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Using Ultrasonic Technique to Improve Agricultural Drainage Water Quality for Agricultural Purposes

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ABSTRACT

In locations where water is scarce, such as Egypt, agricultural drainage water is one of the most popular sources of reused water. However, the drainage water reuse program faces a major obstacle in the form of steady rising pollution loads in drain waters. As a result, this study aimed to improve the quality of agricultural drainage water using low-cost treatment technologies such as ultrasonic (US) waves which are considered one of the novel techniques, non-mechanical methods, and clean technology to protect the environment. The influence of US waves on agricultural drainage water physical properties was estimated using a high ultrasonic frequency device with 1.7 MHz the effect of water volume while applying a constant US wave on water characteristics was explored. Exposing time of US waves was fixed at 10, 20 and 30 min under three varying irradiation power of 50, 100 and 150 W ultrasonic. The experimental results showed that US wave irradiation had impacts on the physical and chemical properties of water such as pH and total dissolved solids (TDS) represented by electrical conductivity (EC). The results further showed that the ultrasonic irradiation strength has a remarkable effect on the sample of water treated. Ultrasonic waves decreased TDS by 22.4% when exposing time increased from 10 to 20 min and by 20.9% when exposing time increased from 20 to 30 min. So, the pH changes with time after exposure to ultrasound waves for treatments water. Where decreased from 8.1 to 7.9 when exposing time increased from 10 to 20 min and from 7.9 to 7.5 when exposing time increased from 20 to 30 min.

Keywords:
Ultrasonic waves; Total dissolved solids; Water treatment; quality; Environmental protection; Physical properties.

1. INTRODUCTION

The word "water quality" defines water conditions, including water's physical, chemical, and microbiological properties. Generally, these properties contribute to its suitability and the water's quality for a specific application. Water suitable for domestic use (drinking water) must meet specific requirements.

The main water treatment process involves flocculation, sedimentation, and media filtration to eliminate colloidal and suspended solids, exchange of ions, carbon adsorption and membrane processes to extract dissolved solids, and finally, microbial inactivation disinfection that is often carried out by chlorination, coronation, and ultraviolet radiation (UV) **(Tansel, 2008)**.

Key factors in the development and implementation of water treatment systems were the identification of rarer new pollutants, the adoption of new water quality standards, and costs. Different studies have been carried out to remove this constraint by applying groundbreaking techniques such as Biosorption **(Nayak *et al.*, 2015)** photo catalytic oxidation **(Rajendran *et al.*, 2016)**, advanced oxidation with nanocomposite membranes **(Saravanan *et al.*, 2015)**; semi-conductor catalysts, reverse osmoses, and magnetic purification **(Zhang *et al.*, 2019)**. Ultrasound is one such recent technique found to be substantially effective in the treatment of wastewater **(Nikolopoulos *et al.*, 2006)**. Ultrasonic could generate by two techniques, firstly “magneto strictive” electrical energy is converted to mechanical energy (or vibration) with a magnetic coil attached to vibrating pieces like nickel and Terfenol-D. Secondly, for the piezoelectric technique, the electrical energy is converted to high-frequency electric energy with piezoelectric crystals (rely on material strain) attached to the vibrating piece (sonotrode, probe, or horn) **(Pilli *et al.*, 2011)** with the discovery of the piezoelectric effect **(Gogate, 2007)**. Method for water treatment has been by use of ultrasound as advanced oxidation has shown to be of great interest in recent years. A variety of mechanical, physical, chemical and biological modifications occur in a fluid due to acoustic cavitations due to ultrasonic requirements of irradiation.

The important technology could be an application of ultrasound for turbidity and total suspended solids reduction, where Turbidity is a major physical feature of air. The presence of scattered hanging solids such as clay, silt, algae and other microorganisms, organic material, and minute particle materials can be detected.

