Article title: Impact of Wi-Fi Energy on EZ Water

Authors: Ji Won Lee[1], Gerald Pollack[2]
Affiliations: Department of Bioengineering, Box 355061, University of Washington, Seattle, WA, 98195[1]
Orcid ids: 0000-0002-5350-9295[1]
Contact e-mail: leej233@uw.edu

Funder: SAGST Foundation, Mary Gates Endowment
DOI: 10.14293/S2199-1006.1.SOR-.PPIQ9G6.v1
Preprint first posted online: 03 August 2021
Keywords: Exclusion Zone, Exclusion Zone water, EZ water, Wi-Fi, wifi, cell functionality

Introduction

It is well-known that water has three phases: solid, liquid and gas. Yet, a gel-like phase of water, called Exclusion-Zone (EZ) or “fourth-phase” water has recently been identified.[1~5] In this phase, molecules are ordered, commonly forming a liquid crystal around hydrophilic surfaces, including those inside the cell.

Thus, the body’s cells are largely filled with EZ water, a feature critical for cell function.[3] Agents that impair cell function may act by diminishing the quantity of EZ water, while health-promoting agents generally build EZ water.[6] The body’s cells are also commonly exposed to various electromagnetic signals. Multiple reports imply the possible negative effects of electromagnetic fields on living organisms. [7~11] Thus, we hypothesize that electromagnetic fields could alter bodily function through their impact on EZ water. We therefore investigated possible changes in the buildup of EZ water with and without exposure to one of the most common electromagnetic fields in our daily lives: Wireless Fidelity (Wi-Fi, also known as wireless LAN or WLAN).

Materials and Methods

General Background

Wi-Fi technology for networking of devices is based on the standard, set by the Institute of Electrical and Electronics Engineers (IEEE). The standards are the 802.11 series classified by alphabet by features, the most widely accepted standard being 802.11 b and 802.11 g, with their balance of range, network throughput, and support for device mobility.[12] The frequencies of Wi-

Fi are 2.4 GHz or 5 GHz, depending on the particular IEEE standard. Table 1, below, shows the different standards of Wi-Fi and their corresponding features and frequencies.

Table 1: Corresponding frequencies of different types of Wi-Fi. [12]

IEEE Standard	Main Features	Frequency (GHz)
802.11 a	1. Applies to wireless local area networks (LAN) 2. Maximum connect rate of 54 Mbps	5
802.11 b	1. Applies to wireless LAN 2. Maximum connect rate of 11 Mbps with fallback to 5.5, 2, and 1 Mbps	2.4
802.11 g	1. Maximum connect rate of 54 Mbps 2. Compatibility with the 802.11b standard	2.4
802.11 n	1. Multiple-input and multiple-output (MIMO) 2. Allows for increased data throughput and range.	2.4 & 5

Wi-Fi systems work as two-way traffic, using radio waves to transmit information across a network, as shown in Figure 1.[13] A Wi-Fi router's antenna converts the electrical signal form of data to electromagnetic (EM) waves and emits to the atmosphere, and vice versa.[14, 15] Three major types of Wi-Fi antenna exist: omni-directional, semi-directional, and directional. Omni-directional antennae can radiate equal magnitudes of power in all directions. Directional and semi-directional antennae radiate the power as a one directional beam. The most commonly used Wi-Fi router antennas are the omni-directional, half-wave dipole antennae, where the length of the antenna is half of its wavelength. This allows the antenna to radiate effectively, and provides capability in many applications.

