HUMAN GENDER IDENTIFICATION USING PERMITTIVITY OF URINE

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ABSTRACT

Study on gender identification is one of the interesting issues, which helps researchers to learn more about disease pathogenesis and to discover more effective treatments, if not cures. Many significant gender differences were found that can help us individually tailor clinical management of disease processes. There are different techniques for gender identification such as face detection, voice detection, and human metabolism test, which have some weaknesses such as, the procedure of getting result is time-consuming and some are invasive. The main objective of this research is to explore a fast and non-invasive technique to identify human gender using urinalysis. This research examines the dielectrically properties of human urine at microwave frequencies as well as the quantitative analysis in the laboratory to identify differences between males and females urine. In this research, urine samples were collected from 60 healthy subjects (30 males and 30 females) in age group between 20-30 years. The permittivity analysis were carried out in less than 1½ hours after collecting the samples and Vector Network Analyzer was used to measure the permittivity of urine in the frequencies between 10Mhz-20GHz. The data obtained from Vector Network Analyzer, dielectric constant and loss factor, were plotted and analyzed using the MSExcel and SPSS. The obtained results show that there is a significant difference in permittivity, loss factor, and loss tangent, between males and females in different frequencies, which resulted in identifying human gender. This research shows that using the permittivity of urine can be used as one of the fast and non-invasive techniques to identify the human gender.

ABSTRAK (Bahasa Malaysia)

Kajian mengenai jantina adalah salah satu isu yang menarik kerana belajar mengenai pathogenesis penyakit dan untuk mencari rawatan yang paling berkesan terhadap sesuatu penyakit. Banyak perbezaan jantina yang ditemui dan boleh membantu pengurusan diri untuk menyesuaikan pihak hospital menyelesaikan proses-proses penyakit. Terdapat pelbagai teknik untuk mengenal pasti jantina seperti pengesanan muka, pengesanan suara dan ujian metabolisme manusia, yang mempunyai beberapa kelemahan seperti, prosedur mendapat keputusan mengambil masa yang lama dan invasif. Objektif utama kajian ini dijalankan adalah untuk meneroka teknik yang paling berkesan dan bukan invasif untuk mengenal pasti jantina manusia yang menggunakan air kencing. Kajian ini mengkaji sifat-sifat elektrik air kencing manusia pada frekuensi gelombang mikro serta analisis kuantitatif di dalam makmal untuk mengenal pasti perbezaan antara air kencing perempuan dan lelaki. Dalam kajian ini, sampel air kencing yang dikumpul daripada pelajar yang kesihatannya terjaga (30 wanita dan 30 lelaki) yang berumur antara 20-30 tahun. Analisis telah dijalankan selepas 1 ½ jam mengumpul sample air kencing dan Penganalisis Rangkaian Vector telah digunakan untuk mengukur ketelusan air kencing dalam frekuensi antara 10Mhz-20GHz. Data yang diperolehi dari Vector Network Analyzer, dielektrik dan kehilangan faktor yang tetap telah diplot dan dianalisis menggunakan MSExcel dan SPSS. Keputusan yang diperolehi menunjukkan bahawa terdapat perbezaan yang signifikan dalam ketelusan, faktor kehilangan dan kekurangan tangen, antara lelaki dan perempuan dalam frekuensi yang berbeza yang akan menyebabkan pengenal pasti jantina manusia. Kajian ini menunjukkan bahawa ketelusan air kencing boleh digunakan sebagai salah satu teknik yang pantas dah bukan invasif untuk mengenal pasti jantina manusia.

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In the name of Allah, Most Gracious, Most Merciful

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LIST OF ACRONYMS AND ABBREVIATIONS

BPA	Bisphenol A
CSF	Cerebrospinal Fluid
EM	Electro Magnetic
EMS	Electro Magnetic Spectrum
GC/MS	Gas Chromatography
GC/EI-MS	Gas Chromatography/Electron Ionization Mass Spectrometry
GHz	Gigahertz
HIV	Human Immunodeficiency Virus
HNMR	High-resolution Nuclear Magnetic Resonance
IC3	Crime Complaint Center
ICA	Independent Component Analysis
LC–MS	Liquid Chromatography–Mass Spectrometry
LVQ	Learning Vector Quantization
MS	Mass Spectrometry
NMR	Nuclear Magnetic Resonance
PCA	Principal Component Analysis
PLS-DA	Partial Least Squares for Discriminant Analysis
RBF	Radial Basis Function
RNA	Ribonucleic Acid
S-Parameters	Scattering Parameters
SVM	Support Vector Machine
VNA	Vector Network Analyzer

CHAPTER 1: INRODUCTION

1.1 Overview

Interior sense of human being resulting from a mixture and combination of environmental and genetic influences is usually foundation in infancy, continuing during childhood, and attainment maturity in teenage years of the gender and it is related to human biological sex. Generally, apparent and clear differences between two groups of males and females consist of some characteristics, which are linked to hormonal systems, gonadal differentiation, physiological, behavioral effects, genital system, breast differentiation, differentiation of muscle mass, hair distribution, and height. Many surveys and studies have been conducted to find useful gender identification methods and techniques such as gender identification using human voice, face, whole body, and specific properties of metabolic composition such as blood, urine differentiation, and a combination of these methods and techniques. For example, gender identification using face detection can be merged with neural network analyzer, Eigen face, template matching, and geometrical analysis to produce accurate gender identification results. Beside of these techniques, urine is one of the properties of human metabolic that can be used to identify the differences between human males and females. Generally, human urine includes ninety-six percent water and four percent wastes such as urea and salts. Urine is mostly yellow in color due to bile pigments. Urine consists of wide variety of substances which introduce different characteristics and condition of human body. Except of water, urine consists of a range of organic compounds, inorganic salts, hormones, proteins, and an assortment of metabolites. These substances are helpful for medical therapy. The variations in urine characteristics may propose an abnormality though certain variations or some markers of pathogens and disease. For example,

postmenopausal level of female urine can be used to fertility therapy. Urine sample can be collected through special spot, as shown in Figure 1.1. Urine consists of antibodies, which helps in diagnostic antibody tests for a variety of pathogens, including HIV-1 (Putnam, 1971). Analysis of urine or urinalysis is categorized to different type of tests as follow:

- Macroscopic urinalysis
- Chemical urinalysis
- Microscopic urinalysis
- Urine culture

Figure 1.1: Spot Collection Urine Sample

The analysis of urine is done using some instrument such as mass spectrometer, and High-resolution nuclear magnetic resonance. This study investigates on one of the properties of material that is permittivity using Vector Network Analyzer. The obtained information from the dielectric parameters in body tissue using microwave frequency can be used to detect diseases then help to propose a better treatment for them. Analysis of dielectric

constant of body fluids and its classifications at different levels of microwave frequencies, shows that a better diagnosis is achievable through this technique (Kumar, Mathew, Raveendranath, & Augustine, 2001; Zhao et al., 2004). Materials can transmit or permit electric field. This ability is named permittivity. When the material is placed to an electrical field, the calculated permittivity shows how much electrical charge or energy can save and store in the material. This is the physical definition of permittivity (Afsar, Birch, Clarke, & Chantry, 1986). The value of permittivity, for free space or vacuum is $\varepsilon_0 = 8.8542 * 10^{-12}$ F/m. Ratio of a given material to permittivity of vacuum is named relative permittivity and it is calculated through the following equation:

$$\varepsilon = \varepsilon_0 * \varepsilon_r \qquad (1.1)$$

Where ε_r is relative permittivity, ε_0 is the permittivity of free space, and ε is the absolute permittivity of a given material.

1.2 Problem Statement

Base on the conducted literature review, there are few techniques for gender identification such as face detection, voice analysis, text investigation, and metabolic composition. Most of these techniques have limitations such as less accuracy, time-consuming, and invasive. These limitations lead us to explore non-invasive and more accurate techniques. This study focuses on the gender identification using the permittivity of urine.

1.3 Research Objectives

The main objective of this research is to investigate the gender identification using permittivity of urine at different microwave frequencies. Besides, achieving better understanding of permittivity properties of urine in males and females, which resulted in human gender identification, is considered.

1.4 Scope of Study

This study aims to use the permittivity of urine of 60 normal human subjects (30 males and 30 females) to analyze the permittivity, loss factor, and loss tangent of urine in males and females. In this research, we also compare and analyze these factors to find the relationship between males and females urine. In this study, a non-invasive, fast, and convenient method for gender identification using permittivity of urine is investigated. The urine samples used in this study were collected from 30 males and 30 females of Iranian undergraduate and postgraduate students in University of Malaya. The subjects that participated in this study were normal and healthy people with age between 20 and 30 years old. The Network Vector Analyzer was used to measure the permittivity of these urine samples in the range of frequency between 10MHZ and 20GHZ. As each material has special Electromagnetic (EM) properties, therefore, the permittivity of urine with healthy people in two groups of males and females has dissimilarity properties (Ryynanen, 1995). The analysis of the obtained permittivity, loss factor, and loss tangent in different frequencies using SPSS, was used to identify the human gender. In this research, related

graphs were plotted such as dielectric constant (ε′), loss factor (ε″), and loss tangent (tan δ) in different frequencies.

1.5 Significance of the Study

The main purpose of this research is to find the significant difference in permittivity of urine between males and females. The significant of this study is to discover the non-invasive, convenient, and fast technique to identify human gender. This study has influence on more learning about disease pathogenesis, with the purpose of suggestion a better treatment. In addition, gender identification can help us to treat disease processes much better. It does not mean that a patient's sex has fundamentally influence on therapeutic or diagnostic efforts clinically but can be help to get a better treatment progressing due to some physical and psychological differences between males and females.

1.6 Thesis Organization

This thesis includes five chapters. Chapter 1 presents the background of the study, problem statement, scope of study, and the research objectives. Chapter 2 provides a detailed literature review on the existing gender identification methods and techniques, strengths, weaknesses, and comparison among them. Chapter 3 explains the research methodology followed to obtain the outcomes. Chapter 4 discusses the data collection procedure, experimental results, statistical analysis of the results, and plots of the final results. The last chapter concludes the research findings, research limitations, and future works.

CHAPTER 2: LITERATURE REVIEW

Sex difference is defined as differences of some characteristics related to males or females such as biological and/or physiological. These distinctions in human being include direct and indirect type. Direct differences are resulted of the Y-chromosome, and characteristic are influenced by the Y-chromosome in indirectly manner (e.g. hormonally).

Some differences in appearance of men and women are as follows:

- Muscle—normally males are physically powerful than females because of the females having less total muscle mass than males(Conley et al., 2000).
- Bones—on average, males have stronger and denser bones. Men have deeper voices because of larger vocal cords. Male have differences in skulls and head bones compare to female skulls, for example, in the eye cavities and bony brow, and the shape of the jaw. Male pelvis shaped is taller, more compact, and narrower, but the female pelvis is wider pelvic cavity. The female pelvis has changed to maximum of width for childbirth so this matter can make some problem to women walking. In contrast, male pelvis is more comfortable for walking (Maughan, Watson, & Weir, 1983).
- Skin—male skin has more collagen and more sebum than female skin so the male skin is thicker than female skin. Usually the female skin is warmer than male skin.
- Hair—males have more body hair especially on the face, abdomen, chest compare with females. Baldness is more general in males than in females (Hernández González, Cruz Acosta, & Brito Gómez, 2011).

- Color—according to most studies after the sexual maturity males have darker skin and hair than females. Male eyes are usually darker eye than female. The differences in color are mainly caused by higher levels of melanin in the skin, hair and eyes in males (Frost, 2006).
- Sexual organs and reproductive systems—sex organ is another part of body that is different in male and female. Females sexuality organ consist of two ovaries for storing the eggs and uterus that it connect to a vagina. Male's sexuality organ includes testicles that produce sperm and is located behind the penis. Men and women have different sex organs. Women have two ovaries that stores the eggs, and uterus which is connected to a vagina. Men have testicles that produce sperm. The testicles are placed in the scrotum behind the penis. This organ is external part in male body and is placed inside the body of female.
- Brain—size of brain in male is larger than female. This difference is about 100 grams in terms of weight. In fact many animals have significantly difference in their brain in both sexes that means in males and females of the species (Ankney, 1995).
- Genetic and Hormonal Causes—genes and hormones act on information of brains and behavior of adult before birth. Various genes have different code for identifying brains in male and female.
- Sensory systems—sense of smell in female is stronger than males, both in the separation of odors, and discovery of slight odors. Females feel more pain in the skin (Alonso-Nanclares, Gonzalez-Soriano, Rodriguez, & DeFelipe, 2008).
- Tissues and Hormones—women commonly have more percentage body fat in compared to men, beat faster during the day and even at night, lower blood pressure. Also, women have obvious difference in levels of hormones,

concentration of androgens is higher than female but concentration of estrogens is higher in men. Men have higher red blood cells of blood. But, have fewer white blood cells compare with women (Ankney, 1995).

2.1 Overview of Urine

Urine is sterile liquid and waste product of the body that is exuded by the kidneys, after that it passes through the urinary tract and repulse throughout the urethra. There are several components of the urinary that prepare the process of expelling and making urine. The four main parts of the urinary tract are kidneys, ureters, bladder and urethra. The urine exits at the tip of the penis in the male urethra, exits the urethra cavity situated the above of vagina and the bellow of clitoris in a woman. Cellular metabolism produces some liquid rich in nitrogen that need exclusion from the bloodstream.

In fact Urine consists of several parts with a large amount of water. The water carries the wastes out of body. Urine is composed of about 95% water; however, the contents of urine can depend on what have drunk, eaten or breathed. The rest of urine typically consists of ammonia, salts urea, dead blood cells, uric acid, proteins, and minerals, hormones, and toxins. Kidneys process extra and useless materials from blood. Fundamentally, the blood is filtered by kidney. Thus, wastes, salts, water, sugars, minerals, etc. are eliminated. Some of these materials such as sugar are reabsorbed back into blood. These by-products are finally excluded from the body in a process recognized as micturition. This is the main way for extraction dissolves in water from the body and this process is called urination. These water-soluble chemicals are able to be detected and analyzed by urinalysis.

2.2 Permittivity

Permittivity was discovered in the 1800s by James Maxwell (1834-1879) as a constant in the equations on magnetism and in the electrical currents. In the view of physics the permittivity is defined as an expression of how much energy or electrical charge can store in the material when the desired object is located in the electrical area. In other words electric permittivity is a constant parameter that is between electric field intensity and electric displacement. This constant in free space or vacuum is equal to about 8.85 x 10^{-12} and in SI system its unit is defined farad per meter (F/m). This parameter is much different in several materials and bigger than the value of free-space (ε_0). The permittivity effect is primarily on the field's strength. The parameters that permittivity is making up Vacuum permittivity, Relative permittivity, Loss tang part.

- Vacuum permittivity—the vacuum permittivity (ε_0) is called the electric constant or permittivity of free space emerges in the Coulomb force constant $1/4\pi\varepsilon_0$. Its definition is (Alonso-Nanclares, et al., 2008).

$$\varepsilon_0 = \frac{1}{c_0^2 \mu_0} = \frac{1}{35950207149.4727056\pi} \frac{\mathrm{F}}{\mathrm{m}} \approx 8.8541878176 \ldots \times 10^{-12} \frac{\mathrm{F}}{\mathrm{m}} \qquad (2.1)$$

  Where c_0 is defined as the speed of light in free space, μ_0 is defined as the vacuum permeability. In SI units, c_0 and $\mu_0$have precise arithmetical and numerical values, via the determination of the meter and the ampere.

- Relative permittivity is defined the ratio of a known material to the permittivity of free space. Accordingly it is considered using the following correlation:

$$\varepsilon = \varepsilon_0 * \varepsilon_r \qquad (2.2)$$

Where ε_r shows relative permittivity and $\varepsilon_0$shows the permittivity of vacuum. For given material ε is the absolute permittivity. Table 2.1 demonstrates relative permittivity of some materials.

Table 2.1: Relative permittivity of some material

Material	Relative Permittivity
Free space	1
Air	1.0006
Water	80
Barium Titanate	1200

The real permittivity is defined by the following equation:

$$\varepsilon = \varepsilon_r \varepsilon_0 = (1 + x)\varepsilon_0 \qquad (2.3)$$

Where: X is the electric capability of the material (Alonso-Nanclares, et al., 2008).

2.3 Complex Permittivity

The spectrum of dielectric permittivity consists of real and imaginary parts versus frequency. ε' and ε'' indicate two part of permittivity (respectively ,the real and the imaginary part). Different processes are illustrated in Figure 2.1, ionic and dipolar relaxation, atomic and electronic resonances at higher frequency. Electric charge carriers in dielectric material are in order when they are affected by an electric field. For balancing the electric field, polarizing charge is occurred and leads to negative and positive charges shift in opposite directions. At microwave frequencies dipole orientation and ionic conduction have strong network together. For instance, molecules of water are constant dipoles that have alteration with effect by changeable electric field.

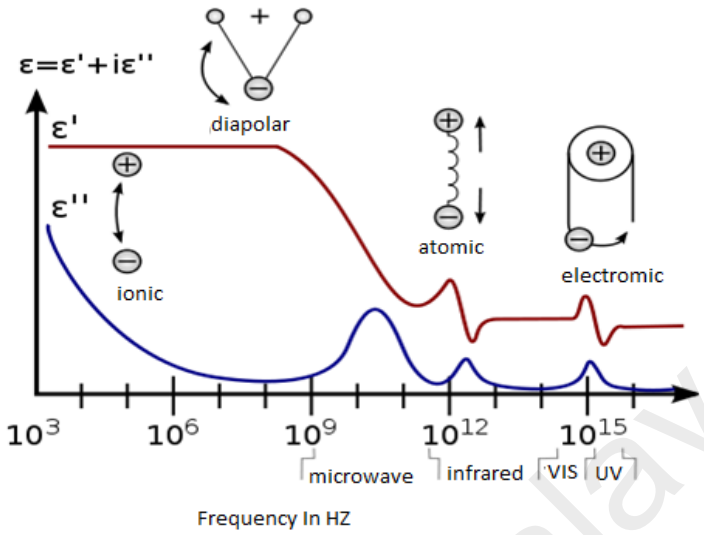


Figure 2.1: Polarization effects at a broad frequency range

The response of normal materials to external fields is dependent on the frequency of desired field. This issue that material polarization is dependent to frequency shows that polarization does not appear in a field instantaneously. All the time the reaction of polarization must be causal and occur following the applied field which can be displayed by phase variation.