A variety of methods have been used in the water treatment process for reducing turbidity, Total Suspended Solid (TSS) filtration and slow-filtration, ultra-filtration, and coagulation/flocking **(EPA, 2014)**. American procedure for turbidity reduction (TSS) and advanced oxidation treatment **(Manson and Lorimer, 2002)** has been extensively studied. The ultrasonic efficiency may improve by increasing turbidity or suspended solids and so, compared to conventional methods that are negatively affected by the suspension of effluent solids.

Mutiarani and Mise (2019) studied the use of ultrasound in TSS elimination and found that removal efficiency in the different conditions was extremely high. **Stefan and Balan, (2011)** found that, using a frequency of 28 kHz and 60 W of power, the most turbidity reduction (76%) was achieved at 27.2 kHz and time of 30 s, water turbidity decreases 4 times over (39 NTU). The results showed also that, TSD reduction was increased at 30 min ultrasound rate but was unpredictability from 60 to 120 min of irradiation at all power densities for all energy densities. **(Abdullatif *et al.*, 2009)** studied the impact of power density on TSS reduction. The efficiency was 0.024 W/cm^3, 120 min with 84% of output, and 60% with a minimum percentage reduction at 0.06 W/cm^3 for 60 min. The most effective result was reduced the turbidity of raw water by a precursor to coagulation from 10.3 NTU to 1.48 NTU and by 15 s ultrasonic irradiation at 40 kHz 60 W **(Liang *et al.*, 2009)**.

This study aims to examine the effect of ultrasound technology to improve agricultural water drain quality for agricultural purposes.

2. MATERIALS AND METHODS

2.1.The experimental setup

The experimental set up consists of an ultrasound wave generator, attached to the six ultrasound cells from the bottom. Figs. 1 and 2 shows the apparatus

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details. The electrical source was attached to the apparatus. All experiments were conducted at 24 volts and 10 A. The ultrasonic vibrator is comprised of a 0.020 m diameter transducer, which contains piezoceramics (sandwich) with stainless-steel end masses leading the face from which the ultrasonic is emitted and it is fabricated for this study.

Fig. 1: Experimental apparatus

2.2. Procedure

The experiment was conducted using three different periods time for ultrasound exposure were selected and fixed at 10, 20 and 30min.Under three varying irradiation power of 50, 100, and 150 W ultrasonic.

All collected samples were analyzed by measuring their pH, TDS represented by EC and water production rate, using two separate devices, type Adwa AD32 and Arduino PH meter Instruments (pH/conductivity meter), with electrode cells one for pH and the other for TDS.

The vessel was filled with the water, at desired and the specified volume. Before placing the sample, water's volume was measured simply by using a graduated cylinder. Soon after water was pouring into the vessel, the ultrasound device switched on and determined the treatment time by using a stopwatch when the pre-specified time was reached ultrasound device was switched off and both temperature and volume of water were measured after every run.

