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Stimulation of Biochemical Effect Using EM Field for Diagnosis & Treatment of Disease

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ABSTRACT

Exogenous electromagnetic fields have long been considered to have an impact on living cells, but endogenous electromagnetic fields may also be used to study the action of biological entities. Exogenous and endogenous electromagnetic fields also allow noninvasive detection of biological entities' internal states possible. In certain situations, however, endogenous signals may be preferable because they don't need external excitation. Exogenous signals, alternatively, may be use to observe and alter the internal process of biological organisms. An in-depth understanding of these associations will contribute to the advancement of non-invasive diagnostic methods and non-medicated disease therapies in the field of medical science. We had to analyze pure water, Clostridium Perfringens, Streptococcus, and staphylococcus solution in this article. This method is used to classify bacteria in real time, with no need for additional chemicals or testing. We hope that this paper will aid researchers in gaining a thorough understanding of these methods as well as recent developments in the area.

Keywords
Electromagnetic Waves Sensor; Clostridium Perfringens; Streptococcus; staphylococcus.

Introduction

The biological causes of EMF and signals have been the field of research studies as the identification of electromagnetic radiation (EMR). Since then, they've gathered a lot of data on its effects on particular existing cells with humans [1].

Electromagnetic radiation, also known as waves, be the product of combined field of electrical and magnetic oscillations. Frequencies of EM waves range from above 0 Hz to 1025 Hz. Ionizing radiation is defined as frequencies above the UV group (3 Peta Hertz) that have enough energy to detach electrons from an atom or molecule. This creates is extremely unsafe for existing cells because it can crack chemical bonds and cause irreversible damage, resulting in cell death. Furthermore, ionising radiation has the potential to trigger cell mutation. However, only the microwave (300 MHz) band is included in this study. Table 1 lists the names of the frequency bands and their frequency ranges within the 300 MHz band.

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Band	Range Of Frequency	
	Beginning	beginning
Extremely Low Frequency	3 Hz	30 Hz
Super Low Frequency	30 Hz	300 Hz
Ultra Low Frequency	300 Hz	3 kHz
Very Low Frequency	3 kHz	30 kHz
Low Frequency	30 kHz	300 kHz
Medium Frequency	300 kHz	3 MHz
High Frequency	3 MHz	30 MHz
VeryHigh Frequency	30 MHz	300 MHz
Ultra High Frequency	300 MHz	3 GHz
Super High Frequency	3 GHz	30 GHz
Extra High Frequency	30 GHz	300 GHz

Table 1: EM Spectrum

Modern studies of EMR's influence on living cells can be traced back to the early twentieth century, when interest in the field began to develop. H.S. Burr et al [2] published a systematic analysis of growth during that time span in 1935.

Microwaves are EM signals of wavelengths range as of 300 MHz to 300 GHz. Tissue can be break by using Microwaves with a width of milli meters in a LF range [3], there is still a face up to for mainly visual approaches. Furthermore, microwave sensors are typically inexpensive and simple to produce [4].

Applications of exogenous electromagnetic fields

The interaction between a biological component and an externally induced electromagnetic field is known as exogenous electromagnetic field interaction. A variety of studies have been conducted to support its use as a diagnostic tool or a treatment procedure.

Exogenous Electromagnetic Field for Diagnosis

The blood glucose monitoring using 1.4 GHz frequency:
Heungjae Choi et al.[5] created a blood glucose monitoring device that uses a microwave frequency of about 1.4 GHz.

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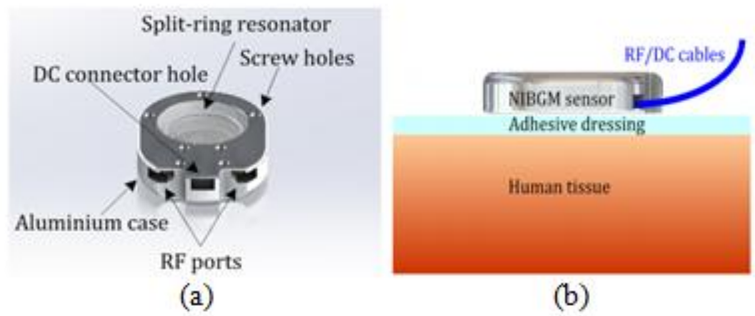

Figure 1:Detail of the sensor head which is a microwave resonant circuit based on a split-ring resonator as presented in [4].

(1) Sensor Head, (2) A portable vector network analyzer, (3) A data logger, and (4) A control software along with Printed Circuit make up the basic experimental setup (LabVIEW, National Instruments).

Vector network analyzer (VNA) is used to send a swept frequency signal & approx1mili watt output energy to the head of the sensor & to estimate the transmitted power. By appropriate to a distorted function of the Lorentzian, the variations in f_R, 3 dB BW, & losses due to insertion are monitored in instantaneously. Every 2 seconds, the process is repeated, and the produced data is registered.

The current technique measures the dielectric properties of the dermis, epidermis & subcutaneous tissue exists at the abdominal region's top few milli metres. As shown in Fig. 1, the head of the sensors is a resonant microwave circuitry dependent on a split-ring resonator. The resonant frequency is about 1.4 GHz, and the ring radius is 12 mm with a 1 mm distance on one side.

The device's accuracy is tested on twenty-four human being issues, both including and not including diabetes, in a clinical trial. The suggested method's outstanding sensitive and repeatable functionality was demonstrated through assessment among the most precise bench top glucose analyzer.

Blood glucose monitoring using UWB signals:

Using ultra-wide band (UWB) microwave, Xia Xiao et al [6] developed a measurement method for non-invasive blood. The goal of the study was to use UWB signals to detect blood glucose levels and use that information to calculate blood glucose levels.

The human earlobe is fitted with one pair of antennas. In several similar studies, the earlobe is regarded as a locally planar structure. The geometry configuration of the detection structure modeled the earlobe in this analysis is shown in Figure 2. Blood is thought to be a layer in the earlobe.