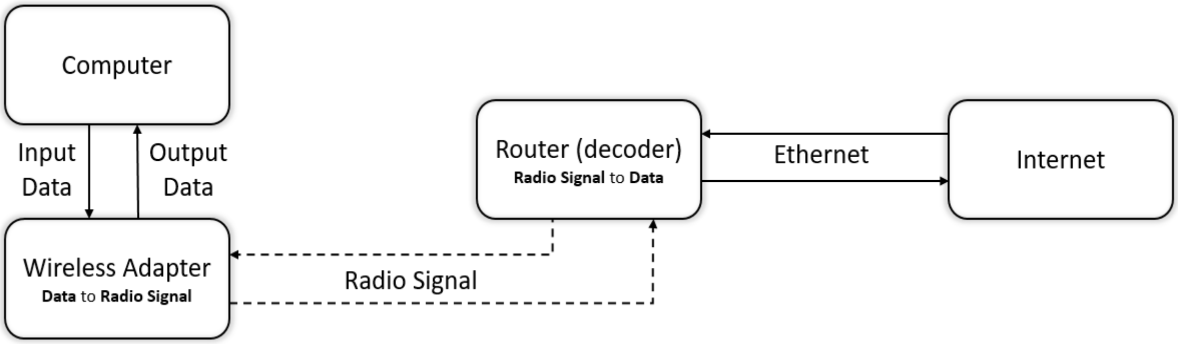


Figure1. Two-way traffic system of Wi-Fi.[15] In performing tasks online using Wi-Fi, a wireless adapter in a computer translates input data to a radio signal. The radio signal is then transmitted via an antenna to a decoder, otherwise known as a router. The router decodes the radio signal to the form of data, which is then sent to the Internet via an Ethernet connection on the router. The input data are processed on the Internet and then sent back to the router as output data after being translated into a radio signal. The radio signal is then detected by the computer's wireless adapter and translated back to output data.

The particular router used in this experiment was chosen to be set up easily in the experimental environment, while sharing features of widely used Wi-Fi routers such as the omni-directional, half-wave dipole antenna, omni-directional and 2.4 GHz frequency (see Table 2).

Table 2: Specifications of the Wi-Fi router used in the experiment [16]

Model	Rajant Jr2-24
IEEE Standard	802.11 n
Antenna Type	Half-wave dipole Antenna (Omni-Directional)
Number of Antennas	1
Maximum Radio Transmit Power (DBM*)	32
Receiving Sensitivity (DBM)	-93 ~ -71
Frequency (GHz)	2.4

*DBM: decibels relative to milliwatts.

Before setting up the router, the 3D dispersion pattern of the EM wave was investigated, revealing that the center of the router antenna could maximize the impact of Wi-Fi. (see Figure 2).