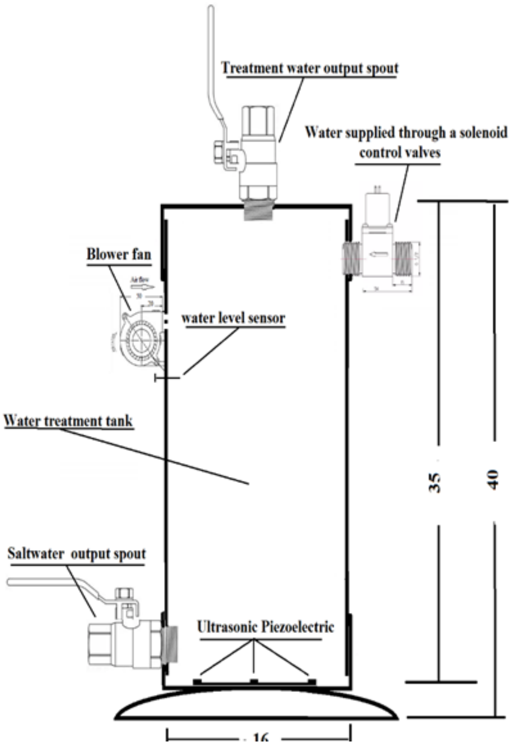

Fig. 2: Experimental apparatus sketch

3. RESULTS AND DISCUSSION

3.1 Effect of ultrasound waves on pH for treatment water

Fig. 3 shows the result of pH changes with time after exposure to ultrasound waves for treatments of water. The pH decreases as the ultrasound wave exposing time increases. The pH started at 8.2 and end up at 7.59 according to the time of exposure. Where decreased from 8.2 to 8.1 and from 8.1 to 7.9 and finally from 7.9 to 7.5 at 10, 20 and 30 min, respectively.

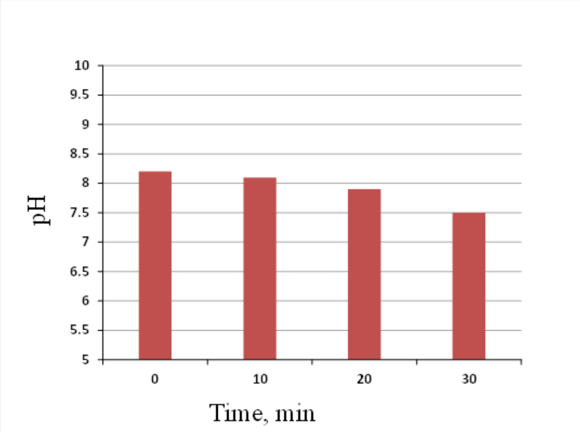

Fig. 3: Effect of ultrasound waves on pH for treatment water

3.2 Effect of ultrasonic pretreatment on total dissolved solids (TDS)

Fig. 4 shows the results of treatment water exposed to ultrasound and TDS values. TDS decreases as the exposing time for ultrasound waves increases. TDS started at around 7300 ppm and end up at around 3650 ppm according to the time of exposure. Where decreased from 7300 to 5890 and from 5890 to 4570 and finally from 4570 to 3650 ppm at 10, 20 and 30 min respectively. This behavior may be explained due to the existence of other dissolved solids i.e., microorganisms, algae, etc.; such dissolved solids during their exposure time to ultrasound waves this kind of dissolved solids will be degraded and hence will decrease the TDS value, due to the effect of high-frequency ultrasound waves.

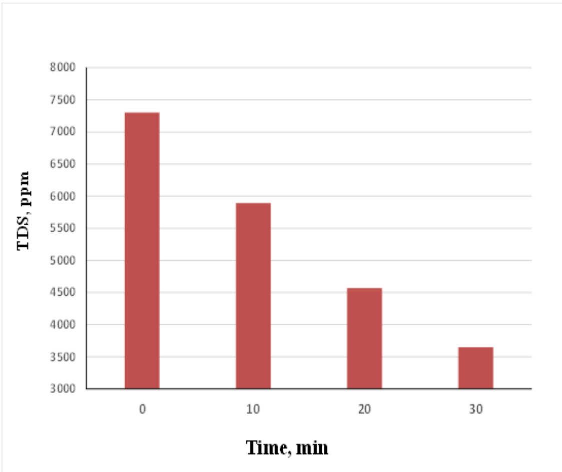

Fig. 4: Effect of ultrasonic pretreatment on total dissolved solids (TDS)

3.3 Effect of pretreatment by the different ultrasonic exposing power on the treated water rate production

Fig. 5 shows the result of the production rate ml/h of treated water with changes in ultrasound wave exposing power. The production of treated water increases as the ultrasound wave exposing power increases. The production of treated water rate is 760, 1759 and 3714 ml/h according to the exposing power of 50, 100 and 150 W, respectively.

