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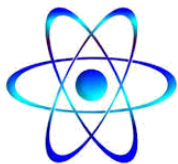
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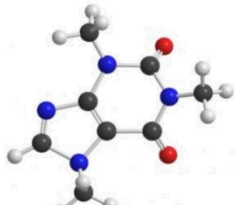
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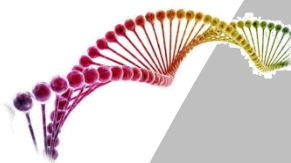
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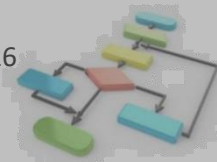


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## **Effect of a rotating Frame on Peristalsis Flow of a Walter's B fluid model suspension in a Porous medium, Physical Survey**

**Hana I. Lafta<sup>1</sup>, Zainab A. Jaafar<sup>2</sup>, Rana G. Ibraheem<sup>3</sup>**

<sup>1</sup> Department of Mathematic, Diyala Education Directorate, Diyala, Iraq.

<sup>2</sup> Department of Physics, College of Education / Tuz Khurmatu, Tikrit University, Tikrit, Iraq

<sup>3</sup> Ministry of Science and Technology, Baghdad, Iraq

# Effect of a rotating Frame on Peristalsis Flow of a Walter's B fluid model suspension in a Porous medium, Physical Survey.

Hana I. Lafta<sup>1</sup>, Zainab A. Jaafar<sup>2</sup>, Rana G. Ibraheem<sup>3</sup>

<sup>1\*</sup> Department of Mathematic, Diyala Education Directorate, Diyala, Iraq.

<sup>2</sup> Department of Physics, College of Education / Tuz Khurmatu, Tikrit University, Tikrit, Iraq

<sup>3</sup> Ministry of Science and Technology, Baghdad, Iraq.

## ABSTRACT

An effect of a rotating frame on peristalsis flow of Walter's B fluid model suspension in a porous medium, physical survey in an asymmetric channel is analyzed. In the asymmetric channel, initially we took into account the condition of non-slip on the channel walls and treated the equations of continuity, momentum, energy and concentration by using the wave frame work with assumptions of long wavelength and low Reynolds number for the purpose of simplification. The regular turbulence method was used to analyze and study the salient features of the flow properties by solving the constitutive equations for each. From the axial velocity, pressure gradient and temperature distribution, in addition to the concentration equation, and then discuss with explain the behavior of the parameters graphically using the mathematical program "MATHEMATICA" software and obtain practically accurate results.

**Key words:** Rotating frame, Walker's B fluid, Porous medium, peristalsis flow, perturbation technique.

## 1. INTRODUCTION

Peristalsis flow is the vital mechanism used to distinguish a progressive wave of region expansion or reduction which spreads above the length of the walls of channel. Peristaltic stream is an ingrained characteristic of numerous tubiform body part of the human. It is further employed for many industrial enforcement just as corrosive as well as noxious fluids transmit, the blood pumps in heart lung gadget and transport the sanitary fluid. The studies on peristalsis flow is widely expanded and developed and several studies, researches on the peristalsis transport [1]–[4]. Rotation effect on peristaltic flow of Walter's B fluid in the porosity space on an asymmetric channel with No-slip condition [5]–[7]. Effect of couple stress with slip condition and rotation on peristaltic flow of a Powell- Eyring fluid with the influence of an inclined asymmetric channel with porous medium, has been investigated by R. G. Ibraheem and L. Z. Hummady [8]. Abd-Alla and Abo- Dahab [9] studied the rotation effect on peristaltic transport of a Jeffrey fluid in an asymmetric channel with gravity field. Z. A. Jaafar et al. [10], discussed the impact of couple stress with rotation on Walters, B fluid in porous medium. Abd-Alla et al. [11] investigated Radially Varying magnetic field on the peristaltic flow in a tube with an endoscope under the effect of rotation. Mahmoud et al. [12] investigated the effect of the rotation on wave motion through cylindrical bore in micropolar porous medium. Abd-Alla et al. [13] discussed the effect of rotation and magnetic field on non-linear peristaltic flow of second-order fluid in an asymmetric channel through a porous medium. Abd-Alla et al. [14] analyzed the effects of an endoscope and rotation on peristaltic flow in a tube with long wavelength. Saba and Ahmed [15] discussed influence of rotating frame on the peristaltic flow of a Rabinowitsh fluid model in an inclined channel. Many studies deal with the outcome of rotation because of its significance in fluid mechanics as decorated in industrial fields as well as mechanical engineering besides physical operations, for examples food treatment biochemical operations, biomedical engineering, transfer in polymers,

oxygenation, promulgation of chemical feculences and hemodialysis. The investigations with regard to the rotation influences have been detailed in [16]–[18]. There are other attempts to explain the effect of this phenomenon in Refs. [19]–[21]. The sight of this paper was to study the effect of a rotating frame on peristalsis flow of a Walter's B fluid model suspension in a porous medium, physical survey in an asymmetric channel. Here, naturally the non-linear governing equations are studied under long wave length assumption with the low Reynolds number to obtain has been done. Closed assertion for axial velocity, pressure gradient, temperature distribution and concentration equation is attained. The impacts of various parameters for this flow are evaluated and graphically presented by applying mathematical program called "MATHEMATICA" software.

### 3. CONCLUSIONS

It was found in this paper some applications of the notion of differential subordination as it relates to subclasses of univalent functions that use specific convolution as operators. We did examine geometric properties of these kinds of functions, including coefficient bounds, distortion theorem, starlikeness and convexity radii, among others. Extreme points and the integral operator have both been studied.

We investigated a few of the characteristics of variations subordination of analytical univalent functions over an open unit disc as well as deduced specific subordination as well as superordination properties using the characteristics of the broader a byproduct operator. Additionally, it gave insight into geometrical traits like coefficient disparities and Hadamard product characteristics. There were installed certain intriguing findings for derivatives differential subordination as well as superordination of analytical univalent functions. Then, a few findings of variations subordination that involve linear operators have been presented employing the convolution with two linear operators. The convolution operator has been used to deal with a number of leads to over differential subordination within the unit disk with open edges employing broader hypergeometric function.

Through the use of an operator with linearity as well as variations subordination, we arrived at a few conclusions as well as a few sandwich theorems. As an a few convolution as a operators, we as a species provided a few variations subordination programs towards subclasses about univalent functions. Through the application of a straight-line operator, it was possible to achieve certain important outcomes in the variations subordination as well as variations superordination about meromorphic analyzing univalent functions of the second order. Lastly, we provided a few outcomes over 2nd-order differential subordination within the open section disk involving broader hypergeometric function employing the convexity operator.

### 2. Mathematical Formulation

This paper test an incompressible Walter's B fluid model in a peristalsis transport with effect of a rotating frame suspension in a porous media, physical survey. The non-Newtonian. (Walter's B fluid) fills in two dimensional and a symmetric channel of width " $d_1 + d_2$ ". This flow induced by a sinusoidal wave train of ( $\lambda$ ) wavelength, ( $C$ ) Constant wave speed,  $a_1$  and  $a_2$  are amplitudes of the waves, ( $t$ ) is the time wave.



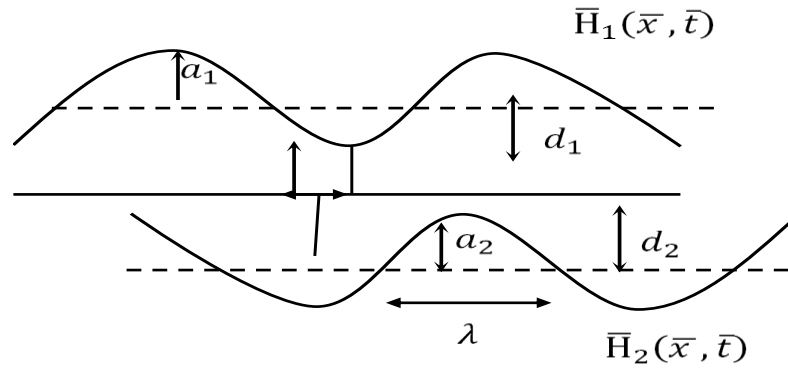


Figure (1): physical sketch

The physical sketch of this problem (Fig-1) represented the geometrical equations of the walls can be expressed as:

$$\begin{aligned}\bar{H}_1(\bar{x}, \bar{t}) &= d_1 + a_1 \sin \frac{2\pi}{\lambda} (\bar{x} - c\bar{t}) \\ \bar{H}_2(\bar{x}, \bar{t}) &= -d_2 - a_2 \sin \left( \frac{2\pi}{\lambda} (\bar{x} - c\bar{t}) + \theta \right)\end{aligned}\quad (1)$$