- Complex Permittivity and Loss Tangent—permittivity is actually describes the interaction between material and electric field and has compound and complex number, thus "epsilon" consists of two components (real and imaginary):

Relative Permittivity:	$\varepsilon_r = \frac{\varepsilon'}{\varepsilon_0}$	(2.4)
Permittivity:	$\varepsilon = \varepsilon' - j\varepsilon''$	(2.5)
Loss Tangent:	$\tan\delta = \frac{\varepsilon''}{\varepsilon'}$	(2.6)

Where: The imaginary part ε'' of complex relative permittivity is named the loss factor. This factor describe that how loss or dissipative a material is to an external

field. $\varepsilon'' > 0$ at all times and is commonly much smaller than ε', and ε_0 is free space permittivity. The real part (ε') of complex relative permittivity (ε_r) can be measured the stored energy in material from an external field; always $\varepsilon' > 1$ for most liquids and solids.

Permittivity is usually represents relative permittivity rather than in absolute terms. The unreal epsilon with double-prime is the problem. Microwave experts generally use the ratio between the real and unreal parts that is called tangent delta. Tangent delta (Tan D) is equal to zero when there is no loss because of dielectric. For instance, we do not have any dielectric loss in dry air. Consequently the loss tangent products a loss that is relative with frequency and actually it is proportional to frequency. Permittivity also is inconsistent and it alters depend on frequency, mixture, pressure, and temperature of the material. Capability of material to polarization in reaction to the field, and is also measured by permittivity.

As shown in the below diagram exist 90° differences in phase between the real and imaginary components, as shown in Figure 2.2. Between the sum and the real vector (ε'_r) an angle δ is created. The ratio of Energy lost to the energy stored presents the relative "lossiness" of an object.

$$D = \frac{1}{Q} = \tan\delta = \frac{\varepsilon''_r}{\varepsilon'_r} = \frac{\text{Energy Lost Per Cycle}}{\text{Energy Stored Per Cycle}} \qquad (2.7)$$

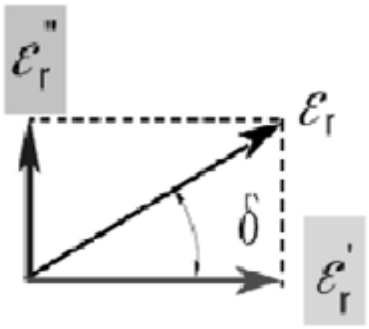


Figure 2.2: Definition of loss tan and relative complex permittivity

Loss tangent and is named as Tan δ or dissipation factor. It is achieved from the proportion of the loss factor and the dielectric constant. Quality factor is represented by Q and dissipation factor is denoted by D. On the whole permittivity is contribution of polarization consequence (Pohl, 1986), as shown in Figure 2.2.

2.4 Review of the Dielectric Properties of Tissue

Information of dielectric characteristics of tissues prior to around 1950 is hard to get hold of; they are less practical than historical (Gabriel, Gabriel, & Corthout, 1996). During half past century, numerous researches have been carried out about the microwave measurement of complex permittivity. Nowadays the combination of the advanced computational data processing and transmission line method techniques are extensively used in the medical detect and diagnoses (Wang, Che, & Zhou, 2009). An obvious alteration in permittivity of human tissues can be seen during changing the microwave frequency, as shown in Figure 2.3. Changing in microwaves on biological tissues is considered by power applied

in unit mass or field in the tissue (A. Rosen, Stuchly, & Vander Vorst, 2002; A. Rosen, Stuchly, M.A., Vorst, A.V., 2002).

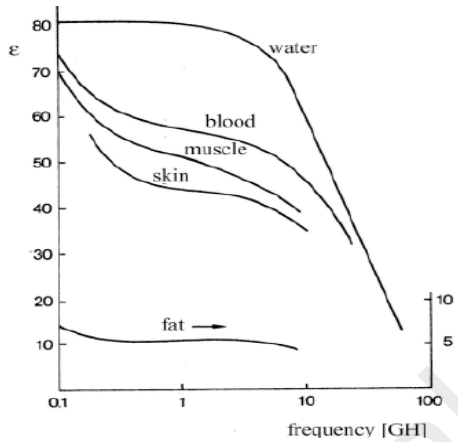


Figure 2.3: Dielectric constant according to frequency in several biological tissues

(A. Rosen, et al., 2002)

Water is the most available molecule within the human body. However, dissimilar tissues have different amount of water. Electromagnetic field can be applied to water molecules and lead to polarized it. Permittivity value is related to water concentration. When the applied frequency is increased, arrangements of molecules become slower than the expected resulting of the stored energy in the tissues. Therefore total energy is not allowed to pass through the tissues. Therefore, the permittivity shows reduction by increasing the frequencies (Chang, Chen, Sun, & Lin, 2004; Shen, 1995) . Dielectric of human blood and distilled water are shown in Figure 2.4.

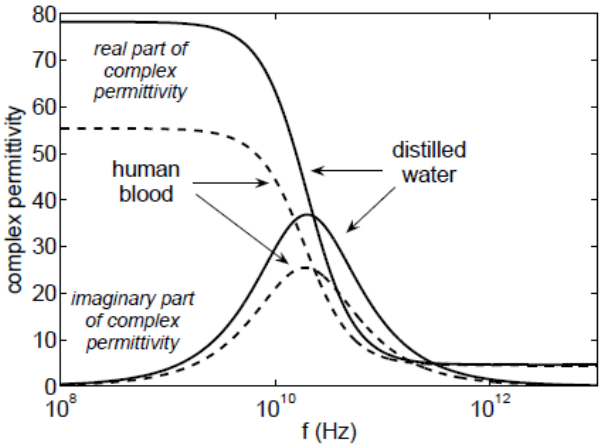


Figure 2.4: Dielectric of human blood and distilled water (Zajícek & Vrba)

When real part of relative permittivity drops off by increasing the frequency in separate steps, which called dispersion (Pethig, 1987b) . Each dispersion area happens at different frequencies and indicates different effects of electromagnetic waves on the human body (Martinsen, Grimnes, & Schwan, 2002).

2.5 Microwave

Electromagnetic Spectrum includes wide variety types of waves that covers a range of frequency between 0 to 10^{24} Hz. Commonly, Electromagnetic spectrum classify according to wavelength into radio, microwave, infrared, and visible area as light, ultraviolet, X-rays and gamma rays (Lonappan et al., 2004), as shown in Figure 2.5 and Figure 2.6.

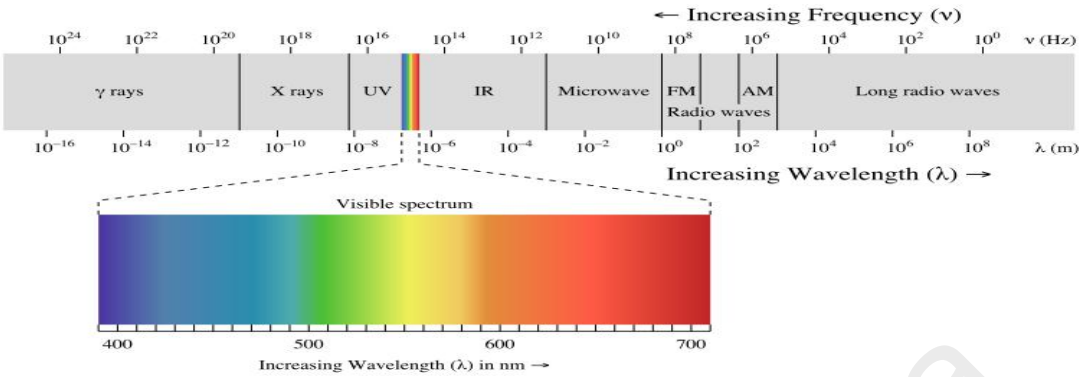


Figure 2.5: The Electromagnetic Spectrum
(ABSOLUTE ASTERONOMY, 2010)
(http://www.absoluteastronomy.com/topics/Electromagnetic_radiation**)**

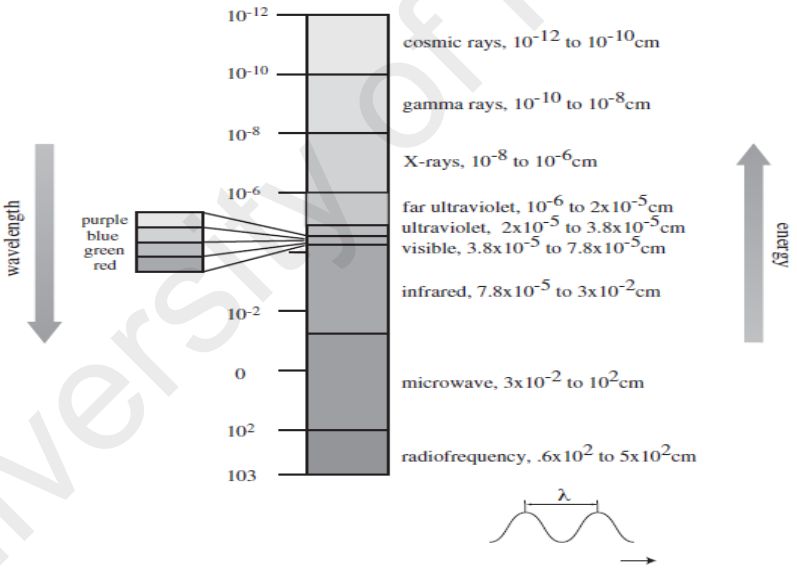


Figure 2.6: The Electromagnetic Spectrum
(Tolstoy, Chernyshova, Skryshevsky, & Wiley, 2003).

Radio waves are between infrared light region and audible sound waves of the Electromagnetic Spectrum. Microwave energy frequency is between range of 10kHz and 1 million megahertz. Microwaves are between far infrared region of Electromagnetic Spectrum with its higher frequency 300,000 MHz and lower frequency 300 MHz (Lantis II,

Carr, Grabowy, Connolly, & Schwaitzberg, 1998). The wavelength of microwaves is calculated by following equation:

$$\lambda = \frac{c}{f} \qquad (2.8)$$

Wavelengths usually are between 1 cm and 1 m. Microwaves have capacity to go through different materials due to of their long wavelengths. Wavelengths which are up to 50 GHz can be evaluated by some devices that are available.

2.6 Permittivity and S-Parameters

Particles of material are charged by contact with the magnetic and electric fields. That means the particles be polarized when the electric and magnetic fields across them .the polarization, conduction, and magnetization leads to material act as dielectric (Sarkar, Rao, & Djordjevic, 1990). When the electric field passes across the dielectric simultaneously has an effect on the electric field that is called permittivity (ε). As mentioned before permittivity is an ability of the material to transmit the electric field and is determined by the capability of materials to arrange and polarize its particles when the electric field is applied (Rao, 1987) .

Dielectric characteristics of a material are dependent on its molecular structure, so changing in the molecular structure lead to alteration of dielectric characteristics of the material. Evaluate the correlation between molecular structure and dielectric of a material can indirectly demonstrate other properties of the material (Pethig, 1987a). This issue can be useful when the characteristic of interest is complex to obtain directly. Most devices for

measuring both permittivity and microwaves are using Vector Network Analyzer (VNA). It is equipment that is used to calculate the S-parameters, refer to scattering matrix with mathematical construct that evaluates how RF energy spreads through a multi-port network, in microwave range over a particular frequency range, as shown in Figure 2.7.

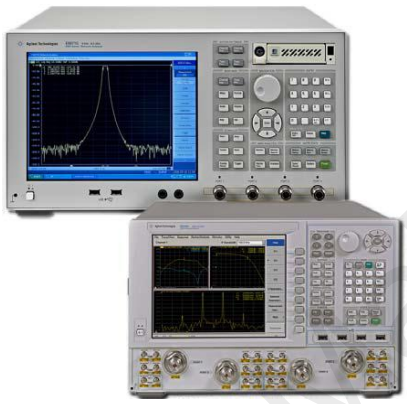


Figure 2.7: Vector Network Analyzer
(http://www.testequipmentconnection.com/32104/Agilent_E5070A.php)

2.7 Applications of Microwaves in Biological System

The relationship between An EM field and biological systems is a novel research area. The EM fields have various effects on different fields of studies. Influence on reaction time of man, decreasing time of treatment after injury or operation, control of pain, and etc. (Blad, 1996). Microwave medical applications trends to research about the development of new diagnostics based on EM field respond. Recently many new medical achievements are utilizing of microwave technology (Siauve, Scorretti, Burais, Nicolas, & Nicolas, 2003; Vrba, 2005). Because microwaves are able to measure wide variety of parameters inside the closed volume, they have become ideal to measure the biological applications through harmless penetration. In addition microwaves is used in microwave tomography scanning systems, RF/Microwave ablation for treatment of cardiac arrhythmias, breast tumour

detection, microwave balloon angioplasty, electro thermal arthroscopic surgery, and so on (A. Rosen, Stuchly, M.A., Vorst, A.V., 2002; Stuchly & Stuchly, 1980)

According to the overview of application of microwave in medical, we can recognize them in three fundamental groups as follow:

- Using to treat of patients
- Using to diagnosis of disease
- Using as a section of a treatment or diagnostic system

This study consists of concentration on microwave in diagnostics of diseases, using permittivity measurements.

2.8 Review of Gender Identification Methods

In the recent 25 years, there has been rising interest and attention to study and find out some relationship between gender differences and disease pathogenesis, also to discover more effective and valuable treatments if there is not exist and aggregation of analyzed results by other methods (Dao Jr & Kazin, 2007). Many significant and considerable gender differences can assist to clinical management of disease processes. Gender based distinction in cause of disease (etiology) and pathophysiology such as metabolic disorders and autoimmune disorders has well-documented in many disease states (Azzi, ElAlfy, & Labrie, 2006). Gender differences are well identified to be present several vital markers of disease consist of uric acid, triglycerides, enzymes, and hormones. Some study is

recognized about the dissimilarity between urinary markers in males and females (Zajícek & Vrba).

Some researches for identifying gender have not associated to biological tissue, for example, gender identification using the human text. Short Text document is the most common type of Internet media. For example, social network applications are mainly text based. Text is applied in Craigslist, Twitter, and Facebook or in web applications such as e-mail, chat rooms, etc. Annual report of Internet Crime Complaint Center (IC3) in the 2008 has mentioned that there was about 33.1% increasing in online crime in this year. Recent issue that people introduced with false information their gender on the Internet encourage researcher to solve this problem. Machine Learning Algorithms (MLA) has been used on that study and found significant differences in texts. Support vector machine, Bayesian logistic regression have been designed according to the proposed types. The problem in this method to obtain the gender identification is briefly as follows:

- The length of text messages is generally smaller than documents and traditional texts such as books
- Emoticons elements often disappear in Internet texts
- The situation of user and organization and format of internet text are variety

There is an interaction between the general writing and psycho-linguistic from the text. By creating a suitable relationship between psycholinguistic and gender-linked, can be detected that different function and structural features of words represent an important distinction in gender identification. Investigational results show that there is difference between individual writing by male and female, and performance of identification is increased by

the rate of number of words in text and dataset (Cheng, Chandramouli, & Subbalakshmi, 2011).

One of the obvious dissimilarity between male and female refers to voice which is one of the biological characteristics. Fundamental frequency for men is usually between 100Hz and 146Hz, while the common fundamental frequency for women is generally between 188Hz and 221Hz. These pitch levels can be useful correctly to detect and identify the speaker's gender by a listener. So, fundamental frequency can be playing a role in gender identification (Gelfer & Mikos, 2005). Someone has persistent and strong feeling about themselves that they are transgendered biological gender is unsuitable for their psychological character. Therefore these contradictory character and behavior might lead to altering the gender to become a human with an appropriate gender (Yuan & Liberman, 2008). Detect the particular gender by voice characteristics can be a challenge for transgendered persons to conversion male-to-female, since the vocal mechanism leads to achieve the adult male dimensions. It is not concerned with the management of female hormones (Yuan & Liberman, 2008). The weakness of this method is the large value of error in matching of the voice in different states.

Skin is also one of the body tissues that are influenced by distinction in gender. Gender differences in skin cancers and distinguish hormonal relations as a major goal for which more research is required to interpret recent findings to significant clinical diagnostic and therapeutic applications. Epidermal, the outer layer of the skin, has difference between male and female. this difference between gender assist to identify the poorly understood in the severity of diseases and abnormal skin, for instance, atopic dermatitis and harsh

psoriasis (is a chronic disease of skin), which happen more commonly in males compare to females (Dao Jr & Kazin, 2007).

Trace Element Reference Values (TERV) project in human tissues trends at establishing reference intervals for trace elements in blood, urine and other human tissues and to consider the special effects of age, gender and some personal lifestyle factors. For instance, some researchers discover that women have higher levels of urinary cobalt than men (Kristiansen, Christensen, Iversen, & Sabbioni, 1997). Rate of autoimmune disease is higher in women compare to men. That means when autoimmune diseases increase in men, they are more sensitive and subsequently harsher. Autoimmune disease have shown same rate in many animal models. Testosterone and progesterone lead to most of the biased differences related to sex in the immune response (Bourgeois, 2011).

Another investigation in gender identification is to use automated face detection based on computer vision and pattern recognition methods. In one experimental research on 250 females and 250 males that are selected randomly and using the Independent Component Analysis, a method to separate a multivariate signal, indicate each image. After classification Support Vector Machine is used. In this situation researcher get 96% accuracy for identification. This machine is a conception of computer science and statistics for a set of methods that evaluate data and identify patterns to obtain data classification.