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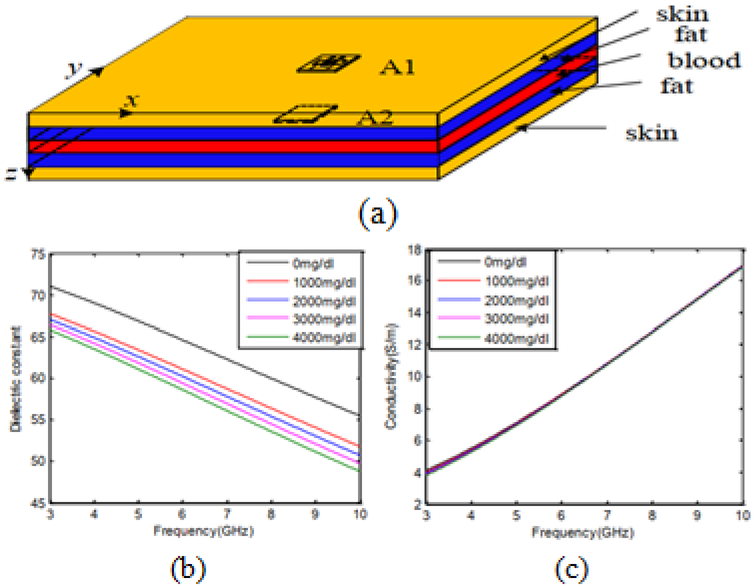

Figure 2: (a) Geometry Configuration Details, (b) Dielectric Constant Variation, and (c) Conductivity Variation, with respect to Blood Glucose.

The measurements of the structure shown in Fig. 2 are 80 mm 60 mm 10 mm, with 2 mm thick fat tissue layers on double planes covering a 2 mm thick blood layer. On equally areas, the fat tissue layers are often covered by 2 mm thick skin layers. The air layer is located on the outside of the skin layer. Two antennas (A1 and A2 in Fig.2 (a)) are set differing on either part of the skin layer in the structure.

Experimental findings with a practical earlobe phantom with a phase of 50 mg/dl in the vary of human blood glucose concentrations 0 mg/dl to 400 mg/dl also support the method's reliability.

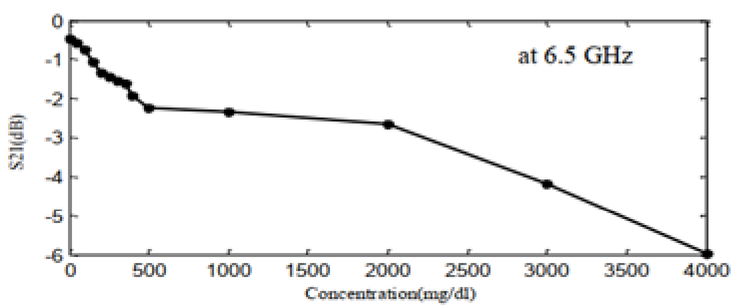

Figure 3: The dependence of the S_{21} of different blood glucose concentration at 6.5 GHz.

The Fig. 3 shows the variations in S_{21} with respect to blood glucose concentration. It also elaborates the non-linearity in the relation, which indicates that a linearization function is required.

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Hemoglobin (Hgb) concentration determination using microwave:

BaseyFisher et al[7] proposed a non-toxic ex vivo determination of haemoglobin (Hgb) concentrations using microwaves, which allows haematological tests on a single sample for multiple red blood cell which optical techniques cannot perform.

The system presented is a non-optical method that can not only calculate Hgb concentrations in a non-destructive and precise manner, but also overall concentrations of electrolyte & serum protein without the need for lysing or chemical binding.

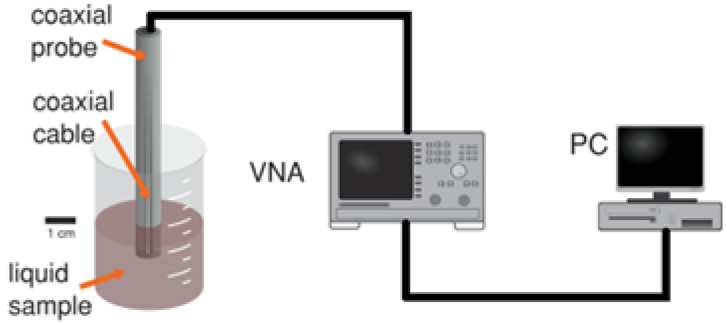

Figure 4: Experimental setup for non-destructive ex vivo determination of hemoglobin (Hgb) concentration.

To establish a method of viable Hgb analysis, tiny volumes of samples & cautious frequency choices with less influence from other dielectric structures & constituents in the blood are needed.

To do so, researchers developed a high Q-factor 9.4 GHz di-electric resonator with a device which has the feature of integrated microfluidic that achieves the maximum frequency (200 - 40 GHz) µ-wave dielectric response of Hgb in serum. Increases in the f (change in f_R) and reduce in the value of Q (change in quality factor) as a purpose of improving concentration of ionic were discovered in an analysis of the effect on resonant parameters of electrolyte levels.

The procedure was tested on stable & anaemic APC(min/+) mice with colorectal cancer using minimally invasive independent measurements. Aside from being able to quantify Hgb levels.

Skin diagnosis with near-field microwave & mm-wave

S. Kharkovsky et al.[9] suggested using Near-Field Microwave & mm-Wave Non-invasive to analyze human skin. It is demonstrated in this study that preferring a waveguide which is open-ended test, measurements of non-contact parameter of skin's reflective features can be made, allowing for the distinction of standard & diseased skin's dielectric properties. This kind of approach can then be outspreaded into a differential method that distinguishes skin properties regardless of the position of the body.

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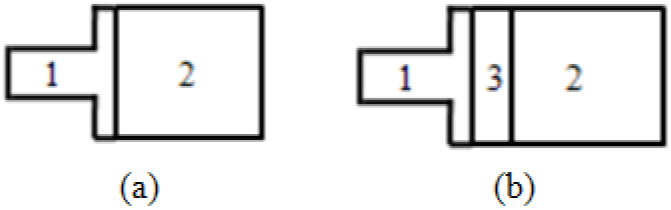

Figure5: Flange-mounted open-ended rectangular waveguide probe 1 irradiats into skin 2 (a) without (structure A) and (b) with (structure B) couplant 3.