### 3. Constitutive Equation

The constitutive equations of two-dimensional for Walter's B fluid flow in a laboratory frame write as follows:

$$\frac{\partial \bar{u}}{\partial \bar{x}} + \frac{\partial \bar{v}}{\partial \bar{y}} = 0 \quad (2)$$

$$\begin{aligned}\rho \left( \frac{\partial \bar{u}}{\partial \bar{t}} + \bar{u} \frac{\partial \bar{u}}{\partial \bar{x}} + \bar{v} \frac{\partial \bar{u}}{\partial \bar{y}} \right) - \rho \Omega \left( \Omega \bar{u} + 2 \frac{\partial \bar{v}}{\partial \bar{t}} \right) &= -\frac{\partial \bar{f}}{\partial \bar{x}} + \frac{\partial \bar{\tau}_{\bar{x}\bar{x}}}{\partial \bar{x}} + \frac{\partial \bar{\tau}_{\bar{x}\bar{y}}}{\partial \bar{y}} \\ -\sigma B_0^2 \cos \beta^{**} (\bar{u} \cos \beta^{**} - \bar{v} \sin \beta^{**}) - \frac{\mu}{k_*} \bar{u}\end{aligned}\quad (3)$$

$$\begin{aligned}\rho \left( \frac{\partial \bar{v}}{\partial \bar{t}} + \bar{u} \frac{\partial \bar{v}}{\partial \bar{x}} + \bar{v} \frac{\partial \bar{v}}{\partial \bar{y}} \right) - \rho \Omega \left( \Omega \bar{v} + 2 \frac{\partial \bar{u}}{\partial \bar{t}} \right) &= -\frac{\partial \bar{f}}{\partial \bar{y}} + \frac{\partial \bar{\tau}_{\bar{x}\bar{y}}}{\partial \bar{x}} + \frac{\partial \bar{\tau}_{\bar{y}\bar{y}}}{\partial \bar{y}} \\ +\sigma B_0^2 \sin \beta^{**} (\bar{u} \cos \beta^{**} - \bar{v} \sin \beta^{**}) - \frac{\mu}{k_*} \bar{v}\end{aligned}\quad (4)$$

$$\begin{aligned}\rho c_p \left( \frac{\partial \bar{T}}{\partial \bar{t}} + \bar{u} \frac{\partial \bar{T}}{\partial \bar{x}} + \bar{v} \frac{\partial \bar{T}}{\partial \bar{y}} \right) &= k^* \left( \frac{\partial \bar{T}}{\partial \bar{t}} + \bar{u} \frac{\partial^2 \bar{T}}{\partial \bar{x}^2} + \bar{v} \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} \right) + \\ \mu \left( \left( \frac{\partial \bar{u}}{\partial \bar{y}} + \frac{\partial \bar{v}}{\partial \bar{x}} \right)^2 + 2 \left( \frac{\partial^2 \bar{u}}{\partial \bar{x}^2} \right)^2 + 2 \left( \frac{\partial^2 \bar{v}}{\partial \bar{y}^2} \right)^2 \right)\end{aligned}\quad (5)$$

$$\frac{\partial \bar{c}}{\partial \bar{t}} + \bar{u} \frac{\partial \bar{c}}{\partial \bar{x}} + \bar{v} \frac{\partial \bar{c}}{\partial \bar{y}} = D^* \left( \bar{u} \frac{\partial^2 \bar{c}}{\partial \bar{x}^2} + \frac{\partial^2 \bar{c}}{\partial \bar{y}^2} \right) + \frac{D^* K_T}{T^*} \left( \frac{\partial^2 \bar{T}}{\partial \bar{x}^2} + \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} \right) \quad (6)$$

The velocity components  $(U, V)$  in  $(X, Y)$  directions with an associated conditions of the boundary are no slip at the channel walls as:

$$\begin{aligned}\bar{U} &= 0, \quad \bar{T} = \bar{T}_b, \quad \bar{C} = \bar{C}_b \text{ at } y = H_1 \\ \bar{U} &= 0, \quad \bar{T} = \bar{T}_s, \quad \bar{C} = \bar{C}_s \text{ at } y = H_2\end{aligned}\quad (7)$$

A non-Newtonian Walter's B fluid is externally stratified electrically conducting in the entity of Magnetic field in the direction that makes an angle  $(\beta^{**})$  with the axis  $(X)$  in  $x y$  -planned.

By Ohm's low,  $\mu = \sigma(V \times B_s)$ ,  $V = (\bar{u}, \bar{v}, 0)$  the velocity vector and  $B_s = (B_s \cos \beta^{**}, B_s \sin \beta^{**}, 0)$  the magnetic flux density vector, Loren TZ force vector can be formulated as:

$$j \times B_s = (-\sigma B_s^2 \sin \beta^{**} (\bar{u} \sin \beta^{**} - \bar{v} \cos \beta^{**}), \sigma B_s^2 \cos \beta^{**} (\bar{u} \sin \beta^{**} - \bar{v} \cos \beta^{**}), 0)$$

In rotating frame we have two terms  $(\rho \Omega (\Omega \bar{u}))$  the centrifugal force and  $(2\rho \Omega \bar{u})$  the coriolis force with the constituent equation of Warter's B flavid model is expressed as [21] :

$$\bar{\tau} = 2\mu r - 2L_s W_s, \quad W_s = \frac{\partial r}{\partial t} + \nabla \cdot \nabla r - r \nabla \cdot \nabla - (\nabla \cdot \nabla)^T r \quad (8)$$

$$\text{And } \mu = \int_s^\infty N(\tau) d\tau, \quad L_s = \int_s^\infty \tau N(\tau) d\tau \quad (9)$$

Where  $L_s, \eta$ , the small shear rate and the short memory coefficient.

$N(\tau)$  is the distribution function with relaxation time and  $\int_s^\infty \tau N(\tau), \mu \geq 2$ , are neglected in case of Walter's B fluid model.

$$\begin{aligned}\bar{\tau}_{\bar{x}\bar{x}} &= 2\mu \bar{u}_{\bar{x}} - L_s (2\bar{u}_{\bar{x}\bar{x}} + 2\bar{u}\bar{u}_{\bar{x}\bar{x}} + 2\bar{v}\bar{u}_{\bar{x}\bar{y}} - 2\bar{v}_{\bar{x}}\bar{v}_{\bar{y}} - 2\bar{v}_{\bar{x}}^2 - 4\bar{u}_{\bar{x}}^2) \\ \bar{\tau}_{\bar{y}\bar{y}} &= 2\mu \bar{v}_{\bar{y}} - L_s (2\bar{v}_{\bar{y}\bar{y}} + 2\bar{u}\bar{v}_{\bar{y}\bar{x}} + 2\bar{v}\bar{v}_{\bar{y}\bar{y}} - 2\bar{u}_{\bar{y}}^2 - 4\bar{v}_{\bar{y}}^2 - 2\bar{u}_{\bar{y}}\bar{v}_{\bar{x}}) \\ \bar{\tau}_{\bar{x}\bar{y}} &= \bar{\tau}_{\bar{y}\bar{x}} = \mu (\bar{u}_{\bar{y}} + \bar{v}_{\bar{x}}) - L_s \left( \bar{u}_{\bar{y}\bar{x}} + \bar{v}_{\bar{x}\bar{y}} + \bar{u}\bar{u}_{\bar{y}\bar{x}} + \bar{u}\bar{v}_{\bar{x}\bar{x}} + \bar{v}\bar{u}_{\bar{y}\bar{y}} + \right. \\ &\quad \left. v\bar{v}_{\bar{x}\bar{y}} - 3\bar{u}_{\bar{y}}\bar{u}_{\bar{x}} - 3\bar{v}_{\bar{x}}\bar{v}_{\bar{y}} - \bar{v}_{\bar{y}}\bar{u}_{\bar{y}} - \bar{u}_{\bar{x}}\bar{v}_{\bar{x}} \right)\end{aligned}\quad (10)$$

Now assume the motion peristalsis steady by using the labortory frame which is given as:

$$\bar{x} = \bar{x} - \bar{c}\bar{t}, \quad \bar{y} = \bar{Y}, \quad \bar{u} = \bar{u} - \bar{c}, \quad \bar{v} = \bar{v}, \quad \bar{P}(\bar{x}, \bar{y}) = \bar{P}(\bar{x}, \bar{y}, \bar{t}) \quad (11)$$

There after we introduce dimensionaless quantities as follows:

$$x = \frac{\bar{x}}{\lambda}, \quad y = \frac{\bar{y}}{d}, \quad u = \frac{\bar{u}}{c}, \quad v = \frac{\bar{v}}{sc}, \quad \delta = \frac{d_1}{\lambda}, \quad t = \frac{c\bar{t}}{\lambda}, \quad P = \frac{\bar{p}d_1^2}{\mu c \lambda}, \quad h_1 = \frac{\bar{H}_1}{d_1}, \quad h_2 = \frac{\bar{H}_2}{d_2},$$

$$k_s = \frac{\bar{k}_s}{d_1^2}, \quad H_a = d_1 B_s \sqrt{\frac{\sigma}{\mu}}, \quad R_e = \frac{pc d_1}{\mu}, \quad S_c = \frac{\mu}{\lambda \rho}, \quad S_r = \frac{\rho D^* k_T (\bar{T}_b - \bar{T}_s)}{T^* (\bar{C}_b - \bar{C}_s)},$$

$$\theta = \frac{\bar{T} - \bar{T}_s}{\bar{T}_b - \bar{T}_s}, \quad \beta^{**} = \frac{a_1}{d_1}, \quad E_c = \frac{C^2}{C_p (\bar{T} - \bar{T}_s)}, \quad P_r = \frac{C_p \mu}{k^*}, \quad \bar{\tau} = \frac{\tau c \mu}{d_1}, \quad d = \frac{d_2}{d_1}$$

$$d = \frac{d_2}{d_1}, \quad b = \frac{a_2}{d_2}, \quad \Omega = \frac{\bar{\Omega} d_1^2}{\mu} \quad (12)$$

