinity properties.

Overall, the diagram visually represents the relationship between the number of electromagnetic field treatments and the corresponding pH values of the treated water. It demonstrates how the pH increases with each treatment until it reaches a stable value of 7, signifying a balanced pH level.

To ensure that these tests were correct, another water sample was studied in a Milk's Factory with different equipements use for the test and the results are show in figure 3.10

with the same Treatements:

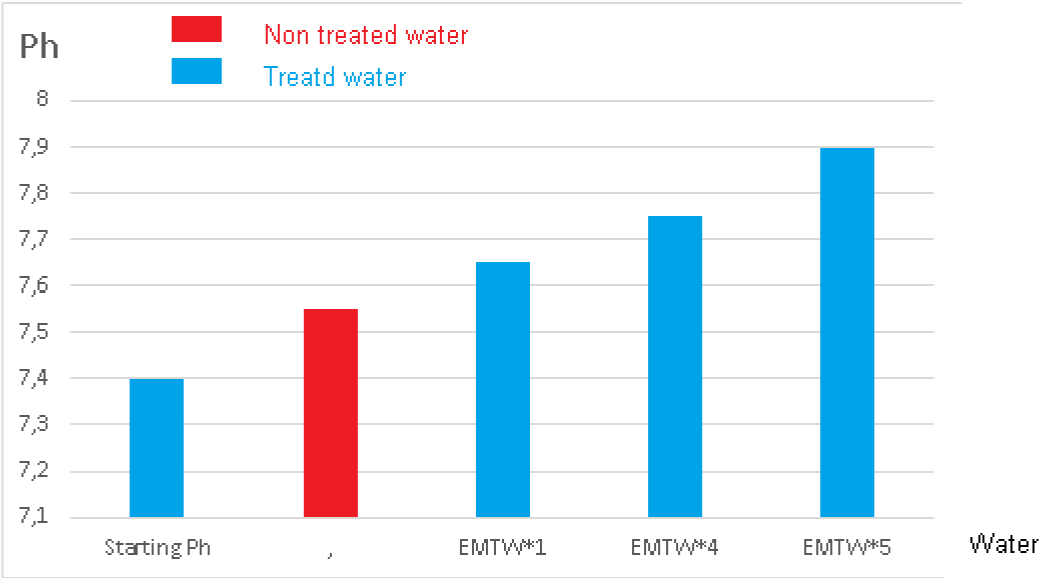


Figure 3.10: Comparison of pH values passed through EMTD with a different water

3.6.2 Discussion on the pH test:

The study that has been done on the pH test with Different water samples in different locations was shown that the pH level Increases pH is a measure of the acidity or alkalinity of a solution, with a scale ranging from 0 to 14.

A pH of 7 is considered neutral, below 7 is acidic, and above 7 is alkaline.

In this case, the water initially had a pH level of 7.4, which is slightly on the acidic side of neutral. However, through a particular process or treatment, the pH of the water increased gradually to nearly 7.9.

An increase in pH indicates a shift towards alkalinity or a decrease in acidity. As the water's pH level moves closer to 7.9, it becomes more alkaline. The specific cause of this pH increase would need to be determined through the context of the experiment or situation in question.

This is due to:

1. Ionization of water molecules: When water is subjected to an electromagnetic field, the energy from the field can lead to the ionization of water molecules. This ionization process involves the separation of water molecules into charged particles known as ions. Specifically, the electromagnetic field can cause an increase in the concentration of hydroxide ions (OH-) in the water, which contributes to a rise in pH.

2. Reduction in dissolved carbon dioxide: Carbon dioxide (CO_2) dissolved in water can react with water molecules to form carbonic acid (H_2CO_3), which contributes to acidity. When an electromagnetic field is applied to water, it can accelerate the breakdown of carbonic acid into carbon dioxide gas (CO_2) and water (H_2O). This removal of dissolved carbon dioxide results in a decrease in the concentration of hydrogen ions (H^+), leading to an increase in pH.