The skin's reflection characteristics were determined using identical rectangular waveguide which is open-ended samples with size of the aperture of 10.74.3 mm & 7.113.56 mm on both the frequency bands, specifically K-band (18 - 26.5 GHz) & Ka-band (26.5 - 40 GHz). The vector characteristics (magnitude |Γ| and has Φ_Γ) of the 'Γ' were calibrated using a vecto-network analyzer.

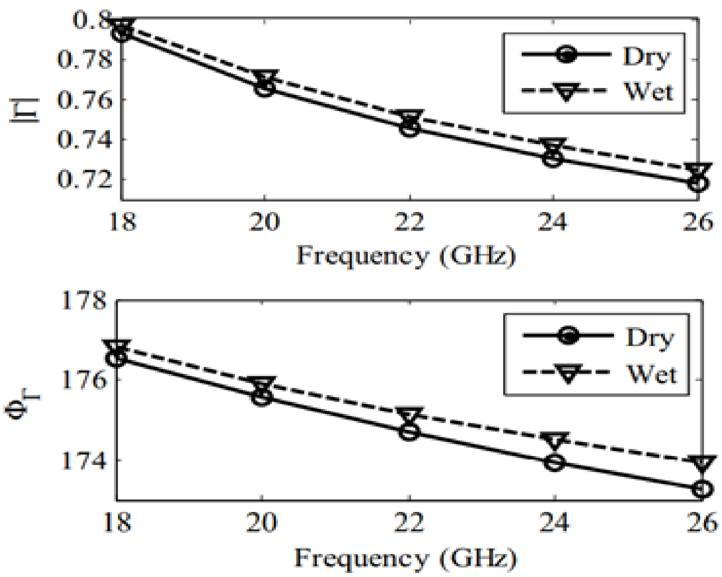

Figure 6: Simulated magnitude $|\Gamma|$ and phase Φ_Γ of the reflection coefficient

The probe was gently put against the skin under inspection, either straightly or via a di-electric couplant, during the experiments. The couplant provided a predetermined standoff distance (Plexiglas, or Teflon). In vitro experiments were carried out at single frequencies at two different locations (forearm and palm), with an average rate measured at individual position. The work discusses the system's concepts as well as some preliminary findings.

Electromagnetic Field for Treatment

Low-frequency low-intensity electromagnetic fields for rapid healing of fractures:

Andrew et al[10] defined a non-invasive method for rapid fracture healing using electromagnetic fields. This was the first research to show that pulsing electromagnetic fields originating from points external to the body could speed up patch-up procedure. This initial study demonstrates that low-frequency low-intensity EM fields applied throughout a boundary that can induce voltages comparable to those induced by deformation.

These voltages, which may have biochemical significance due to their near proximity to the wire, varies from 0.1 to 50 mV/cm in bone and above in soft tissues. In dogs, this activated voltage will change the strength and sequence of bone healing, resulting in a substantial increase in the stiffness of the reparative tissues 28 days after osteotomy (fracture).

Pulsed electromagnetic fields on osteoporosis:

Based on a total of 111 linked papers, HUANG Li-qun et al [11] published a Clinical apprise of pulsed EM fields on osteoporosis. The aim of this study is to learn more about the impacts of low-frequency pulsed EM fields (PEMFs) on biochemical markers, bone strength, bone mineral density (BMD), chronic bony pain, and of bone metabolism in patients with osteoporosis.

PEMFs had a frequency of less than 50 Hz, & the magnetic field strength in each individual was variable rather not greater than 20 mT. While the clinical circumstances were not identical, PEMFs had a similar pain-relieving effect on primary osteoporosis. PEMFs successfully alleviate chronic bony pain without any side effects after 40 minutes of therapy, five days a week, according to the report.

Long-term impacts of Pulsed EM Fields on osteoporosis patients' bone mineral density have also been studied, with results showing that it improves substantially 2 to 6 months after thrice 30-day therapy sessions.

Radio frequency field induced targeted hyperthermia:

Mustafa Raoof et al.[8] demonstrated the use of nanoparticles to induce targeted hyperthermia using an EM area. Several nanoparticles, such as gold nanoparticles (AuNP), gold silica Nano shells, single-walled carbon nanotubes (SWNT), and water-soluble C60 fullerene derivatives, were heated in the sample.

There are several advantages to a therapeutic approach focused on molecular targeting of gold and carbon nano particles:

- Because of their distinctive optical absorptions, they are easily identified.

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- Their surface chemistry allows for easy modulation of charge and shape, as well as the attachment of cancer cell-targeting molecules such as pharmacologic, peptides, antibodies agents.

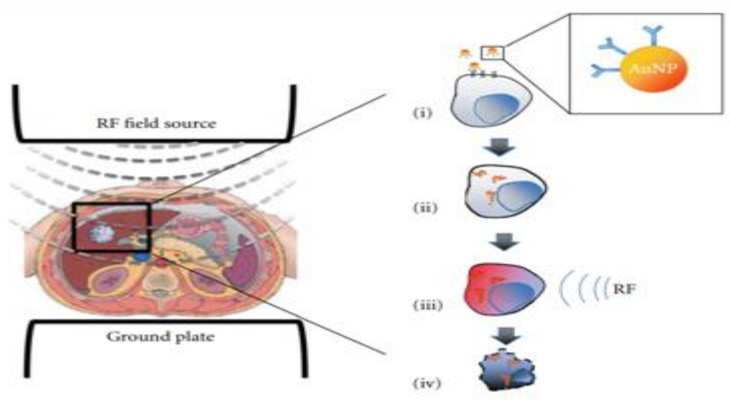

Figure 7: Showing the process of targeted heating of tumor. (left) tumor with Nano particles, (right) destruction of tumor through heating of Nano particles by RF waves.

Following RF activation, both AuNPs and SWNT functionalized with a bio-compatible non-ionic polymer (Kentera) exhibit a linear increase in temperature. The rate of heating increases in lockstep with the output power of RF generator's. The heating rate of SWNT suspensions, on the other hand, increases nonlinearly with concentration.

Tumor Treating Fields (TTFields) are target-cell type based, with a frequency that is unique to the type of tumour cells being treated. The fields are disrupt particular structures during mitosis, low-intensity and induce apoptosis as a result. At intermediate frequencies (100–300 kHz), TTFields alter the polarity of tumour cells [12].