In light of eqs.(11)-(12), and their substitution in the eqs.(2-6), we conclude the following:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (13)$$

$$R_e \delta \left( \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) - \frac{\rho \Omega^2 d_1^2}{\mu} u = -\frac{\partial f}{\partial x} + \delta \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} - H_a^2 \cos \beta^{**} (u \cos \beta^{**} - v S \sin \beta^{**}) - \frac{u}{k} \quad (14)$$

$$R_e \left( \delta^2 u \frac{\partial v}{\partial x} + \delta^2 \frac{\partial v}{\partial y} \right) - \frac{\rho \Omega^2 d_2^2}{\mu} v \delta = -\frac{\partial f}{\partial y} + \delta \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} - H_a^2 \sin \beta^{**} (u \cos \beta^{**} - v S \sin \beta^{**}) - \frac{v}{k} \quad (15)$$

$$R_e \delta \left( u \frac{\partial \theta}{\partial x} + V \frac{\partial \theta}{\partial y} \right) = \frac{1}{Pr} \left( \delta^2 \frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} \right) + E_c \left( \left( \frac{\partial u}{\partial y} + \delta^2 \frac{\partial v}{\partial x} \right)^2 2\delta^2 \left( \frac{\partial^2 u}{\partial x^2} \right)^2 + 2\delta^2 \left( \frac{\partial^2 v}{\partial y^2} \right) \right) \quad (16)$$

$$R_e \left( \delta(u+1) \frac{\partial \Omega}{\partial x} + \delta V \frac{\partial \Omega}{\partial y} \right) = \frac{1}{Sc} \left( \delta^2 \frac{\partial^2 \Omega}{\partial x^2} + \frac{\partial^2 \Omega}{\partial y^2} \right) + S_r \left( \delta^2 \frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} \right) \quad (17)$$

$$U = -1, \quad T = T_b, \quad C = C_1 \quad \text{at } y = h_1$$

$$U = -1, \quad T = T_o, \quad C = C_o \quad \text{at } y = h_2 \quad (18)$$

After simplify and using  $u = \psi_y, v = -\psi_x$  we get:

$$\begin{aligned} & R_e \delta \left( \psi_y \frac{\partial}{\partial x} + \psi_x \frac{\partial}{\partial y} \right) \nabla^2 \psi + \frac{\rho \Omega^2 d_1^2 S \delta^2}{\mu} (\psi_x - \psi_y) \\ & = \delta \left( \frac{\partial^2}{\partial x \partial y} (\tau_{xx} - \tau_{yy}) \right) + \left( \frac{\partial^2}{\partial y^2} + \delta^2 \frac{\partial^2}{\partial x^2} \right) \tau_{xy} - H_a^2 \cos \beta^{**} \frac{\partial^2 \psi}{\partial y^2} + \delta^2 H_a^2 \sin \beta^{**} \\ & \frac{\partial^2 \psi}{\partial x^2} - \delta H_a^2 \cos \beta^{**} \sin \beta^{**} \psi_{xy} - \frac{1}{k} (\psi_{yy} - S \psi_{xx}) \end{aligned} \quad (19)$$

Where  $\nabla^2 = \delta^2 \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$

$$R_e \delta \left( \psi_y \frac{\partial \theta}{\partial x} + \psi_x \frac{\partial \theta}{\partial y} \right) = \frac{1}{Pr} \left( \delta^2 \frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} \right) + E_c \left( \left( \frac{\partial \psi_y}{\partial y} - \delta^2 \frac{\partial \psi_x}{\partial x} \right)^2 2\delta^2 \left( \frac{\partial^2 \psi_y}{\partial x^2} \right)^2 - 2\delta^2 \left( \frac{\partial^2 \psi_x}{\partial y^2} \right) \right) \quad (20)$$

$$R_e \left( \delta(\psi_y + 1) \frac{\partial \Omega}{\partial x} + \delta \psi_x \frac{\partial \Omega}{\partial y} \right) = \frac{1}{Sc} \left( \delta^2 \frac{\partial^2 \Omega}{\partial x^2} + \frac{\partial^2 \Omega}{\partial y^2} \right) + S_r \left( \delta^2 \frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} \right) \quad (21)$$

The dimensionless boundary conditions in wave frame:

$$\begin{aligned} \psi &= \frac{F}{2}, \quad \theta = 1, \quad \Omega = 1 \quad \text{at } y = h_1 \\ \psi &= \frac{F}{2}, \quad \theta = 0, \quad \Omega = 0 \quad \text{at } y = h_2 \end{aligned} \quad (22)$$

$$\frac{\partial \psi}{\partial y} = -1 \quad \text{at } y = h_1 \quad \text{and at } y = h_2$$

when we use the laboratory frame  $Q = \int_{h_2}^{h_1} (u+1) dy$  the mean flow rate is related to F by:

$$Q = F + d + 1 \tag{23}$$

Also  $h_1(x) = 1 + a \sin x$

$$h_2(x) = -d - b \sin(x + \emptyset) \tag{24}$$

When  $\emptyset, a, b$  and  $d$ , satisfy the relation

$$a^2 + b^2 + 2ab \cos \emptyset \leq (1 + d)^2 \tag{25}$$

**4. Exact solution**

From eq. (19), which is non-linear with difficultness, then we solve it by perturbation method and expand as:

$$\begin{aligned} \psi &= \psi_0 + \delta \psi_1 + \dots \\ P &= P_0 + \delta P_1 + \dots \\ \theta &= \theta_0 + \delta \theta_1 + \dots \\ \Omega &= \Omega_0 + \delta \Omega_1 + \dots \end{aligned} \tag{26}$$

**5. Zero order Solution**

$$\left. \begin{aligned} \frac{\partial^2 \tau_{oxy}}{\partial y^2} - R_0 \psi_{oyy} &= 0 \\ \text{Where } R_0 &= H_a^2 \cos^2 \beta^{**} + \frac{1}{k_0} \end{aligned} \right] \tag{27}$$

$$\frac{\partial p_0}{\partial x} = \frac{\rho \Omega_0^2 d_1^2}{\mu} \psi_{oy} + \frac{\partial \tau_{oxy}}{\partial y} - R_0 (\psi_{oy} - 1) \tag{28}$$

$$\left. \begin{aligned} 0 &= \psi_{oyyy} - \psi_{oyy} N_0 \\ \text{Where } N_0 &= \frac{\rho \Omega_0^2 d_1^2}{\mu} + R_0 \end{aligned} \right] \tag{29}$$

$$\frac{\partial p_0}{\partial y} = 0 \tag{30}$$

$$\left. \begin{aligned} \frac{\partial^2 \theta}{\partial y^2} &= -B_r \left( \frac{\partial \psi_{oy}}{\partial y} \right)^2 \\ \text{Where } B_r &= P_r E_C \end{aligned} \right] \tag{31}$$

$$\frac{\partial^2 \Omega}{\partial y^2} = -S_C S_r \frac{\partial^2 \theta}{\partial y^2} \tag{32}$$

$$\tau_{oxy} = \psi_{oyy}, \tau_{oxx} = 0, \tau_{oyy} = 2k \psi_{oy}^2 \tag{33}$$

$$\left. \begin{aligned} \psi_0 &= \frac{F_0}{2}, \theta_0 = 1, \Omega_0 = 1 \text{ at } y = h_1 \\ \psi_0 &= -\frac{F_0}{2}, \theta_0 = 0, \Omega_0 = 0 \text{ at } y = h_2 \end{aligned} \right] \tag{34}$$

$$\frac{\partial \psi_0}{\partial y} = -1 \text{ at } y = h_1 \text{ and at } y = h_2$$

