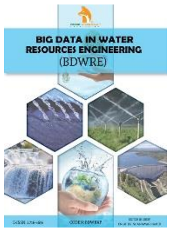
ZIBELINE INTERNATIONAL PUBLISHING
ISSN: 2716-5655 (Online)
CODEN: BDWRAP

Big Data in Water Resources Engineering (BDWRE)

DOI: http://doi.org/10.26480/bdwre.01.2024.06.13



RESEARCH ARTICLE

DETERMINATION OF THE EFFECTIVENESS OF ULTRASONIC TREATMENT FOR IRRIGATION USING SALINE GROUNDWATER ON SOIL SALINITY

Atef Ghandor[a*], Fawzya A. Nagm Al Deen[b], Mohamed Y. El Ansary[b], Montaser A. Awaad[b]

[a]Agricultural Engineering Research Institute (AENRI), Dokki, Giza, Egypt.
[b]Faculty of Agriculture, Benha University, Mushtoher, Egypt
[*]Corresponding Author Email: atef_ghandour@yahoo.co.uk

ARTICLE DETAILS

Article History:

Received 15 April 2024
Revised 23 May 2024
Accepted 24 June 2024
Available online 26 June 2024

ABSTRACT

This experiment was conducted at a private vineyard called El-Wafrah Farm on a desert road to the El-Minya Governorate, Samalout Centre, Egypt. This study aimed to evaluate the effect of ultrasonic treatment (MAXGROW device 4 inches) on the salinization of underground wells in Minya, Egypt, by studying the effect of ultrasound on some physical and chemical properties of irrigation water, and following up on the impact of the treatment process on the chemical properties of the soil at intervals of the treatment process. The results were compared with those of soil irrigated with untreated water. Soil samples were collected from representative areas irrigated with two water sources (well water treated with ultrasound and untreated water). At El- Wafrah Farm, three soil profiles were dug to a depth of 90 cm, and soil samples were collected from successive depths (0–30, 30–60, and 60–90 cm). The effect of saline water treated by the system on soil properties was adverse compared to the non-treated water qualities used in the study. Concerning the impact of the ultrasonic device on soil chemical properties, the results indicated that soil salinity decreased after using the US device compared to normal groundwater. Soil salinity decreased from 1.50 dsm^{-1} to 0.9 dsm^{-1} after 45 days; besides, the pH values of the soil were reduced from 8.52 to 7.6 before and after ultrasonic treatment.

KEYWORDS

Ultrasonic water treatment, MAXGROW system, Sandy soil, Soil salinity, Saline groundwater, desalinization.

1. INTRODUCTION

The primary element that restricts plant growth in arid and semiarid locations is water, and as water sources become scarcer, so does the need for water. Egypt is confronted with an acute scarcity of water resources as the country's population continues to grow and its living standards rise. Egypt has started a strategic strategy to extend agricultural lands to the desert areas that are situated on the edge of historically farmed lands in the Nile Delta and Valley in order to address the water and food deficit. In order to meet the demands of agricultural expansion and desert reclamation in the isolated regions far from the Nile River and the irrigation canal network, sufficient quantities and quality of groundwater resources are principally needed. The Egyptian government's development plans include the western Minya region, which is a significant area. The governorates of northern Upper Egypt, which are home to the majority of Egypt's population and make up a small portion of the nation's total area, are currently undergoing land reclamation based on recently assessed groundwater resources. These governorates are located between Beni- Souf and Assiut. West El Minya Governorate's desert region is regarded as one of those that can be reclaimed, mostly because of its groundwater resources. Water resources are under severe strain due to urbanization, agricultural growth, and population growth; nonetheless, the ratio of land to people resources remains Egypt's most pressing issue. The West El-Minya region is regarded as one of the most promising for sustainable agriculture in Egypt (Rashed, 2020). On the other hand, excessive groundwater use could result in inland seawater invasion or saline deep water. Contact between water and the rock matrix during transportation and residency can cause saline to rise through ion exchange, dissolution, leaching, and other processes. Water's solute and trace element content dictates its acceptability for various applications as well as how to handle associated hazards (Sadek, et al., 2021).

The extension of irrigation using groundwater resources in the past few years has significantly increased agricultural output, but it has also brought up the issue of groundwater sustainability in the plain. However, the advancement of irrigation might result in two simultaneous hydrological issues: low aquifer levels and groundwater salinization if the issue of irrigation system management and groundwater salinization is not addressed. As a result, it was decided to do a thorough investigation on the topic. The goal of this research is to find a solution to the issue of soil salinization those results from the salinization of underground wells, raising the pH of the soil, and degrading the soil's inherent chemical and physical qualities. Soil zones become salted due to highly salinized water used for continuous irrigation. In addition to its toxicity to certain ions, excessive soil salinity also affects osmotic pressure and reduces plant roots' capacity to draw water. This phenomenon is known as high sodicity salinity. These impacts result in a significant reduction in plant yield. Up to a certain threshold value that varies depending on the crop, different crops may withstand high salinity in soil and irrigation water without experiencing a drop in yield; beyond these thresholds, yield is reduced at a steady rate that is related to the salinity (Ayers, 1977). Over 25% of the

