Microwave Ultrasonic Pre-Treatment for Enhanced Aeration and Anaerobic Degradation of Pharmaceutical Waste

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ABSTRACT

Pharmaceutical plants produce a huge amount of sludge and effluent; around 15% of this waste can be considered toxic to the environment and humans. The development of the pharmaceutical industry includes a different amount of production and a complex process known as high concentration and poor biodegradability. There are several physical chemical and biological treatment methods for the degradation of pharmaceutical waste. Yet, most of these technologies are expensive and suffer from technical limitations. An alternative to address this problem is Anaerobic Digestion process (AD) which is a biodegradation process that removes organic matter and total and suspended solids in oxygen free reactors. However, anaerobic digestion has a very slow rate-limiting hydrolysis stage. To address this problem and make the process faster and improve the efficiency, pretreatment methods as microwave, ultrasonic, chemical, mechanical or thermal pretreatment techniques can be applied. This research focuses on investigating the use of microwave, ultrasonic and oxidation pretreatment techniques at microwave frequency of 2450 MHz and a maximum power supply of 640 W. Ultrasonication, creates high shear forces which result in cavitation and sludge disruption due to the ultrasonic waves. These forces damage the membranes at lower sonic intensities, making the bacteria more vulnerable to the effects of biocides. Additionally, cavitation's hydroxyl radical can help with disinfection, the experiment is sampled in three stages to note the affected of different pretreatment on anaerobic and note digestion settings. The effect of the pretreatment on the process was analyzed by studying total solids, volatile solids, total and soluble COD, pH, dewaterability, temperature, and particle size.

Introduction

Sludge management is a significant challenge in waste treatment plants due to the amount of production from industrial and municipal sources. Among the primary industrial sources, pharmaceutical plants produce a massive amount of sludge. Where its treatment costs around 85% of the total operating cost of wastewater treatment, and around 15% of this waste can be considered hazardous, infectious, radioactive, or toxic(Gupta *et al.*, 2014). Furthermore, in this waste, there are dangerous bacteria that can affect the ecosystem. Other potential hazards may include drug-resistant microorganisms which spread from health facilities into the environment. By discharging infections and harmful contaminants into the environment, the treatment and disposal of healthcare waste might indirectly result in health hazards. If landfills are not built appropriately, the disposal of untreated pharmaceutical wastes might result in the pollution of drinking, surface, and ground waters. If chemical disinfectants used to treat pharmaceutical wastes are not handled, stored, and disposed of in an ecologically responsible manner, chemical compounds may be released into the environment (Pepin.,2014). Thus, there is a considerable effort to find and develop friendly, environmentally, and economical technologies to minizine this waste. As a result, one of the most efficient technologies to help remove this waste is the anaerobic digestion (AD)process, a biodegradation process without using oxygen. It is used for pharmaceutical waste to produce biogas, which is considered a source of energy. Thus, this process is one of the valuable technologies for treating pharmaceutical wastewater, owing to its advantage in solving this problem: it produces less sludge and lower operating (Mesfin Yeneneh, 2014).

Despite the development of water treatment technologies worldwide, it suffers from some drawbacks, as well as in the anaerobic process. In addition, there are some disadvantages, slow rate-limiting hydrolysis of organics. As a result of this problem, this research focused on developing this process by ultrasonic, microwave pre-treatment.