## 6. First order Solution

Replace eq.(26) in eq.(19) and (20), obtain:

$$R_e \left( \psi_{xy} \psi_{xyyx} - \psi_{yx} \psi_{xyyy} \right) - N_0 \psi_{1yy} = \frac{\partial^2}{\partial x \partial y} \tau_{oxy} + \frac{\partial^2}{\partial y^2} \tau_{1xy} - H_a^2 \cos \beta^{**} (\psi_{1yy} + \sin \beta^{**} \psi_{xxy}) - \frac{1}{k} (\psi_{xyy} - \psi_{1yy}) \text{ where } N_0 = \frac{\rho \Omega^2 d_1^2}{\mu} \quad (35)$$

$$\frac{\partial P_1}{\partial x} = \frac{\partial}{\partial y} \tau_{1xy} - R_c (\psi_{1y} - 1) + \psi_0 \sin \beta^{**} - R_e (\psi_{xy} \psi_{xyyx} - \psi_{yx} \psi_{xyyy}) + N_0 \psi_{1y} \quad (36)$$

$$\frac{\partial^2 \theta}{\partial y^2} = -B_r \left( \frac{\partial \psi_{1y}}{\partial y} \right)^2 \text{ Where } B_r = P_r E_c \quad (37)$$

$$\frac{\partial^2 \Omega}{\partial y^2} = -S_c S_r \frac{\partial^2 \theta}{\partial y^2} \quad (38)$$

$$\left. \begin{aligned} \tau_{1xy} &= \psi_{1yy} - k \left( \psi_{xy} \psi_{xyyx} - \psi_{yx} \psi_{xyyy} - 2\psi_{xxy} \psi_{xyy} \right) \\ \psi_{1xx} &= 2\psi_{xxy} \\ \psi_{1yy} &= -2\psi_{xxy} + 2k\psi_{1yy}^2 \end{aligned} \right\} \quad (39)$$

$$\left. \begin{aligned} \psi_1 &= \frac{F_1}{2}, \quad \theta_1 = 1, \quad \Omega_1 = 1 \text{ at } y = h_1 \\ \psi_1 &= -\frac{F_2}{2}, \quad \theta_1 = 0, \quad \Omega_1 = 0 \text{ at } y = h_2 \\ \frac{\partial \psi_1}{\partial y} &= -1 \text{ at } y = h_1 \text{ and at } y = h_2 \end{aligned} \right\} \quad (40)$$

## 7. Discussions and Graphical

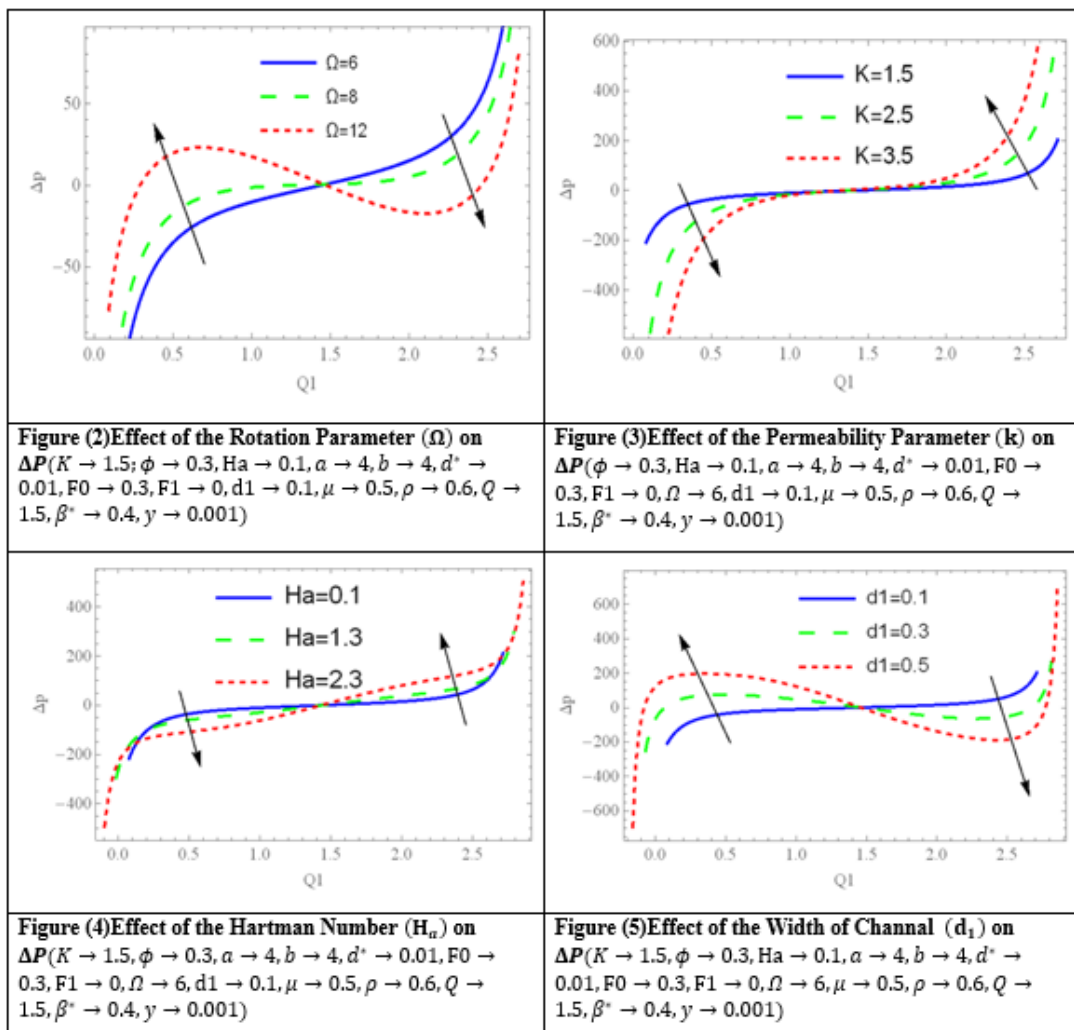
To study the influence of physical Parameters such as  $(\Omega, H_a, d_1, k, \mu, \rho, \beta^*, E_c, P_r, \phi, a, b, S_c, S_r, F_2)$  and  $F_1$  we have plotted the pressure rise profile ( $\nabla P$ ) and concentration distribution in figures (2 - 20), all figures are plotted for the values  $\Omega = 6$ ,  $H_a = 0.1$ ,  $d_1 = 0.1$ ,  $k = 1.5$ ,  $\mu = 0.8$ ,  $\rho = 0.6$ ,  $\beta^* = 2.5$ ,  $E_c = 1$ ,  $P_r = 3$ ,  $d = 2.5$ ,  $a = 0.4$ ,  $b = 0.6$ ,  $S_c = 0.5$ ,  $F_2 = 0.9$  and  $F_1 = 0.5$  using "MATHEMATICA" software. using the most important values of the parameters affecting the solution of the equations of the problem, the profile of the pressure rise was defined according to the order of the values  $(\Omega, H_a, d_1, k, \mu, \rho)$  and which were accurately described in the graphical figures (2,3,4,5,6,7). Using the Mathematica software, the variation of the pressure rise for each wavelength is explained in agreement with the average flow rate of the asymmetric channel under the influence of the periodic frame on the peristalsis flow of the non-Newtonian Walter's B model suspended in a porous medium, for the relevant

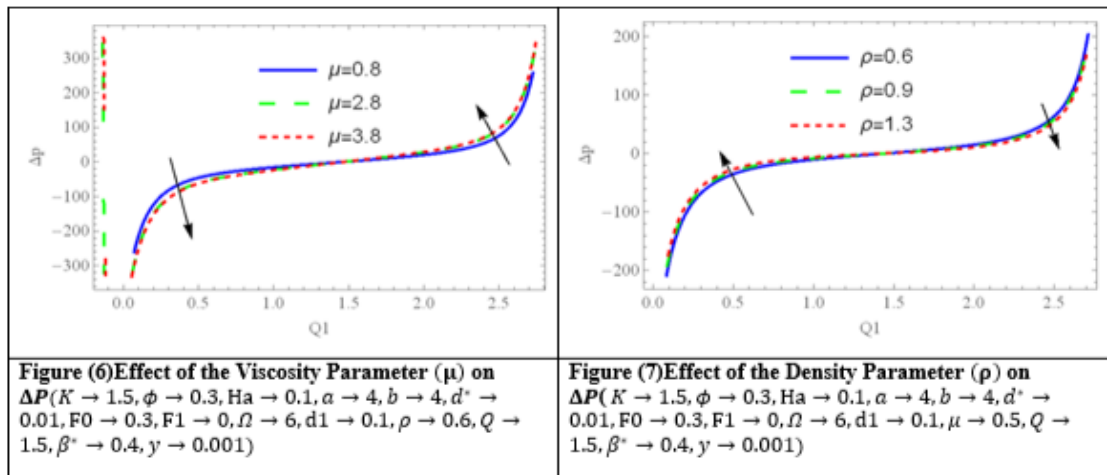
parameters, the entire pumping area consists of three main areas. The first is called the retrograde pumping  $\Delta P > 0 \& Q < 0$  and the second is the co-pumping  $\Delta P < 0 \& Q < 0$ , and the third area is called augmented pumping  $\Delta P < 0 \& Q > 0$ .