Alkaline substances generated: In some cases, the application of an electromagnetic field can lead to the generation of alkaline substances or the release of minerals and ions present in the treatment system. These alkaline substances, such as hydroxides or carbonates, can act as buffering agents and increase the pH of the water.

3.6.3 Results on Calcium, Magnesium, TDS, Hardness and Chloride:

The Table shows the water analysis values before the exposure of the electromagnetic field:

Settings	Tap Water 1	Tap water 2	EMTW 1	EMTW 2
pH	7.45	7.49	7.95	7.89
Conductivity	1743 µS/Cm	1695 µS/Cm	1255 µS/Cm	1201µS/Cm
TDS	889 ppm	843 ppm	495 ppm	512 ppm
Salinity	0.9 PSU	0.85 PSU	0.49 PSU	0.55PSU
Calcuim	132.26mg/l	125.81mg/l		
Oxydability	0.41mg/l	0.33mg/l	0.55mg/l	0.48mg/l
Chlorure	84.5 mg/l	81.5 mg/l	82.5 mg/l	81.5 mg/l
Temperature	19.5°C	22°C	19.8°C	19.7°C
Magnesium	125.77mg/l	121.22mg/l		
Hardness	250	340	230	311

Table 3.2: Results of the water Parameters

The mineral content of water such as Magnesium and calcium had changed after treating the water with electromagnetic field due to the change in pH levels pH is a measure of the acidity of the liquid. The lower the pH, the higher the acid content. This will dissolve more calcium carbonate.

The electromagnetic field alters the crystallization process of calcium and magnesium ions, leading to the formation of smaller, more manageable particles. Instead of large, rigid scale deposits, the treated water may contain smaller particles that are less likely to adhere to surfaces and form scale. This modification in the crystallization process helps to mitigate scaling issues and reduces the concentration of calcium and magnesium in the water.

Note:

The electromagnetic field can create an environment where the treated water becomes more effective at keeping mineral particles in suspension. This means that rather than precipitating out as solid scale deposits, the calcium and magnesium particles remain dispersed and suspended in the water. As a result, the concentration of these minerals in the treated water appears to decrease.

3.7 Conclusion:

In conclusion, this chapter has presented the methodology for evaluating an electromagnetic water treatment device and conducting laboratory analysis to assess its efficacy. The study sought to address the pressing need for innovative approaches to water treatment, considering the increasing challenges posed by water pollution and the quest for clean and safe water sources.

The efficacity of the device depends on the type of water that is being treated, the quality of the EMTD and it's configurations and the material that is used to analyse the water and the results.

Furthermore, a critical review of the existing literature on electromagnetic water treatment provided a theoretical foundation for the study, facilitating the integration of current knowledge with the experimental investigation. By building upon established principles and addressing gaps in understanding, this research aimed to contribute to the advancement of electromagnetic water treatment methodologies.

Part III

General conclusion

In addition to the aforementioned points, further details regarding the conclusion of the thesis on electro-magnetic water treatment are as follows:

The comprehensive examination of previous research and studies indicates that electro-magnetic treatment has shown promising results in various water treatment applications. It has been found to effectively reduce the formation of calcium deposits, which is a common issue in many water systems. This reduction not only helps in maintaining the efficiency of water distribution and storage systems but also extends the lifespan of equipment such as pipes, faucets, and appliances that come in contact with water.

Moreover, the improvement in taste and odor resulting from electro-magnetic water treatment enhances the overall consumer experience and satisfaction. Many consumers are sensitive to the taste and smell of water, and by addressing these factors, the method provides a more pleasant and enjoyable drinking experience.

The potential for further advancements in water quality through the utilization of various techniques within the electro-magnetic treatment process is another key finding. Researchers have explored different configurations of magnetic field generators, electrode materials, and treatment durations to optimize the efficiency of the process. By continuing to investigate and develop these techniques, it is possible to enhance the effectiveness of electro-magnetic water treatment and expand its range of applications.