Quick Response Code	Access this article online	
	Website: www.bdwre.com.my	**DOI:** 10.26480/bdwre.01.2024.06.13

world's irrigated land is currently negatively impacted by these issues. Moreover, by 2050, these issues may have spread to more than half of the irrigated fields globally if they are not addressed (Singh et al., 2022). A lost soil cannot be replaced in a human lifetime because it is a non-renewable resource. For 10,000 years, soil salinity has contributed to the downfall of agricultural societies. It is the second leading source of land degradation, after soil erosion. Salinization causes an estimated 2000 acres of arable land to be lost to agriculture every day on a global scale. For many crops, salinization can result in yield reductions of 10% to 25%. In extreme cases, it can even be fatal and induce desertification. Achieving food security and preventing desertification require addressing soil salinization through better crop, water, and soil management techniques in 2018. Few studies have started to look for radical and practical solutions that farmers can implement on the ground to reduce the damage caused by salinization of ground lands, whether on soil or crops. Many researchers have studied the problem of groundwater salinization and soil salinization through remote sensing (Rashed 2020; Negm and Elkhouly 2021). A sound with a frequency above 20 kHz that is beyond human hearing is referred to as ultrasound (US). Power ultrasound, or ultrasonic energy within the 16–1000 kHz range, is utilized in sonochemistry (Zheng, 2004). When aqueous solutions are exposed to ultrasonic radiation, gas bubbles known as cavitation can form and burst, resulting in high pressures and temperatures that can last for a short while. This can cause the thermal dissociation of oxygen and water, which in turn produces free radicals (oOH and oOOH).

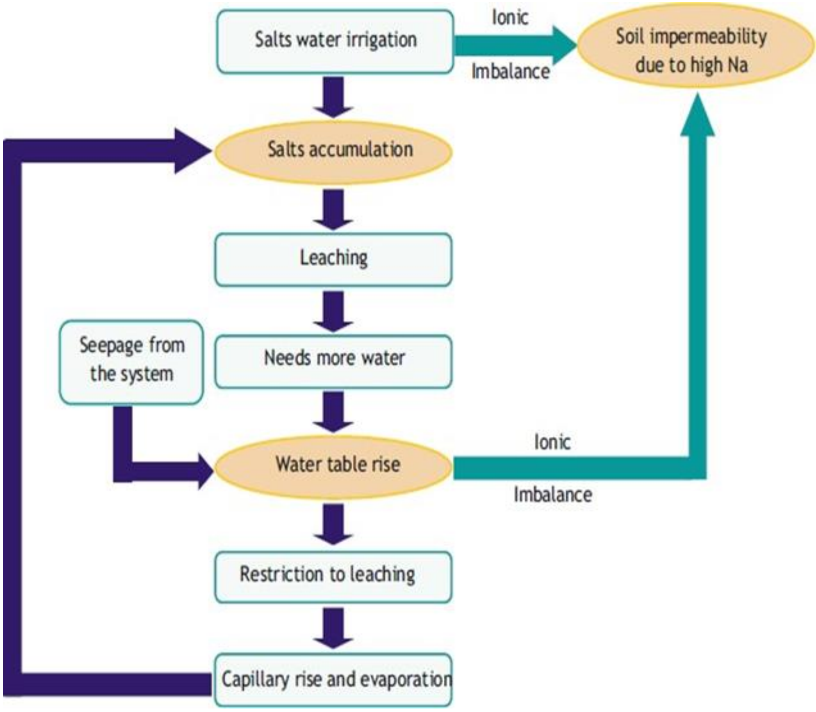


Figure 1: A hypothetical soil salinization cycle. (Adapted from Zaman et al. 2018).

These free radicals oxidize the dissolved salt molecules by penetrating water. Moreover, neither the ultrasonic system nor any items produced with its help received any additions. Thus, this method is not expected to raise any environmental issues (Buchholz et al. 1998). Oncolysis is a technology that can work on a small scale, but because it uses a lot of energy, it is difficult to commercialize (Crittenden et al., 2004).

Four vegetable species green onions, spinach, radishes, and arugula that were irrigated with two different qualities of irrigation water a highly saline and regular irrigation water treated and untreated with the MAXGROW technology were the subjects of an evaluation by researchers on the effects of ultrasonic irrigation water treatment (MAXGROW) on some vegetable species under greenhouse study in pots (Gertsis and Zoukidis, 2017; Greties et al., 2015). The treatment of practically all species and both growth substrates with saline water resulted in an improved yield, according to the data. As far as we are aware, no study has looked at how this technique affects productivity or soil in actual field settings.

Worldwide grapevine (Vitis vinifera L.) is a valuable and cost-effective fruit crop. With a total fruit production of 89 million tons, the world's area was 10.5 million hectares (FAO, 2015). Grapes are a significant crop for Egypt's economy; in 196905 feddan, 1.6 million tons of grapes were produced. Furthermore, with an export value of almost 10% and a quantity of roughly 3% of all horticulture exports, grapes are the most significant crop for export (MALR, 2019). The early sweet cultivar is highly valued in both domestic and foreign markets since it was acknowledged as an early cultivar in the Egyptian market. Since grapes are considered to be fairly sensitive to salinity, increasing demand for grapevine cultivation necessitated the development of new techniques (Maas, 1990).

They found that grapevines had a salinity response of 9.6% yield drop for every unit (ds m^{-1}) increase in saturated paste electrical conductivity (ECe), with threshold values of 1.5 dSm^{-1}. The variations can be attributed to variations in cultivar, soil type, or environmental factors like temperature. All of the responses fall into the category of grapevines that are considered "moderately sensitive", with a 50% loss rate predicted at an ECe value of 4.5 dSm^{-1} (Maas, 1990).

2. Material And Method

Three groundwater samples from the research region were taken before treatment to perform hydro-chemical investigations to understand the sources of dissolved ions and analyze the chemical quality of groundwater in order to examine the physical and chemical features of groundwater in the experimental area. Four water irrigation sample sets were made: one before the Ultrasonic devices were set up (control), and one every fifteen days after that. The water samples that were collected were sent in for chemical examination. pH, EC, anions, and soluble cations. Together with soluble Fe, Zn, Cu, and Mn (Table 3), an atomic absorption spectrophotometer was used to measure them. The following table presents the findings:

Table 1: The physico-chemical parameters of the irrigation water (groundwater).