The limitations of SVMs are size and speed, both in testing and training and it has complex algorithmic and need extensive memory to quadratic programming in large tasks. Gender identification can be performed through neural network classification methods (Jain, Huang, & Fang, 2005), as shown in Figure 2.8.

There are different neural network classifiers such as:

- Learning Vector Quantization (LVQ) network—more favorable than another feature-based method with a hit rate of 100% without any information of hair
- Radial Basis Function (RBF) network—more favorable than another feature-based method with a hit rate of 98.04% without any information of hair
- RBF model learns faster its task compare to LQV model
- Results of these technique based on neural network are favorable compared with Eigen-decomposition-based techniques

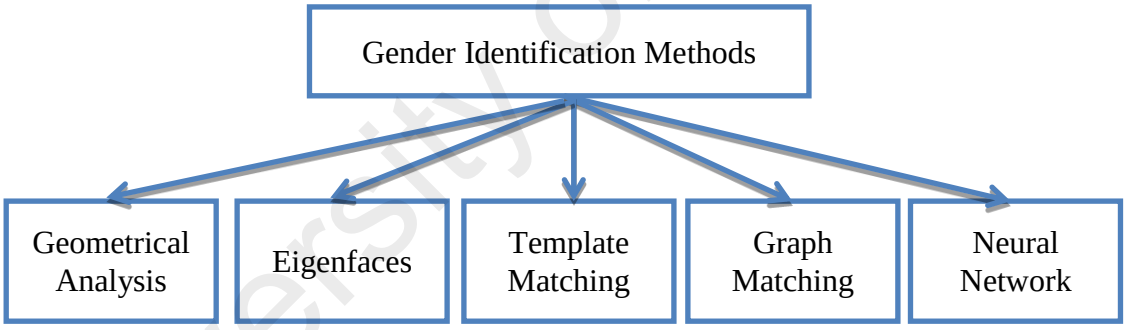


Figure 2.8: Several techniques for gender recognition exist according the feature extraction

Geometric Analysis, such as angles and distance between different parts of face, is a traditional method to representation of face. Geometrical Analysis is sensitive to altering in facial expressions and light conditions. The main defect and disadvantage of this method is due to the sufficient representation of face with minimum set of features is difficult. Different part of facial areas has different result in sex classification and prediction for human performance. Top of their female face is better for sex classification inverse; bottom

partial of males is more helpful. Graph matching is employed to compare a new face with previously stored graphical models. Problems such as the effect of alteration is size, background, orientation, and lighting conditions have not been absolutely resolved to date and merit further investigation (Tolba, 2001).

Study about some specific information to discover the gender based on face is considered. Principal Component Analysis (PCA) is a mathematical method that linked to scaling of the original variables approach quantifies the different types of data in faces. Some information have shown that eigenvectors with larger shape-based information is more valuable for categorizing faces into two groups of male or female.

Prediction of individual faces by eigenvector can be estimate the sex of the individual face. Some studies explore the gender-based information by laser scans of human heads. The quality of information and structure in three dimensions and the image based on gray-level of human heads helps to classify the heads by sex. Data from laser scanned of human heads is divided into 3D-structure information and image intensity information. The result of two methods indicate that 3D structure information supported more accuracy in detected the sex classification in compare with gray-level image. Gender identification using neural network has some problem that are listed as follow:

- Feature -based methods remove some texture, composition or structure, of the tissues characteristics of human face
- Apparently neural networks extract a more expressive and descriptive set of facial features

Several research works to solve the problem of a variety of types of neural networks to the gender identification (Tolba, 2001).

2.9 Urinalysis and Devices

There are several methods to get urine test and these are categorized as follow:

- Macroscopic Urinalysis
- Chemical Urinalysis
- Microscopic Urinalysis
- Urine Culture

Macroscopic Urinalysis is usually the first step in analysis of interest sample and directly checks the color, existence of red blood cells, and presence of any particles for cloudiness with naked eye. This method has less accuracy for clinical diagnosis.

However, certain foods, and medications can be effective on result of urine color. Chemical Urinalysis involves introducing certain chemicals characteristics of urine sample to recognize a specific condition. The pregnancy kit is one of the chemical urinalysis in pregnant women using the presence of a hormone by change of color to prove pregnancy, as shown in Figure 2.9. Another example of chemical urinalysis is Urine dipstick. Its structure is a narrow plastic strip with several squares by different colors that attached to it. Each small square represents a particular component of urine. The color change occurs after a few minutes from dipping it. Too early time or too long time to read the outcome may be leads to obtain inaccurate result. In this process usually use the PH of urine, determine the specific gravity of urine to survey the ability of kidneys.

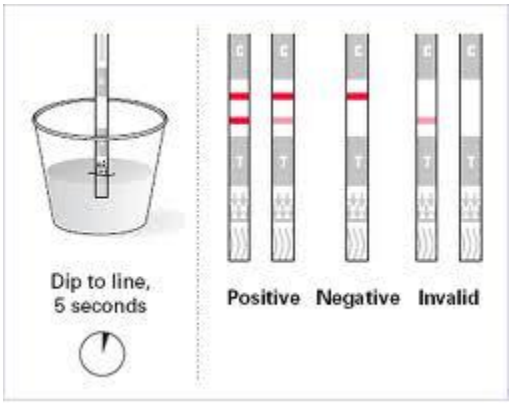


Figure 2.9: One type of chemical urinalysis

The chemical analysis may provide the reason of specifically identifying disorder. Microscopic urinalysis is considered as an indispensable tool to detect the certain disorders that remain asymptomatic. For example, in certain abnormal subject such as kidney stones disease, number of one particular type of crystals is increased. Therefore the diagnostic of this state are noted. The urine culture may be recommended at an infection condition in urine.

There are several methods to urine sample is based on the temporary diagnosis and disorder suspected . In addition, there are some diffrences in metabolism and chemistery into human body to detect the significant diffrences for gender identification . Biomedical researchers attempt to find the relationship between disease and influence of metabolism and biochemical basis of human body (Mashimo, Miura, & Umehara, 1992). Impact of genetic alterations on the proteins, and metabolites found within cells, tissues, or individuals. These new omics such as trancriptomics, set of all RNA and unlike the genome can change with

external environmental conditions, proteomics, study about function and structure of proteins, metabolomics, study about metabolite profile of small cellular, affect technology to measure and describe the changing biological in different levels of bimolecular structure, as shown in Figure 2.10.

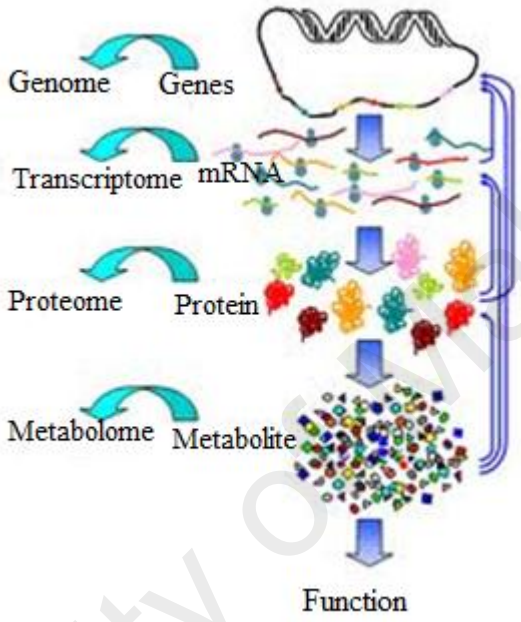


Figure 2.10: Samples prior to more in depth mass

The human body has dynamic and complex interacting metabolic pathways. Generally in healthy individual complex chemical reactions are kept in balance. Some metabolomics Researches endeavor to understand metabolic processes and pathways, and have tried to diagnose a particular disease (Saude, Adamko, Rowe, Marrie, & Sykes, 2007) Metabolomics help to identify and discover the predictors and metabolic biomarkers connected with a particular biochemical event (Kochhar et al., 2006). Base of disease diagnostics refer to understanding about the relationship between the normal physiology and epidemiology and related issues at the population—study about the functions of living organs and their parts and the health and illness samples. In some animals influence of sex,

diurnal cycle, genetic, stress, strain and diet has been determined on metabolic composition of plasma and urine (Stuchly, Athey, Stuchly, Samaras, & Taylor, 1981). Furthermore, in humans on urinary metabolic profile affect by cultural, dietary diversities, and geographic location. In addition, perturbations can be important and significant to detect disease progression and development (Slupsky et al., 2007). Variation in concentrations of physiological combinations in urine can be able to represent the characteristic for particular traits, including response to toxicity or disease (Lutz, Lutz, & Lutz, 2006).

Mass Spectrometry can be able to discover unknown compounds to find out the isotopic composition of fundamental elements in a molecule, and to discover structure of a compound by detecting its disintegration (Macdonald, 1992), as shown in Figure 2.11. It is a technique to utilize the magnetic properties to achieve chemical and physical properties of atoms or molecules.

Figure 2.11: Mass spectrometer
http://www.chem.gla.ac.uk/cronin/research.php?t=Mass%20Spectrometry

It is based on the phenomenon of nuclear magnetic resonance and is able to make available detailed data about the structure, chemical environment, and reaction state of molecules. MS is widely being used for metabolic profiling, but often this device can not report the

detection modes such as multiple reaction monitoring or constant neutral loss. These modes permit structure of compounds be center of attention. So this is beneficial for situations that are under investigation with a particular set of metabolites (Lutz, et al., 2006).

High-resolution Nuclear Magnetic Resonance (HNMR) is as a promising non-invasive technique due to its capability to simultaneously distinguish and detect a large number of compounds in a fast manner and needs little sample manipulation (Scott, Attrill, & Anderson, 1967). Non-invasive property of chemical or mechanical sample modification is important. This technique permits the samples to be analyzed, saved, and again re-analyzed. Also, the information collected may be analyzed by wide variety of techniques, consist of spectral integration, Partial Least Squares for Discriminant Analysis (PLS-DA). PLS-DA is a regression extension of PCA that obtains improvement of class information to effort to get maximum of the separation among the groups of observations. Principal Components Analysis (PCA) data reducing technique that leads to decrease the dimension of a multi-dimensional dataset whereas keep the characteristics of the dataset that contribute mainly to its variance, and neural networks.

High-resolution Nuclear Magnetic Resonance (HNMR) spectroscopy is a capable, efficient, and helpful device to generate data on a large amount of metabolites in tissues or biofluids. Spectral profile of biofluids such as plasma, urine, or saliva states the metabolic position of the body and change during the response of factors which generate stress. Analysis of urine using H-NMR provide a baseline metabolic of normal human urine for outlook metabolomics and clinical researches to build upon(Wagner et al., 2006).

NMR spectroscopy has become one of the most important tools for measuring these alters due to NMR spectrum can identify metabolites and also their concentrations accurately. Using both (NMR) spectroscopy and liquid chromatography–mass spectrometry (LC–MS) are one of the analytical techniques to determine of potential biomarkers. For instance, researcher attempt to identify and find the relevance of the steroid that is a type of organic compound and one of the urinary components using NMR. This approach can be useful in future studies of toxicity to discover, disease, and identify biologically related markers (Hodson et al., 2007).

For rich analyzing and recovery the NMR data , apply and mixture coupled with the multivariate statistical tools are essential to create the relationship between the biochemical interpretation and NMR spectral profiles and allows imaging of changing biological to response the genetic modification, disease process, change in nutrition, and so on. Mass Spectrometry (MS) coupled with Liquid Chromatography (LC/MS), or Gas Chromatography (GC/MS) and Nuclear Magnetic Resonance (NMR) spectroscopy. These are good analytical equipment when joined with multivariate statistical analysis. NMR spectroscopy can be used to biological samples, such as urine with minimum preparation of metabolites, and can be applied to measure the concentrations in the micro molecular range, so it can be an ideal device for metabolomics due to highly analytical feature. To achieve useful diagnostic information of small-molecule must be quantified and after that compared with normal samples (Bollard, Stanley, Lindon, Nicholson, & Holmes, 2005). Metabolomics researchers frequently come up to the challenge of analyzing enormous of data. NMR-based metabolomics workflow characteristically starts with a series of acquired NMR spectra, followed by data pre-processing algorithms, and at the end process finished by powerful chemometric techniques. Spectral binning is a common technique used for

high-throughput data pre-processing. A novel targeted profiling technique is related to metabolite and its concentration. Targeted profiling produces powerful models and creates accurate metabolite concentration information to help discover difference metabolite in a healthy population. Metabolites that are related to mitochondrial energy metabolism were represented differentiate gender. The main approach in analyzing NMR data has been combined the technique of spectral binning. But, one of the weakness of this device is due to identification of spectral regions in an NMR spectrum is uncomfortable for diagnostic evaluation. Since unknown areas of interest of NMR spectrum are severely caused by metabolic changes or caused by simply artifacts. Most studies of the analysis human urine, tissue, or blood are a combination of H NMR spectroscopy and type of spectral binning (Vitols, Chang, Weljie, & Newton, 2007)

Other weaknesses of H-NMR spectrometer

- The high cost of NMR instruments and its maintenances although low-cost, low-field proton NMR have been developed for limited applications.
- NMR requires complicated data analysis.
- The NMR is a secure access facility for authorized users only.
- There is lack of NMR equipment specifically designed for general purposes.
- There are a lot of compounds which are not IR active and therefore can't be detected.

In fact, all markers of disease are associated with metabolic alterations in the human. So, metabolites in body tissues and fluids can represent correlate between progression of the disease and these changes. For instance, different disease conditions consist of diabetes,

breast cancer, high blood pressure and coronary heart disease. The testing urine samples assist to non-invasively track the progression of the disease (Neves, 1996).

2.10 Characteristics Urine

Corresponding to investigation of the metabolic pathway, it is necessary to consider that what type of biological sample is suitable and appropriate. Biological samples can be in variety range from highly invasive and specific, for example, by tissue biopsy, to more general that are easy to gather and non-invasive for human (i.e., urine) (Kraszewski, Stuchly, & Stuchly, 1983). Urine is often used due to easy of collection, the rich and wealthy metabolite composition, repeated samples. Most of the time Urine has higher metabolite concentrations obtained relative to plasma. As mentioned before some analytical techniques have been applied in metabolomics studies are included as various types of mass spectrometry, high performance liquid chromatography, and nuclear magnetic resonance spectroscopy (NMR) (Saude, et al., 2007). Presently, there is restricted information existing regarding normal metabolite concentrations and amounts of variance in urine. A certain quantity of homeostasis, the trend of an organism to adjust its internal conditions, is considered in the metabolites excretion of normal urine (Raveendranath & Mathew, 1996). It is exceedingly important to describe the inter- and intra-individual metabolite variation before making results according to metabolite altering in diseased individuals. This meaning of the normal metabolic profile is foundation in human studies when extra variation is introduced through a number of uncontrolled factors such as genetics, ethnicity, stress, exercise level, and diet (Robertson, 2005). Urine is not a fluid in steady circulation within the body and does not require monitoring like the blood. In addition, urine is

produced by gathering of waste and biological by-products. These processes are reflective of a larger combination of metabolic processes and have occurred over a long time period. The large inconsistency in metabolite concentrations in control subjects may be a reaction of the biological function of urine. However, the easy collecting of urine sample lead to it uses widespread as biofluid metabolomics for studying of many human disease states (Paul et al., 2002).

There are numerous ongoing researches and studies looking for disease-related biomarkers in urine. Another experiment that uses urine is deals with microwave. comparison the dielectric constants, conductivity and dielectric loss of abnormal and normal CSF (Cerebrospinal Fluid) samples using different range frequencies of microwaves have been conducted. The dielectric constants at two point frequencies has significant different between abnormal and normal CSF samples. The decrease in dielectric constant of abnormal samples possibly will be due to alter in the dielectric property of CSF because of the different diseases. Varying in dielectric constants in several body fluids like colostrums, urine and breast milk samples have been reported (Rajasekharan, Girishkumar, Lonappan, Mathew, & Mathew, 2010). For instance, dielectric constant of urine samples from normal women compare to pregnant has significant difference. High variation in the biological characteristic of any living organism in which decreased and/or increased values compare to normal range is considered as abnormal. Just detailed analysis can provide information on the dielectric constant range in each case or disease.

2.11 Analysis of Human Urine Using Biomedical Devices

a) Gender difference in human urine using Gas Chromatography/Electron Ionization Mass Spectrometry (GC/EI-MS)

In particular research has been performed gender differences by this device in the levels of urinary BPA (is an organic compound) conjugates.

- BPA–glucuronide: men (2.34-0.85 ng ml/l) have higher level than women (1.00-0.34 ng ml/l)
- BPA–sulphate: women (1.20-0.32 ng ml/l) have higher level than men (0.49-0.27 ng ml/l)
- Levels of free and total BPA: similar in men and women
- Ratios of free BPA to total BPA: similar in men and women

This result demonstrated that women had better and great ability than men for the sulfation of BPA (Kim, et al., 2003).

Table 2.2 shows the results of Comparison of urinary BPA levels between male and female subjects in that research.

Table 2.2: Comparison of urinary BPA levels between male and female subjects

Sex	Types of BPA	Range	Mean (SE)	% (SE)
Men	Free BPA	0.28–2.36	0.58 (0.14)	29.1 (5.04)
	BPA-glucuronide	0.16–11.67	2.34 (0.85)**	66.2 (8.41)
	BPA-sulfate	<MDL[a]–1.03	0.49 (0.27)**	4.78 (7.77)
	Total	0.85–9.83	2.82 (0.73)	100
Women	Free BPA	0.068–1.65	0.56 (0.10)	33.4 (7.41)
	BPA-glucuronide	<MDL[a]–4.34	1.00 (0.34)**	33.1 (6.43)
	BPA-sulfate	<MDL–3.40	1.20 (0.32)**	33.5 (8.40)
	Total	1.00–7.64	2.76 (0.54)	100

[a] <MDL, below minimum detection limit.

