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The Bio-Effect of Microwave Treatment on Coliform Bacteria in Tap Water in Badoush Region-Mosul

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Abstract
This study investigated the use of microwave treatment to address E. coli contamination in tap water. It utilized an antenna frequency of 2.4GHz, an aperture distance of 40cm, and a relative power of 14.2dB. The Most Probable Number (MPN) method assessed the contamination levels. Samples were divided into two groups; one group received microwave treatment, while the other group served as a control without treatment. Some samples exhibited a percentage decrease, while others eliminated coliform bacteria, reducing contamination to zero. The rate decreased significantly after the treatment, with the probability value reaching ($P < 0.01$).

Keywords: microwave, bio-effects, MPN, coliform, tap water

Introduction

Microwave radiation is widely used in various applications, one of it is sterilization. One important area of research is the impact of microwaves on microorganisms, particularly in the context of water treatment and public health. Coliform bacteria, a group of rod-shaped bacteria commonly found in the intestines of warm-blooded animals, serve as indicators of potential fecal contamination in tap water. Understanding how microwave radiation affects these bacteria is crucial for evaluating its efficacy in water purification and ensuring safe drinking water. Microwaves affect biological systems primarily through dielectric heating, which increases the temperature of the water and the microorganisms within it. This heating can lead to cell damage or death in bacteria. Additionally, the interaction of microwaves with bacterial cells may induce other bio-physical effects, such as alterations in cellular structures or metabolic processes. The impact of microwaves on living organisms depends on factors like frequency, exposure time, sample size, and distance from the transmitter [1]. Mishra and Lewis explored the mechanisms through which microwave radiation affects coliform bacteria, including the role of temperature increase and the potential for direct microwave interaction with bacterial cells. It evaluates the efficiency of microwave disinfection compared to conventional methods [2]. Smith, and Thompson investigates the effectiveness of microwave treatment on coli form bacteria, analyzing how factors such as microwave power and exposure time influence bacterial inactivation in tap water [3]. Recent research by Al Naimi *et al*. demonstrated that exposing Staphylococcus aureus and Escherichia coli to specific microwave frequencies (8-12 GHz) significantly reduces bacterial counts. This finding aligns with the results observed when microwaves were utilized to treat water contaminated with sewage, leading to a notable reduction in germ count [4]. Another study by Zhang *et al*. further explored the interaction between microwaves and water, showing that media with higher water content exhibit increased absorption of microwaves within the frequency range of 10^9-10^{12} Hz. This increased absorption is attributed to the higher relative dielectric constant of water molecules, which facilitates more effective artificial polarization of the medium when placed in an electromagnetic field [5]. Polivka discuss the potential effects of microwave radiation on biological systems, including its impact on the metabolic state of oocytes and the protoplasm in microorganism cells. The study explores how microwave exposure can influence cellular processes and metabolic activities, potentially leading to alterations in cell function and viability [6]. Additionally, it has been observed that the duration of microwave exposure directly influences the extent of microbial killing.

The World Health Organization has underscored the significance of microwave technology for sterilizing human food, emphasizing its effectiveness in microbial control [7]. Variability in bacterial sensitivity to microwave radiation is noted, with bacterial spores exhibiting high resistance compared to Gram-negative rod-shaped bacteria, which show greater sensitivity to radiation [8].

This study employed microwaves to process wastewater contaminated with E.coli. The contamination was identified using the MPN method. The samples were split into two groups: one group underwent microwave treatment, while the other served as the control group and did not receive microwave treatment. Our experiment entailed creating a microwave source with a higher electric field concentration and determining the collection and radiation intensity for these treatments based on the available equipment.