By implementing electro-magnetic water treatment methods, the provision of safe and clean drinking water can be significantly improved. This is especially crucial in areas where water contamination and pollution pose significant risks to public health. Electro-magnetic treatment offers an environmentally friendly and sustainable solution that reduces reliance on chemical additives, benefiting both human health and the ecosystem.

To fully unlock the potential of electro-magnetic water treatment, further research and development efforts are necessary. This includes conducting additional studies to better understand the underlying mechanisms, optimizing treatment parameters, and exploring potential synergies with other water treatment methods. Collaboration between researchers, engineers, and water industry professionals is vital to advancing the field and implementing electro-magnetic water treatment on a larger scale.

In conclusion, electro-magnetic water treatment holds great promise as an effective and sustainable approach to enhance water quality. Its ability to mitigate calcium deposits, improve taste and odor, and contribute to the provision of safe drinking water makes it a valuable tool in water treatment processes. Continued research and development will drive advancements in this field, leading to more efficient and widespread implementation of electro-magnetic water treatment technologies for the betterment of society and the environment.

Part IV

Appendix

LABORATOIRE DE CONTROLE QUALITE ET DE CONFORMITE
KHALFAOUI CHIHAB EDDINE
CHIHAB LAB
Autorisation ministérielle N°004 DU 22 /02/2018

ADRESSE : ZONE D ACTIVITE ET DE STOCKAGE
RTE ANNABA Local 114 /03 ; Tébessa/ALGERIE
Tel : +213 550 324 430/+213 561 905 216
Mail : chook8419@Gmail.com

CHIHAB.LAB

BULLETIN D'ANALYSES PHYSICO-CHIMIQUES

RAPPORT N° PH 206 /23

CLIENT
•*CLIENT:* Stagier

ECHANTILLON
•ID echantillon E 206 A lot / prelevé le : 06/05/2023
•denomination EAU PROCESS NON Traité par TECH LABO
•nature: EAU PROCESS

resultats
•recu le 05/05/2023 A 10H
•lancé le 06/05/2023

PARAMETRE	RESULTATS	NORMES	METHODE/REFERENCE	
DURETE	220	100 -500	NA 752	
pH à 20°C	6.63	6.5 à 8,5	NA 751	JO N°27-26/04/2006 JO N° 18DU 23 /03/ 2011
CHLORURE CL^-	241.4 g /l	<400 g /l	NA 6362	
CONDUCTIVITE A 20°C	1763 µsm/cm	<2800 µ sm/cm	NA 749	
SALINITE	0 .1	< 1	/	
TDS	825 ppm	<1000 ppm	/	
MAGNISUM	125.77	150 mg/l	NA 1655	
CALCIUM	132.26	75à 200mg/l	NA 1655	

FACTEURS SONSORIELLES		
Paramètre	résultats	Référence
Couleur	nulle	Cac/misc 06 /2013 CCFA 2013 JO N°27-2006 codex alimentaire
Odeur	nulle	
Saveur	nulle	

NB : résultat est représentatif seulement pour l'échantillon prélevé LE 06/05/2023

LE DIRECTEUR DU LABORATOIRE

Eau de processe 06/05/2023 Page 1 sur 2

LABORATOIRE DE CONTROLE QUALITE ET DE CONFORMITE
KHALFAOUI CHIHAB EDDINE
CHIHAB LAB
Autorisation ministérielle N°004 DU 22 /02/2018
ADRESSE : ZONE D ACTIVITE ET DE STOCKAGE
RTE ANNABA Local 114 /03 ; Tébessa/ALGERIE
Tel : +213 550 324 430/+213 561 905 216
Mail : chook8419@Gmail.com