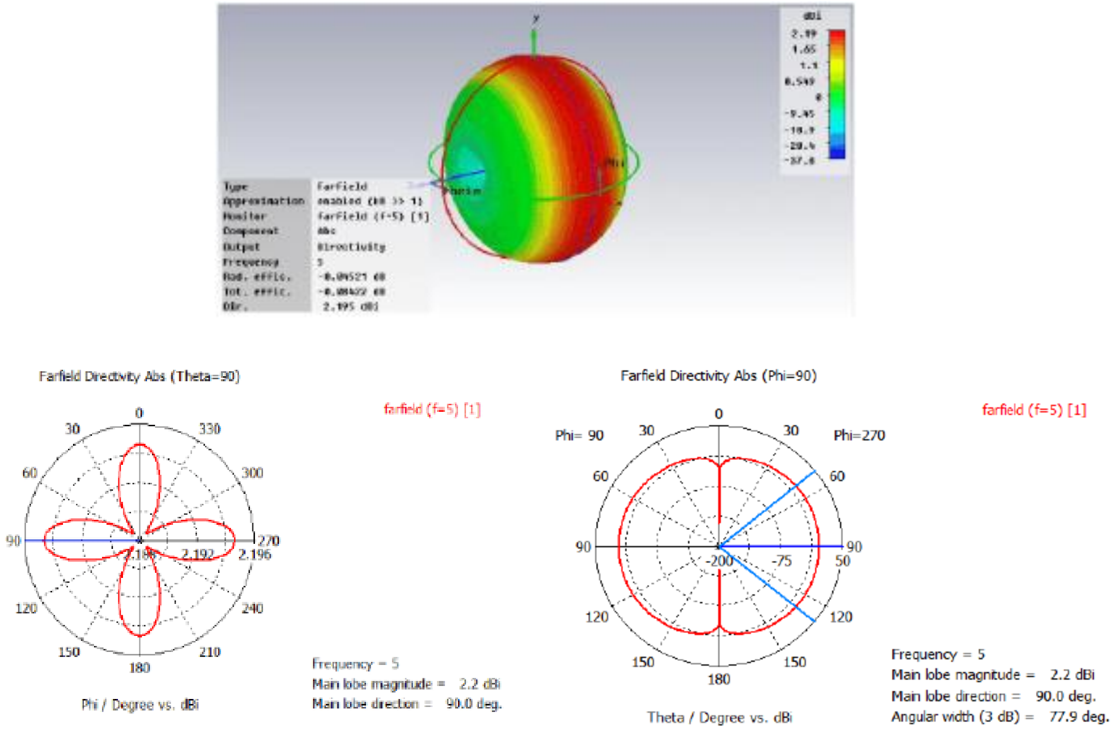


Figure 2: Expected dispersion pattern of router's omni-directional antenna[15] The electric field distribution (top), the polar plot of the azimuthal angle (bottom left) and the elevation angle (bottom right) of the antenna are shown. The strength of the electric field distribution of the antenna is shown by blue to red, the minimum to the maximum radiation. All diagrams show that the maximum distribution is directed perpendicular to the antenna in 360 degrees except at 0 and 180 degrees.

Nafion and Microsphere-Solution Preparation

To create an EZ, we used a tube made from Nafion, a copolymer of tetrafluoroethylene and perfluoro-3,6-dioxa-4-methyl-7-octene-sulfonic acid, which strongly absorbs water.[17] A 4 mm length of TT-30 Nafion tubing was prepared for pre-hydration, for optimum EZ development. The tube was pre-hydrated with 3 ml of DI water for 10 minutes in a Falcon 35 x 5 mm Petri dish. Before placing the tube in the reservoir, to help pre-hydration of the inside of the tube, where the air inside the tube might restrict water penetration, a 10-mL syringe with 0.6 mm outer diameter needle was used to inject water directly to the inside of the tube. During the pre-hydration, a microsphere suspension was made by adding 1 drop of 2-µm polycarboxylate microspheres into 25 mL of DI water in a Falcon 45 mL tube. After the tube was pre-hydrated and microsphere suspension was created, a new Falcon 35 x 5 mm Petri dish was used to create a reservoir containing a microsphere suspension with the pre-hydrated tube lying at the bottom of the dish.

Controlled Variables

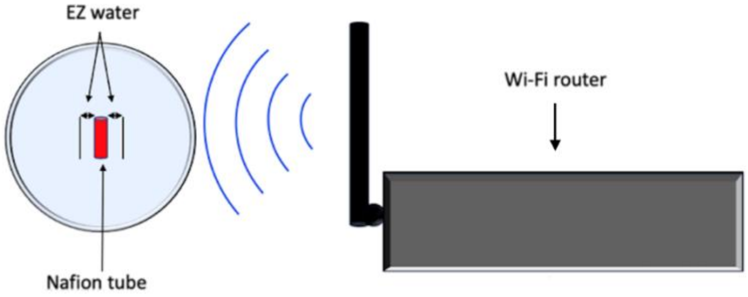
EZ-water development can be impacted by multiple factors, including incident-light level, microsphere type and concentration, length and type of Nafion tube, and possible radiation from the lab setting. Therefore, the experiment was controlled as follows:

1. Microscope: A ZEISS Axio Observer.A1 was used throughout the experimental series, under preset conditions: polarizer at 45˚, 100% strength of luminous-field stop control, 75% intensity of halogen illumination and LD condenser at 0.35 H.
2. Minimizing radiation: absence of any persons within 5 meters of microscope, to prevent infrared radiation from the human body from impacting the results. The public router was fixed on the ceiling ~5 m away from the microscope.

Experimental Setup

The experimental set-up is shown in Figure 3. A Petri dish containing the Nafion tube and microsphere suspension was positioned in the optical field, with the tube placed at center. The router antenna was placed parallel to the Nafion tube at various distances: 2 cm, 10 cm, and 20 cm away from the tube.

Top View



Oblique View

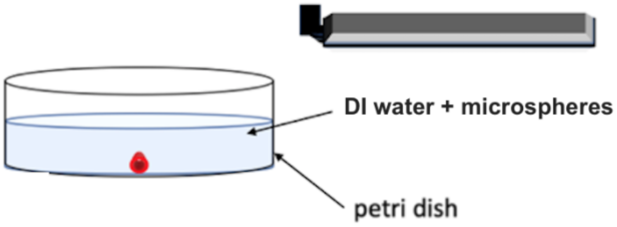


Figure 3. Schematic diagram of the experimental set-up. A 4mm TT-30 Nafion tube was placed on the bottom of the chamber containing 3 ml of 2-µm polystyrene microspheres with carboxylate functional groups, diluted in 25 ml of DI water. The 2.4 GHz router with omni-directional antennae was set next to the microscope on which the chamber was placed. The vertical position of the router's antennae was fixed 5 cm above the chamber with a styrofoam stand.