Eilon D. Kirson and colleagues [13] On tumour cells, alternating electric fields have an impact. Four of the utmost ideal forms of cancer, glioma, malignant melanoma, breast carcinoma, & non-small-cell lung carcinoma, were exposed to TT for 24 hours. Figure 8 illustrates the different fields. The quantity of untreated (control) cells approximately get double for every 24 hours, while the proliferation amount of exposed cells slows throughout the treatment and progressively mends after treatment is stopped Fig.8 (a).The effects' frequency dependence is depicted in Fig.8 (b).

For mouse melanoma, the optimum frequency is 100 kHz, 150 kHz for human breast carcinoma, & 200 kHz for rat glioma. Similar studies were also performed on two lines of human glioma cells.

The optimum frequency of TT Fields in both cases was the same as in rat glioma cell lines (i.e. 200 kHz). The "dose–response curve," or the association between the behavior of the TT Fields

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& field power, is depicted in Fig.8(c). The impact on cell division & death (by apoptosis) appears to be intensity-dependent, with mouse melanoma cells having the highest sensitivity, rat glioma & human non-small cell lung carcinoma having lower sensitivity, & human breast cancer having the lowest sensitivity.

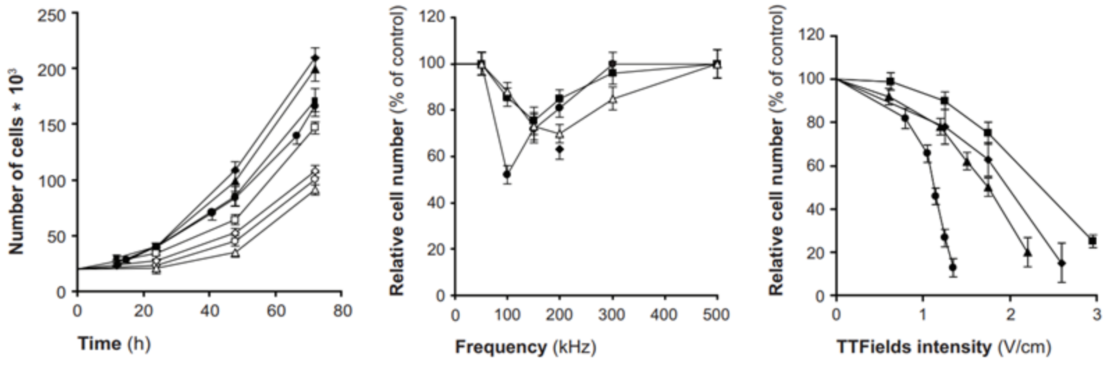

Figure 8: Time, frequency, and intensity dependence of the effect of TTFields on cancer cell proliferation. (A) The number of cells in untreated cultures (b) The relative change in number of cells after 24 h of treatment of different frequencies (same TTFields intensity). (c)The effect of 24 h of exposure to TTFields.

Transcutaneous electrical nerve stimulation (TENS) for pain-relieving

Bjordal et al.[14] looked at the literature and conducted randomized placebo-controlled trials to see whether acupuncture-like transcutaneous electrical nerve stimulation (ALTENS) or transcutaneous electrical nerve stimulation (TENS) could decrease analgesic consumption throughout surgery.

The sub-group was tested for appropriate treatment pulse frequency: 25–150 Hz[TENS] or 1–8 Hz[ALTENS], current intensity: "strong, definite, sub-noxious, maximum tolerable" or above15 mA, & electrode deployment in the area of incision.

There were 21 randomized, placebo-controlled tests with a sum of 1350 patients found. TENS/ALTENS reduced analgesic consumption by 26.5 percent more than placebo in all trials (range: -6 to + 51 percent). A powerful, sub-noxious electrical stimulation was administered with adequate frequency in eleven of the studies involving 964 patients.

They registered a mean weighted minimization in analgesic intake of 35.5 percent (varies 14–51 percent) as compared to placebo. The mean weighted analgesic intake in favor of active treatment was 4.1 percent (range-10 to+ 29 percent) in nine studies that lacked clear evidence of adequate current intensity and suitable length.

The mean frequencies used in successful treatment studies were 85 Hz for TENS and 2 Hz for ALTENS. TENS was found to substantially reduce analgesic intake for postoperative pain when administered at an adequate dose in the wound region with a strong, subnoxious pressure.

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Regeneration of the sciatic nerve through sinusoidal magnetic field:

The impact of sinusoidal magnetic field stimulation on rat sciatic nerve re-creation was investigated by Rusovan et al[5]. Following a crushed nerve lesion, rats were exposed to a 50 Hz magnetic field of 0.2 mT or 0.4 mT between a pair of Helmholtz coils.

The "pinch test," or immunocytochemical staining for neurofilaments 1 - 6 days subsequently the crush lesion, was used to assess sciatic nerve regeneration. Sporadic stimulation (4 hours a day) at 0.2 mT had no impact on re-creation, but constant stimulation with the identical field increased the re-creation distances evaluated on days 1, 2 & 3.

Intermittent 0.4 mT stimulation increased regeneration distances in regenerated nerves over a 5-day period. In rats regularly exposed to 0.4 mT, re-creation was huge in entire groups (1, 2, 3, 4, & 6 days).

The rate of re-creation was increased by 21% as a result of this study. The re-creation of the sciatic nerve following a crush lesion was unaffected by a 7-day pretreatment of frequent stimulation at 0.2 mT or 0.4 mT.

Immune-Modulating Perspectives for Low Frequency electromagnetic fields:

Immune-Modulating Perspectives in Innate Immunity for Low Frequency EM Fields are explored by Rosado et al[16]. To elicit beneficial reactions, the immune system must eliminate pathogens while "respecting" the organism & bearing inappropriate antigens.

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Damage-related molecules emitted by injured or wounded cells or concealed by innate immune cells, according to current thinking, generate dangerous signals that activate an immune response.