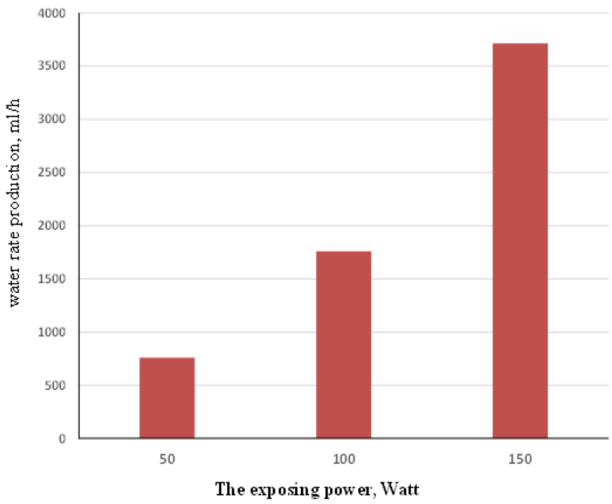

Fig. 5: Effect of ultrasonic exposing power on the water production rate

4. CONCLUSION

All samples of water indicate that after exposure to ultrasound waves, both show a decrease in TDS and pH when the time of ultrasound wave exposure increased. This may explain getting low TDS treated water and can reuse it for agricultural purposes. Also, one explanation for this behavior may be attributed to the microorganism and other dissolved solids that exist originally in the sample, and exposure to an ultrasound wave will give the chance for these solids to be removed or coagulate.

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استخدام تقنية الموجات فوق الصوتية لتحسين جودة مياه الصرف الزراعي للأغراض الزراعية

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مجلة العلوم الزراعية والبيئية المستدامة

الملخص

تعد مياه الصرف الزراعي في مصر واحدة من أكثر مصادر المياه المعاد استخدامها شيوعا. ومع ذلك، يواجه برنامج إعادة استخدام مياه الصرف عقبة رئيسية في شكل ارتفاع مستمر لأحمال التلوث في مياه الصرف. ونتيجة لذلك، هدفت هذه الدراسة إلى تحسين نوعية مياه الصرف الزراعي باستخدام تقنيات معالجة منخفضة التكلفة مثل الموجات فوق الصوتية التي تعتبر واحدة من التقنيات الجديدة والطرق غير الميكانيكية والتكنولوجيا النظيفة لحماية البيئة.

في هذه الدراسة تم تطبيق جهاز عالي التردد بالموجات فوق الصوتية مع ١,٧ ميغاهيرتز لدراسة تأثير الموجات فوق الصوتية على الخصائص الفيزيائية لمياه الصرف الزراعي. تم دراسة تأثير حجم الماء أثناء تطبيق موجة فوق صوتية ثابتة على خصائص المياه. تم تحديد وقت تعريض الموجات فوق الصوتية عند ١٠ و٢٠ و٣٠ دقيقة تحت ثلاث طاقات مختلفة من التعرض تبلغ ٥٠ و١٠٠ و١٥٠ واط بالموجات فوق الصوتية.

أظهرت النتائج التجريبية أن تعريض عينات من ماء الصرف للموجات فوق الصوتية عند فترات زمنية مختلفة له تأثير على الخصائص الفيزيائية والكيميائية للمياه مثل الأس الهيدروجيني، والمواد الصلبة الذائبة الكلية وبالتالي الموصلية الكهربية. أظهرت النتائج التجريبية أيضا أن قوة التعرض المختلفة للموجات فوق الصوتية لعينات الماء لها تأثير على كمية المياه المعالجة المنتجة. خفضت الموجات فوق الصوتية إجمالي المواد الصلبة الذائبة بنسبة ٢٢,٤٪ عند زيادة وقت التعريض من ١٠ إلى ٢٠ دقيقة، وبنسبة ٢٠,٩٪ عند زيادة وقت التعريض من ٢٠ إلى ٣٠ دقيقة. وعلى ضوء النتائج السابق ذكرها توصى هذه الدراسة بأن استخدام الموجات فوق الصوتية قد أدى إلى تحسين جودة مياه الصرف الزراعي ويمكن استخدام هذه التقنية وعمل مزيد من الدراسات على نوعيات مختلفة من المياه رديئة الجودة.