We conducted 18 experiments. Each experiment comprised 4~6 trials, 1~3 without Wi-Fi exposure, and 3 with Wi-Fi exposure, where the router was positioned 2 cm, 10 cm, and 20 cm away from the chamber. Each trial lasted for 20 minutes, during which the evolving size of the EZ was recorded as 2D images, obtained each minute by using AmScope software. The sequence of trials was random, in order to exclude the possible EZ-size dependency on experimental time and surroundings.

Measurement

After each experiment, the recorded 2D images showing EZ development were analyzed by using Image J software. EZ size was measured in successive 5-minute intervals. To minimize the effect of any irregular development of EZ around the Nafion tube, measurements were made at three different points along the tube, top, middle and bottom, and averaged (see Fig. 4). The average value was then converted from pixels to micrometers. The average Nafion tube outer diameter, 838 µm, was subtracted from the calculated average, and then divided in half to give "EZ size."

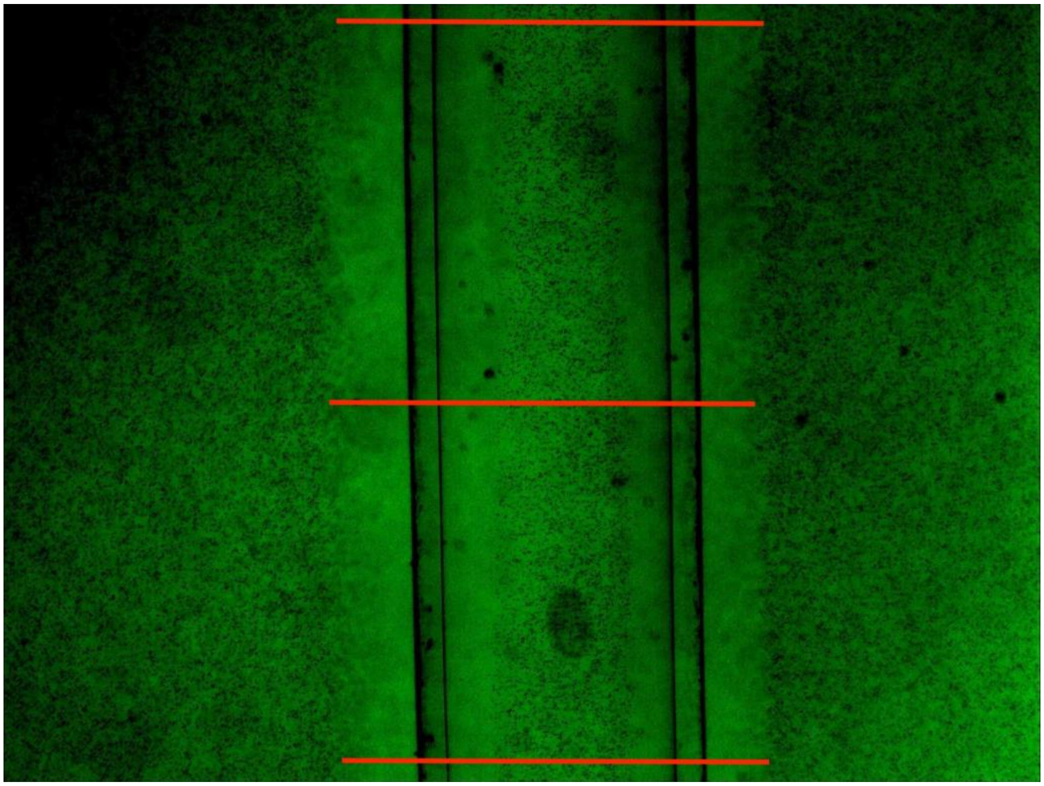


Figure 4. Measurement of EZ size with computer-generated measuring line. Red lines represent the measurements made on top, middle and bottom, averaged to yield mean EZ size.

EZ sizes were measured, both with and without the presence of Wi-Fi. We then calculated the percentage differences between the two values. To test for statistical significance, a two tailed t-test with equal variance was performed on mean EZ sizes with and without the presence of Wi-Fi, for all 18 experiments.