** $p < 0.01$, compared between the two sexual groups.

b) Gender difference in human urine using NMR-based metabolomics

- Creatinine (used as diagnostic marker of kidney disease and muscle mass): Male has higher than female, so, it is reasonable that males usually have a higher muscle mass than females.
- Estrogen: female have higher than male (Dai et al., 2008).

c) Gender difference in human urine using LC-MS/MS

Except citrate, all spiking compounds experiments, was accurate to measurement. Targeted profiling provides metabolite concentration information for changing the NMR spectral peak position because of variability in ionic strength and pH, as shown in Figure 2.12.

- Citrate, fumarate: female have higher concentration than male Carnitine, acetylcarnitine
- Acetone: male have higher concentration than female
- PH: no significant difference between male and female (Slupsky, et al., 2007)

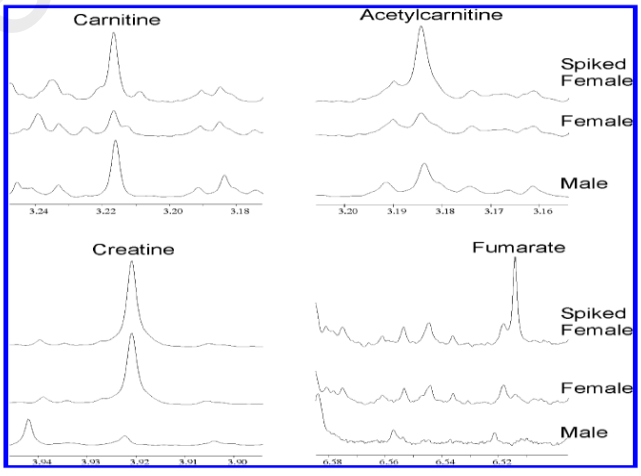


Figure 2.12: Comparison of typical male and female NMR spectral regions related to tetabolite peaks used for identification and quantitation of some metabolite.
(Slupsky, et al., 2007)

d) MINITAB Statistical Software

- Urinary Levels (U-As)—difference in levels between men and women up to 50 years (Median: 155 (male) and 105 (female) nmol/l;), but this difference disappears after 50 years
- Urinary chromium (U-Cr)—levels of this component were not significantly influenced by gender and it is independent on gender
- Urinary cobalt (U-Co)—Cobalt is essential to humans in the form of vitamin B, women were found to have significantly (p=0.018) higher U-Co levels compared to men. In conclusion, gender must be considered when evaluating U-Co results (Kristiansen, et al., 1997)

Summary of the parameters that having statistical gender differences are presented in Table 2.3.

Table 2.3: Summary of the parameters that having statistical gender differences

Parameter	Description
Fundamental Voice Frequency	Fundamental frequency for men is usually between 100 and 146 Hz, while the common fundamental frequency for women is generally between 188Hz and 221Hz.
Urine	• BPA–glucuronide: men (2.34-0.85 ng ml/l) have higher level than women (1.00-0.34 ng ml/l) • BPA–sulphate: women (1.20-0.32 ng ml/l) have higher level than men (0.49-0.27 ng ml/l) • Levels of free and total BPA: similar in men and women • Ratios of free BPA to total BPA: similar in men and women • Urinary Levels (U-As)—difference in levels between men and women up to 50 years (Median: 155 (male) and 105 (female) nmol/l;) • Urinary chromium (U-Cr)—levels of this component were not significantly influenced by gender and it is independent on gender • Urinary cobalt (U-Co)—Cobalt is essential to humans in the form of vitamin B, women were found to have significantly (p=0.018) higher U-Co levels compared to men.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Overview

In this chapter, method of research is explained by overall procedures and investigational setup .Process of research is divided in many steps that are completed in sequence. In this method gender identification using the permittivity of urine between healthy male and female are investigated via the Vector Network Analyzer.

3.2 Data Collection

In this experiment, the urine samples collected from healthy Iranian men and women. The collection processing was done in the morning before eating breakfast. Participates in the experimentation were asked to filled the confidential health and lifestyle such as specific dietary regimes, married statues, weight, height. Questionnaires, reported age, gender, and indicated informed consent of participants in the research. The profiles of these subjects are listed in APPENDIX A. Urine samples were collected of females from 10th to 15th days after the menstruation cycle. pregnant females and acutely ill individuals who suffering from influenza or common cold, or taking antibiotic or something like that were excluded from the experimentation to increase the accuracy of test.

After participants were informed about the process of urine collection, 60 ml container is used for collecting sample of urine. In this case control of sample concentration, amount of

urine sample and time of sample collection, should be considered because can be effective on investigation in clinical studies.

In order to having a good determination of actual variation in normal individuals, we do not choose the idealized normal subjects because they cannot represent an actual normal population, for example, human who never take medicine. In this study use the general understanding of health subject.

In addition Considerable data using biofluids of human are rare, particularly by using permittivity. This issue be appears not only due to inherently great variability in human samples but also can be appears because of lifestyle factors, genetic variability, and environmental influences.

3.3 Activities Involved in Urine Collection

- Giving the consent form to the subjects.
- Ensuring the consent form is signed, after that the information sheet is loudly read to the participants and if they have any question should be answered.
- Asking them that they do not having breakfast before urine collection.
- Informing the subjects of the urine collection procedure.
- Urinate into the urinal or toilet.
- Do not collect this urine.
- Wash your hands.
- Drink a large glass of water to urinate easily.

- Clean the area of your genitals.
- After a few seconds that the urine has flowed, Put urine into the urine cup and collect about 50 ml of the urine.
- Wash your hands.

3.4 Measuring Permittivity

In recent times, electronic instrument technology has significantly evolved to the point where electronic component characteristics of material play a major role in medical area. Impedance analysis and network analysis are two technologies to measurement of permittivity parameter. They are associated with some methods and particular measurement. In impedance analysis technology used the parallel plate and put a thin sheet of liquid or material between two electrodes in form of capacitor. The measured capacitance is then used to calculate permittivity. In network analysis technique used some methods such as reflection wave, s-parameter, cavity, and free space. In this study permittivity is measured by a vector network analyzer using s-parameter .VNAs have different model which in this study model E8362C is used. Using this device to obtain the permittivity of material a certain process has been followed. Before starting the test on each sample and achieve the permittivity instrument should be calibrated. This attempt leads to decrease the drift errors and therefore the accuracy of measurement is increased.

3.5 Measuring Tool

Aim of this research is measure the one property of material that is called permittivity. This characteristic is a dielectric property that depends on molecular structure of material. Any changing in structure of molecule can be detected by measurement of dielectric property. This relationship can be applied to detect some properties that cannot be considered directly (Gabriel, Grant, & Young, 1986). Agilent Technologies Dielectric Probe Kit (85070E) and slim form probe is used to obtain the permittivity of material. The open-ended coaxial-line process permits measurements in a wide variety of frequencies (Gajda & Stuchly, 1983). Dielectric samples with standard waveguide allow measurements in whole the microwave region with a high degree of accuracy, apart from at lower frequencies where size of sample is very large (Athey, Stuchly, & Stuchly, 1982).

Basically measurement can be done easily through immersing a probe into the semisolid or liquid samples, with no use the special fixer or container. The non-destructive procedure in real time is one of the strength using of Dielectric Probe Kit tin analytical technology.
This instrument is capable to measure the reaction of material to radio waves (microwave) energy by using a Network Analyzer. Signal ranges of 10MHZ to 20GHZ transmit through the probe into the Material Under Test (MUT). Therefore the generated frequency is related to Agilent Network Analyzer and its probe.

Related software controls the Network Analyzer and provides easy setup and simple measurement steps, as shown in Figure 3.1. In addition, Network Analyzer can be display the complex permittivity in different formats including dielectric loss factor, dielectric constant, loss tangent, and Q-Q plot by using the software that mentioned before. So, data

can be simply analyze by using the activating marker and just move it and click on point of interest on table or chart. Connect to the other program by using the copy and paste the data into any windows and doing more analysis is easy.

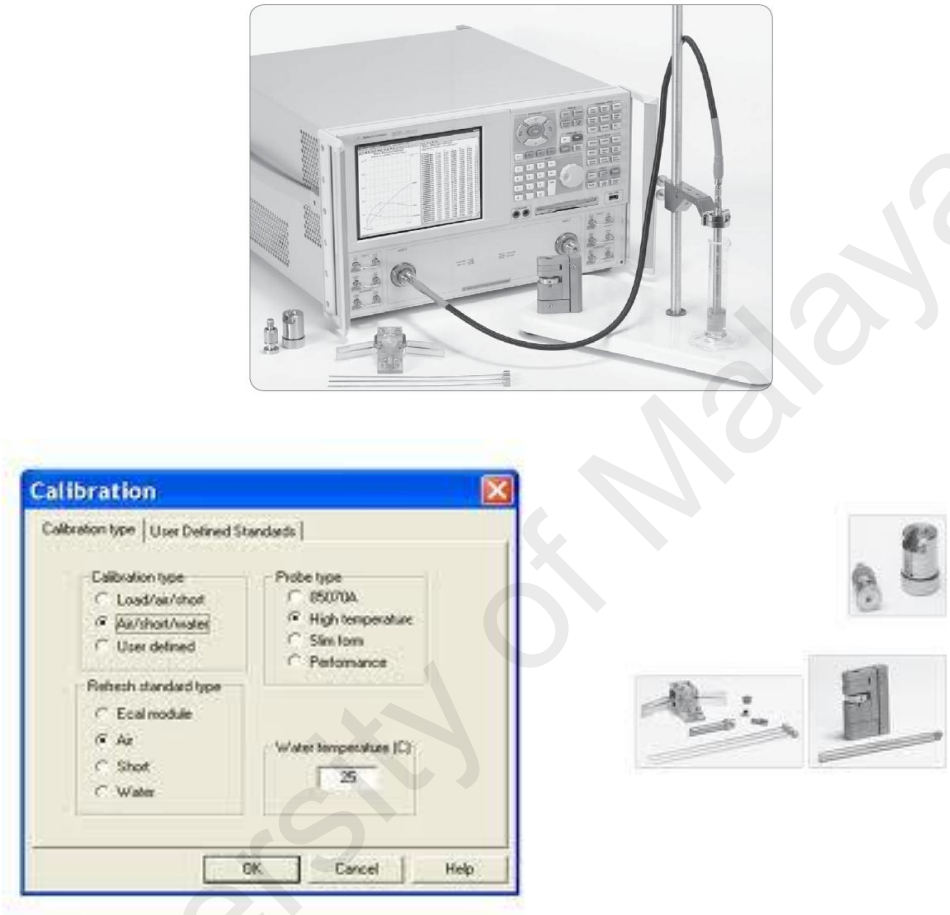


Figure 3.1: Agilent 85070E dielectric probe kit calibration

This instrument has capability to refresh calibration automatically before each measurement. This advantage help to stability of system, decrease the drift errors, and represent the process over the long time; even testing environment has changeable temperature and pressure over the time. In this tool, probe and test port cable connect the Agilent Electronic Calibration module microwave ports for calibration, so before every measurement the complete calibration has been done. Consequence, eliminate errors that

result from test port cable. The software conducts the user through a "three standard" calibration. For this aim, at the end of probe, open, short probe, water is performed.

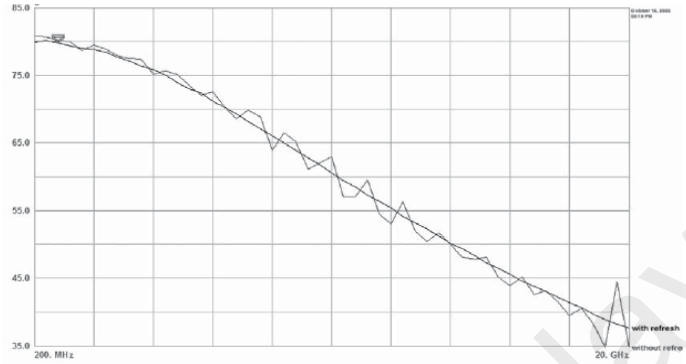
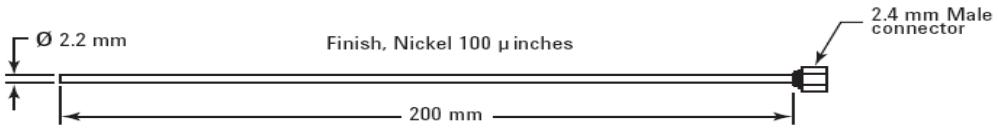


Figure 3.2: Water with and without electronic calibration refresh (Kaatze & Uhlendorf, 1981)

Figure 3.2 demonstrates cable instability by effect of calibration on measurement the permittivity of water.

- Slim Form Probe:

  The probe is designed in slim form; this feature allows it to have easy applying in chemical reaction chambers, fermentation tanks and each tool with the small apertures. This advantage leads to use the probe in liquid and soft semi-solid. It has also enough economical characteristic in nature. It consists of three parts for consumable nature. The probe has been designed by 2.2 mm outer diameter and 10 mm inner diameter, as shown in Figure 3.3.



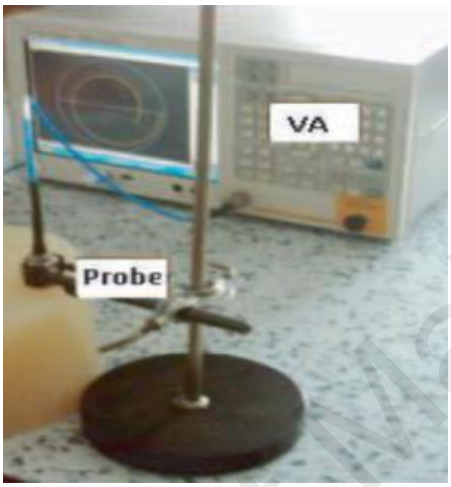


Figure 3.3: Slim form holder, probe, and Vector Analyzer

Some of the important factors to select this technique of measurement are summarized in below:

- Frequency Range
- Expected Convenience
- Expected Values of ε'
- Material Properties (i.e., isotropic, homogeneous,)
- Required Measurement Accuracy
- Form of Material (i.e., powder, solid, liquid, sheet)
- Destructive or Non-destructive
- Sample Size Restrictions
- Temperature

- Contacting or Non-contacting
- Cost

3.6 Experimental Setup

The purpose of this study is to achieve the novel methods to find the discrimination between male and female using electromagnetic property in non-invasive way. To obtain factors such as ε' (dielectric constant or real permittivity), ε"(loss factor or imaginary permittivity), and loss tangent (δ) the 85070E Network Analyzer has been used. This device is able to calculate these factors over a wide variety frequency range between 10 MHZ and 20 GHZ. In the first step, collecting the urine of healthy male and female has been done.40ml of urine sample of each subject is enough. All normal subjects are Iranian race and they are between 20 to 30 year olds. The second step measure and find the permittivity of samples using slim form and Vector Network Analyzer. Measurements can be obtained thorough immersing the probe into samples. Instrument is based on measures the response of material to RF or microwave energy using the network analyzer. The third step is analysis of these information that be achieve by transmitted RF or microwave signal of the slim probe to material under test. Whole system is based on the Agilent Network Analyzer. The range of frequency that be used in this test is from 10MHZ to 20GHZ.The Network Analyzer is conducted by software that gives some valuable guidelines to the user through obvious and simple instructions, within few seconds; complex permittivity can be computed in different formats. After that the information collected during the test is analyzed with statistical tools.

3.7 Data Analysis

The statistical analysis is done by helping the well-known statistical tools which are called Microsoft Excel and SPSS. One of the efficient and prominent statistical software to help the analysis data is SPSS. This statistical software package is run a large amount of data automatically. Analyzing data using descriptive, correlation, frequency, and regression can be performed by a few statistical procedures. These data can be transferred from most of files (e.g. Excel) to SPSS. SPSS able to arrange charts, reports, extremely versatile data processing, and Q-Q plots of distribution. The interest Range of frequency is imported from the Microsoft Excel to obtain the analysis of data using SPSS. The statistical analysis method which is used in this study is the independent T-Test. For each sample the test has been done three times. To provide more accurate data, among these three sets of data, outer set of data is deleted by comparison the mean of data sets. Then the evaluation is performed for the selected data sets. The complex permittivity of urine under test is analyzed using SPSS.

3.8 Independent T-Test

The independent t-test attempts to find the considerable difference between two independent groups. In other words, an Independent t-test is used to identify the differentiation between two samples which are not matched with each other. In this study, this test is applied to two groups (healthy men and healthy women). This test states that if the small enough difference is between the analyzed samples, therefore the researcher may confirm that a significant difference is between the samples. The value of the significant difference in this test is ≤ 0.05.

3.9 Graph Results Plotting

In This experiment obtain the dielectric constant and imaginary part in terms of frequency in rang of 10 MHZ to 20 GHZ. After that data that related to each participant is transferred in Excel format. By using this software the loss tangent is calculated by dielectric constant and loss factor. So for each sample three graphs can be plotted that are related to dielectric constant and imaginary part and loss tangent in terms of frequency (10 MHZ – 20 MHZ). After plotting each graph for each sample, attempt to obtain the mean of each parameter for each group (male and female). The distribution of the graphs represents the differentiation between healthy male and healthy female. This results lead to researchers become able to compare the graph for finding the significant difference between the groups of interest.

CHAPTER 4: RESULTS AND DISCUSSION

This chapter discusses and presents the analysis of data. . In this study, 60 subjects (30 males and 30 females) were involved in the data collection. These results are obtained after analyzing the data using the Statistical Package for the Social Sciences (SPSS version 19). The obtained results were analyzed using statistical test such as normality test and independent t-test. Also, the bivariate correlation test was performed in order to determine if there is a relation between the permittivity, loss factor, and loss tangent values of urine in males and females. Section 4.1 explains the research validity and reliability. Section 4.2 presents the data were validated using statistical methods.

4.1 Research Validity and Reliability

Planning a research and interpreting it findings and subsequent impacts are dependent upon two concepts—research validity and reliability. The concept of validity should answer the question, "Does your measurement process and assessment, actually measures what you intend to measure?" The concept of reliability is an indication of whether repeated measurements or assessments provide a consistent output under the same initial circumstances (Cooper, Hedges, & Valentine, 2009).