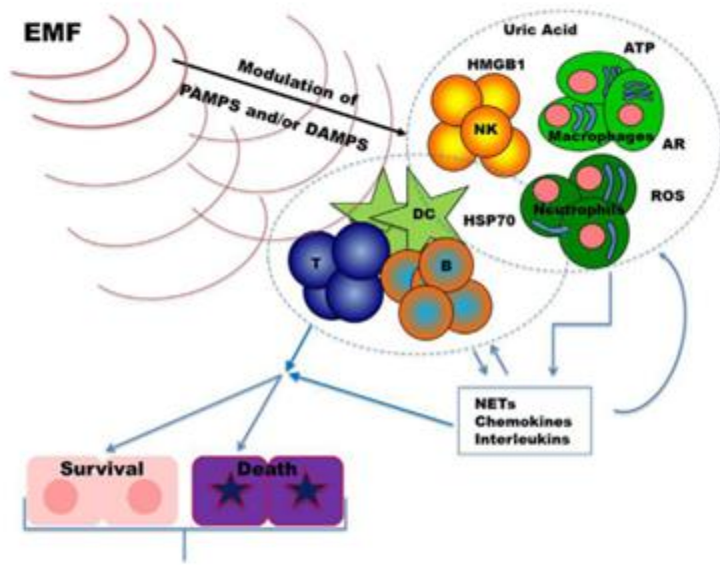

Figure 9: Process of alerting the immune system by injured cells.Exposure to EMFs to modulate inflammatory responses by targeting, in different cell types, signal.

Such signals as well are essential for the successive initiation of metabolic mechanisms that regulate the immune reaction in anti- or pro-inflammatory responses, a function that therapeutic therapies can influence.

The impacts of extremely low frequency (ELF) EM Field & PEMF on cell signals & factors related to the initiation of hazard signals & inherent resistance cells are described and discussed in this study. We envision the consideration of EMF as a therapeutic agent to control resistant reactions related among wound curing by exploring the modulating impacts of EMF on cell features.

The successive initiation of metabolic mechanisms to control the immune reaction in anti-provocative responses, a role that allows therapeutic treatment modulation, is also based on such signals. The reviews in this study identify and analyze the effects of ELF-EMF & PEMF on cell signals & factors involved in the initiation of hazardous signals & inherent resistant cells.

Finally, it is concluded that using EMF as a preventive cause to adjust resistant reactions related to wound curing by addressing EMF modulating impacts on cell features has promising results.

Applications of endogenous electromagnetic fields

The observation of EM fields produced by a biological entity is known as endogenous electromagnetic field observation. It's just good for diagnosing problems.

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Montagnier et al[17] proposed a quantum field theory-based explanation of low frequency EM waves produced by bacterial and viral DNA in broad aqueous dilutions. This paper looks at this occurrence through the lens of quantum field theory. A model is proposed that could explain the findings. The observed phenomenon could pave the way for the development of ultra-sensitive devices for detecting chronic bacterial & viral infections.

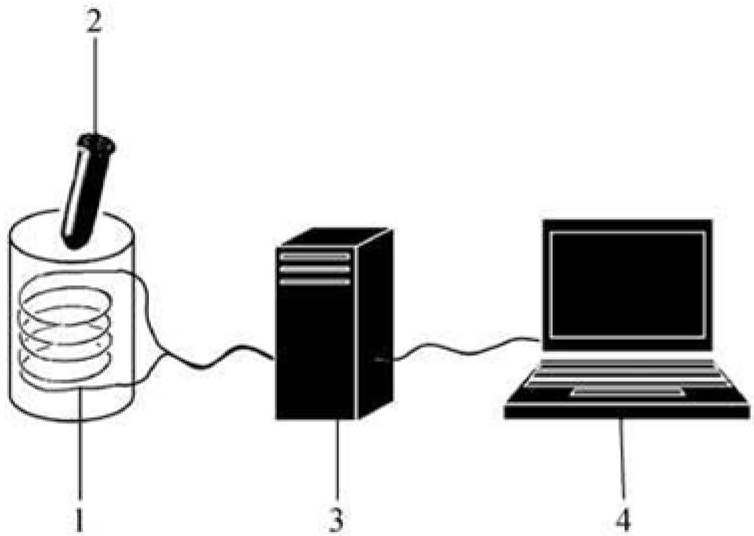

Figure 10: Device for the capture and analysis of em signals. (1) Coil made up of copper wire, impedance 300 Ohms. (2) Plastic stoppered tube containing 1 ml of the solution to be analyzed.

The following is a description of the laboratory findings, which are detailed in [18, 19, and 20]:

- Ultra-Low Frequency EM Waves (500-3KHz) were observed in some dilutions of filtrates (100 nm, 20 nm) from microorganism cultures (virus, bacteria) or in the plasma of humans diseased with the similar agents.
- Their extracted DNA yields the same results. EM signals (EMS) are not directly inter-related with the primary number of bacterial cells until they are filtered. During one instance, the EMS in a suspension of E. coli cells was similar from 10^9 to 10. It's an all-or-nothing situation.
- Only certain filtrates with high water dilutions contain EMS. Dilutions in some E-ColiFiltrate preparations, for example, range from 10^9 to 10^{18}.
- Some bacteria, including probiotic bacteria including Lactobacillus & few laboratory strains of E-Coli preferred as cloning vectors, do not produce EMS.

Real time pathogenic bacteria detection:

Using EM wave sensing, Nakoutiet al [21] proposed a real-time pathogenic bacteria detection technique in aqueous media. Changes in electromagnetic wave signals in the microwave frequency spectrum, in particular, are used as indicators of bacteria existence. Reflected signal spectra were recorded whenever the sensor was in interaction to deionized water, Escherichia coli, Pseudomonas aeruginosa, and sterile nutrient broth solutions.

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Nakouti et al[21] proposed a real-time EM wave sensing technique for detecting harmful bacteria in ionic substances. In fact, the presence of bacteria is determined by a variation in the EM wave signal within the µ-wave frequency spectrum.

Microwave Sensor is a microwave frequency sensor that is printed as an inter-digital shaped pattern on FR4 substrate. It was selected for its flexible nature which associates ease of manufacture with anticipated features. To preserve chemical neutrality when the system is in connection with aqueous bacterial existence, gold was preferred as a metal material for both the top pattern, which resembles as a ground layer, and the bottom layer.