Results

Presence of Wi-Fi

From the measured and calibrated data from 18 experiments, average EZ size and the percent difference at each interval of time were calculated and plotted (Figure 5). For the 5-, 10-, 15-, and 20-minute intervals, the differences in average EZ size with and without exposure to Wi-Fi were 12.8%, 18.0%, 18.7%, and 17.4%, respectively (see Figure 5).

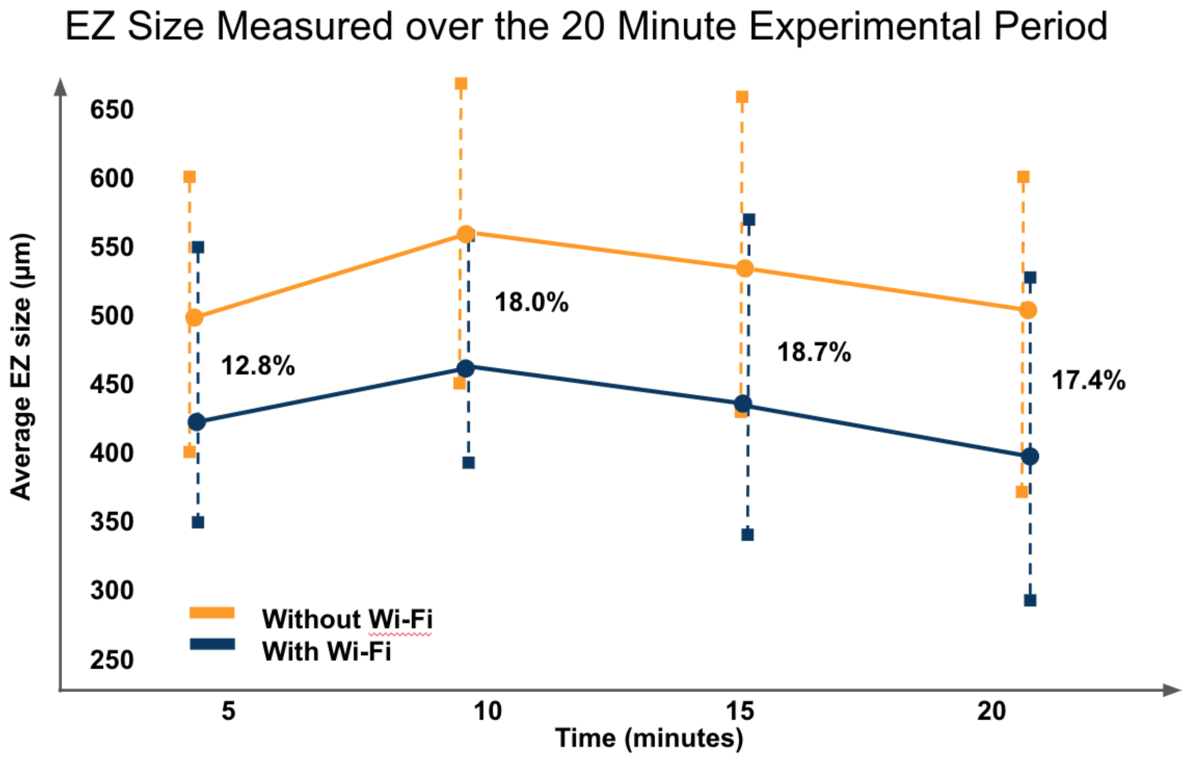


Figure 5. Comparison of EZ water sizes after 5, 10, 15 and 20 minutes (n = 18). Data points represent mean size of EZ while the dotted lines denote the standard deviations. The orange and blue line represent the mean size of EZ without Wi-Fi and with Wi-Fi, respectively.

Validation

A two-tailed t-test with equal variances was used to determine the statistical significance of the apparent differences. Respective *p*-values for the above time intervals were 0.040, 0.0093, 0.018 and 0.029, respectively. In other words, the differences were statistically significant (p value < 0.05).

Distance variation

To explore the impact of varied distances between router and chamber, the router antenna, always placed parallel to the Nafion tube, was positioned at various distances from the tube: 2 cm, 10 cm, and 20 cm. Figure 6 shows that the percent difference between 20 cm and 10 cm positions at various times was modest, only -2.35%, 0.32%, 5.95% and -0.02%, respectively. Between 10 cm and 2 cm positions, however, the differences were 10.90%, 8.31%, 8.28% and 10.62%, i.e., EZ size was 8 – 13% smaller at the 2-cm position than at the 10 cm position.