Figures (2,4,5) highlight the variation of the pressure rise for different values of the parameters  $(\Omega, H_a, d_1)$  as the pressure rise increases with increasing  $(\Omega, H_a, d_1)$  in the retrograde pumping and co-pumping area on the contrary in the augmented pumping area. Figures (3 and 6) are plotted to see the impact of  $K$  and  $\mu$  on the pressure rise, it's observed that decreases in retrograde pumping area and co-pumping area with an increase in augmented pumping area. The opposite thing happens with  $\rho$  increasing as shown in figure (7). The graphical novits for concentration profile are illustrated in figures (8-20) figure (18) explain that the effect of parameters on the concentration profile it is observed that the concentration distribution exhibits oscillating behavior with an increase in the  $(F_1)$ , from figure (12) the concentration distribution decreases in the central area and right channel wall, but incenses near the left channel wall for increasing in  $(\phi)$  while the opposite behavior is occurring with the increase in (a), as shown in figure (13), figures (8,9,10,11) deduced that the concentration decreases by increasing in  $(E_c, P_r, d_1)$  and  $(N)$ .

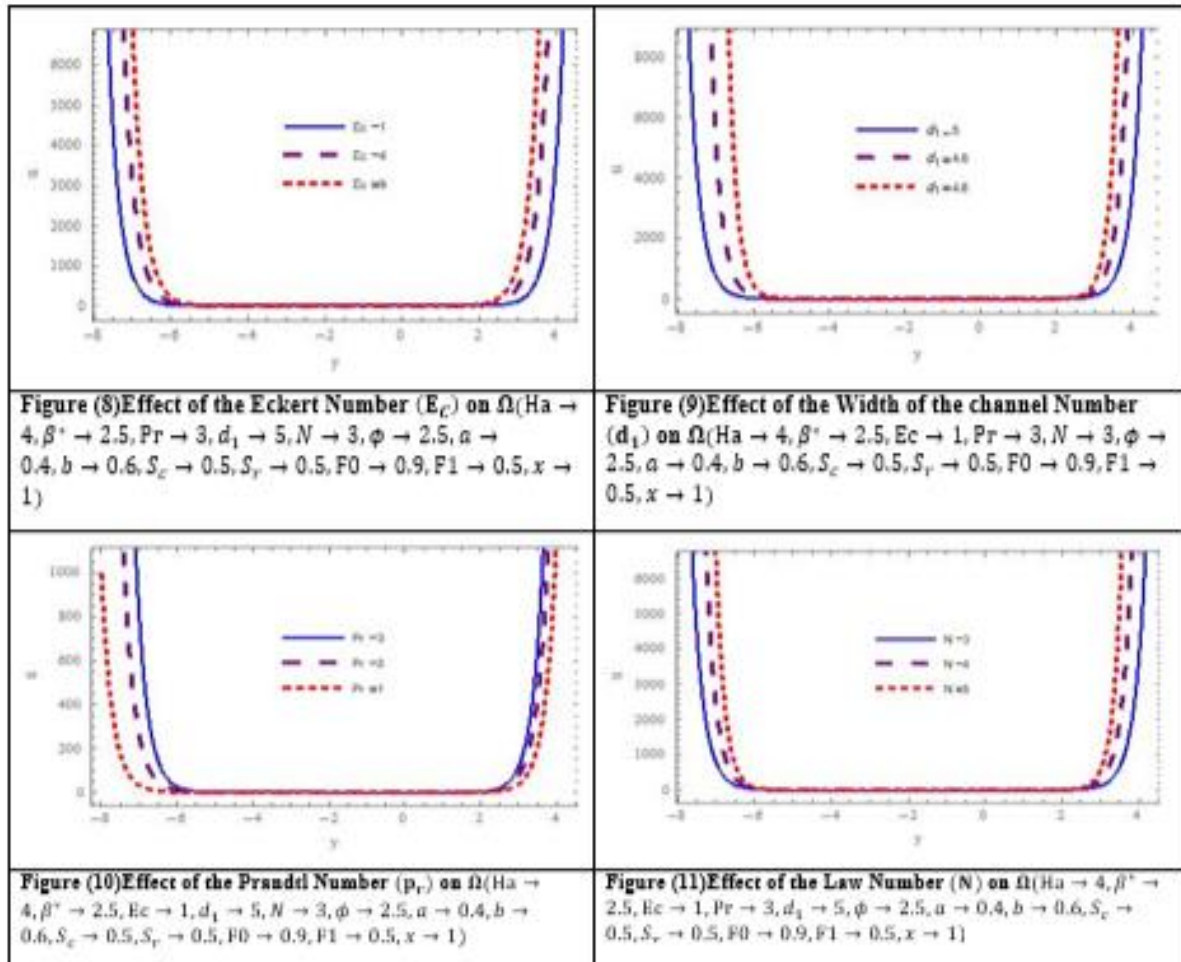
Figures (14,15,16) and (17) shown that the concanbehan distribution decreases near the channel walls and then gradually disappear as there is no effect on the concentration distribution to the rest of the channel with an increase in  $(b, S_c, S_r)$  and  $F_s$ .

### 7.1. Pressure rise





**.2. Concentration:**



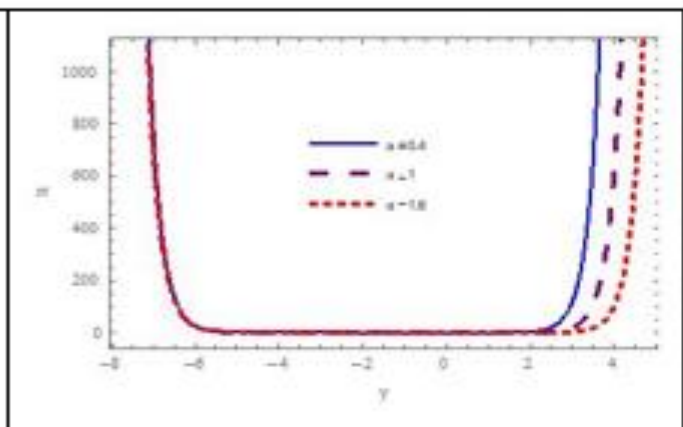
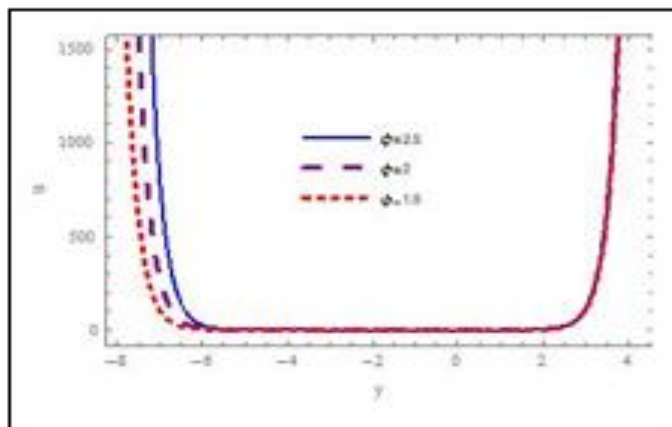


Figure (12)Effect of the Implitude Ratio Number ( $\phi$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, a \rightarrow 0.4, b \rightarrow 0.6, S_c \rightarrow 0.5, S_r \rightarrow 0.5, F0 \rightarrow 0.9, F1 \rightarrow 0.5, x \rightarrow 1$ )

Figure (13)Effect of the Amplitude of the wave Number ( $\alpha$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, \phi \rightarrow 2.5, b \rightarrow 0.6, S_c \rightarrow 0.5, S_r \rightarrow 0.5, F0 \rightarrow 0.9, F1 \rightarrow 0.5, x \rightarrow 1$ )

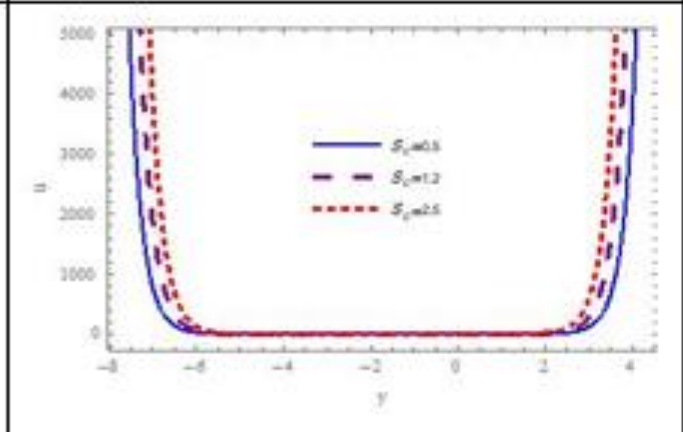
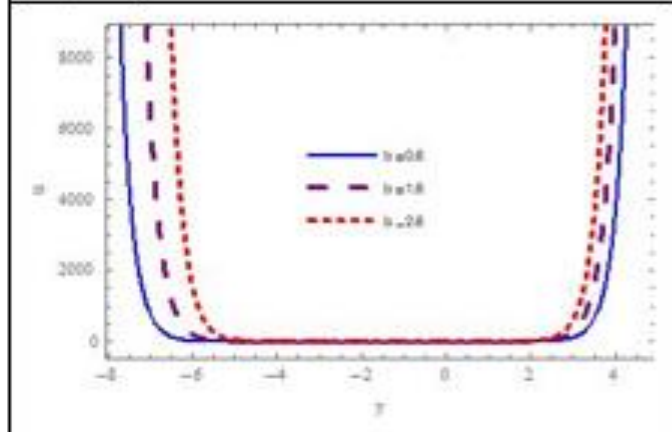