BULLETIN D'ANALYSES PHYSICO-CHIMIQUES

CLIENT

- *CLIENT:*
- *ADRESSE*

ECHANTILLON

- **ID echantillon** E 206 A **lot** / **prelevé le : 06/05/2023**
- **denomination** EAU PROCESS NON Traité **par TECH LABO**
- **nature**: EAU PROCESS

resultats

- **recu le 05**/05/2023 A 10H
- **lancé le 06**/05/2023

PARAMETRE	RESULTATS	NORMES	METHODE/REFERENCE	
DURETE	257	100 -500	NA 752	
pH à 20°C	6.63	6.5 à 8,5	NA 751	JO N°27-26/04/2006 JO N° 18DU 23 /03/ 2011
CHLORURE CL⁻	244.4 g /l	<400 g /l	NA 6362	
CONDUCTIVITE A 20°C	1763 µsm/cm	<2800 µ sm/cm	NA 749	
SALINITE	0 .1	< 1	/	
TDS	825 ppm	<1000 ppm	/	
MAGNISUM	125.77	150 mg/l	NA 1655	
CALCIUM	132.26	75à 200mg/l	NA 1655	

FACTEURS SONSORIELLES		
Paramètre	résultats	Référence
Couleur	nulle	Cac/misc 06 /2013 CCFA 2013 JO N°27-2006 codex alimentaire
Odeur	nulle	
Saveur	nulle	

LE DIRECTEUR DU LABORATOIRE

Eau de process 06/05/2023 Page **1** sur **1**

Bibliography

[1] Qingxiang Zhou, Yalin Wu, Yongyong Yuan, Xianqi Zhou, Hongyuan Wang, Yayan Tong, Yali Zhan, Yi Sun, and Xueying Sheng. Determination of sudan red contaminants at trace level from water samples by magnetic solid-phase extraction using fe@ nial-layered double hydroxide coupled with hplc. *Environmental Sciences Europe*, 31:1–10, 2019.

[2] Meng Nan Chong, Bo Jin, Christopher WK Chow, and Chris Saint. Recent developments in photocatalytic water treatment technology: a review. *Water research*, 44(10):2997–3027, 2010.

[3] PL Clech, V Chen, and TAG Fane. Fouling in membrane bioreactors used in wastewater treatment. *J. Membr. Sci*, 48:534–541, 2008.

[4] M Hachicha, B Kahlaoui, N Khamassi, E Misle, and O Jouzdan. Effect of electromagnetic treatment of saline water on soil and crops. *Journal of the Saudi Society of Agricultural Sciences*, 17(2):154–162, 2018.

[5] Syed Nabeel Ahmed and Waseem Haider. Heterogeneous photocatalysis and its potential applications in water and wastewater treatment: a review. *Nanotechnology*, 29(34):342001, 2018.

[6] Pierre Le-Clech, Vicki Chen, and Tony AG Fane. Fouling in membrane bioreactors used in wastewater treatment. *Journal of membrane science*, 284(1-2):17–53, 2006.

[7] Lakshmi Prasanna Lingamdinne, Yoon-Young Chang, Jae-Kyu Yang, Jiwan Singh, Eun-Ha Choi, Masaharu Shiratani, Janardhan Reddy Koduru, and Pankaj Attri. Biogenic reductive preparation of magnetic inverse spinel iron oxide nanoparticles for

the adsorption removal of heavy metals. *Chemical Engineering Journal*, 307:74–84, 2017.

[8] Ewa Lipczynska-Kochany. Effect of climate change on humic substances and associated impacts on the quality of surface water and groundwater: A review. *Science of The Total Environment*, 640-641:1548–1565, 11 2018.

[9] Certification Body. International electrotechnical commission. 2019.

[10] Lu Lin, Wenbin Jiang, Xuesong Xu, and Pei Xu. A critical review of the application of electromagnetic fields for scaling control in water systems: mechanisms, characterization, and operation. *NPJ Clean Water*, 3(1):25, 2020.

[11] Craig Andrew McMahon. Investigation of the quality of water treated by magnetic fields. 2009.

[12] Catherine Ricordel, Andre Darchen, and Dimiter Hadjiev. Electrocoagulation–electroflotation as a surface water treatment for industrial uses. *Separation and purification Technology*, 74(3):342–347, 2010.