			Anions (mg/L)				Cations (mg/L)					Class of water
EC dS/m	TDS (mg/L)	PH	HCo3	Co3	Cl-1	SO4-2 (mg/L)	Na⁺ (mg/L)	Ca+2 (mg/L)	Mg+2 (mg/L)	K+ (mg/L)	SAR	
3.42	2188.0	7.19	3.50	-	26.10	4.59	22.17	6.15	5.45	0.42	9.21	C4-S3

C4= very high salinity water S3= High sodium water.

The purpose of this investigation is to evaluate the physicochemical quality of the soil and irrigation water in El Wafrah's irrigated region. The physical characteristics of the well water (pH, temperature, salinity, electrical conductivity, and total dissolved solids) were measured on- site every fifteen days, and then soil samples were taken for chemical investigations.

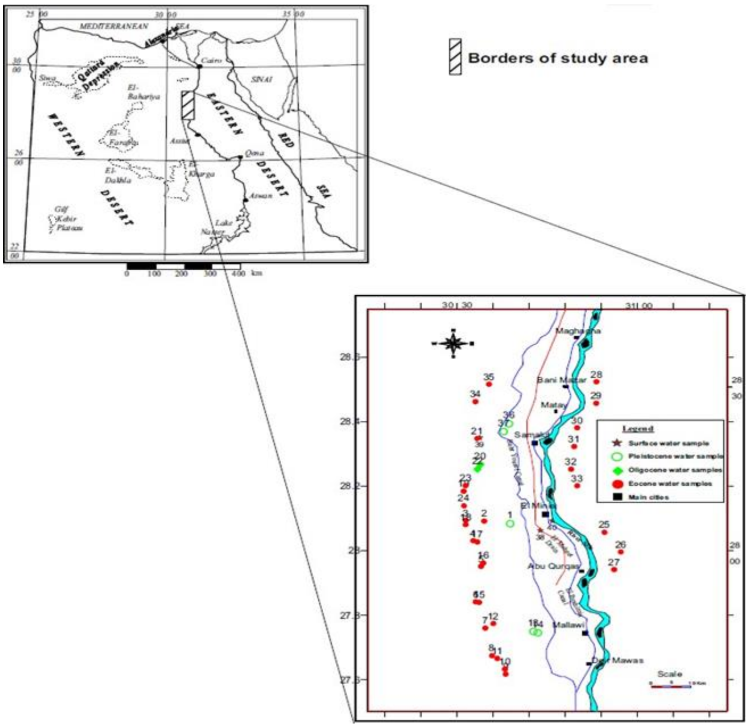


Figure 2: Keymap with well locations in El Minya Governorate, Egypt

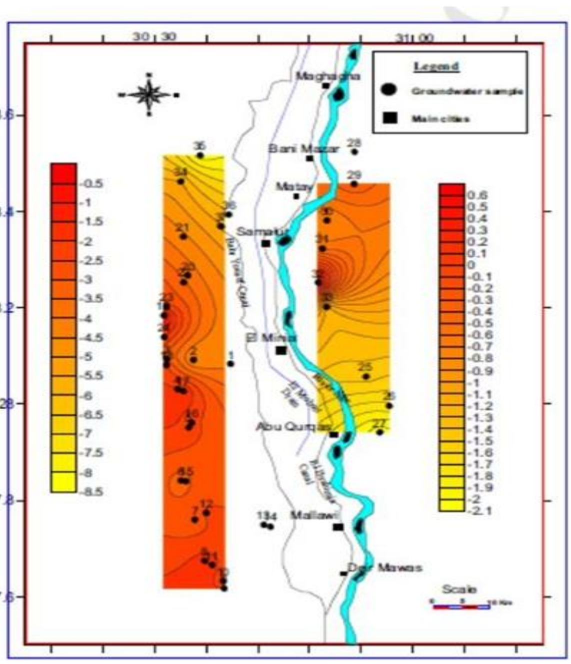


Figure 3: Iso-δ 18O distribution map for Eocene groundwater in the eastern and western desert fringes, El Minya Governorate, Egypt. Source: (Ibrahim, R.G., and Lyons, W. B., 2017).

2.1 Soil sampling and analysis

Samples of soil were selected from locations at El-Wafrah Farm that represented areas that were watered using two distinct irrigation water sources. Treated water was used to irrigate the first site after it had been through a 4 inch (110 mm) ultrasonic device with an hourly output of 130 m^3. Untreated groundwater was used to irrigate the second location. Three soil profiles were excavated to a depth of 90 cm in each site, and soil samples were taken at intervals of 0-30, 30- 60, and 60-90 cm. Four soil samples were collected (at depth of 90 cm); the first sample was taken prior to the ultrasonic device (control) being installed, and the second, third, and fourth samples were taken a month after the ultrasonic treatment. The primary attributes of soil locations were identified in 2007 and are represented in Tables 2 and 3 (Bashour and Sayegh, 2007).

Samples were gathered and secured with a necktie and twist in polyethylene bags. After soil samples were air-dried and finely crushed, they were run through a 1 mm filter to check for heavy metals' chemically accessible forms, pH, EC, and soluble ions. Conventional procedures were used to determine the general properties of the soil (Jackson's, 2005). According to Lindsay and Norvell, the available metal content was recovered from the soil using a DTPA solution (Lindsay and Norvell, 1978). After that, inductively coupled plasma-emission spectrometry (ICP-OES) was used to assess the amounts of heavy metals in the clear extracts.

This location has silty, sand-textured soil. The Soil, Water, and Environment Research Institute (SWERI), ARC conducted an analysis of the physical and chemical parameters of the soil at the experimental location. The findings are shown in Tables 2 and 3, respectively.