Figure (14)Effect of the Amplitude of the wave Number ( $b$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, \phi \rightarrow 2.5, a \rightarrow 0.4, S_c \rightarrow 0.5, S_r \rightarrow 0.5, F0 \rightarrow 0.9, F1 \rightarrow 0.5, x \rightarrow 1$ )

Figure (15)Effect of the Schmidt Number ( $S_c$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, \phi \rightarrow 2.5, a \rightarrow 0.4, b \rightarrow 0.6, S_c \rightarrow 0.5, F0 \rightarrow 0.9, F1 \rightarrow 0.5, x \rightarrow 1$ )

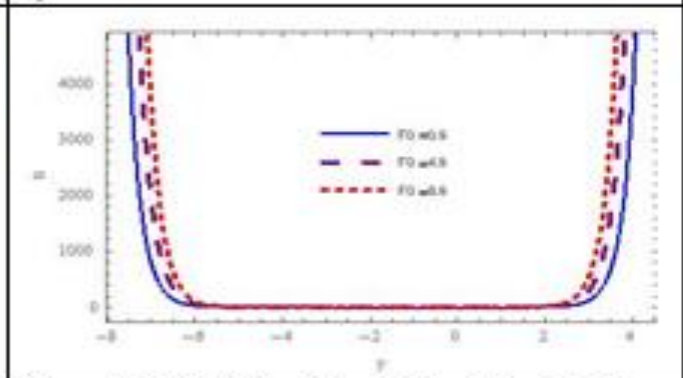
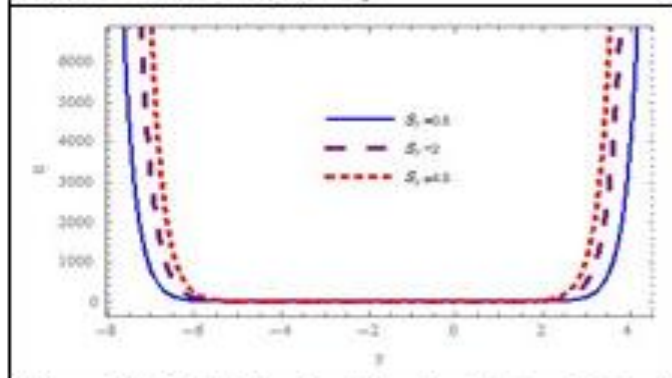
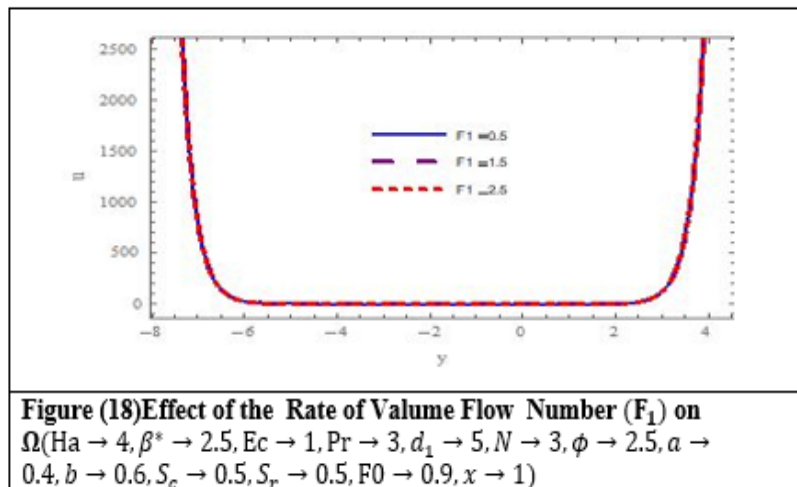


Figure (16)Effect of the Soret Number ( $S_r$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, \phi \rightarrow 2.5, a \rightarrow 0.4, b \rightarrow 0.6, S_c \rightarrow 0.5, F0 \rightarrow 0.9, F1 \rightarrow 0.5, x \rightarrow 1$ )

Figure (17)Effect of the Rate of Volume Flow Number ( $F_0$ ) on  $\Omega$ ( $Ha \rightarrow 4, \beta^* \rightarrow 2.5, Ec \rightarrow 1, Pr \rightarrow 3, d_1 \rightarrow 5, N \rightarrow 3, \phi \rightarrow 2.5, a \rightarrow 0.4, b \rightarrow 0.6, S_c \rightarrow 0.5, S_r \rightarrow 0.5, F1 \rightarrow 0.5, x \rightarrow 1$ )





## 8. Conclusions

The influence of a rotating frame on peristalsis flow of Walter's B fluid model suspension in a porous medium in an asymmetric channel is investigated under low Reynolds number and long wavelength. The flow is considered in two-dimensional, non-linear partial differential equation was solved by using perturbation technique, some of interesting conclusions are Summarized as follows:

- The impact of various parameters on the pressure rise are different for different pumping area.
- Opposite behavior for pressure rise profile is noticed compared to concentration distribution.
- Pressure rise is decreasing function of the parameters ( $K$  and  $\mu$ ) and the opposite thing happens with parameter ( $\rho$ ).
- Concentration distribution increases in the presence of ( $\phi$ ) near the left channel wall while the opposite behavior is occurring with increase of ( $a$ ).
- Concentration distribution decreases in the presence ( $b, S_c, S_r$ ) and  $F_s$  near the channel walls and then gradually disappear as there is no effect on the concentration distribution to the rest of the channel with an increase in this parameter.

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## **Evaluation of Tumor necrosis factor-TNF $\alpha$ and some vitamin levels and ferritin in women with Breast Cancer in Kirkuk City**

**Fidan Fikrat Ahmed<sup>1</sup>, Arjan Aydin Zeynel<sup>2</sup>**

Department of Dialysis Techniques<sup>1</sup>, Medical Laboratory Technology Department<sup>2</sup>,  
College of Health and Medical Techniques- Kirkuk, Northern Technical University, Iraq.

[fidanfikrat1972@ntu.edu.iq](mailto:fidanfikrat1972@ntu.edu.iq)

[argan.ayden@ntu.edu.iq](mailto:argan.ayden@ntu.edu.iq)

## Evaluation of Tumor necrosis factor-TNF $\alpha$ and some vitamin levels and ferritin in women with Breast Cancer in Kirkuk City

Fidan Fikrat Ahmed<sup>1</sup>, Arjan Aydin Zeynel<sup>2</sup>

Department of Dialysis Techniques<sup>1</sup>, Medical Laboratory Technology Department<sup>2</sup>, College of Health and Medical Techniques- Kirkuk, Northern Technical University, Iraq.

Email: [fidanfikrat1972@ntu.edu.iq](mailto:fidanfikrat1972@ntu.edu.iq)

Email: [argan.ayden@ntu.edu.iq](mailto:argan.ayden@ntu.edu.iq)

### Abstract

This study aimed to evaluate the role of Vitamin D3 deficiency in women with breast cancer. This study was conducted to estimate tumor necrosis factor (TNF)-  $\alpha$  and vitamins (D3, B12, folate), and ferritin levels this study estimate. Some hematological parameters such as hemoglobin (Hb), white blood cells (WBC), platelet level, erythrocyte sedimentation rate (ESR) in women with breast cancer patients. The study started from november 2022 to march 2023, The study population included 50 females, with them 15 in the healthy control (control group) and 35 patients with breast cancer (patient group), whose ages ranged from 25 to 96 years also the mean age is 53 years.

The current study showed a significant low ( $P < 0.05$ ) in the mean vitamin D3 level ( $25.97 \pm 13.5$  ng/ml), vitamin B12 ( $288.63 \pm 78$  pg/ml), folate ( $9.44 \pm 4.6$  ng/ml), hemoglobin level ( $11 \pm 1.52$  g/L), and percentage of packed cell volume ( $31 \pm 10.6$ ) in the patient group with the control group. Also, the current study shows elevated ( $P < 0.05$ ) in the TNF  $\alpha$  and the mean of white blood cells ( $20 \times 10^9 \pm 24.5$  cell/mm<sup>3</sup>) and Platelet level ( $269 \pm 143.8$  billion/L) and ESR ( $203 \pm 11.3$  mm/hr) and ferritin level ( $157.4 \pm 113.4$  ng/ml) in the patient group among to the control group.