Materials and Methods

Physical preparations

A signal generator of the SMPD type was used to obtain the frequency f=2.4GHz in the exposure of the prepared samples, and these microwave waves were sent from a standard gain funnel antenna with an aperture area of (35×25). The coefficients in our measurements were chosen to be suitable for the frequency and processing type. The measurement of antenna gain by power is an absolute measure. It is difficult to determine accurately, so a (Tektronix) macro spectrum analyzer was used to determine the calibrated power in (dB) units. The gain here is the power ratio and can be calculated mathematically from the equation [9]:

$$G\,(dB) = 10 \log Gr \qquad (1)$$

Where Gr can be calculated from the following relationship

$$Gr = 0.42 \times d \times f\,(P / P_o) \qquad (2)$$

Here, P is the received power, while Po represents the power transmitted from the transmitting antenna. d, represents the distance between the sample and the antenna aperture sending the waves. A partial loss occurs in the originally transmitted power P_o in the antenna itself and the surrounding parts before the samples arrive. Therefore, the antenna radiation effectiveness (e) constitutes that ratio P/P_o and ranges between ($0<e<1$), and this is the slight difference in the theoretical values and practical values attributed to it.

From a distance (d = 40 cm), the relative power was measured practically. The acquisition value was calculated from equation (2). It was (26.4) and equals (14.2 dB), which is calculated from the inverse of the relationship (1) mathematically. At the same time, the scale of the macro spectrum analyzer device above read (14.7 dB), so we notice that the difference is simple due to the ratio (e) above.

Experimental work

The samples were exposed vertically from the antenna nozzle at a distance of (40 cm); the samples were placed in sterile plastic dishes to obtain a surface area as wide as possible. The exposure time took 90 minutes in two stages; each stage took (45) minutes under the same conditions for the entire meal.

Biological preparations

***A- The samples*:** A number of 250 ml beakers were meticulously prepared, each containing an exact amount of sodium thiosulfate to neutralize residual chlorine in the tap water. The beakers were covered with aluminum foil and sterilized by autoclaving at a precise temperature and pressure, ensuring the samples were taken directly from clean and sterilized tap water. This process, following the method [10], was carried out with utmost care and attention to detail.

B- Multiple Tube Method: Bacteriological examination of water using the multiple-tube method. E. coli bacteria are the main focus of this method, where nine tubes containing inverted Dirham tubes were used, and the tubes were divided into three groups with three tubes for each group. The first group contained MacConkey broth (Double Strength) medium in an amount of 10 ml for each tube. The other two groups contained MacConkey broth Single Strength medium in an amount of 10 ml for each tube. They were sterilized by autoclaving at a temperature of 121 °C for 15 minutes and under a pressure of 15 pounds/inch^2; the first group of tubes was inoculated with 10 ml of the water sample, the second group was inoculated with 1 ml of the water sample, and the third group was inoculated with 0.1 ml of the water sample. The tubes were incubated at 37°C for 48-24 hours, and the results were recorded by observing the formation of gas in the Dirham tube, with the medium's color changing to yellow, indicating the formation of acid. The results were based on special statistical tables known as MPN Tables, which were prepared by McCrady in 1918 and modified by the World Health Organization.

***C- Exposing to microwave*:** The samples were divided into two groups, and the exposure process was carried out with precision. The first group was exposed to microwave rays from a microwave transmitter for a specific duration, and the second group was left without exposure. The samples were replanted using the MPN examination method after the exposure, ensuring the precision and control of the entire process.

Result and Discussion

In the Badush district, tap water has been found to be contaminated with coliform bacteria, potentially as a result of issues with the sterilization system in the water distribution network. Analysis presented in Table 1 indicates varying levels of contamination in different regions, possibly due to pipe breakages near sewage lines or the age of the network. The highest bacterial contamination was found in sample No. 4, with an MPN test result of 21. However, treatment with microwaves reduced the contamination to 7. Sample No. 7 had the lowest coliform bacteria contamination, with an MPN test result of 4, which was reduced to zero after treatment with microwaves. Table (1) MPN test results for tap water samples taken from different areas in Badoush district.