Data validation is critical because serious errors can arise during data analysis and these could be caused by erroneous individual data values (Yin, 2009). In this research, internal validity was ensured by the use of a data collection form to record all the subject information such as subject name, age, gender, health status, etc. The form was completed

by data collector to ensure that all the provided data are consistent in format and correct. The completed forms were checked by the data collector to ensure that all the subjects' information, have been completely and correctly collected. Before data analysis was carried out, the normality and homogeneity of the data sets were checked using statistical methods. In terms of research reliability, if the same research method uses for other set of data over time, the same results would be obtained.

4.2 Data Analysis Using Statistical Methods

As the data were collected from different people, males and females in different range of age, it is necessary to test the normality and homogeneity of these data using statistical methods. These methods include standard deviation, t-Test, analysis of variance (ANOVA), regression analysis, to name a few (Bryman & Bell, 2007; Cooper, Hedges, & Valentine, 2009). Among these methods, the t-test is the most commonly used to test the means of the data when there are two categories of data are used. If only one or two data categories are used, the t-test is the more suitable method. As two data categories, males and females, were used in this study, the t-test was used to compare the means of the two data categories as well as to calculate the standard deviation of each data category.

The t-test is a statistical method to analyze the means of one or two data sets. The test requires that the data being tested are normally distributed, independent of each other, and have the same variances. The t-test uses the variation between data samples and between categories and within a category. If the variation between data sets is relatively small, it shows that there is no significant variation between the means of all data sets. In the t-test, there are two default hypotheses (Casella & Berger, 2002):

- Null hypothesis (H_0)—the data sets means are equal
- Alternative hypothesis (H_1)—the data set means are different.

The likely range of variation of the averages if the null hypothesis is acceptable (true), is given by the standard deviation of the estimated means (Cooper et al., 2009). The standard deviation measures the data variability or diversity. It indicates how much variation or dispersion of the data from the average or expected value, and how tightly all the various data samples are clustered around the mean in a data set. The standard deviation of a data set is the square root of its variance, shown as follows.

$$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{N}} \quad (4.1)$$

Where σ = standard deviation

x = each value in the data set

$\bar{x}$ = mean of the data values

N= total number of data

A comparison between the actual variation of the data sets averages and that expected from the above formula is expressed in terms of the *F* ratio:

$$F = \frac{\text{Found variation of the data set averages}}{\text{Expected variation of the data set averages}}$$

Thus, the null hypothesis (H_0) is accepted if $F_{DF1,DF2;\alpha}$ (from t-test) is less than $F_{DF1,DF2;\alpha}$ (from F-Distribution table). The *P-value* reports the significance level of how big should *F* be before rejecting the null hypothesis (Sprinthall, 2003).

4.3 T-Test Statistic

A t-test is used to test the equality of two means at one time by using variances. The assumptions made when using the t-test are (Bryman & Bell, 2007):

- The data sets must be normally distributed.
- The samples must be independent.
- The variances of the data sets must be equal.

A summary of the t-test formulas and its calculations are shown in Table 4.1 (Bryman & Bell, 2007).

Table 4.1: Summary of the t-test statistic

T-Test	Formula	Comments
One-sample *t*-test	$t = \frac{\overline{x} - \mu_0}{s/\sqrt{n}},$	• Specified value μ_0 • $\overline{x}$ is the sample mean • *s* is the sample standard deviation • *n* is the sample size • The degrees of freedom is $n - 1$.
Independent two-sample t-test	$t = \frac{\bar{X}_1 - \bar{X}_2}{S_{X_1X_2} \cdot \sqrt{\frac{2}{n}}}$ $S_{X_1X_2} = \sqrt{\frac{1}{2}(S_{X_1}^2 + S_{X_2}^2)}$	• $S_{X_1X_2}$ is the grand standard deviation • 1 = group one, 2 = group two. • *t* is the standard error of the difference between two means • The degrees of freedom for this test is $2n - 2$ where *n* is the number of participants in each group

The decision will be to reject the null hypothesis if the test statistics from the table is greater than the F critical value with k-1 numerator and N-k denominator degrees of freedom. If the decision is to reject the null hypothesis, then at least one of the means is different.

4.4 Analysis of the Data Using the Normality Tests

The homogeneity of the two data sets was checked using the t-test. The Statistical Package for the Social Sciences (SPSS version 19) was used in this research. Using the SPSS, the data were arranged according to the two data sets. The variables in the SPSS were used to store the values of the data sets. For example, Group variable to store the 1 for male and 2 for female; Loss Factor to store the loss factor for each data sample; Loss Tan to store the loss tangent for each data sample, etc. Table 4.1 shows a screenshot of the SPSS data table which stores the variables and their values.

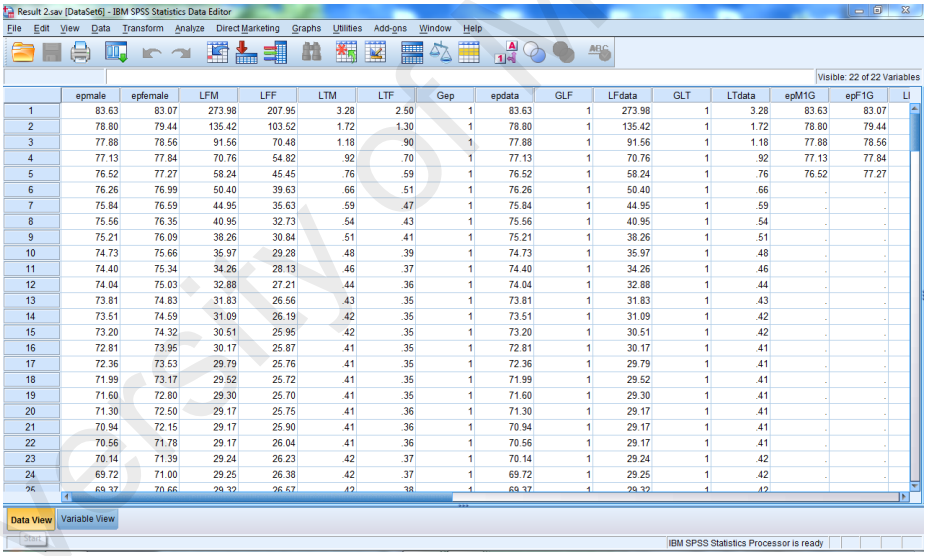


Figure 4.1: Screenshot of the 25 variables in the SPSS

Before applying the t-test, the three assumptions, mentioned above, must be considered. Hence, the normality test was carried out on the average of permittivity (e'), loss factor (e''), and loss tangent values of the two data sets (males and females) for 100 frequency samples. The descriptive statistics and results of the Q-Q normal plot are shown in Table 4.2 and Figure 4.2.

Table 4.2: Descriptive Statistics

	N (Feq. No.)	Minimum	Maximum	Mean	Std. Deviation
Per. Male	100	37.97	83.63	58.1055	12.42185
Loss Factor - Male	100	29.17	273.98	39.0241	26.92210
Loss Tan - Male	100	.41	3.28	.6847	.33596
Per. Female	100	38.72	83.07	59.2264	12.43680
Loss Factor - Female	100	25.70	207.95	35.9407	19.66695
Loss Tan - Female	100	.35	2.50	.6306	.27575
Valid N (listwise)	100				

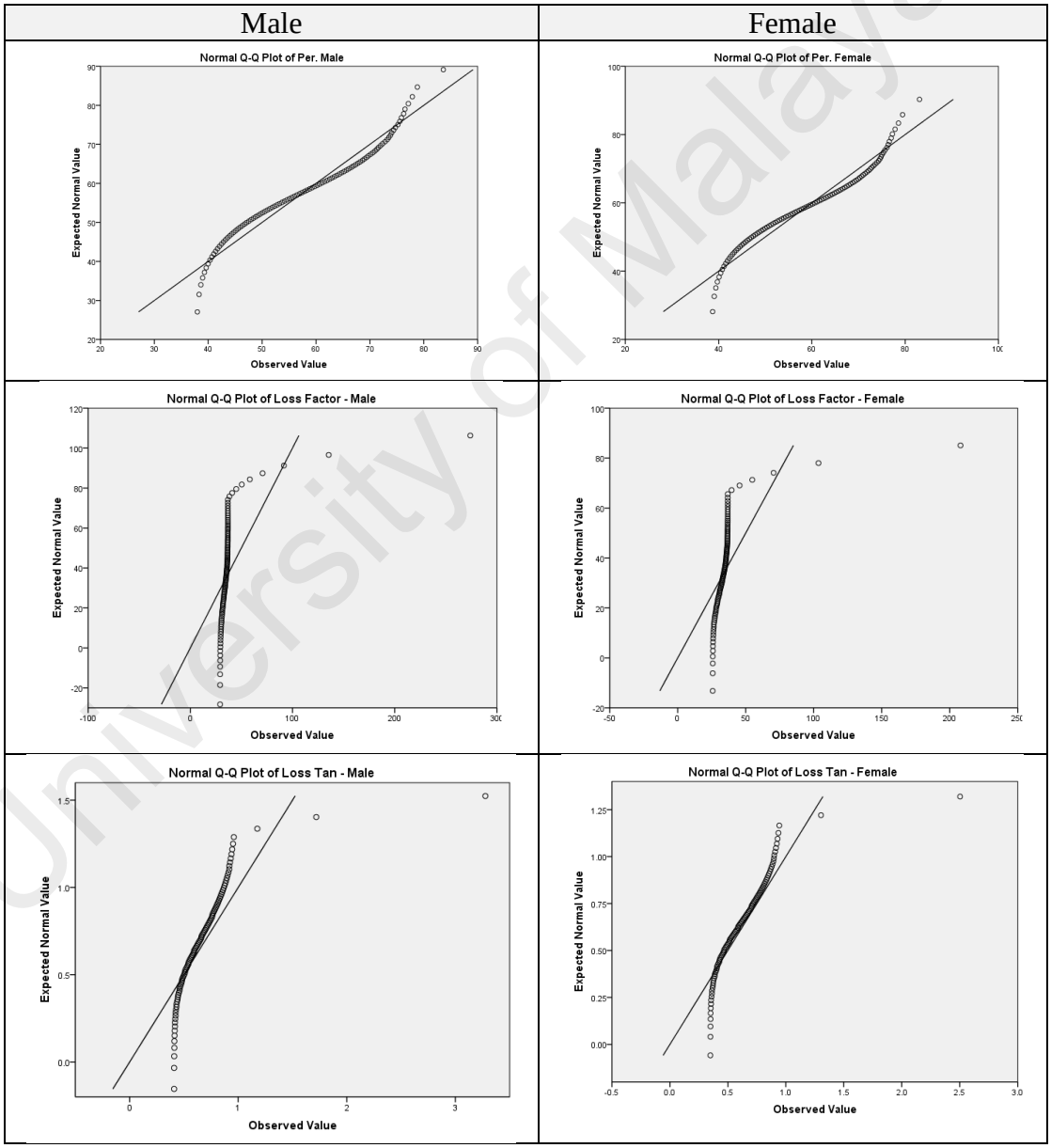


Figure 4.2: Results of the Q-Q normal plot on the permittivity (e'), loss factor (e''), and loss tangent values between males and females

Table 4.2 shows the results of the Q-Q normal plot on the permittivity (e'), loss factor (e''), and loss tangent values between males and females. The two data sets are normally distributed except for Loss Factor of males and females, which is slightly skewed to the left. The two data sets are independent as they were collected from different independent males and females subjects.

4.5 Permittivity of Urine between Males and Females

In this study, the experiment conducted for 60 urine samples from 30 males and 30 females, normal people. There are two categories of data, males and females. Each category includes three variables, Permittivity, Loss Factor, and Loss Tangent.

Figure 4.3 and Figure 4.4 show the results of the experiment on the permittivity of urine of the 10 out of 30 males and females samples, respectively. In the most of cases, the starting points are between 75 and 90 and the end points are between 35 and 45 (for males and females) within frequency between 20MHz to 20GHz.

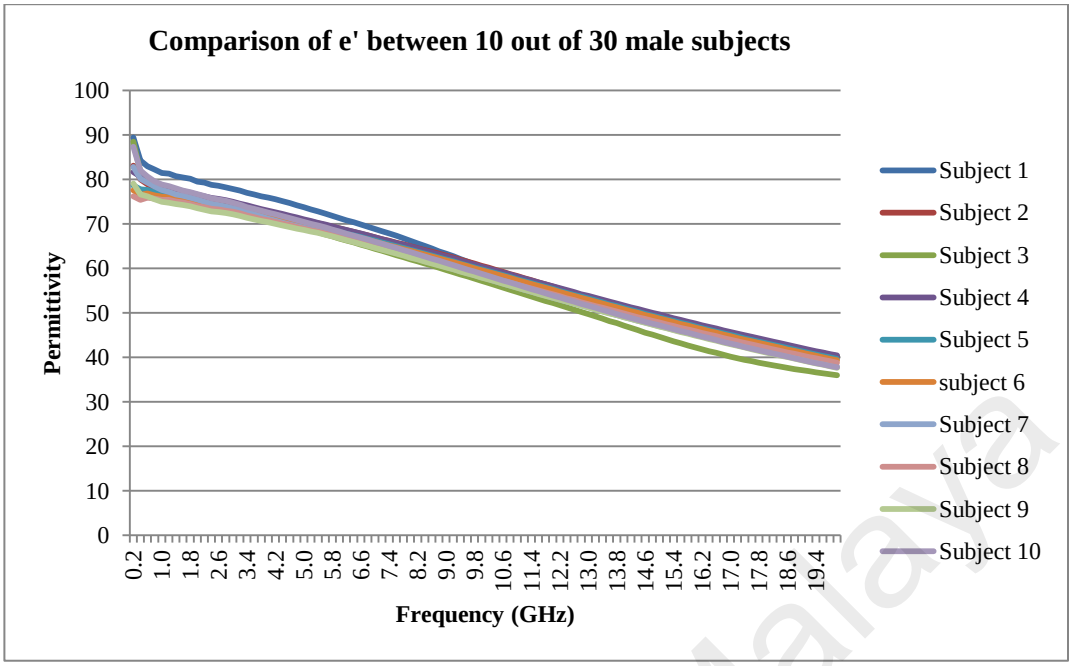


Figure 4.3: Comparison of the permittivity values of urine of 10 out of 30 samples (males)

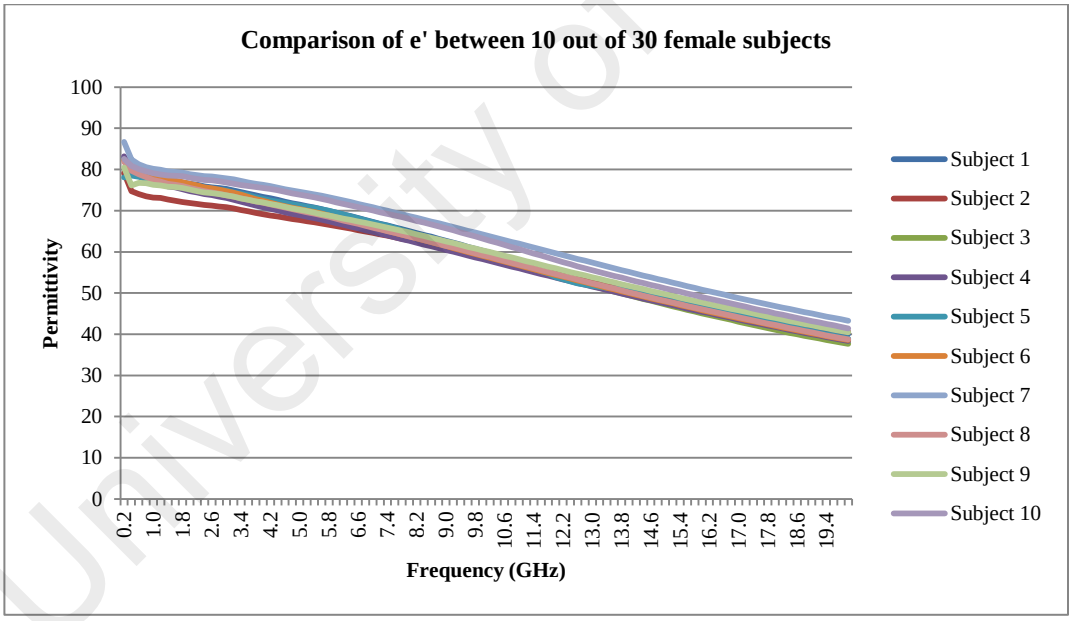


Figure 4.4: Comparison of the permittivity values of urine of 30 samples (females)

4.6 Average of Permittivity of Urine between Males and Females

Figure 4.5 shows the results of the experiment on the permittivity of urine of the 30 males and females, respectively. In this case, the starting points are between 80 and 85 and the end pints are between 35 and 40 (for males and females) within frequency between 20MHz to 20GHz. The figure shows the average permittivity of urine in females is greater than the average permittivity of urine in males.