[13] Sugumari Vallinayagam, Karthikeyan Rajendran, Sivarama Krishna Lakkaboyana, Khantong Soontarapa, RR Remya, Vipin Kumar Sharma, Vinay Kumar, Katta Venkateswarlu, and Janardhan Reddy Koduru. Recent developments in magnetic nanoparticles and nano-composites for wastewater treatment. *Journal of Environmental Chemical Engineering*, 9(6):106553, 2021.

[14] Ali Yadollahpour, Samaneh Rashidi, Zohre Ghotbeddin, M Jalilifar, and Z Rezaee. Electromagnetic fields for the treatments of wastewater: a review of applications and future opportunities. *Journal of Pure and Applied Microbiology*, 8(5):3711–3719, 2014.

[15] Gideon Oron, Claudia Campos, Leonid Gillerman, and Miquel Salgot. Wastewater treatment, renovation and reuse for agricultural irrigation in small communities. *Agricultural water management*, 38(3):223–234, 1999.

[16] Asim Ali Yaqoob, Asma Khatoon, Siti Hamidah Mohd Setapar, Khalid Umar, Tabassum Parveen, Mohamad Nasir Mohamad Ibrahim, Akil Ahmad, and Mohd Rafatullah. Outlook on the role of microbial fuel cells in remediation of environmental pollutants with electricity generation. *Catalysts*, 10(8):819, 2020.

[17] Mario Barteri, Alessandro Pala, and Simona Rotella. Structural and kinetic effects of mobile phone microwaves on acetylcholinesterase activity. *Biophysical chemistry*, 113(3):245–253, 2005.

[18] Shrddhaba J Chudasama, Bhavya J Shah, Khushi M Patel, and Tejas M Dhameliya. The spotlight review on ionic liquids catalyzed synthesis of aza-and oxa-heterocycles reported in 2021. *Journal of Molecular Liquids*, page 119664, 2022.

[19] JMD Coey. Permanent magnet applications. *Journal of Magnetism and Magnetic Materials*, 248(3):441–456, 2002.

[20] V Elia, L Elia, P Cacace, E Napoli, M Niccoli, and F Savarese. 'extremely diluted solutions' as multi-variable systems: A study of calorimetric and conductometric behaviour as a function of the parameter time. *Journal of Thermal Analysis and Calorimetry*, 84(2):317–323, 2006.

[21] Evgenii E Fesenko and Alexander Ya Gluvstein. Changes in the state of water, induced by radiofrequency electromagnetic fields. *FEBS letters*, 367(1):53–55, 1995.

[22] Niall J English and JMD MacElroy. Molecular dynamics simulations of microwave heating of water. *The Journal of chemical physics*, 118(4):1589–1592, 2003.

[23] Sadam Mohamad Hassan, Muhammad Aliyu Sulaiman, Ridzwan Abdul Rahman, and Rezuwan Kamaruddin. Effects of long term and continuous magnetic field exposure on the water properties, growth performance, plasma biochemistry and body composition of tilapia in a recirculating aquaculture system. *Aquacultural Engineering*, 83:76–84, 2018.

[24] Ala Houam, Fares Zaamouche, Rabah Daouadi, and Moussa Attia. Efficiency considerations of llc resonant converter for induction heating application. *European Journal of Electrical Engineering*, 24(5-6):257, 2022.

[25] Moussa Attia, Mohcene Bechouat, Moussa Sedraoui, and Zoubir Aoulmi. An optimal linear quadratic regulator in closed loop with boost converter for current photovoltaic application. *European Journal of Electrical Engineering*, 24(2):97, 2022.

[26] Ehsan Khamehchi, Seyed Arman Hosseini Kaldozakh, and Ali Alizadeh. An experimental investigation of magnetized water effect on formation damage. *Journal of Petroleum Science and Technology*, 7(4):65, 2017.