Table 2: Physical parameters of soil in the experimental site at the beginning of the experiment.

Depth	Particle size distribution			Texture
	Sand	Silt	Clay	
0-30 cm	87.5	11.50	1.0	sandy
30-60 cm	85.5	13.0	1.5	Silty sand
60-90 cm	83.5	15.0	1.5	Silty sand

Table 3: Chemical parameters of soil in the experimental site at the beginning of the experiment.

Area	Depth	pH 1:2.5	EC	SP	Anions (meq/l)				Cations (meq/l)			
					HCo3-	Co3-	Cl^-	SO4-2	Na^+	Ca+2	Mg+2	K+
Soil in El- Wafra farm	0-30 cm	8.42	1.09	24	1.5	-	6.5	3.87	4.90	3.0	2.5	0.38
	30-60 cm	8.47	1.27	25	1.5	-	7.5	4.68	6.20	3.5	2.5	0.48
	60-90 cm	8.45	1.48	29	1.5	-	9.5	4.77	7.25	4.5	2.5	0.52

3. Max-grow Device

To address the issues brought on by saline water, the MAX GROW electronic water treatment system (Figure 4) transmits ultrasound waves (US) many times along with low radio frequencies. It produces safe, easily eliminated by-forms by differentiating the mineral salts with up to a million vibrations per second. The calcium carbonate ions in the water are totally dissolved by the device's ultrasound waves, which are transmitted at continuously changing frequencies. It broadcasts radio waves from the US at continuously changing frequencies that are preset automatically from the device itself, essentially every hundredth of a second, using a mathematical procedure. The process of obtaining groundwater treatment involved circulating irrigation water through the apparatus situated on the water well's sub-main line, as seen in Figure 4 (Max-Grow Salinity Solution Ltd.; industrial-type external power supply transformer). Complies with European standards, this AC input DC output (100 - 250V / 24V) 2.5 A 50Hz/60Hz features power filtration and integrated shortcut protection. By winding wires on the 4-inch pipe, the gadget is placed and radio and ultrasonic waves are sent via the pipe.

Figure 4: The MAXGROW water treatment technology system used in EL Wafrah Vineyard.

About 130 m3/hr of water can be discharged from the device. Every fertilizer was applied in accordance with the Ministry of Agriculture's guideline from Egypt. For NPK nutrients, a drip irrigation system employed the fertigation approach. In the meantime, the spray method is used to fertilize the nutrients Fe, Zn, Cu, and Mn. Farmyard manure was applied to each tree at a rate of 25 m3/fed. On both sides of the trees was installed drip laterals equipped with drippers. In this area, evapotranspiration is measured in several ways. It was 2.5 mm in December, January, and February; 3.7 mm in March and November; 5.8 mm in April, May, September, and October; and 8 mm in June, July, and August. These measurements were used to determine irrigation schedules. 3524 m3/year of water are used overall. Therefore, 4.81 m3/tree of water is used annually per tree for outstanding grapes.

4. Results And Discussion

Soil and water properties under study before the US water treatment

4.1 Soil properties

Data in Table 2 show the percentage particle size distribution of the soil under study at El Wafrah Farm, Samalout, El Minya. The soil is characterized by a silty sand texture (83.5–87.5% sand, 11.5–15 silt, and 1.0–1.5% clay), with a low content of organic matter (0.5–0.7%).

4.2 The physicochemical quality of irrigation water

This farm's groundwater falls under category C4-S3, which is defined as having a very high salinity and a high sodium adsorption ratio (SAR = 9.21). The soil and irrigation water have poor physical-chemical quality, according to the results. In fact, the chemistry, salinity, and physics of the irrigation fluids under study are subpar. The textures of the soils are sand-silt. These findings thus support the UNDESCO System's 1954 conclusion that the irrigation water that is, the farm's well water is inherently unfit for growing grapes and demonstrate that this water is only appropriate for crops that can withstand salt.

The primary ionic connections, as revealed by the chemical analysis of the groundwater sample, are Na+ > Ca+2 > Mg+2 and Cl- > SO4-2 > HCO3-. Evaporation, ion exchanges, and natural mineral dissolution all contribute significantly to groundwater's ion enrichment. It was determined by comparing the groundwater quality samples to FAO water quality requirements that these samples are unsuitable for irrigating a crop that is sensitive to salt, like grapes. Table 4 displays the proportion of groundwater samples that had high salinity enough to result in a 50% or greater reduction in the amount of grapes in the research area when compared to the work of (Grattan, 2002).

Table 4: Estimated yield of tree and vine crops with long term use of irrigation water from Grattan, (2002)					
Vine crops	**Eciw (ds/m)**				**Rating**
	Yield potential				
	100%	90%	75%	50%	
Grapes fruit	1.2	1.6	2.2	3.3	S

Since the salinity of the groundwater is 3.6 ds/m, using it in the irrigation of grapes in this study area, according to Grattan, will cause a decrease in yield of more than 50% (Grattan, 2002).

The mean content of micro-elements in the irrigation water before US treatment is 1.9, 1.7, 0.3, and 0.25 ppm for Fe, Zn, Cu, and Mn, respectively. These values are very low.

Concerning the hypothetical salt composition, found that the dominant salts in normal water without treatment are presented in Table 4 (Piper, 1944).