Methodology

At the beginning, we started by gathering the supplies needed for the experiment including pipes, tubes, valves, pharmaceutical waste (Acetaminophen), wastewater, distill water Conical flasks, funnel, measuring cylinder, dish, Teflon tape, oven, desiccator, Analytical balance, pipette, and adhesive. In the second step**,** Collected 4 conical flasks with two holes one for liquid and the other for gas. After that, cut 12 pipes of equal length, and inserted the liquid pipe deeper than the gas pipe into the perforations. To prevent the piping from entering the air, we will first glue it to the top of the holes Then we will connect a tube inside the bottle from the liquid pipe to the top of the bottle in a straight line. Next, we will put Teflon tape beside the caps of bottles to block entering air. In the third step, we mixed (20ml) of wastewater with (30 ml)of synthetic sludge, put in 4 reactors and put in the oven around 36℃ for 1 week this will help bacteria to grow. Then**,** we prepared again 4 conical flasks (microwave& oxidation, microwave &ultrasonic, Reference (1) & Acetaminophen without glucose and urea (Refrence2). Added 400 ml from synthetic sludge and 0.05g from Acetaminophen in all conical flask. Then, we put the first flask in microwave for 2 min and power 60. After that, we put in ultrasonic machine for 3 min and power 65. Next, in the flask of microwave and oxidation we add 50 ml of hydrogen peroxide. In this step we tested TS, VS, COD, TDS. Thus, first we take 5 ml from each flask by using pipette and we added it in 4 dishes put and measured the empty dish mass by using analytical balance. Then, we put it oven (2hr, 105^{O}C). After that, put in desiccator to absorb moisture. We put the dishes in the France at (550 ℃ for 1 hr.) this step helped us to measure vs. Next, took samples from each reactor to measure Cs (capacitance of the capacitor), Rs (Residual resistance), Zs (Short residual impedance), and Ls (Residual inductance) by using LCR meter. Moreover, we used UV-VIS spectrophotometer the measure the absorption. By adding specific amount of each sample in Chemical Oxygen Demand Reagents to measure COD. Approved method for the COD, Determination of Surface Waters and Wastewaters. This method covers the determination of COD in surface water, domestic and industrial wastes. The sample is digested in the presence of dichromate at 150 °C for 2 hours. Oxidizable organic compounds reduce the dichromate (orange) ion to the chromic (green) ion. Thus, this step helped us to measure COD.

Results and Discussion

pH

Different pH ranges are required for the growth of anaerobic microorganisms. For instance, the needed range of fermentative bacteria is (6.5-7.2) while the appropriate range for methanogens is (6.5-7.2). (4.0-8.5). PH can regulate both the type and quantity of bacteria that produce acids. A typical glass electrode provider with a pH/conductivity /DO meter/temperature meter was used to compute the PH in this experiment. The PH will be continuously monitored while the anaerobic bacteria were being utilized, as well as before and after pretreatment. Instant PH testing will be used to lower the constant between the air and the sample**.**

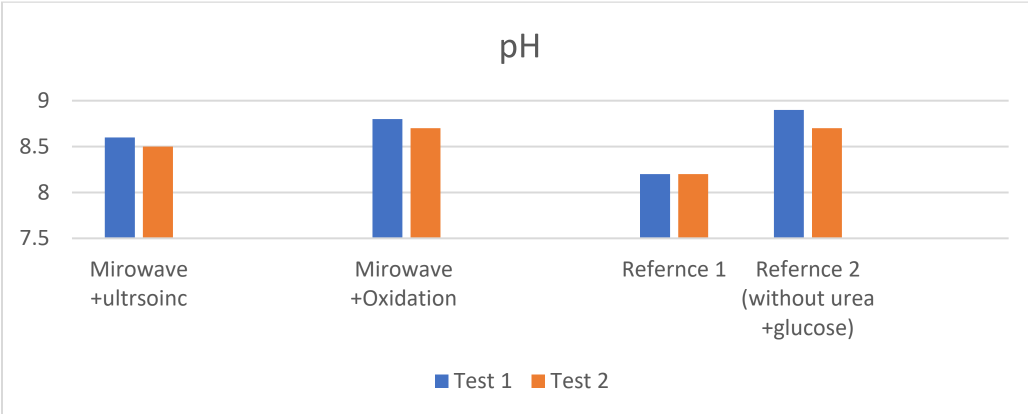

Figure 1. pH measurement

Microwave and Ultrasonic Result

Total Solids (Ts)

The plane is before introducing the pharmaceutical sample, the furnace should be preheated (usually 15 to 20 min ignition is required). Place residue in the furnace and heat to 550°F/50°C for 1 hour. Allow the dish or filter disk to cool in the air until most of the heat has disappeared.