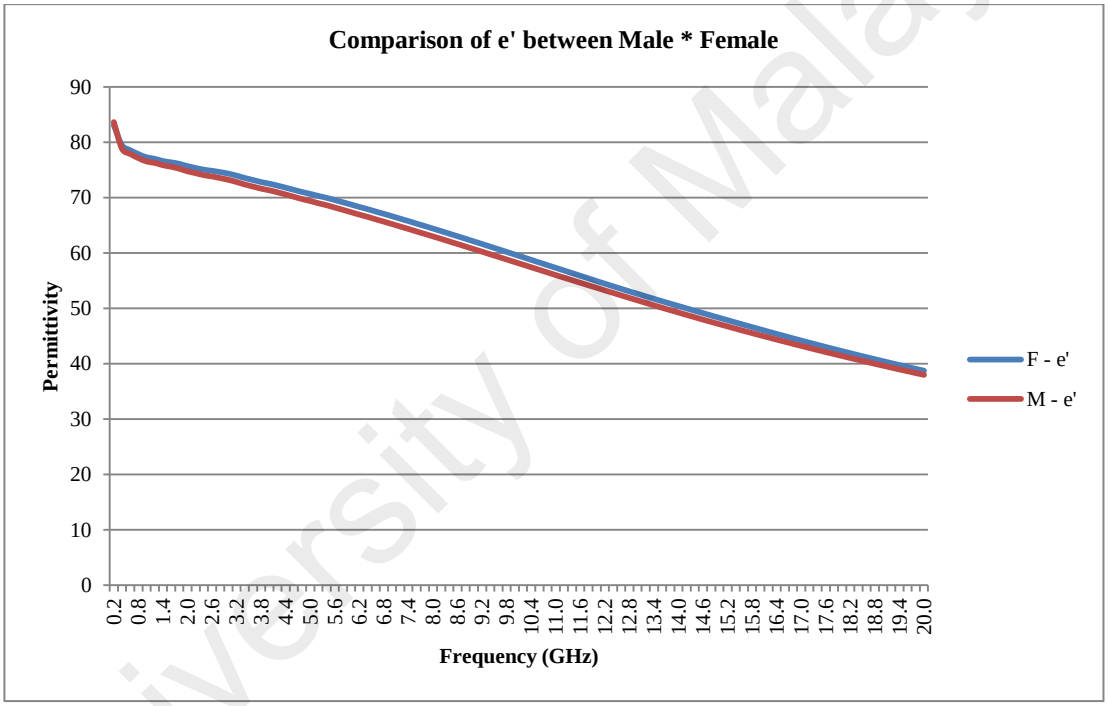


Figure 4.5: Comparison of the average permittivity values of urine between males and females

4.7 Loss Factor Values Between Males and Females

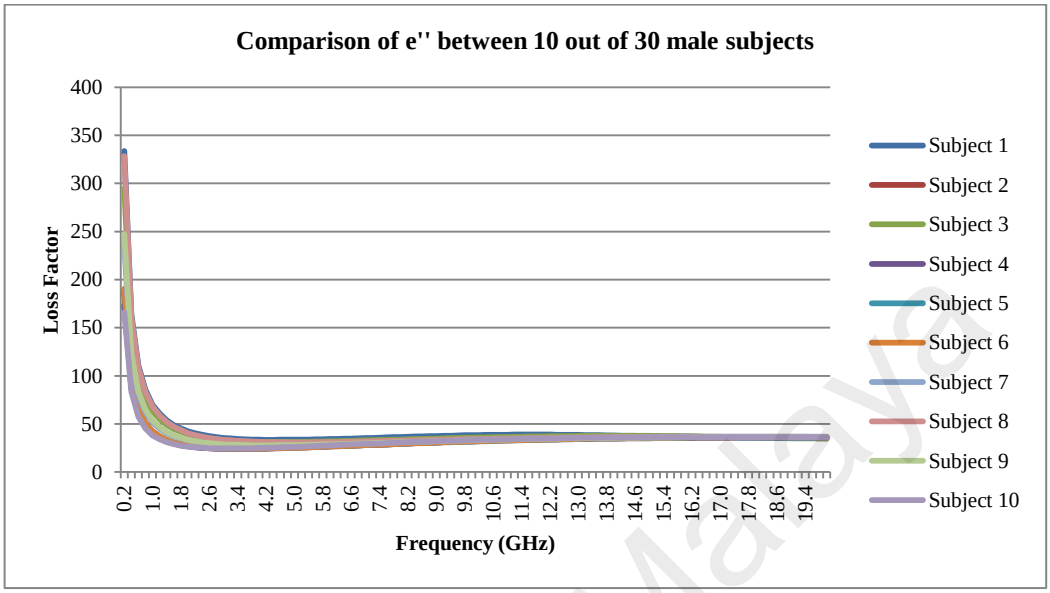


Figure 4.6 and Figure 4.7 show the results of the experiment on the loss factor of urine of the 10 out of 30 males and females samples, respectively. In the most of cases, the starting points are between 120 and 330 and the end pints are around 20 (for males and females) within frequency between 20MHz to 20GHz.

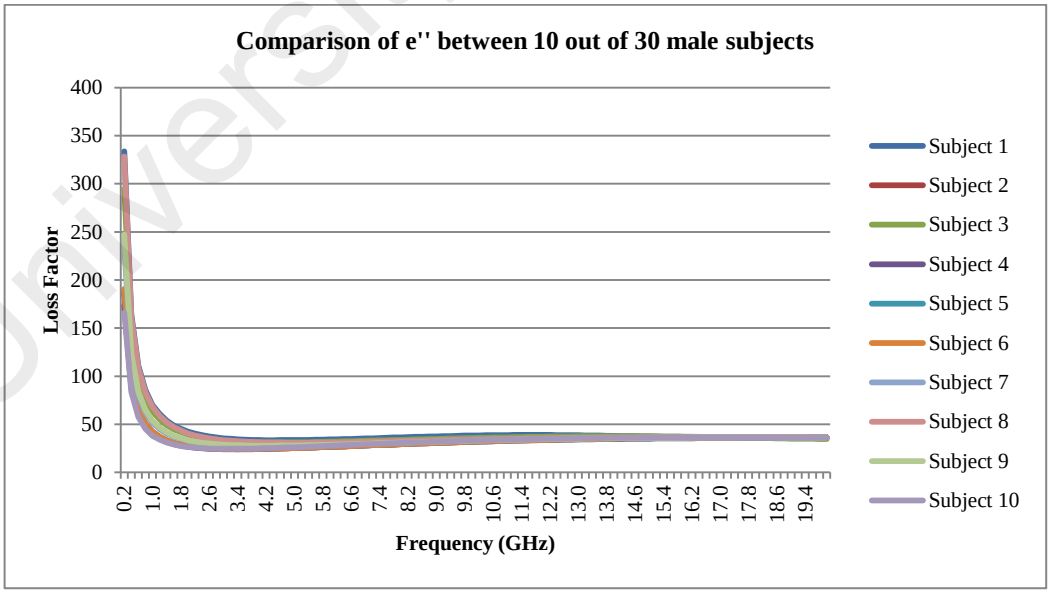


Figure 4.6: Comparison of the loss factor values of urine of 10 out of 30 samples (males)

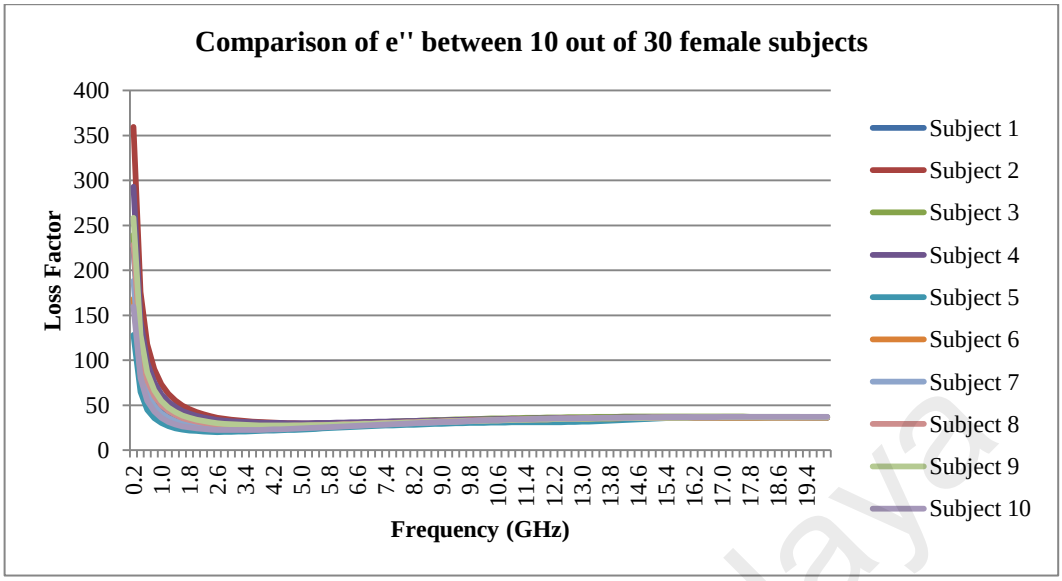


Figure 4.7: Comparison of the loss factor values of urine of 10 out of 30 samples (females)

4.8 Average of Loss Factor Values between Males and Females

Figure 4.8 shows the results of the experiment on the average loss factor of urine of the 30 males and females, respectively. In this case, the starting points are between 200 and 280 and the end points are around 20 (for males and females) within frequency between 20MHz to 20GHz. The figure shows the average loss factor values of urine in males is greater than the average loss factor values of urine in females.

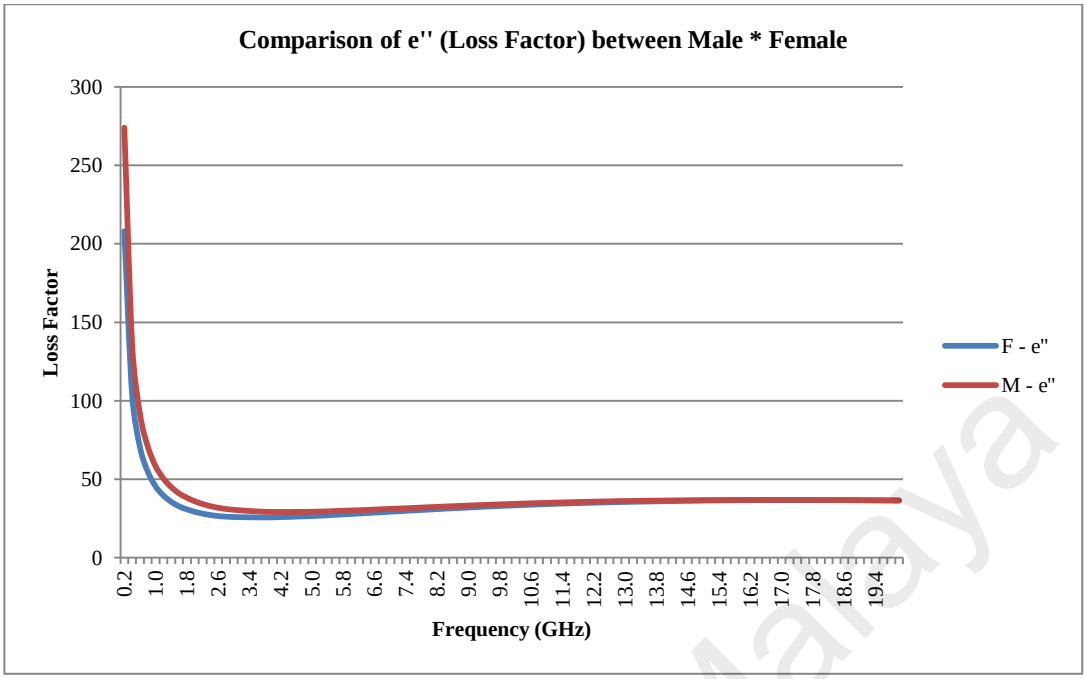


Figure 4.8: Comparison of the average loss factor values of urine between males and females

4.9 Loss Tangent Values Between Males and Females

Figure 4.9 and Figure 4.10 show the results of the experiment on the loss tangent of urine of the 10 out of 30 males and females samples, respectively. In the most of cases, the starting points are between 1.5 and 4.7 and the end pints are between 0.2 and 1 (for males and females) within frequency between 20MHz to 20GHz.

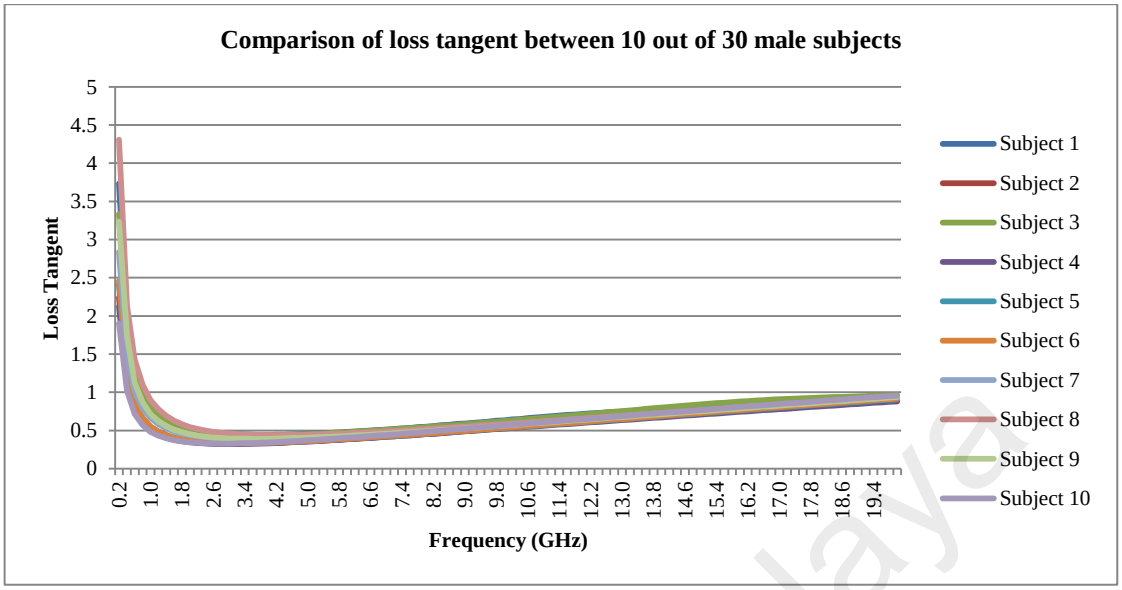


Figure 4.9: Comparison of the loss tangent values of urine of 10 out of 30 samples (males)

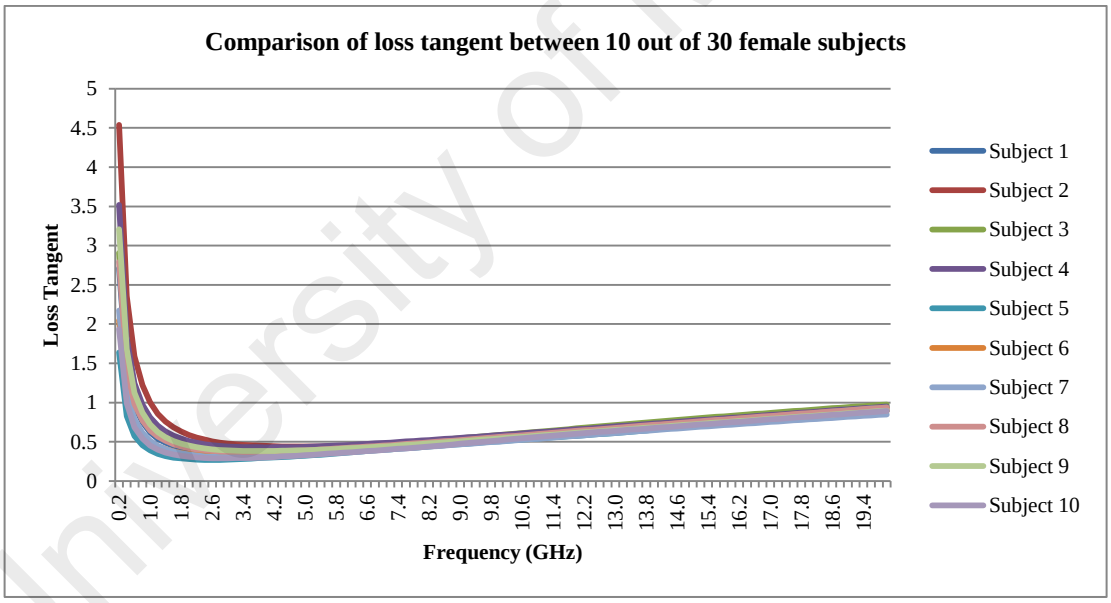


Figure 4.10: Comparison of the loss tangent values of urine of 10 out of 30 samples (females)

4.10 Average of Loss Tangent Values Between Males and Females

Figure 4.11 shows the results of the experiment on the loss tangent urine of the 30 males and females, respectively. In this case, the starting points are between 2.5 and 3.4 and the

end pints are between 0.3 and 1 (for males and females) within frequency between 20MHz to 20GHz. The figure shows the average loss tangent values of urine in males is greater than the average loss factor values of urine in females.

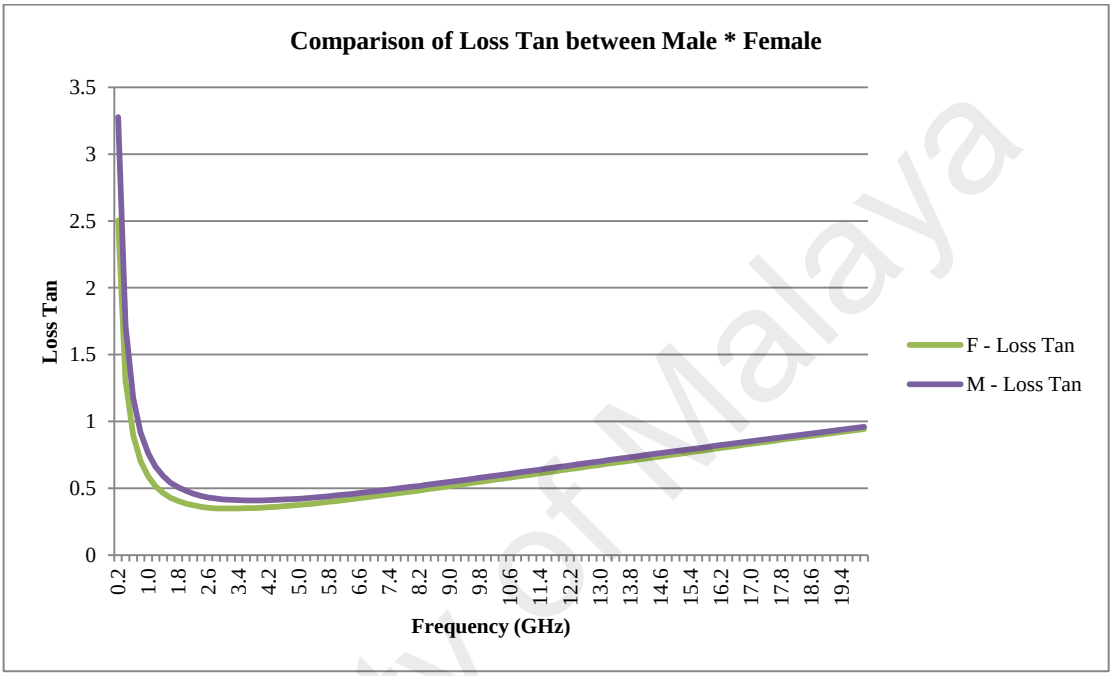


Figure 4.11: Comparison of the average loss tangent values of urine between males and females

4.11 Statistical Analysis Results

As two independent groups of people were taken part in this study, the independent t-test was used to find significant differences of permittivity, loss factor, and loss tangent of urine between two groups, male and female. The range of frequency used in this study ranges from 20MHz to 20GHz. The best method for analysis of result is applying t-test in each point of frequency, which starts from 20 MHz to 20 GHz through step 0.2. Also, the alpha value was set to 0.05.