Ground water without treatment	TDS (ppm)	Ca(HCO3)2 %	CaSO4 %	CaCl2 %	MgCl2 %	NaCl %	KCl %
	2304	7.17	19	2	9.4	60.06	2.37

4.3 Soil and water properties under study after the US water treatment

4.3.1 Effect of Ultrasonic treatment of saline ground water on physico-chemical properties of irrigation water

The pH of the water changed due to vibrations in the cavitation mode, while the groundwater's EC remained the same following treatment. This is consistent with findings by authors in 2020, who found that the frequency of ultrasound impacts pH change (Vikulin and Vikulina, 2020). When water is treated with ultrasonic waves at a frequency of 22 kHz, its pH value rises. When water is treated with ultrasonic waves at a frequency of one megahertz, its pH drops. The water's pH remains unchanged after ultrasonic treatment at a frequency of 8 kHz. In our instance, the pH dropped as a result of the ultrasonic therapy at a frequency of 1 MHz of the irrigation water. The pH values decrease from 7.19 to 7.0 before and after treatment, respectively.

Researchers in 2008 experimentally proved the formation of the free radical hydroxyl (OH+) and atomic hydrogen (H-) under the action of cavitation, the recombination of which leads to the formation of (H2) and (H2O2) molecules in water (Khan and Adewuy, 2008).

Under the influence of ultrasound in the cavitation cavity, the following reactions occur:

$$H_2O \xrightarrow{us} H_2O^+ + \bar{e}; H_2O \xrightarrow{us} H^\bullet + OH^- + \bar{e};$$
$$H_2O \xrightarrow{us} OH^\bullet + H^- + \bar{e}; OH^\bullet + OH^\bullet \rightarrow H_2O_2; H^\bullet + H^\bullet \rightarrow H_2$$

The presented reactions show that free electrons, activated atomic hydrogen, activated hydroxyl groups, hydrogen ions, hydroxyl ions, ionized water, and hydrogen peroxide are formed in ultrasound-treated water. The pH is the negative decimal logarithm of the concentration of hydrogen ions in water.

According to researcher, high temperatures occurred during the cavitation bubble's collapse in water, which is consistent with adiabatic compression (Sirotyuk's, 2008). These temperatures are in the order of 10,000 oK, and there is a shock wave with 104 ATM of pressure. Elevated temperatures in the bubble cavity containing dissolved gas lead to electrification as atomic hydrogen and oxygen, free radicals, and dissociated and ionized molecules develop.

The sonochemical process is the introduction of ultrasonic waves into a liquid medium, which results in the creation of a special chemical environment with a wide range of chemical applications (Rashwan et al., 2020). This procedure has been employed since 1990 in a number of applications, including surface coating and surface treatments, water disinfection, metal corrosion, and environmental treatments (soil and water). They are the ones who first proposed that hydrogen and other valuable gases may be produced by the sonochemical process. Water vapor is trapped inside acoustic cavitation bubbles, which are created when ultrasonic vibrations propagate through water and produce hydrogen. Hydrogen will be produced by the dissociation of this water vapor via a series of reversible chemical reaction processes.

The potential of ultrasound water to directly impact the chemical and physical properties of the soil, followed by an indirect effect on the plant's intake of available nutrients, is the reason behind the use of ultrasonic devices rather than the chemical changes in the salts in ground irrigation water. When ultrasonic energy enters some materials, it can cause molecules to vibrate since it has a lot greater energy than audible sound. Through vibration, molecules acquire energy; the higher the ultrasonic frequency, the more energy the molecules can absorb.

Acceleration of molecular vibration is also influenced by ultrasonic frequency. Water molecules can accelerate significantly when subjected to ultrasonic radiation. Newton's second equation of motion thus indicates that a huge acting force will be induced on the cell membrane due to the extremely high force produced by the oscillation of the water molecules. The germination rate and seed output of plants can be enhanced by the mechanical effect of ultrasonic waves, which also increases the permeability of the cell membrane. Ultrasonography offers a wide range of potential applications in physical agriculture (Cao et al., 2015).

The primary characteristics of ultrasonic include the potential to lower soil pH and EC, enhance soil permeability, accelerate water movement to dissolve soil salts, and promote nutrient absorption that makes the minerals available for plant uptake (Hassanien et al., 2014; Nasr et al., 2019).

4.3.2 Effect of ultrasonic treatment of saline groundwater on soil chemical properties

The results of the field experiment due to the effects of ultrasound on soil properties are recorded in Tables 4, 5, and 6 and reveal the following:

4.3.2.1 The dissolution of soil salts

Table 5's findings demonstrated that there was a drop in EC in soil paste extract following 15 days of irrigation with ultrasound-treated water, particularly at a depth of 60-90 cm, where the values dropped from 1.52 dsm^{-1} prior to applying US to 1.02 dsm^{-1}. In soil paste extract, there is a drop in EC; values went from 1.29 dsm^{-1} prior to employing US to 1.06 dsm^{-1} at a depth of 30- 60 cm.

Table 5: Chemical parameters of soil after 15 day of the experiment.												
Area	**Depth**	**pH 1:2.5**	**EC**	**SP**	**Anions (meq/l)**					**Cations (meq/l)**		
					HCo3-	Co3-	Cl-	SO4-2	Na+	Ca+2	Mg+2	K+
Soil irrigated with US treated water in El-Wafra farm After 15 days	0-30 cm	8.52	1.09	20	0.5	-	6.5	3.87	4.45	3.5	2.5	0.42
	30-60 cm	8.49	1.06	22	0.5	-	6.5	3.58	5.30	3.5	1.5	0.28
	60-90 cm	8.52	1.02	22	0.5	-	6.5	3.18	4.30	3.0	2.5	0.38
Soil irrigated with non-treated water in El-Wafra farm	0-30 cm	8.42	1.09	24	1.0	-	6.5	3.87	4.90	3.0	2.5	0.38
	30-60 cm	8.47	1.27	25	1.0	-	7.5	4.68	6.20	3.5	2.5	0.48
	60-90 cm	8.45	1.48	29	1.0	-	9.5	4.77	7.25	4.5	2.5	0.52

From Table (6), the results of the soil irrigated with treated water showed stability in the EC at a depth of 60-90 cm in the soil compared to the soil irrigated with untreated water, where the accumulation of salts in it at the same depth. The results showed that after 45 days of US-treated water irrigation, there was a decrease in EC in soil paste extract, especially at a depth of 30-60 cm where the values decreased from 1.29 dsm^{-1} before without US treatment to 0.82 dsm^{-1}. There is a decrease in EC in soil paste extract, where the values decreased from 1.09 dsm^{-1} to 0.82 dsm^{-1} at a depth of 0-30 cm.