Table 1: The MPN test results for tap water samples before and after exposure

Samples		MPN result Before exposure	MPN result After exposure
#1	Health center/Badoush	15.00	4.00
#2	School/Badoush	9.00	4.00
#3	Houses 1/Badoush	20.00	7.00
#4	Houses2 /Badoush	21.00	7.00
#5	Houses3/Badoush	15.00	4.00
#6	House4/Badoush	20.00	4.00
#7	Mosque/Badoush	4.00	0.00

Figure (1) illustrates the change in results before and after exposure, demonstrating the impact of microwaves in reducing the amount of coliform bacteria in the tap water samples. This aligns with the findings of the study by reference [11].

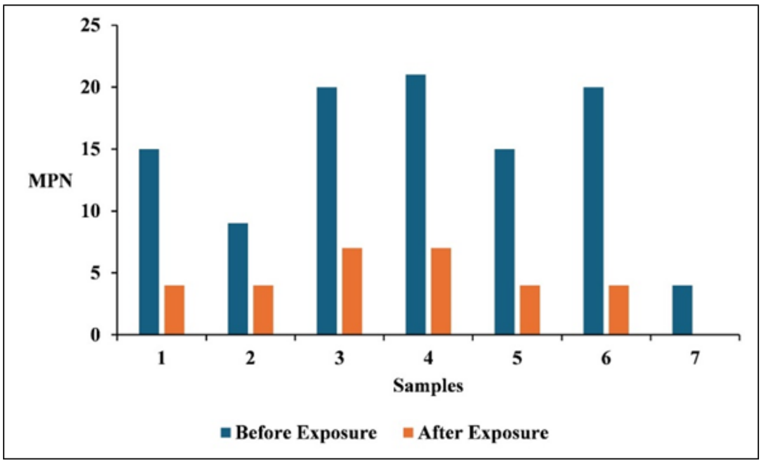

Fig 1: Variation in microwave treatment results before and after exposure

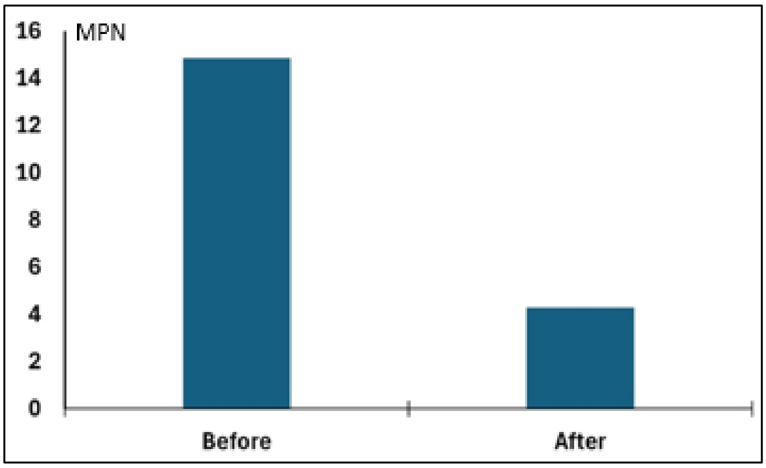

Fig 2: The MPN results for all samples before and after microwave treatment

From Figure (2) on can explain that the; the rate ± standard error before treatment =14.85± 2.4, where the rate ± standard error after treatment =4.28± 0.8. That is, the rate decreased significantly after the treatment, as the probability value reached (P = 0.0008), i.e. $P < 0.01$.

Conclusion

The study highlights the effectiveness of microwave treatment in reducing coliform bacterial contamination in tap water from the Badush district. The varying levels of contamination observed across different regions emphasize the challenges posed by potential issues in the water distribution network. However, microwave treatment consistently demonstrated a significant reduction in bacterial counts. Some samples exhibited a percentage decrease, while others eliminated coliform bacteria, reducing contamination to zero. The rate decreased significantly after the treatment, with the probability value reaching ($P< 0.01$). These results suggest that microwave treatment could be a valuable method for improving water quality and addressing contamination issues in affected areas. Further research and consideration for broader implementation in water treatment practices are warranted.

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