Table 4.3 shows the descriptive analysis of permittivity (e'), loss factor (LF), and loss tangent (LT) in 20 MHz (0.2GHz) frequency for males and females. There are 60 urine samples (30 males and 30 females) in each category. Also, the maximum, minimum, mean, and standard deviation between males and females are presented in this figure.

Table 4.3: Descriptive statistics of permittivity, loss factor, and loss tangent in 20MHz frequency

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Data e' 0.2 - MF	60	74.80	91.99	83.3469	.52274	4.04915
Data LF 0.2 - MF	60	86.13	388.57	240.9638	8.86711	68.68435
Data LT 0.2- MF	60	1.05	5.11	2.8993	.11082	.85838

Table 4.4 shows the descriptive statistics of permittivity, loss factor, and loss tangent between male and female groups (30 subjects in each group) in 20MHz frequency. This table shows there is no significant difference between mean of males and females in terms of permittivity values in 0.2GHz frequency. However, there are significant differences between mean of males and females in terms of loss factor and loss tangent values in 0.2GHz frequency.

Table 4.4: Descriptive statistics of permittivity, loss factor, and loss tangent between male and female groups in 20MHz frequency

	Group	N	Mean	Std. Deviation	Std. Error Mean
Data e' 0.2 - MF	Male	30	83.6281	4.89801	.89425
	Female	30	83.0657	3.03355	.55385

Data LF 0.2 - MF	Male	30	273.9810	64.18124	11.71784
	Female	30	207.9467	56.77215	10.36513
Data LT 0.2- MF	Male	30	3.2909	.82583	.15077
	Female	30	2.5078	.70698	.12908

Table 4.5 shows the independent t-test result for permittivity, loss factor, and loss tangent in 0.2GHz frequency. The results show that there is no significant deference between males and females in terms of permittivity in 0.2GHz frequency, as the Sig. Value (P-value) > 0.05 (Sig. value = 0.595). However, there are significant differences between males and females in terms of loss factor and loss tangent in 0.2GHz frequency, as the Sig. value < 0.05 (Sig. value = 0.00).

Table 4.5: Independent t-test in 0.2GHz frequency

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data e' 0.2 - MF	Equal variances assumed	11.902	.001	.535	58	.595	.56241	1.05187	-1.54313	2.66796
	Equal variances not assumed			.535	48.394	.595	.56241	1.05187	-1.55207	2.67690
Data LF 0.2 - MF	Equal variances assumed	1.497	.226	4.221	58	.000	66.03428	15.64428	34.71884	97.34972
	Equal variances not assumed			4.221	57.149	.000	66.03428	15.64428	34.70891	97.35965

Data LT 0.2-MF	Equal variances assumed	1.287	.261	3.946	58	.000	.78316	.19848	.38586	1.18045
	Equal variances not assumed			3.946	56.654	.000	.78316	.19848	.38566	1.18065

The same method (independent t-test) applied to the other frequency ranges. The complete results of independent t-test of permittivity, loss factor, and loss tangent in all the ranges (0.2GHz to 20GHz) are available in APPENDIX B.

The results show that there is no significant deference between males and females in terms of permittivity from 0.2GHz to 1.4GHz frequencies, as the Sig. Value (P-value) > 0.05. Also, in terms of loss factor and loss tangent still significant differences exist. However, the Sig. Value becomes less than 0.05 (Sig. value = 0.048) in 1.6GHz frequency, as shown in Table 4.6. If the Sig. Value is less than 0.05, it means that there is significant difference between males and females in terms of permittivity. In this frequency, loss factor and loss tangent still show significant differences.

Table 4.6: Independent t-test in 1.6GHz frequency

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data e' 1.6 - MF	Equal variances assumed	1.026	.315	-2.020	58	.048	-.79253	.39234	-1.57788	-.00717

	Equal variances not assumed			-2.020	55.046	.048	-.79253	.39234	-1.57878	-.00627
Data LF 1.6 - MF	Equal variances assumed	1.465	.231	4.444	58	.000	8.22840	1.85165	4.52193	11.93487
	Equal variances not assumed			4.444	57.212	.000	8.22840	1.85165	4.52084	11.93596
Data LT 1.6- MF	Equal variances assumed	1.243	.269	4.392	58	.000	.11322	.02578	.06162	.16482
	Equal variances not assumed			4.392	57.376	.000	.11322	.02578	.06161	.16483

From 1.6GHz to 14.0GHz, permittivity, loss factor, and loss tangent show the significant differences between males and females. In 14.2GHz frequency, the Sig. Value of loss factor becomes greater than 0.05 (Sig. value = 0.051), as shown in Table 4.7. If the Sig. Value is greater than 0.05, it means that there is no significant difference between males and females in terms of loss factor. In this frequency, permittivity and loss tangent still show significant differences between males and females.

Table 4.7: Independent t-test in 14.2GHz frequency

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data e' 14.2 - MF	Equal variances assumed	.000	.986	-3.696	58	.000	-1.18022	.31929	-1.81935	-.54110

	Equal variances not assumed			-3.696	57.246	.000	-1.18022	.31929	-1.81953	-.54092
Data LF 14.2 - MF	Equal variances assumed	.597	.443	1.995	58	.051	.40481	.20296	-.00145	.81108
	Equal variances not assumed			1.995	57.937	.051	.40481	.20296	-.00146	.81109
Data LT 14.2- MF	Equal variances assumed	.553	.460	3.557	58	.001	.02578	.00725	.01127	.04029
	Equal variances not assumed			3.557	57.765	.001	.02578	.00725	.01127	.04029

From 14.2GHz to 19.2GHz, permittivity and loss tangent show the significant differences between males and females. However, loss factor shows insignificant deference between males and females in the same frequencies. In 19.4GHz frequency, the Sig. Value of loss tangent becomes greater than 0.05 (Sig. value = 0.052), as shown in Table 4.8. If the Sig. Value is greater than 0.05, it means that there is no significant difference between males and females in terms of loss tangent. In this frequency, permittivity still shows significant differences, however, loss factor shows insignificant deference between males and females.

Table 4.8:Independent t-test in 19.4GHz frequency

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data e' 19.4 - MF	Equal variances assumed	.004	.951	-2.383	58	.020	-.78420	.32902	-1.44281	-.12560
	Equal variances not assumed			-2.383	57.391	.020	-.78420	.32902	-1.44296	-.12545
Data LF 19.4 - MF	Equal variances assumed	5.307	.025	-.985	58	.329	-.09768	.09913	-.29610	.10074
	Equal variances not assumed			-.985	43.851	.330	-.09768	.09913	-.29747	.10212
Data LT 19.4- MF	Equal variances assumed	.094	.761	1.983	58	.052	.01589	.00802	-.00015	.03194
	Equal variances not assumed			1.983	57.974	.052	.01589	.00802	-.00015	.03194

From 19.4GHz to 20GHz, the permittivity values show significant differences between males and females, as the Sig. value is less than 0.05. However, the loss factor and loss tangent values show insignificant differences between males and females, as the Sig. value is greater than 0.05.

Table 4.9 shows the results of independent t-test for permittivity, loss factor, and loss tangent from 0.2GHz to 20GHz frequencies.

Table 4.9: Results of independent t-test for permittivity, loss factor, and loss tangent from 0.2GHz to 20GHz frequencies

			Independent Sample T-Test			
Frequency (GHz)	e'		Loss Factor		Loss Tan.	
	T Value	(Sig. Value)	T Value	(Sig. Value)	T Value	(Sig. Value)
0.2	0.535	0.595	4.221	0.000	3.946	0.000
0.4	-1.060	0.293	4.244	0.000	4.143	0.000
0.6	-1.420	0.161	4.269	0.000	4.176	0.000
0.8	-1.590	0.117	4.309	0.000	4.225	0.000
1.0	-1.785	0.080	4.346	0.000	4.278	0.000
1.2	-1.814	0.075	4.376	0.000	4.317	0.000
1.4	-1.904	0.062	4.409	0.000	4.350	0.000
1.6	-2.020	0.048	4.444	0.000	4.392	0.000
1.8	-2.233	0.029	4.495	0.000	4.454	0.000
2.0	-2.399	0.020	4.526	0.000	4.503	0.000
2.2	-2.436	0.018	4.541	0.000	4.530	0.000
2.4	-2.571	0.013	4.571	0.000	4.571	0.000
2.6	-2.671	0.010	4.595	0.000	5.857	0.000
2.8	-2.828	0.006	4.609	0.000	4.641	0.000
3.0	-2.941	0.005	4.619	0.000	4.670	0.000
3.2	-2.998	0.004	4.622	0.000	4.691	0.000
3.4	-3.093	0.003	4.612	0.000	4.696	0.000
3.6	-3.107	0.003	4.612	0.000	4.704	0.000
3.8	-3.132	0.003	4.621	0.000	4.719	0.000
4.0	-3.132	0.003	4.636	0.000	4.745	0.000
4.2	-3.158	0.003	4.661	0.000	4.786	0.000
4.4	-3.201	0.002	4.686	0.000	4.830	0.000
4.6	-3.274	0.002	4.716	0.000	4.888	0.000
4.8	-3.381	0.001	4.721	0.000	4.926	0.000
5.0	-3.453	0.001	4.721	0.000	4.960	0.000
5.2	-3.545	0.001	4.741	0.000	4.984	0.000
5.4	-3.607	0.001	4.699	0.000	5.003	0.000
5.6	-3.697	0.000	4.679	0.000	5.024	0.000
5.8	-3.760	0.000	4.652	0.000	5.031	0.000
6.0	-3.820	0.000	4.614	0.000	5.035	0.000
6.2	-3.876	0.000	4.576	0.000	5.032	0.000
6.4	-3.896	0.000	4.531	0.000	5.024	0.000
6.6	-3.941	0.000	4.482	0.000	5.015	0.000
6.8	-3.969	0.000	4.422	0.000	4.997	0.000

7.0	-3.990	0.000	4.365	0.000	4.981	0.000
7.2	-4.015	0.000	4.291	0.000	4.950	0.000
7.4	-4.024	0.000	4.227	0.000	4.927	0.000
7.6	-4.036	0.000	4.161	0.000	4.900	0.000
7.8	-4.050	0.000	4.081	0.000	4.869	0.000
8.0	-4.058	0.000	4.011	0.000	4.836	0.000
8.2	-4.063	0.000	3.925	0.000	4.793	0.000
8.4	-4.083	0.000	3.855	0.000	4.766	0.000
8.6	-4.094	0.000	3.782	0.000	4.733	0.000
8.8	-4.113	0.000	3.693	0.000	4.692	0.000
9.0	-4.119	0.000	3.624	0.001	4.660	0.000
9.2	-4.117	0.000	3.537	0.001	4610	0.000
9.4	-4.130	0.000	3.460	0.001	4.572	0.000
9.6	-4.132	0.000	3.381	0.001	4.529	0.000
9.8	-4.135	0.000	3.305	0.002	4.485	0.000
10.0	-4.126	0.000	3.242	0.002	4.460	0.000
10.2	-4.119	0.000	3.165	0.002	4.407	0.000
10.4	-4.104	0.000	3.088	0.003	4.356	0.000
10.6	-4.088	0.000	3.026	0.004	4.311	0.000
10.8	-4.072	0.000	2.963	0.004	4.271	0.000
11.0	-4.065	0.000	2.878	0.006	4.214	0.000
11.2	-4.032	0.000	2.810	0.007	4.155	0.000
11.4	-3.992	0.000	2.743	0.008	4.105	0.000
11.6	-3.973	0.000	2.679	0.010	4.058	0.000
11.8	-3.922	0.000	2.609	0.012	3.998	0.000
12.0	-3.822	0.000	2.552	0.013	3.946	0.000
12.2	-3.798	0.000	2.498	0.015	3.910	0.000
12.4	-3.758	0.000	2.447	0.017	3.873	0.000
12.6	-3.738	0.000	2.402	0.020	3.837	0.000
12.8	-3.727	0.021	2.373	0.021	3.819	0.000
13.0	-3.718	0.000	2.339	0.023	3.789	0.000
13.2	-3.730	0.000	2.293	0.025	3.759	0.000
13.4	-3.727	0.000	2.259	0.028	3.730	0.000
13.6	-3.722	0.000	2.196	0.032	3.679	0.001
13.8	-3.727	0.000	2.132	0.037	3.647	0.001
14.0	-3.714	0.000	2.056	0.044	3.593	0.001
14.2	-3.696	0.000	1.995	0.051	3.557	0.001
14.4	-3.656	0.001	1.902	0.062	3.493	0.001
14.6	-3.637	0.001	1.793	0.078	3.443	0.001
14.8	-3.577	0.001	1.662	0.102	3.354	0.001
15.0	-3.534	0.001	1.551	0.126	3.283	0.002

15.2	-3.474	0.001	1.379	0.173	3.187	0.002
15.4	-3.419	0.001	1.253	0.215	3.107	0.003
15.6	-3.370	0.001	1.125	0.265	3.031	0.004
15.8	-3.301	0.002	0.974	0.334	2.937	0.005
16.0	-3.247	0.002	0.809	0.422	2.854	0.006
16.2	-3.165	0.002	0.668	0.507	2.760	0.008
16.4	-3.113	0.003	0.529	0.599	2.692	0.009
16.6	-3.056	0.003	0.372	0.711	2.620	0.011
16.8	-2.982	0.004	0.243	0.809	2.539	0.014
17.0	-2.913	0.005	0.097	0.923	2.467	0.017
17.2	-2.854	0.006	-0.017	0.986	2.409	0.019
17.4	-2.806	0.007	-0.128	0.898	2.358	0.022
17.6	-2.751	0.008	-0.229	0.819	2.314	0.024
17.8	-2.683	0.009	-0.346	0.731	2.248	0.028
18.0	-2.639	0.011	-0.439	0.662	2.206	0.031
18.2	-2.606	0.012	-0.543	0.589	2.181	0.033
18.4	-2.533	0.014	-0.640	0.525	2.104	0.040
18.6	-2.528	0.014	-0.722	0.473	2.100	0.040
18.8	-2.497	0.015	-0.742	0.461	2.091	0.041
19.0	-2.471	0.016	-0.865	0.391	2.054	0.044
19.2	-2.426	0.018	-0.923	0.360	2.016	0.048
19.4	-2.383	0.020	-0.985	0.329	1.983	0.052
19.6	-2.356	0.022	-1.094	0.278	1.934	0.058
19.8	-2.338	0.023	-1.117	0.269	1.933	0.058
20.0	-2.297	0.025	-1.163	0.250	1.889	0.064

Green (underlined values) = Significant deference between male and female (Sig. value < 0.05)
Red = No Significant deference between male and female (Sig. value ≥ 0.05)

The results of independent t-test for permittivity shows that the Sig. value from 0.2GHz to 1.4GHz is greater than 0.05, which indicates that there are insignificant differences in permittivity between males and females in this range. In this table, insignificant differences (Sig. value ≥ 0.05) highlighted by green colour and significant differences (Sig. value < 0.05) highlighted by red colour. Also, it shows significant differences in permittivity between males and females from 1.6GHz to 20GHz frequencies.

The results of t-test for the loss factor show that the Sig. value from 0.2GHz to 14.0GHz is less than 0.05, which indicates that there are insignificant differences in loss factor between males and females in this range. Also, it shows insignificant differences in loss factor between males and females from 14.2GHz to 20GHz frequencies.

The results of t-test for the loss tangent show that the Sig. value from 0.2GHz to 19.2GHz is less than 0.05, which indicates that there are insignificant differences in loss tangent between males and females in this range. Also, it shows insignificant differences in loss factor between males and females from 19.4GHz to 20GHz frequencies.

4.12 Statistical Analysis Using Correlation

As 60 samples were collected from male and female subjects in different ages, heights, weights, and so on, therefore, it is necessary to analyze the relationship among these factors and the permittivity, loss factor, and loss tangent. This section presents the correlation among these factors to find out if any significant relationship exists among them.

In SPSS, Bivariate correlation test is used to determine the relationship between two variables. In this research, permittivity and age for males and females groups, was used in the correlation test. The correlation tests were conducted on 30 males and females subjects. The Pearson Correlation and Significant Value in each frequency were insignificant in this study. Table 4.10 shows the top ten highest values of the Pearson correlation coefficients between permittivity and age in males and females in different frequency points. The Pearson Correlation values in all the frequency points (from 0.2GHz to 20GHz) are not

close to 0.8 and higher in males and females group. It indicates that there is a weak relationship between permittivity and age in male and female groups. Also, the Sig. Values are greater than 0.05 in all the frequencies, which indicates that there is no significant difference between permittivity and age in male and female groups.