[27] Bohumil Vybiral and Pavel Vorácek. ” autothixotropy” of water-an unknown physical phenomenon. *arXiv preprint physics/0307046*, 2003.

[28] Haralambos Marmanis. Analogy between the navier–stokes equations and maxwell's equations: application to turbulence. *Physics of fluids*, 10(6):1428–1437, 1998.

[29] Ulrich E Steiner and Thomas Ulrich. Magnetic field effects in chemical kinetics and related phenomena. *Chemical Reviews*, 89(1):51–147, 1989.

[30] James WG Tyrrell and Phil Attard. Images of nanobubbles on hydrophobic surfaces and their interactions. *Physical Review Letters*, 87(17):176104, 2001.

[31] Lehui Ren, Jinxing Ma, Mei Chen, Yiwen Qiao, Ruobin Dai, Xuesong Li, and Zhiwei Wang. Recent advances in electrocatalytic membrane for the removal of micropollutants from water and wastewater. *Iscience*, page 104342, 2022.

[32] Loganathan Sivachandiran and Ahmed Khacef. Enhanced seed germination and plant growth by atmospheric pressure cold air plasma: combined effect of seed and water treatment. *RSC advances*, 7(4):1822–1832, 2017.

[33] Marián Sedlák. Large-scale supramolecular structure in solutions of low molar mass compounds and mixtures of liquids. iii. correlation with molecular properties and interactions. *The Journal of Physical Chemistry B*, 110(28):13976–13984, 2006.

[34] Malathy Ramalingam, Karuppasamy Narayanan, Arivoli Masilamani, Parthiban Kathirvel, Gunasekaran Murali, and Nikolai Ivanovich Vatin. Influence of magnetic water on concrete properties with different magnetic field exposure times. *Materials*, 15(12):4291, 2022.

[35] Chathuri Piyadasa, Thomas R Yeager, Stephen R Gray, Matthew B Stewart, Harry F Ridgway, Con Pelekani, and John D Orbell. The effect of electromagnetic fields, from two commercially available water treatment devices, on bacterial culturability. *Water Science and Technology*, 73(6):1371–1377, 2016.

[36] JMD Coey and Stephen Cass. Magnetic water treatment. *Journal of Magnetism and Magnetic materials*, 209(1-3):71–74, 2000.

[37] PA Ark and Willet Parry. Application of high-frequency electrostatic fields in agriculture. *The Quarterly Review of Biology*, 15(2):172–191, 1940.

[38] Rabah Daouadi, Fares Zaamouche, Moussa Attia, and Ala Houam. Sensorless field oriented control applied for an induction machine by using the discontinuous pwm strategy. *European Journal of Electrical Engineering*, 25(1):9, 2023.

[39] John Jackson. Maxwell's equations. *Science Video Glossary. Berkeley Lab*, 2022.

[40] Vladimir L Voeikov. Biological significance of active oxygen-dependent processes in aqueous systems. *Water and the Cell*, pages 285–298, 2006.

[41] Moussa Attia, Fares Zaamouche, Ala Houam, and Rabah Daouadi. Stability control modeling and simulation strategy for an electric vehicle using two separate wheel drives. *European Journal of Electrical Engineering*, 24(5-6):239, 2022.

[42] Shinji Koide, Kazunari Shibata, Takahiro Kudoh, and David L Meier. Extraction of black hole rotational energy by a magnetic field and the formation of relativistic jets. *Science*, 295(5560):1688–1691, 2002.

[43] XiaoFeng Pang, Bo Deng, et al. Investigation of changes in properties of water under the action of a magnetic field. *Science in China Series G: Physics Mechanics and Astronomy*, 51(11):1621, 2008.

[44] Yassir SK Osman and Elsayed I Salim. A fuzzy logic monitoring system (flms) based on visible light and emf effects on experimental animals. *Journal of Mechatronics and Artificial Intelligence in Engineering*, 2(1):30–43, 2021.

[45] WWR Ball. Point-vortex dynamics. 2006.