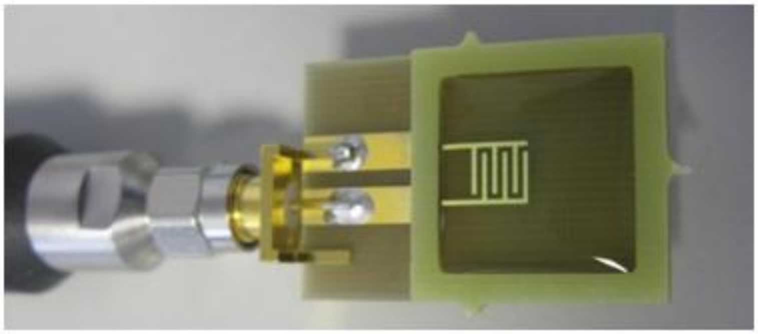

Figure 11: Microwave sensor on FR4 substrate with Au pattern, it also has a reservoir to contain the solution in place. The sensor is connected to a cable via SMA connector.

On a FR4 substrate, an Au patterned microwave sensor is shown in Figure 11. The sensor is associated to a cable through a SMA connector. This connector also includes a reservoir that can hold 0.4 ml of a solution, with the electromagnetic field providing the greatest interaction.

A distinguishing function of this sensor is its extraordinary ability to shift near the sensor's substrate, which rapidly decays with duration far from the surface which is beneficial because it greatly decreases the possibility of unintended factors affecting sensor reaction, such as external electromagnetic signals. Since the procedure is carried out at µwave frequencies, the chances of interference are slim.

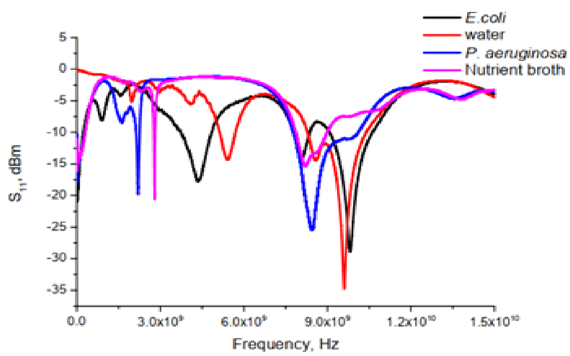

Figure 12: S_{11} signal distribution of microwave sensor in 0.01-15 GHz frequency range when in contact with deionized water, Escherichia coli, sterile nutrient broth and Pseudomonas aeruginosa solutions.

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Figure 12 shows the distribution of S 11 signals obtained from the bespokemicrowave sensor in the 0.01-15 GHz frequency range while in associate with deionized water, E.coli, sterile nutrient broth, & P. aeruginosa solutions. The 4-spectra are plotted on a standard graph, each representing the number of several measurements, to demonstrate that the suggested EM wave sensing system can differentiate among different pathogenic bacteria.

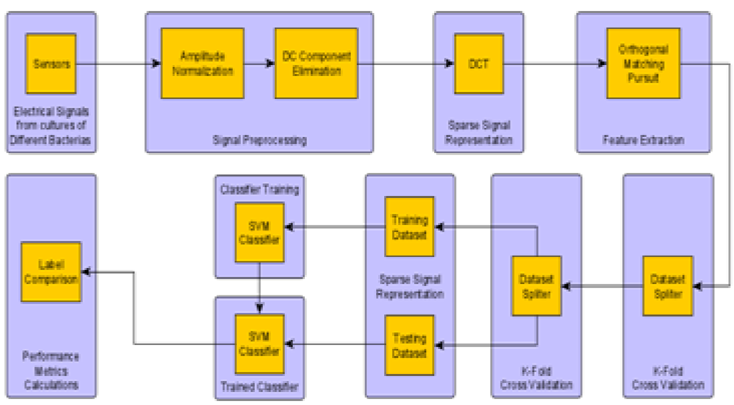
As can be seen in Fig. 12, individual sample has an exclusive reaction to the µwave signal, resembling in a variety of frequency resonant peaks and signal amplitudes.

Deionized water had its first large resonant peak at 5.56 GHz, while E.coli, nutrient broth, and P. aeruginosa had theirs at 4.39 GHz, 2.81 GHz, and 2.22 GHz, respectively. The highest resonant peaks were observed at higher frequencies, in the range of 8.5-10 GHz, for all results. These frequencies are 9.63 GHz for deionized water, 9.82 GHz for E.coli, 8.21 GHz for nutrient broth, & 8.44 GHz for P. aeruginosa.

The proposed system is distinguished by the fact that it performs practical identification in absence of additional sample or chemical handling. This technique of bacterial identification could be preferred in a variety of applications, ranging from wastewater treatment plant water quality management to healthcare and food industry safety assurance.

Methodology

In this paper we proposed the model for detecting & treatment of disease using Electromagnetic Signals.



Signal Acquisition Process:
The sensor signal is obtained from the experimental sensors, which are sampled at 12k and 48k samples per second, respectively; however, we only considered 12ks/s signals in this analysis.

Amplitude Normalization:
It is difficult to define the voltage obtained from such a measuring device in terms of level without a proper reference that can be used as a scale since several variables (such as sensors, amplifiers, and digitizers) influence the observed signal measurement. As a result, the amplitude

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of the signal must be normalised. Normalization is the method of transforming a signal to a known and repeatable value on a scale.

DC Component Elimination:
Since signals do not have zero frequency elements, another preprocessing procedure is to delete DC value (average value) from the sample after normalisation. The removal of the DC level has no effect on the signal's details, but it does reduce unnecessary components.

DCT (Discrete Cosine Transform) and IDCT (Inverse DCT):
DCT (Discrete Fourier Transform) and DFT (Discrete Fourier Transform) both transform the signal into the frequency domain. In contrast to DFT, the DCT uses only real-valued cosine functions, which decreases computational complexity.

Another advantage of the DCT over the DFT is its increased "spectral compaction." As a result, the DCT transformation of a signal has more concentrated energy in a smaller number of coefficients than other related transformations such as DFT.