Table 4.10: Correlation between permittivity and age in males and females groups

Frequency (GHz)	Male (e')		Female (Age)	
	Pearson Correlation	Sig. Value	Pearson Correlation	Sig. Value
20.0	0.295	0.114	0.199	0.293
19.8	0.297	0.111	0.198	0.294
19.6	0.295	0.114	0.197	0.298
19.4	0.295	0.113	0.196	0.300
19.2	0.293	0.116	0.197	0.296
19.0	0.292	0.117	0.199	0.292
18.8	0.290	0.119	0.202	0.288
18.6	0.289	0.123	0.201	0.287
18.4	0.288	0.125	0.198	0.285
18.2	0.285	0.128	0.196	0.282

4.13 Classification of the Gender using Permittivity of Urine

I this section, the classification of the gender using permittivity of urine, comparison of the dielectric constant, loss factor, and loss tangent based on optimal accuracy and threshold values in different frequency points are discussed.

Table 4.11 shows the threshold values of permittivity (dielectric constant, loss factor, loss tangent) in different frequency points. Based on these data the maximum rate of gender classification can be obtained. In this table threshold values are calculated based on the average of permittivity, loss factor, and less tangent between males and females in all the frequency points. Also, the optimal accuracy is calculated based on the number of successful detection (males or females) in each frequency point.

Table 4.11: Comparison of the dielectric constant, loss factor, and loss tangent based on optimal accuracy and threshold in different frequency points

	Dielectric Constant				Loss Factor				Loss Tangent			
Frequency (GHz)	Success rate		Optimal Accuracy (%)	Threshold	Success rate		Optimal Accuracy (%)	Threshold	Success rate		Optimal Accuracy	Threshold
	Male	Female			Male	Female			Male	Female		
0.2	16	14	50.00	83.3469	21	25	76.67	240.96	20	24	73.33	2.8898
0.4	14	18	53.33	79.1216	21	25	76.67	119.47	21	24	75.00	1.5108
0.6	16	19	58.33	78.2195	21	25	76.67	81.02	21	24	75.00	1.0364
0.8	20	19	65.00	77.4832	21	25	76.67	62.79	21	24	75.00	0.8109
1.0	19	20	65.00	76.8935	21	25	76.67	51.85	21	24	75.00	0.6747
1.2	19	18	61.67	76.6258	22	25	78.33	45.01	21	24	75.00	0.5878
1.4	19	18	61.67	76.2149	22	25	78.33	40.29	21	24	75.00	0.5290
1.6	19	18	61.67	75.9563	22	24	76.67	36.84	22	24	76.67	0.4853
1.8	20	18	63.33	75.6504	23	24	78.33	34.55	22	25	78.33	0.4570
2.0	21	18	65.00	75.1989	23	23	76.67	32.62	22	25	78.33	0.4341

2.2	21	18	65.00	74.8721	23	23	76.67	31.20	22	25	78.33	0.4170
2.4	21	18	65.00	74.5356	23	23	76.67	30.04	22	25	78.33	0.4034
2.6	22	18	66.67	74.3191	23	23	76.67	29.19	23	25	80.00	0.3931
2.8	22	18	66.67	74.0539	23	23	76.67	28.64	23	25	80.00	0.3870
3.0	22	18	66.67	73.7590	23	23	76.67	28.23	23	25	80.00	0.3830
3.2	22	20	70.00	73.3790	23	23	76.67	28.02	23	25	80.00	0.3821
3.4	22	20	70.00	72.9478	23	23	76.67	27.77	23	23	76.67	0.3810
3.6	22	20	70.00	72.5815	23	23	76.67	27.62	23	23	76.67	0.3808
3.8	21	21	70.00	72.2014	23	23	76.67	27.50	23	23	76.67	0.3811
4.0	21	22	71.67	71.9018	23	23	76.67	27.46	23	24	78.33	0.3821
4.2	22	22	73.33	71.5466	22	24	76.67	27.54	23	24	78.33	0.3851
4.4	22	22	73.33	71.1700	22	24	76.67	27.61	23	24	78.33	0.3881
4.6	22	21	71.67	70.7646	22	24	76.67	27.73	23	24	78.33	0.3921
4.8	22	21	71.67	70.3616	22	24	76.67	27.81	23	24	78.33	0.3955
5.0	22	21	71.67	70.0166	22	24	76.67	27.94	23	24	78.33	0.3993
5.2	22	22	73.33	69.6309	22	24	76.67	28.12	23	24	78.33	0.4041
5.4	22	22	73.33	69.2819	21	24	75.00	28.31	23	24	78.33	0.4088
5.6	22	23	75.00	68.8683	21	24	75.00	28.56	23	24	78.33	0.4150
5.8	22	23	75.00	68.4574	22	24	76.67	28.78	23	24	78.33	0.4206
6.0	22	23	75.00	68.0391	22	24	76.67	29.03	23	24	78.33	0.4268
6.2	22	24	76.67	67.6082	22	24	76.67	29.25	23	24	78.33	0.4329
6.4	21	23	73.33	67.2107	22	24	76.67	29.49	23	24	78.33	0.4390
6.6	21	23	73.33	66.7691	22	24	76.67	29.74	23	24	78.33	0.4456
6.8	21	23	73.33	66.3488	22	24	76.67	29.98	22	24	76.67	0.4521
7.0	21	22	71.67	65.9145	22	24	76.67	30.24	22	24	76.67	0.4590
7.2	21	22	71.67	65.4665	22	24	76.67	30.47	22	23	75.00	0.4657
7.4	21	22	71.67	65.0337	22	24	76.67	30.73	22	23	75.00	0.4728
7.6	21	23	73.33	64.5756	21	24	75.00	30.97	23	23	76.67	0.4798
7.8	22	23	75.00	64.1357	20	24	73.33	31.22	23	23	76.67	0.4870
8.0	22	23	75.00	63.6811	20	24	73.33	31.48	23	24	78.33	0.4945
8.2	22	23	75.00	63.2322	20	24	73.33	31.71	23	24	78.33	0.5016
8.4	22	23	75.00	62.7677	20	24	73.33	31.97	23	24	78.33	0.5095
8.6	22	23	75.00	62.3075	20	24	73.33	32.19	23	24	78.33	0.5169
8.8	22	23	75.00	61.8462	20	24	73.33	32.43	23	24	78.33	0.5245
9.0	22	23	75.00	61.3707	20	25	75.00	32.66	23	24	78.33	0.5324
9.2	22	23	75.00	60.9138	20	25	75.00	32.87	23	24	78.33	0.5398
9.4	22	23	75.00	60.4355	20	24	73.33	33.09	23	24	78.33	0.5477
9.6	23	23	76.67	59.9675	20	24	73.33	33.30	23	24	78.33	0.5555
9.8	23	23	76.67	59.4975	20	24	73.33	33.51	23	25	80.00	0.5633
10.0	23	24	78.33	59.0188	20	24	73.33	33.70	23	25	80.00	0.5711
10.2	23	24	78.33	58.5558	20	24	73.33	33.89	23	25	80.00	0.5790

10.4	23	24	78.33	58.0719	20	24	73.33	34.07	23	25	80.00	0.5869
10.6	23	24	78.33	57.6016	20	24	73.33	34.26	23	24	78.33	0.5949
10.8	23	25	80.00	57.1267	20	24	73.33	34.43	23	24	78.33	0.6028
11.0	23	25	80.00	56.6508	20	24	73.33	34.59	23	24	78.33	0.6107
11.2	23	25	80.00	56.1797	20	24	73.33	34.75	23	24	78.33	0.6187
11.4	23	25	80.00	55.7094	20	24	73.33	34.89	23	24	78.33	0.6264
11.6	23	25	80.00	55.2405	20	24	73.33	35.03	23	24	78.33	0.6343
11.8	23	23	76.67	54.7724	20	24	73.33	35.17	23	24	78.33	0.6422
12.0	24	23	78.33	54.3043	20	25	75.00	35.28	23	24	78.33	0.6499
12.2	24	23	78.33	53.8362	20	25	75.00	35.42	23	24	78.33	0.6580
12.4	24	23	78.33	53.3768	20	25	75.00	35.53	23	24	78.33	0.6658
12.6	24	23	78.33	52.9183	20	25	75.00	35.64	23	24	78.33	0.6737
12.8	24	22	76.67	52.4617	20	25	75.00	35.75	23	24	78.33	0.6815
13.0	24	22	76.67	52.0154	20	24	73.33	35.85	23	24	78.33	0.6893
13.2	23	22	75.00	51.5628	20	23	71.67	35.94	23	25	80.00	0.6971
13.4	23	23	76.67	51.1215	20	23	71.67	36.02	23	25	80.00	0.7048
13.6	22	22	73.33	50.6808	21	21	70.00	36.10	23	24	78.33	0.7125
13.8	22	22	73.33	50.2465	21	21	70.00	36.18	24	23	78.33	0.7201
14.0	22	22	73.33	49.8183	21	21	70.00	36.25	24	22	76.67	0.7279
14.2	22	22	73.33	49.3868	20	22	70.00	36.32	23	22	75.00	0.7355
14.4	22	22	73.33	48.9627	20	22	70.00	36.38	23	22	75.00	0.7432
14.6	22	22	73.33	48.5348	20	22	70.00	36.44	23	22	75.00	0.7510
14.8	22	22	73.33	48.1161	19	22	68.33	36.50	23	22	75.00	0.7587
15.0	22	22	73.33	47.6965	19	22	68.33	36.55	24	21	75.00	0.7665
15.2	22	21	71.67	47.2856	19	22	68.33	36.59	23	21	73.33	0.7740
15.4	22	21	71.67	46.8679	19	21	66.67	36.64	23	21	73.33	0.7819
15.6	22	21	71.67	46.4557	19	21	66.67	36.67	23	21	73.33	0.7896
15.8	21	21	70.00	46.0531	19	21	66.67	36.70	23	21	73.33	0.7971
16.0	21	20	68.33	45.6462	19	20	65.00	36.73	22	21	71.67	0.8049
16.2	21	20	68.33	45.2501	19	20	65.00	36.76	22	21	71.67	0.8124
16.4	21	20	68.33	44.8533	18	20	63.33	36.77	22	19	68.33	0.8200
16.6	21	20	68.33	44.4614	18	19	61.67	36.79	22	20	70.00	0.8275
16.8	22	20	70.00	44.0692	16	19	58.33	36.80	22	18	66.67	0.8352
17.0	22	19	68.33	43.6846	16	19	58.33	36.80	22	19	68.33	0.8425
17.2	22	19	68.33	43.3008	16	19	58.33	36.80	21	19	66.67	0.8500
17.4	22	19	68.33	42.9233	15	18	55.00	36.80	21	19	66.67	0.8574
17.6	22	19	68.33	42.5469	15	16	51.67	36.79	21	19	66.67	0.8648
17.8	22	18	66.67	42.1777	15	14	48.33	36.78	21	18	65.00	0.8721
18.0	22	18	66.67	41.8143	14	13	45.00	36.77	21	18	65.00	0.8794
18.2	22	18	66.67	41.4467	14	12	43.33	36.75	21	17	63.33	0.8868
18.4	22	18	66.67	41.0897	13	13	43.33	36.73	21	15	60.00	0.8940

18.6	22	18	66.67	40.7356	13	12	41.67	36.71	21	16	61.67	0.9012
18.8	22	18	66.67	40.3796	13	12	41.67	36.69	21	15	60.00	0.9086
19.0	22	18	66.67	40.0357	13	11	40.00	36.66	21	15	60.00	0.9157
19.2	22	16	63.33	39.6876	13	11	40.00	36.62	21	15	60.00	0.9229
19.4	22	14	60.00	39.3452	14	11	41.67	36.59	21	14	58.33	0.9301
19.6	22	14	60.00	39.0134	14	10	40.00	36.55	21	13	56.67	0.9370
19.8	22	15	61.67	38.6780	14	11	41.67	36.51	21	13	56.67	0.9441
20.0	22	14	60.00	38.3456	14	11	41.67	36.48	21	13	56.67	0.9513

The confusion matrix is used to obtain the gender classification rate. The confusion matrix indicates:

- the number of males classified as male—successful gender identification
- the number of males classified as female—unsuccessful gender identification
- the number of females classified as female—successful gender identification
- the number of females classified as male—unsuccessful gender identification

The successful gender identification rate can be calculated through the number of successful gender identification divided by the number of samples in each category.

The best accuracy of dielectric constant obtained from the above table presented in Table 4.12. The best accuracy points are between 10.8GHz and 11.6GHz frequency points.

Table 4.12: Confusion matrix between males and females based on permittivity

	Successful/Unsuccessful Gender Identification		Accuracy
	Male	Female	
Male	23	7	76.66%
Female	5	25	83.34%
Average			80%

The best accuracy of loss factor obtained from the above table presented in Table 4.13 and Table 4.14. The best accuracy points are in 1.2GHz, 1.4GHz, and 1.8GHz frequency points.

Table 4.13 : Confusion matrix between males and females based on loss factor in 1.2GHz, 1.4GHz frequency points

	Successful/Unsuccessful Gender Identification		Accuracy
	Male	Female	
Male	22	8	73.33%
Female	5	25	83.34%
Average			78.33%

Table 4.14: Confusion matrix between males and females based on loss factor in 1.8GHz frequency point

	Successful/Unsuccessful Gender Identification		Accuracy
	Male	Female	
Male	23	7	76.66%
Female	6	24	80%
Average			78.33%

The best accuracy of loss tangent obtained from the above table presented in Table 4.15. The best accuracy points are between 2.6GHz and 3.2GHz, between 9.8GHz and 10.4GHz, 13.2GHz, and 13.4GHz frequency points.

Table 4.15 : Confusion matrix between males and females based on loss tangent

	Successful/Unsuccessful Gender Identification		Accuracy
	Male	Female	
Male	23	7	76.66%
Female	5	25	83.34%
Average			80%

CHAPTER 5: CONCLUSION

This chapter is organized into four sections. Section 5.1 summarizes the purpose of the research, the research method used. The limitations of the research are presented in section 5.2. Section 5.3 presents the conclusion of the research and focuses on the research findings and how they contribute to the area of gender identification. Section 5.4 proposes future studies that can be conducted in gender identification.

5.1 Summary of the Research

In this research, a new method for non-invasive gender identification was proposed. The permittivity, loss factor, and loss tangent of urine in males and females were studied at certain frequencies between 10MHz and 20GHz. The results show that there is a significant difference in permittivity between males and females. In this study, 60 subjects (30 males and females) were participated. The urine samples were collected from all the subjects through following steps:

- Informing the subjects of the urine collection procedure.
- Urinate into the urinal or toilet.
- Do not collect this urine.
- Wash your hands.
- Drink a large glass of water to urinate easily.
- Clean the area of your genitals.
- After a few seconds that the urine has flowed, Put urine into the urine cup and collect about 50 ml of the urine.

- Wash your hands.

The collected urine samples were analyzed through Network Analyzer. Data analysis was conducted based on permittivity, loss factor, and loss tangent using SPSS.

5.2 Problems Encountered and Research Limitations

Some of the limitations of the research and the problems encountered include:

- Difficulty in getting the cooperation from the subject in different races to participate in the study.
- Unable to verify the correctness of the urine collecting process from the subjects.
- Only 60 subjects (30 males and 30 females) were participated in this research. More subjects from different races are needed to evaluate the accuracy of this method.

5.3 Research Conclusion

In this research, a novel method for gender identification using permittivity of urine between males and females was investigated. Study on gender identification is one of the significant issues to find relationship between the different sexuality and disease pathogenesis. Urine is one of the human metabolite that consists of many characteristics of human body and indicates human body status to help the diagnosis and treat the particular disease. Urinalysis using Network Vector Analyzer can be used as the non-invasive, fast, and convenient method to recognize the human gender. Urine is sterile liquid and actually waste product of the human being body that is prepared by the kidneys. Study of non-

invasive, inexpensive, fast, and convenient gender identification methods is still one of the interesting approaches to identify the component of urine and seeking the good method for gender identification. This method can be used to discover a novel treatment method for faster recovery. These advances will enable us to learn more about disease pathogenesis, with the goal of offering better treatments. By measuring and analyzing the permittivity of urine of male and female, the significant differences was observed between these groups at particular range of frequency, which is from 10MHz to 20GHz.

The results of independent t-test for permittivity shows that the Sig. value from 0.2GHz to 1.4GHz is greater than 0.05, which indicates that there are insignificant differences in permittivity between males and females in this range.

The results of t-test for the loss factor show that the Sig. value from 0.2GHz to 14.0GHz is less than 0.05, which indicates that there are insignificant differences in loss factor between males and females in this range. Also, it shows insignificant differences in loss factor between males and females from 14.2GHz to 20GHz frequencies.

The results of t-test for the loss tangent show that the Sig. value from 0.2GHz to 19.2GHz is less than 0.05, which indicates that there are insignificant differences in loss tangent between males and females in this range. Also, it shows insignificant differences in loss factor between males and females from 19.4GHz to 20GHz frequencies.

The outcomes of this research have contributed to:

- Better knowledge of the strengths and weaknesses of gender identification methods and techniques.

- Proposing a non-invasive, fast, and convenient gender identification method using permittivity.

5.4 Future Research

This research is one of the very few researches that focus on non-invasive gender identification using permittivity of urine. The findings from this research should provide the motivation for further research on the advantages of using permittivity of urine. This study has a few limitations, which it is hoped, that future researches will address.

In this context, future studies should consider the following:

- Using more subjects in different races, ages, weight to evaluate the accuracy of this method.
- Using other urinalyses methods to obtain permittivity and ensure the accuracy of urine results.
- Make improvement to the existing urine analysis method and make it more accurate and fast.
- Study the use of other gender identification methods using permittivity.

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GLOSSARY

Artificial Neural Network

An artificial neural network (ANN) is a mathematical or computational model that is inspired by the structure and functional aspects of biological neural networks.

Data Analysis

Process of inspecting, cleaning, and modelling data with the goal of highlighting useful information.

Data Validation

Process of ensuring that a program operates on clean, correct and useful data.