Table 6: Chemical parameters of soil samples for soil after 45 days.

Area	Depth	pH 1:2.5	EC	SP	Anions (meq/l)					Cations (meq/l)		
					HCo3-	Co3-	Cl^-	SO4-2	Na^+	Ca+2	Mg+2	K+
Soil irrigated with US treated water in El-Wafra farm After 45 days	0-30 cm	7.70	0.82	23.5	0.5	-	4.5	3.17	3.85	2.5	1.5	0.32
	30-60 cm	7.78	0.72	21.5	0.5	-	3.5	3.18	3.0	2.5	1.5	0.18
	60-90 cm	7.66	1.02	20.5	0.5	-	6.5	3.17	4.25	3.0	2.5	0.42
Soil irrigated with non-treated water in El-Wafra farm	0-30 cm	8.42	1.09	24	1.0	-	6.5	3.87	5.05	3.6	1.81	0.41
	30-60 cm	8.47	1.29	25	1.0	-	7.80	4.68	6.50	3.5	2.5	0.48
	60-90 cm	8.45	1.51	29	1.0	-	9.3	4.77	7.55	4.5	2.5	0.52

From Table (7), the results showed that after 75 days of US treated water irrigation, there is a decrease in EC in soil paste extract, especially at a depth of 60-90 cm, where the values decreased from 1.52 dsm-1 before using US to 0.9 dsm-1. The values of EC in soil paste extract dropped from 1.29 dsm-1 without US water treatment to 0.72 dsm-1 at a depth of 30 to 60 cm.

The values of EC in soil paste extract fell from 1.09 dsm-1 without US water treatment to 0.82 dsm-1 at a depth of 0-30cm. The findings also demonstrated that when saline groundwater is used for drip irrigation without treatment, the soil becomes more salinized over time and salts build up in all soil layers, although the salt buildup is concentrated around the wet perimeter of the drippers. Aside from drippers, the concentration of salt in the soil increased. These findings align with the findings of (Rafie and El-Boraie, 2017). In surface drip irrigation, the salinity of the soil generally rose during the growth season in the soil that was irrigated with untreated water. Two distinct salinity zones were created by saline water irrigation: a lower zone where salt levels rise with depth and distance from the water source, and an upper zone near the soil surface where salinity levels are low near the surface drippers. For every discharge rate, the salinity of the soil rose as the radius from the dripper increased and as crop growth advanced (El-Boraie and Rafie, 2017).

It was established by researchers that water's dissolving qualities rise (Prasad and Dalvi, 2020). It is anticipated that water will move more quickly and permeate soil pores more readily when subjected to ultrasound since it has smaller molecules and less viscosity.

These findings show that ultrasonic irrigation is one of the most beneficial contemporary technologies for improving soil conditions surrounding plant roots and lowering salt buildup in soils. Our findings concur with those of (Gertsis et al., 2015).

Table (7): Chemical parameters of soil samples for soil after 75 days.

Area	Depth	pH 1:2.5	EC	SP	Anions (meq/l)					Cations (meq/l)		
					HCo3-	Co3-	Cl^-	SO4-2	Na^+	Ca+2	Mg+2	K+
Soil irrigated with US treated water in El-Wafra farm After 75 days	0-30 cm	7.81	0.82	19.0	0.5	-	4.5	3.17	5.10	3.5	2.5	0.26
	30-60 cm	7.79	0.72	21.0	0.5	-	3.5	3.18	5.55	2.5	2.5	0.32
	60-90 cm	7.76	0.90	22.0	0.5	-	5.5	3.17	5.15	3.5	1.5	0.22
Soil irrigated with non-treated water in El-Wafra farm	0-30 cm	8.75	1.06	24	1.0	-	6.5	3.58	5.20	3.5	1.5	0.38
	30-60 cm	8.83	1.71	25	1.0	-	10.5	5.57	8.65	5.5	2.5	0.42
	60-90 cm	8.79	1.62	29	1.0	-	9.5	5.67	7.85	4.5	3.5	0.32

4.3.2.2 Soil pH

Often known as soil response, pH is a measurement of the concentration and activity of hydrogen ions in the soil. Bicarbonate content and soil pH are tightly correlated, and both can affect nutrient availability. Anecdotal evidence and fertility studies have generally shown that soil pH should be between 6.0 to 7.5; attempts to alter the pH outside of this range are unlikely to have an impact on productivity (Allan Fulton, 2010). When compared to soil irrigated with non-treated water, data in Table (6) demonstrate that irrigation with ultrasonic-treated water resulted in a drop in pH values in soil samples at different depths.

The findings made it clear that the pH of the soil dropped from 8.52 before using ultrasonic to 7.66 after 45 days of use. This is mostly because of how ultrasonography affected the irrigation water. It caused the PH of the irrigation water to drop, which in turn caused the PH of the soil to drop. As a result, 45 days after watering, the soil's pH dropped from 8.52 to 7.66 at a depth of 90 cm. As a result, water is ionized by ultrasound into hydrogen and hydroxyl, increasing the concentration of hydrogen and lowering the PH of the water, which in turn lowers the PH of the soil.