This is useful when a sparse representation of a signal is needed and only a small number of nonzero samples are available. Just a few DCT coefficients retain significant quantities of energy when DCT is applied to a signal, so all other coefficients be able to put the zero exclusive lose of signal information. That is, the signal will be represented in a sparse manner.

Compressive Sensing:
It is a communication system that finds approaches to indeterministic linear structures in order to efficiently acquire and recreate a signal. This is dependent on the idea that the sparsity of a signal can be exploited by computation to restore it with much smaller parameters than the Nyquist–Shannon sampling theorem needs. There are two scenarios in which you would be able to recover. The first is sparsity, which necessitates a sparse signal in few domains. The other is incoherence, that has been implemented using the isometric property and is suitable for sparse signals.

The typical method of reconstructing a Sampled Signal has two major drawbacks:

• The sampling rate must be twice or greater than the signal bandwidth also known as Shannon Theorem.

• According to linear algebra number of collected data samples should be at least as long as its length.

The CS (compressive Sensing) is based on the empirical observation that a sparse expansion achieved through the transformation using a suitable basis set can closely approximate several types of signals.

By focusing only on the largest basis coefficients, a compression can be obtained. When complete signal information is readily accessible, the CS strategy works well. The aim of CS is to get a more direct representation of the compressed signal during sampling.

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The CS proposes a method for reconstructing a compressed form of the actual signal using less linear & non-adaptive measurements. The following is the basic equation for CS Sparse signal recovery:

$$[y]_{M\times 1} = [\phi]_{M\times N} \cdot [x]_{N\times 1} + [v]_{M\times 1},$$

Where y is the measurement matrix, ϕ is the recovery matrix, x is the sparse signal, and ν is the noise. Here the important considerations are:

M<<N, hence infinite many solutions are possible.

x is a k sparse signal and k<<N.

All rows in matrix ϕ are linearly independent or it's a full rank matrix and the goal is to recover x from y.The solution of equation is not straight forward as the estimation of x requires the inverse of ϕ.

Orthogonal Matching Pursuit Algorithm:

Image & video coding, image processing, control theory, & statistics all benefit from the issue of optimal approximation of events of a vector space by a straight grouping of events of a huge over complete library of vectors.

In the general case, finding the best solution is mathematically impossible. The greedy explanations to this issue are similar pursuit and its orthogonal variant. In most cases, orthogonal matching pursuit yields a substantially better result.

Support Vector Machine (SVM)

The SVM is an optimal binary classifier that performs classification by determining the best partitioning plane between two classes' feature vectors. The partitioning plane ensures that the nearest feature vectors are separated by a minimum distance margin; these feature vectors are referred to as support vectors.

PERFORMANCE EVALUATION METRICS

The classifier is calculated based on four common measures known as accuracy, precision, recall and F1 to estimate the efficiency of the methods. Accuracy determines the predictive ability of the classifier for normal and anomaly assessments. Accuracy defines the predicted accuracy of the label. Recall determines the completeness of the category. Measurement of F1 is the harmonic mean of precision and recall used to balance accuracy with recall.

Accuracy: It's the number of exact predictions upon the overall sum of predictions.

$$Accuracy = \frac{TP+TN}{TP+FP+FN+TN}$$

Precision: It's the number of right documents returned by our machine learning model.

$$Precision = \frac{TP}{TP+FP}$$

Recall or Sensitivity: The number of positives returned by our ML model is known as recall.

$$Recall = \frac{TP}{TP+FN}$$

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F1 Score: We'll get the harmonic mean of precision and recall from this score. F1 score is the weighted average of precision and recall in mathematics. F1 has a maximum value of 1 and a worst value of 0.

$$F1 = 2 * (precision * recall) / (precision + recall)$$

F1 score is having equal relative contribution of precision and recall.

Observed Signal

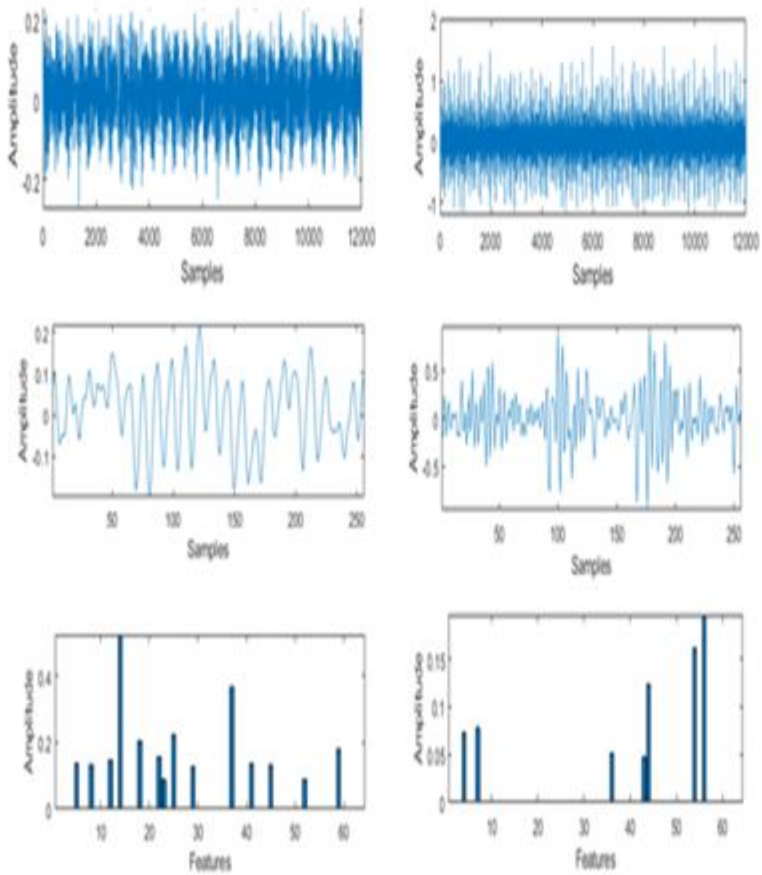

Figure : the figure shows the signal plots in time domain 12000 samples (top), time-domain 256 samples (middle), feature domain 64 features extracted from 256 samples (bottom), (a) pure water, (b) Clostridium Perfringens bacteria.