Table 3: % difference of the EZ size measured at all time intervals at various distances from the router's position.

Router's Distance	20 cm – 10 cm				10 cm – 2 cm			
Time (minutes)	5	10	15	20	5	10	15	20
% Difference	-2.35%	0.32%	5.95%	-0.02%	10.90%	8.31%	8.28%	10.62%

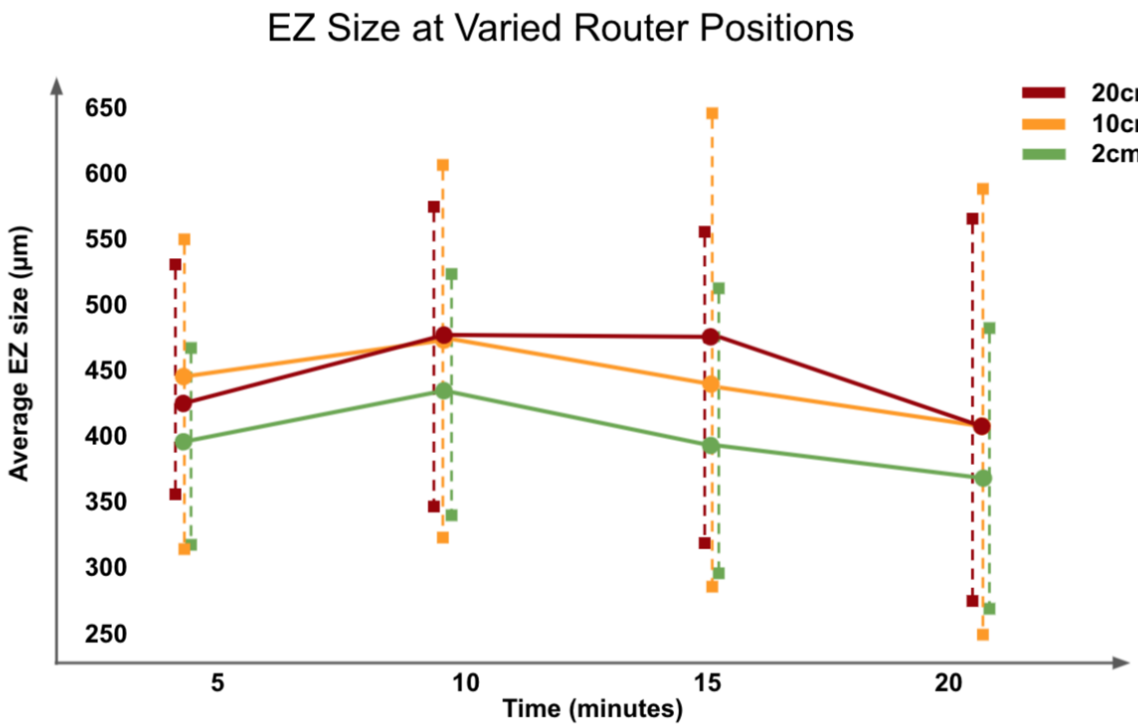


Figure 6. Comparison of average EZ size at varied router distances: 2 cm, 10 cm and 20 cm from the Nafion tube. Data points represent mean size of EZ while the dotted lines denote the standard deviations. The red, orange and green line represent the mean size of EZ at 20 cm, 10 cm and 2 cm router distances, respectively.

Discussion

Under the conditions of these experiments, exposure to Wi-fi energy diminished EZ size by 15 - 20%. The results were statically significant, indicating the negative effect of the Wi-Fi energy on EZ size. Hence, the presence of Wi-fi has a negative impact on EZ-water buildup.

Regarding the router's distance from the target, we found that the negative effect of the Wi-Fi on EZ size was strongest when the antenna was closest to the chamber. Mean EZ size measured at all time intervals was 8~13% smaller at a shorter distance between the router and chamber.

The main result was that the presence of Wi-Fi negatively impacted EZ size. The result is not surprising. Several reports indicate that electromagnetic fields negatively impact human health, including reduced male fertility, neuropsychiatric changes, and more.[8~12] At the same time, health-promoting agents build EZ,[7] indicating that EZ water appears to have a facilitating impact on human health. Thus, the reduction of EZ size in the presence of Wi-fi energy implies that Wi-fi radiation may have a negative impact on health.