**Key words: - Breast cancer, Tumor necrosis factor, Vitamins, Ferritin .**

### Introduction:

Breast cancer is one of the most common malignant types of tumors<sup>(1,2,3)</sup>. It's incidence is higher in women than men<sup>(4,5)</sup>. It is a disease that has a genetic background but environmental factors donate to it' occurrence and shows a large degree of heterogeneity between and within tumors<sup>(6,7,8)</sup>. Tumor necrosis factor (TNF)- $\alpha$  is one of the cytokines that are secreted from macrophages and natural killer cells. This cytokine promotes inflammation. It is contribute to development of cancer<sup>(9)</sup>. TNF is used as a tumor marker to determine the stage of breast cancer<sup>(10)</sup>, and that its mechanism of action is through receptors on the cell surface to regulate the programmed cell death pathway<sup>(11)</sup>. Vit.D3 is a known has potential anticarcinogenic impacts, including regulation of cell growth and proliferation, stimulation of apoptosis, and down-regulation of estrogen receptors<sup>(12, 13)</sup>. Ferritin is protein mainly

synthesized in the liver (14). Recently, there is an evidence that ferritin has a role of in the pathogenesis of a number of diseases, including breast cancer (15).

### **Materials and methods:**

#### **Study design:**

Fifty blood samples were collected, 35 samples from women with breast cancer, and 15 samples from control group whose ages ranged between (25-96) years. After that, the blood was separated and preserved until tests were conducted.

#### **-Estimation of complete blood count (CBC) levels in the blood:**

The level of CBC was evaluated according to a kit manufactured by the company Starlab.

#### **-Estimation of Tumor necrosis factor levels in the blood serum:**

The level of tumor necrosis factor was estimated according to a kit prepared by the company Starlab.

#### **-Estimation of Vit. D3, B12 and folic acid level in the blood serum:**

The level of vitamins (D3, B12, and folic acid) was estimated according to a kit organized by the company Nepegon health crop.

#### **-Estimation of ferritin level in the blood serum:**

The level of ferritin was evaluated according to a kit prepared by the company Nepegon health crop.

#### **Statistical analysis:**

The result analyzed using the statistical package for the social science (SPSS) program. Descriptive statistics like mean, frequency, and percentage were conducted. Other inferential statistical test like unpaired T-test was employed for assessing relation between TNF- $\alpha$  levels and breast cancer. The differences were taken as statistically significant when  $P < 0.05$ .

#### **Result and Dissection:**

##### **Hematological parameters:**

The blood from participants (patient and control) was tested for hemoglobin Hb, packed cell volume (PCV), Platelets (PLT), and ESR, and the results shown in Table 1

Table 1 shows the mean  $\pm$  standard deviation (SD) of hematological parameters in control group and patient group.

Variables	Control group	Patient group	P value t- test
	Mean $\pm$ SD	Mean $\pm$ SD	
Hb ( g/L )	14.4 $\pm$ 1.8	11 $\pm$ 1.52	1.95 *
PCV ( % )	39.6 $\pm$ 4.57	31 $\pm$ 10.6	0.32
WBC ( cell/mm <sup>3</sup> )	7.5 $\times$ 10 <sup>9</sup> $\pm$ 2.3	20 $\times$ 10 <sup>9</sup> $\pm$ 2.56	0.15
PLT ( billion/L)	254.3 $\pm$ 88.8	269 $\pm$ 143.8	0.021
ESR ( mm/hr )	8.7 $\pm$ 5.3	203 $\pm$ 11.3	0.22

Figures (1, 2, 3, 4 and 5) demonstrated a significant reduce in the level of Hb, PCV in the patinas compered control group. Also the results showed the increase in the mean of platelet and ESR for the patient compared to the control group.

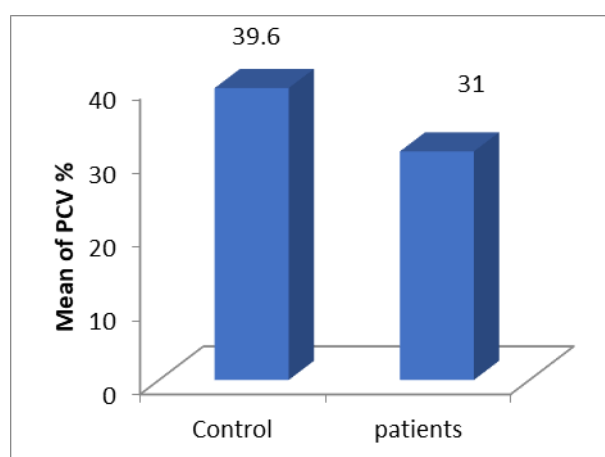


Figure 2: The level of PCV in blood group.

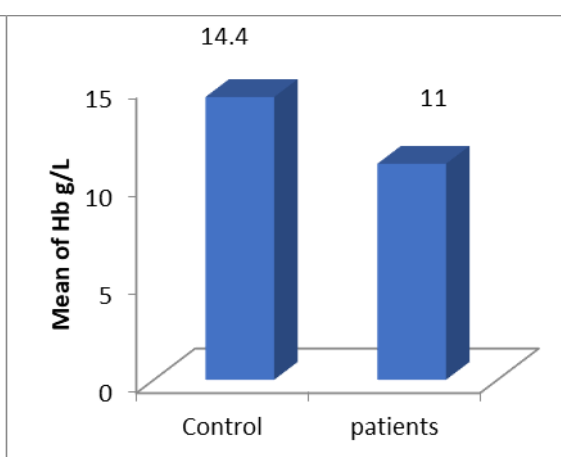


Figure 1: The level of Hb in blood group.

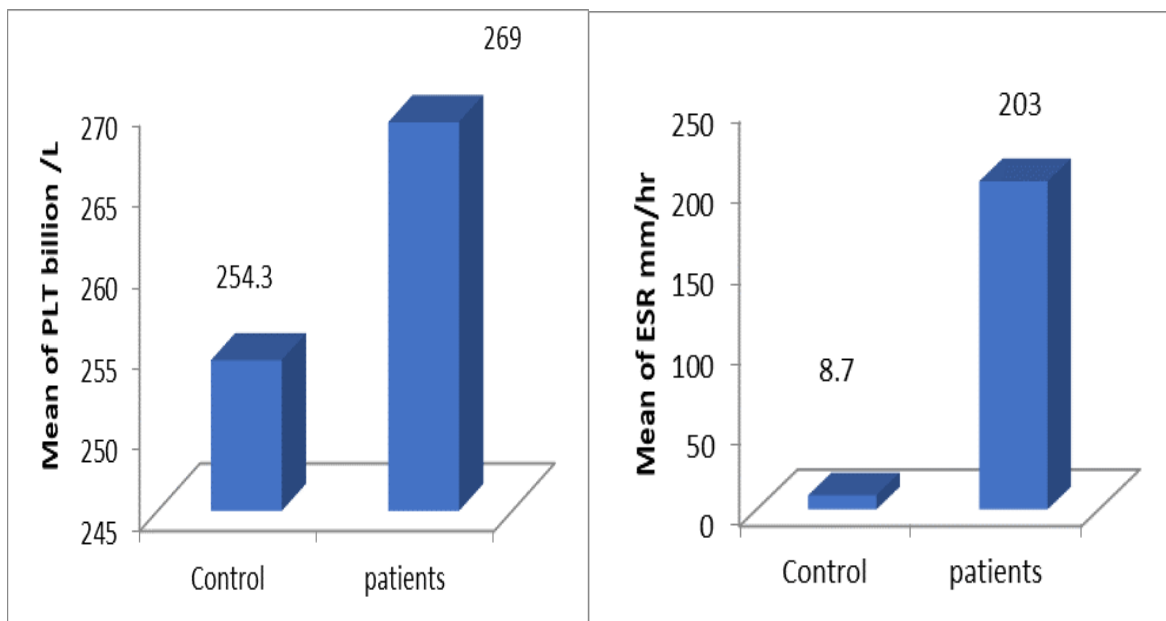


Figure 4: The level of PTL in blood group.

Figure 3: The level of ESR in blood group.

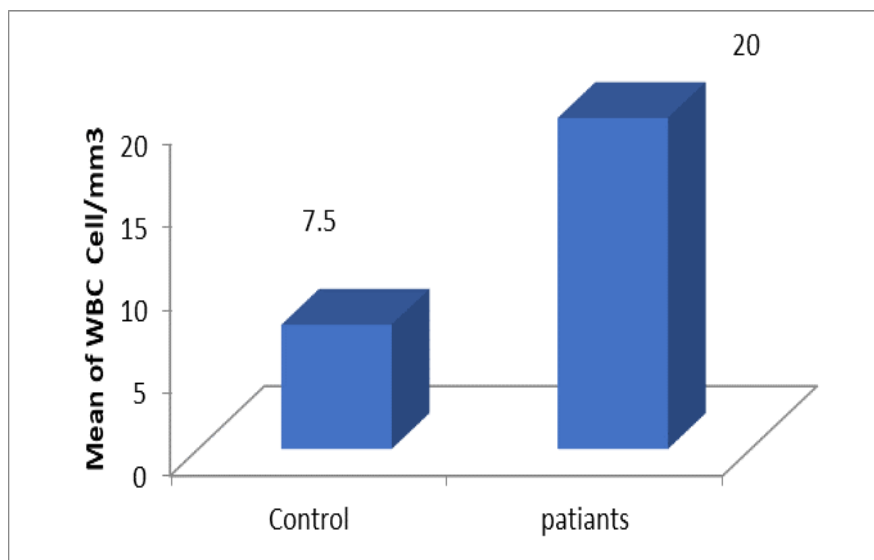


Figure 5: The level of WBC in blood group.