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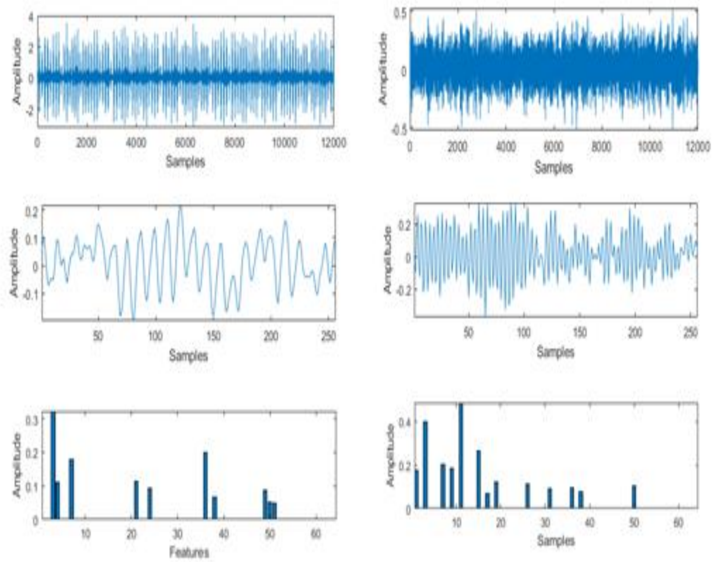

Figure : the figure shows the signal plots in time domain 12000 samples (top), time-domain 256 samples (middle), feature domain 64 features extracted from 256 samples (bottom), (a) Streptococcus bacteria, (b) Staphylococcus bacteria.

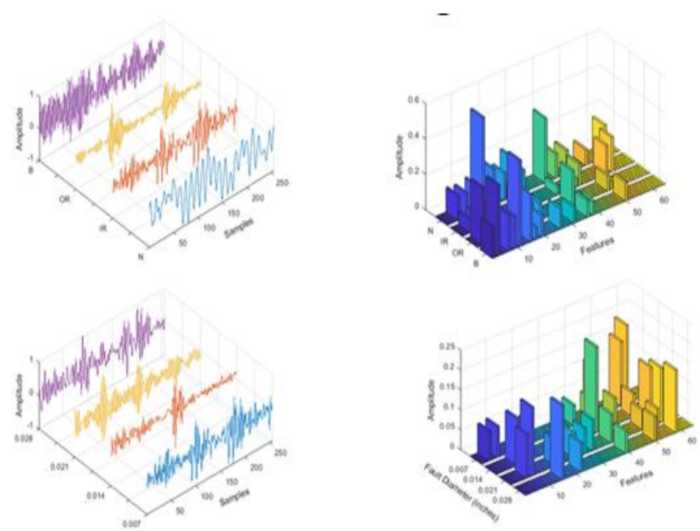

Figure : Time domain and feature domain comparison of observed signals for (1) pure water, (2) Clostridium Perfringens bacteria

Signal Analysis

The proposed technique's simulation is carried out in the MATLAB setting. A basic programming language framework, a wide number of mathematical functions, and plotting tools are all included in MATLAB.

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The comparison plots of the observed signals in the time domain and function domain for pure water and various pollution conditions are shown in Figure above.

The distribution of information over the time and function domains is also depicted in the figure.

By manually inspecting the figure, it can be shown that the signals are not sufficiently separable in the time domain to uniquely classify the bacteria; however, the plot of the feature vectors obtained by the proposed method shows that these signals are easily separable in the feature domain.

TPR			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
1	76.68	60.19	55.66
TNR			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
95.71	93.15	85.68	87.21
FPR			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
0	23.31	39.80	44.33
FNR			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
4.28	6.84	14.35	12.79
Accuracy			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
95.71	85.03	77.12	73.28
Precision			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
1	76.68	60.19	55.66
Recall			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
86.00	80.00	54.00	64.00
F-Measure			
pure water	Clostridium Perfringens	Streptococcus	Staphylococcus
91.88	77.53	55.86	59.08

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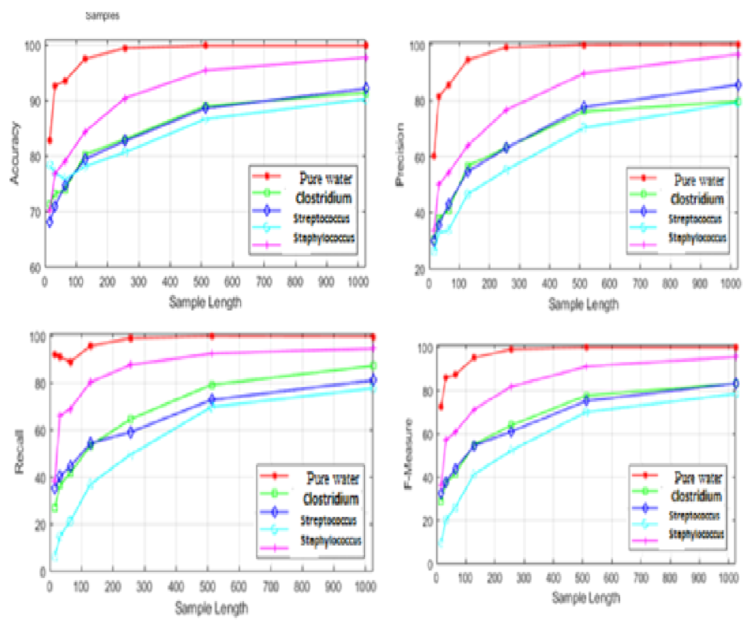

Figure : Plots showing the variations in (a) accuracy, (b) precision, (c) recall and (d) f-measure for detecting the Bacteria for different sampling sizes.

Conclusion

The use of both exogenous and endogenous EM fields on medical diagnosis, control, and treatment is discussed in this paper. The research shows that EM methods have a lot of potential in this area. The majority of the studies are focused on laboratory research and clinical trials. Pure water, Clostridium Perfringens, Streptoccocus, and staphylococcus solution were used to evaluate the method. This method is used to classify bacteria in real time, with no necessity for supplementary chemicals or testing. This technique will be useful for monitoring water quality in the healthcare and food industries to ensure safety.

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