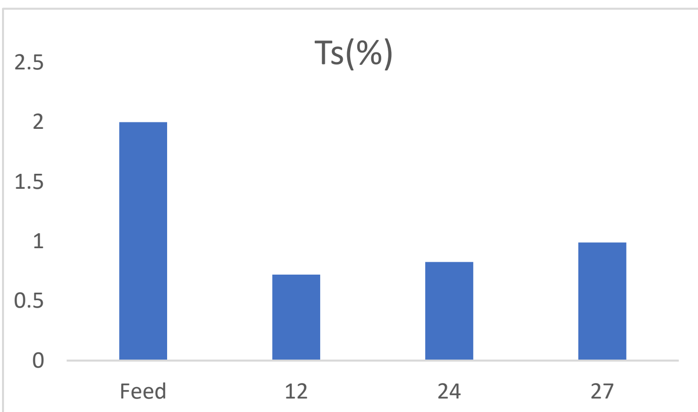

Figure 2. Ts measurement

Total Volatile Solids (Vs)

Total and volatile solids content were calculated using Standard Methods for the Examination of Water and Wastewater. To analyze the total and volatile solids in pharmaceutical waste samples, dried the samples at 105°C. If any residue is found, it will then be burned at 550°C for 2 hr.

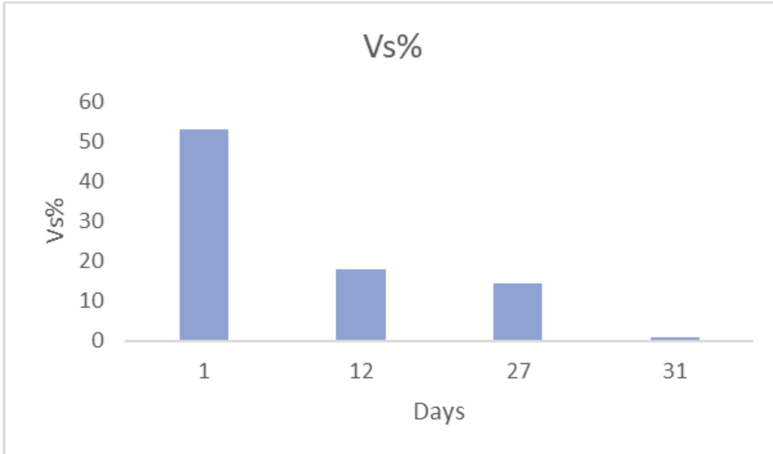

Figure 3. Vs measurement

Total Dissolved Solids (TDS)

The term total dissolved solids (TDS) are used to describe the quantity of all dissolved organic and inorganic components present in a liquid. Inorganic salts and trace amounts of organic stuff found in solution in water are referred to as total dissolved solids (TDS). The main components are typically carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions, as well as calcium, magnesium, sodium, and potassium cations and anions. The electrical conductivity of water is also measured by TDS. This measured by using LCR meter.

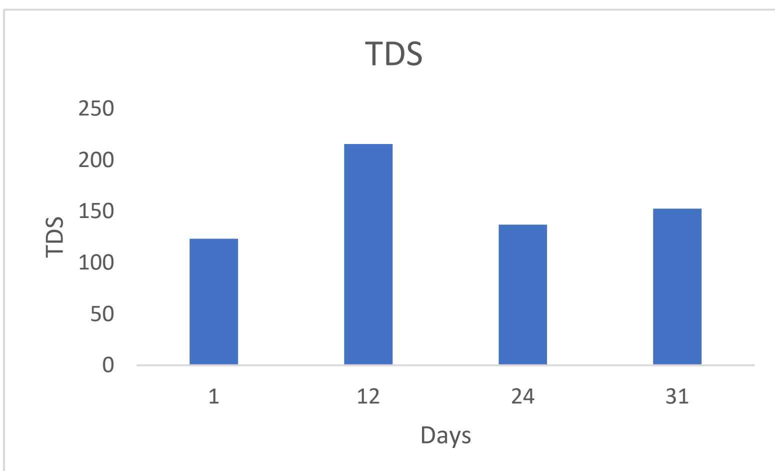

Figure 4. TDS measurement

Chemical Oxygen Demand (COD)