The measurement of soil pH, hydrogen ion concentration (H+), is correlated with nutrient availability in soils (Msimbira and Smith, 2020). The availability of nutrients and plant growth are directly impacted by variations in pH in the environment; yet, it is unclear how these circumstances critically affect microbial communities. The pH has a significant role in determining the architecture of the soil microbial communities. Under such circumstances, the ability of microbes to detect and adjust to environmental changes is necessary for their survival and colonization.

The essential pH of the soil is 8.5 for grape growing. Generally speaking, a pH of 5.5 to 6.5 is ideal for grapes and provides a better nutrient balance for plant growth than more acidic or alkaline soils. A pH of 4.0 to 8.0 is ideal for vine growth; however, pH values below 5.5 and over 8 can reduce yields and cause issues for the vines. The pH of the soil has an impact on the microbial activity and nutrient availability. As soil pH rises, numerous micronutrients (including Mn, Cu, Zn, and B) become less available. When sulfur and fertilizers are used, the pH of the soil frequently wanders lower over time.

The results revealed that the application of saline water higher the salt content in the soil and also increased the soil pH. These results agree with (El-Agrodi et al.,2012 and Singh, 2022).

4.3.2.3 Soluble Content of Ca, Mg, K, and Na in Soil

Values of electrical conductivity, soluble anions Cl-, SO4-2, and HCO-3, and cations Na+, Mg+2, Ca+2, and K+ concentration presented in Tables 5, 6, and 7 show their distribution through successive soil layers irrigated with Ultrasonic treated water and non-treated water from El-waffra farm. Data show that irrigation with ultrasonic treated water led to a decrease in EC and soluble ions contents in soil samples at different depths compared to soils irrigated with non- treated water. These results agree with those obtained by (Gertsis, 2015; Gertsis and Zoukidis, 2017).

The findings showed that ultrasound had an impact on the solubility of the key components for plants—Ca, Mg, K, and Na—in the soil. After 75 days of using US for Ca, Mg, K, and Na, respectively, the mean value of soluble concentrations of these elements decreased from 4.5, 3.5, 0.52, and 7.25 meq/l before applying ultrasonic treatment of water to 3.0, 2.5, 0.38, and 4.0 meq/l (Table 5,6&7). It is evident that these elements' solubility has dropped by 33.3%, 28.6%, 26.2%, and 44.8%, respectively. It seems that the use of ultrasonic reduces soluble Na salts more than 40%, while other elements (such as Ca, Mg, and K) only decrease by less than 30%.

As well as data in Table 8 show that cl- is decreased from 9.5 meq/l to 5.5 meq/l before and after using Ultrasonic.

TABLE 8: The mean values of essential elements (Soluble cations meq/l) in Soil.

	Ca+2	Mg+2	Na+	K+	Cl
1month before treated	4.5	3.5	7.25	0.52	9.5
75 days after treated	3.0	2.5	4.0	0.28	5.5

Changes in the chemical, physical, physicochemical, and biophysical properties of water brought about by Ultra-Sound treatment resulted in certain functions. It is thought that exposure to ultrasonic and radio waves may change cellular metabolism by employing the water in the cell as the principal radiation receptor. Water is thought to be the primary medium of biochemical reactions and has a vital role in regulating how plants respond to radiation. The polarization of water and the activation of ions in exposed cells are affected by radio waves and ultrasound. They also alter the permeability of cell membranes, ion activity, and associated processes, which upsets the equilibrium of ion concentration within the cell and modifies the pH inside the cell.

As a result, they have an impact on protein production, enzyme activity, gene expression, and mRNA quality. As a result, the exposed plants' phenotypic, genotypic, growth characteristics, and several functions—including seed germination, root and shoot growth, yield parameters, productivity, reproduction, chlorophyll contents, and meristem cell proliferation—will alter. As a result of these modifications, the soil is better able to eliminate salts, which improves plant absorption of nutrients during the vegetative stage. Moreover, a white layer of calcium bicarbonate forms on a therapeutic or ornamental plant when it is irrigated with untreated water. with the soil's surface, some of which is deposited on plant roots by water seeping through the soil. The plant begins to suffocate and grows more roots to stay alive, which slows down the plant's regular growth. The findings are in agreement with (Hassanien et al., 2014 and Nasr et al., 2019).

In technical terms, pH represents the amount of hydrogen ions present in a medium. It is actually a measurement of the water's acidity or alkalinity. One of the primary markers of water quality is the pH. The findings show that soil watered with treated ultrasonic water has a lower pH than soil irrigated with untreated water. This is due to the decrease in PH, and irrigation water from

7.19 to 7.0 before and after treatment, respectively. This result agrees with (Vikulin and Vikulina, 2020).

5. Conclusion

It could be concluded that the ultrasonic treatment of saline water used in irrigating desert sandy soils could be a promising, friendly, and environmentally friendly technology for soil and agricultural improvements under arid conditions. Based on these research results, using ultrasonic water for irrigation is recommended to increase fertilizer use efficiency, improve grape crop productivity, and save irrigation water, especially in underwater shortage conditions. Irrigation with ultrasonic-treated water caused higher soil moisture compared with the control at different irrigation events. In addition, significant improvements in the soil's chemical properties (i.e., pH, ECe, Na+, Cl-, and soil SAR) occurred due to irrigation with ultrasonic-treated water compared to irrigation with untreated saline groundwater (control treatments).

The results confirmed that using such groundwater in irrigation may cause severe salinity buildup problems in the investigated sandy soil in the long term if not managed properly.

Even though the results from this study are promising, numerous field studies should be conducted to study the effects of ultrasonic treatment technology when irrigation resources are switched from lower-salinity Nile water to higher-salinity groundwater sources in the Egyptian desert.

Reference

Buchholz, K., Tanis, D., Macomber, S. and Farris, E., 1998. Ballast water treatment technology review. Chapter 3. Available from: http://www.nemw.org/Balsurv3_Us.htm.