To determine the seriousness of the effect, additional experiments will need to be carried out at the larger distances characteristic of typical installations. Nevertheless, the observed effect gives some preliminary reason for concern that Wi-fi energy may negatively impact human health.

Acknowledgement

We hereby wish to show our appreciation to great supports from the SAGST Foundation and Mary Gates Endowment for this research.

References

1. Pollack, G. H. (2013). *The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor*. Ebner & Sons, Seattle.
2. Ling, G. N. (2001). *Life at the Cell and Below-Cell Level: The Hidden History of a Fundamental Revolution in Biology*. Pacific Investment Research Inc.
3. Pollack, G. H. (2001). *Cells, Gels, and the Engines of Life*. Ebner & Sons, Seattle.
4. Zheng, J. M., & Pollack, G. H. (2003). Long-range forces extending from polymer-gel surfaces. *Physical Review E*, *68*(3). https://doi.org/10.1103/physreve.68.031408
5. Zheng, J. M., Chin, W. C., Khijniak, E., Khijniak, E., & Pollack, G. H. (2006). Surfaces and interfacial water: Evidence that hydrophilic surfaces have long-range impact. *Advances in Colloid and Interface Science*, *127*(1), 19–27. https://doi.org/10.1016/j.cis.2006.07.002
6. Sharma, A., Adams, C., Cashdollar, B. D., Li, Z., Nguyen, N. V., Sai, H., Shi, J., Velchuru, G., Zhu, K. Z., & Pollack, G. H. (2018). Effect of Health-Promoting Agents on Exclusion-Zone Size. *Dose-Response*, *16*(3), 155932581879693. https://doi.org/10.1177/1559325818796937
7. Firstenberg, A. (2020*). The Invisible Rainbow: A History of Electricity and Life.* Chelsea Green Publishing.
8. Kim, J. H., Lee, J. K., Kim, H. G., Kim, K. B., & Kim, H. R. (2019). Possible Effects of Radiofrequency Electromagnetic Field Exposure on Central Nerve System. *Biomolecules & Therapeutics*, *27*(3), 265–275. https://doi.org/10.4062/biomolther.2018.152

9. National Research Council (US) Committee on Assessment of the Possible Health Effects of Ground Wave Emergency Network (GWEN). (1993). *Assessment of the Possible Health Effects of Ground Wave Emergency Network*. National Academies Press.
10. Ozdemir, F., & Kargi, A. (2011). Electromagnetic Waves and Human Health. *Electromagnetic Waves*. Published. https://doi.org/10.5772/16343
11. Pall, M. L. (2018). Wi-Fi is an important threat to human health. *Environmental Research*, *164*, 405–416. https://doi.org/10.1016/j.envres.2018.01.035.
12. Abdelrahman, R. B. M., Mustafa, A. B. A., & Osman, A. A. (2015). A Comparison between IEEE 802.11a, b, g, n and ac Standards IOSR Journal of Computer Engineering. https://doi.org/10.9790/0661-17532629
13. Katanbaf, M., Chu, K. D., Zhang, T., Su, C., & Rudell, J. C. (2019). Two-Way Traffic Ahead: RF\/Analog Self-Interference Cancellation Techniques and the Challenges for Future Integrated Full-Duplex Transceivers. *IEEE Microwave Magazine*, *20*(2), 22–35. https://doi.org/10.1109/mmm.2018.2880489
14. Khan, A.Q., Riaz, M., & Bilal, A. (2016). Various Types of Antenna with Respect to their Applications: A Review.
15. Tareq, M., Ashraful Alam, D., Islam, M., & Ahmed, R. (2014). Simple Half-Wave Dipole Antenna Analysis for Wireless Applications by CST Microwave Studio. *International Journal of Computer Applications*, *94*(7), 21–23. https://doi.org/10.5120/16355-5734.
16. Rajant. (2015, December 18). *BreadCrumb JR2 Data Sheet*. https://www.navigationsolutions.eu/wp-content/uploads/2017/06/Rajant-BreadCrumb-JR2-Data-Sheet.pdf

17. Prema Pure. (n.d.). *All About Nafion™ Tubing*. Retrieved August 15, 2020, from https://www.permapure.com/nafion-tubing/