The amount of oxygen that a reaction in a measured solution can consume is assessed by the chemical oxygen demand in environmental chemistry. Utilizing chemical oxygen demand tests, the purpose is to ascertain. Using a micropipette and 1 ml of a representative sample diluted in 50 ml of distilled water, the total chemical oxygen demand may be computed. Additionally, it is anticipated that 2 ml of each sample were added to each

HACH-COD vial, the mixture was well homogenized, and each vial will be for 2 hours at 1500C in the COD reactor (digester). The COD vials were refrigerated, and COD will be measured with an ORION UV/V spectrophotometer designed especially for this task (Anteneh et al., 2014).

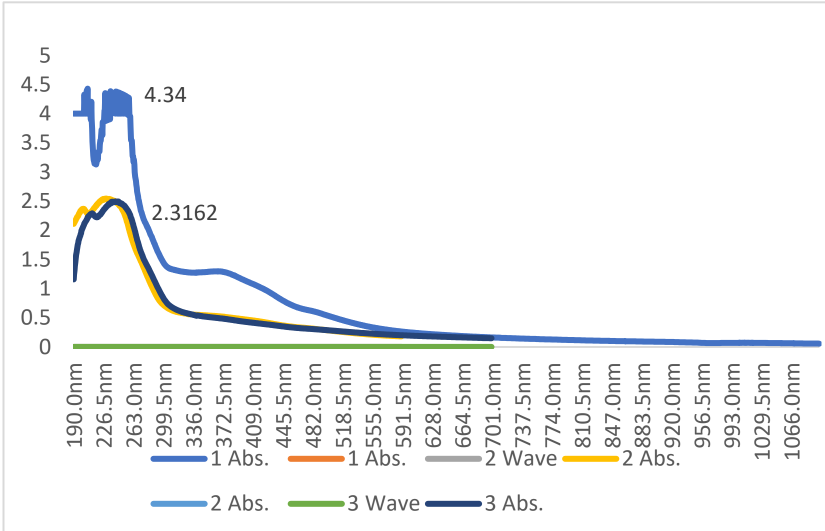

Figure 5. UV/V spectrophotometer

Conclusion

Sludge management is a significant challenge in treatment technology due to the amount of production from pharmaceutical waste and with development of producing medical which can be affected negatively in the environment. Many sewage treatment plants use anaerobic digestion to treat the wastewater that stabilizes organic matter, to improve their efficacy. Numerous experimental research has been recorded on the pretreatment of waste to enhance its hydrolyses, bio-compatible, and originally described. Therefore, this research focused on how to improve the anaerobic process by ultrasonic which is a chemical and physical process. It depends on the resulting chemical and physical change and the ultrasonic cavitation effect that depends on supercritical water oxidation, free radical oxidation, and pyrolysis. Several factors can affect the ultrasonic of metal pollutants in wastewater, for example, sound power, frequency, time of US, kind of metal, good power, PH, and temperature of the solution. Microwave is a form of electromagnetic radiation which work with frequencies around (300MHz to 300GHz) and the most effective range for dielectric heating is around (0.915 and 2.45GHz). Sludge can be stabilized in several ways, although anaerobic digestion is one of the most common and efficient that need lower operation costs and capital, it produces high-quality methane and the energy consumption is less because it happens at low temperatures. However, due to the presence of extracellular biodegradable polymers and the limited biodegradability of cell walls, its rate-limiting hydrolysis phase is extremely slow. Furthermore, in this experiment will take several stages, at the beginning will take pharmaceuticals wastewater samples to note the characteristics before and after the experiment. Then, will treat by MW and US to not (Temperature, TS, TSD, PH and COD) at specific time.

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