Cao, H.; Huang, W., Qiao, J.;Wang, Y.P.; and Zhao, H. J., 2015. Research on vibration mechanism of plant cell membrane with ultrasonic irradiation. Chinese Physical LETT. 32 (3).

Crittenden, J. C., Trussell, R. R., Hand, D. W. and Tchobanglouse, G., 2004. Water treatment- principles and design. 2nd Ed, John Wily and Sons.

El-Agrodi, M.W.M., Ahmed, G. L., and El-Hamad, M. A., 2012. EFFECT OF DIFFERENT SOIL SALINITY LEVELS ON SOME SOIL PROPERTIES AND WHEAT PLANT. *Journal of Soil Sciences and Agricultural Engineering*, 3 (2), Pp. 175-188.

FAO, 2015. Food and Agriculture Organization of the United Nations‟ Rome, Cited from www.fao.org/publications.

Fulton, A., 2010. Interpreting Soil pH and Saturation Percentage Measurements. UC Farm Advisor Tehama, Glenn, Colusa and Shasta Counties. https://cetehama.ucanr.edu/newsletters/Soil_Testing_Articles-by_Allan_Fulton39342.pdf

Gertsis, A., and Zoukidis, K., 2017. Irrigation with highly saline water: A new innovative water treatment system evaluated for vegetable production in greenhouse.

Gertsis, A., Zoukidis, K., and Vasilikiotis, C., 2015. Evaluation of an Irrigation Water Treatment Technology (MAXGROW) on its Effects to Vegetable Species Yield. In *HAICTA.* Pp. 284-290.

Grattan, S., 2002. Irrigation water salinity and crop production (Vol. 9). UCANR Publications.

Hassanien, R., Tian-Zheng, H.O.U., and Bao-Ming, L.I., 2014. Effect of acoustic frequency technology on the growth of strawberry in solar greenhouse. In 18th world congress of CIGR, Beijing.

Jackson, M.L., 2005. Soil chemical analysis: advanced course. UW-Madison Libraries parallel press.

Khan, N.E., Mahamuni, N.N., and Adewuyi, Y.G., 2008. Modeling the ultrasonic cavitation-enhanced removal of nitric oxide from flue gases in a bubble column reactor. In 2008 AIChE Annual Meeting, AIChE 100.

Lindsay, W. L., and Norvell, W., 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil science society of America journal, 42 (3), Pp. 421-428.

M.A.L.R., 2019. Ministry of Agriculture and Land Reclamation Publishes. Economic Affairs Sector Bull, Agric. Statistics, Egypt.

Msimbira, L.A., and Smith, D.L., 2020. The roles of plant growth promoting microbes in enhancing plant tolerance to acidity and alkalinity stresses. Frontiers in Sustainable Food Systems, 4, Pp. 106.

Nasr, G.E.M., Darwish, E.M., Sharobeem, Y.F., and Abd-Elrahman, S.H. (2019). ULTRASOUND IMPACT ON GREENHOUSE LETTUCE PRODUCTIVITY. Plant Archives, 19 (2), Pp. 1606-1611.

Negm, A., and Elkhouly, A. (Eds.)., 2021. Groundwater in Egypt's Deserts. Springer International Publishing.

Piper, A.M., 1944. A graphic procedure in the geochemical interpretation of water-analyses. *Eos, Transactions American Geophysical Union*, 25 (6), Pp. 914–928.

Prasad, R., and Dalvi, S.V., 2020. Sonocrystallization: monitoring and controlling crystallization using ultrasound. *Chemical Engineering Science*, 226, Pp. 115911.

Rafie, R. M., and El-Boraie, F.M., 2017. Effect of Drip Irrigation System on Moisture and Salt Distribution Patterns under North Sinai Conditions. *Egypt. J. Soil Sci*, 57 (3), Pp. 247-260.

Rashed, H.S., 2020. Classification and Mapping of Land Productivity, Capability and Suitability for Production Crops in West El-Minia Governorate, Egypt. Journal of Soil Sciences and Agricultural Engineering, 11 (12), Pp. 709-717.

Sadek, M.A., Hussien, R.A., and Hassan, H.B., 2021. Salinization Processes and Quality Constrains for Irrigation Water Management in Southwest El Minia, Upper Egypt. International Journal of Research in

Environmental Science, 7 (2). https://doi.org/10.20431/2454-9444.0702001

Singh, A., 2022. Groundwater recharge assessment and long-term simulation for managing the threat of salinization of irrigated lands. *Journal of Hydrology*, 609. https://doi.org/10.1016/j.jhydrol.2022.127775

Singh, A., 2022. Soil salinity: A global threat to sustainable development. Soil Use and Management 38, 39–67. doi:10.1111/sum.12772

Sirotyuk, M.G., 2008. Acoustic cavitation. Moscow: Nauka, 271.

UNDESCO System, 1954. Review of research on problems of utilization of saline water. U.N. *Ed. Sci. and Cult.* Organ, U.S.A

Vikulin, P., and Vikulina, V., 2020. Influence of ultrasound on the concentration of hydrogen ions in water. In *IOP Conference Series: Materials Science and Engineering,* 869 (4), Pp. 042007. IOP Publishing.

Vikulina, V. B., and Vikulin, P. D., 2016. The use of ultrasound within coagulation process. *Industrial and Civil Engineering*, 10, Pp. 116-119.

Zaman, M., Shahid, S. A., Heng, L., 2018. Introduction to soil salinity, sodicity and diagnostics techniques. Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques, Pp. 1-42.

Zheng, W., 2004. Mechanistic study of pollutant degradation. Ph.D thesis in the department of chemistry, University of New Orleands, chapter 5.