Estimation of tumor necrosis factor and Vitamin D3, Vitamin B12, Folate, and Ferritin level:

Table 2 shows the mean  $\pm$  SD of biochemical parameters in control group and patient group.

Parameters	Control group	Patient group	P value t - test
	Mean $\pm$ SD	Mean $\pm$ SD	
TNF- $\alpha$ (ng/ml)	55.312 $\pm$ 10.421	130.212 $\pm$ 20.421	1.7*
Vitamin D ( ng/ml )	31.6 $\pm$ 13.9	25.97 $\pm$ 13.5	1.7*
Vitamin B12 ( pg/ml)	316.5 $\pm$ 82.3	288.63 $\pm$ 78	0.038
Folate ( ng/ml )	11.7 $\pm$ 4.6	9.44 $\pm$ 4.6	0.8
Ferritin ( ng/ml )	144.6 $\pm$ 68	157.43 $\pm$ 113.4	0.028

The result showed a significantly increase in TNF- $\alpha$  and ferritin levels in breast cancer patients compared to controls as in figure (6,7) , also the results showed a significantly decline in all vitamins ( D3, B12 and folic acid) in breast cancer patients compared to controls as in figure (8,9, 10) .

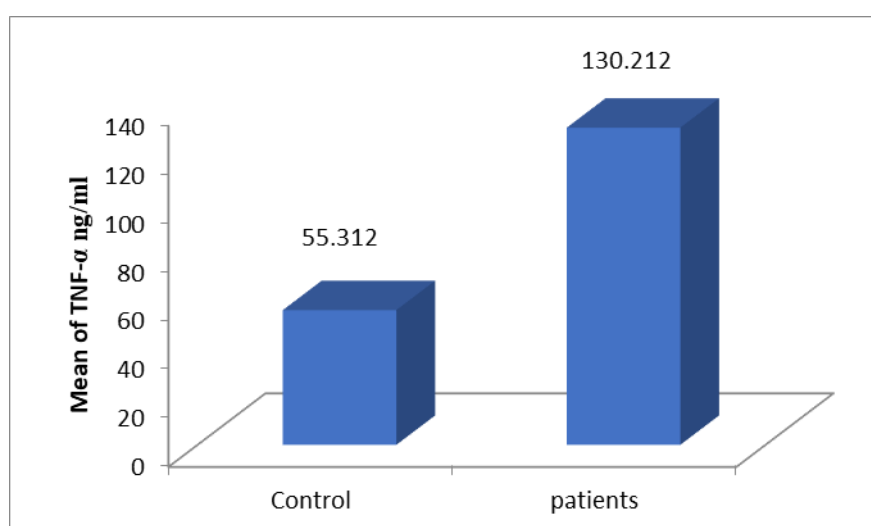


Figure 6: TNF- $\alpha$  level in blood serum



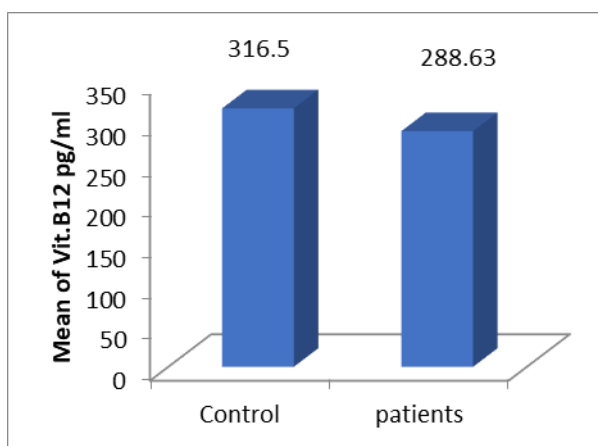


Figure 8: Vit.B12 level in blood serum

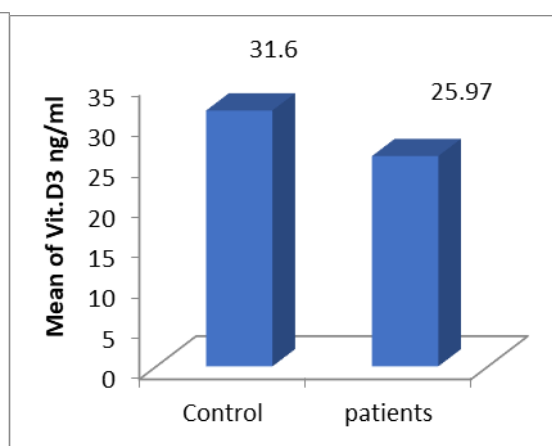


Figure 7: Vit.D3 level in blood serum.

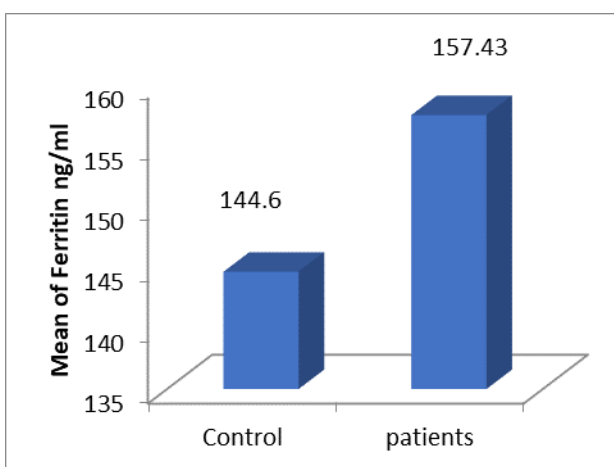


Figure10: Ferritin level in blood serum.

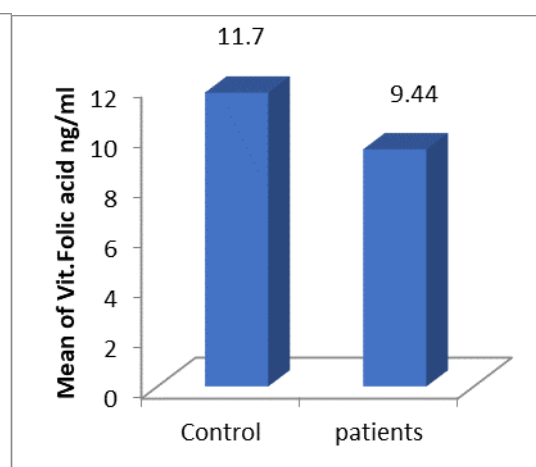


Fig 9: Folic acid level in blood serum.

The result displayed that the bleeding occurring and related to the tumor's invasion of the bone marrow may be lead to low level of Hb rate and the PCV percentage, the consequence is the bone marrow failure<sup>(16)</sup>. Alternatively, white blood cells have been found to be associated to breast cancer<sup>(17)</sup>. Cancer cells causes thrombocytosis and platelet aggregation that are the reasons for high platelets<sup>(16)</sup>. On the other hand, it was found that the cancer has relationship with increased level of erythrocyte sedimentation ratte<sup>(18)</sup>.

TNF-blockers act as therapeutic agents in solid tumors, but patients with elevated in TNF- $\alpha$  fail to respond to infliximab, due to consumption of circulating TNF-blockers and tumor progression<sup>(19)</sup>. TNF activates nuclear factor Kappa (NFK) B<sup>(19)</sup>. TNF when exposed to cancer cells<sup>(20)</sup>, as NKB-TNF plays an important role in inflammation, immune regulation, cell differentiation, and tumor formation<sup>(21)</sup>, and contributes to cancer cell proliferation, tumor angiogenesis in cancer cells, stimulation of cell proliferation and prevention of apoptosis<sup>(22)</sup>. One of the TNF receptors TNF- $\alpha$  that is located inside the mitochondria and has relationship with apoptosis<sup>(23,24)</sup>. Vitamin D deficiency is highly valuable

consequence of breast cancer in women <sup>(25)</sup>. The low level of serum folate and vitamin B12 is considered indicator for improved breast cancer risk <sup>(26)</sup>,

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**Study of the effect of *Fucus Vesiculosus* algae and relationship to thyroid hormones in rabbit serum dosed with Thiourea.**

Sara H. Oubid <sup>1</sup>

Huda F.Ramadan <sup>2</sup>

Sara O. Rasheed <sup>3</sup>

1,2 Biodept, College of Education for Women, University of Kirkuk .

3 Ministry of Education, General Directorate of Education, Salah al-Din, Tikrit Division.

[sarahalbayaty839@gmail.com](mailto:sarahalbayaty839@gmail.com)

[hudafeasal@gmail.com](mailto:hudafeasal@gmail.com)

[saraomran@yahoo.com](mailto:saraomran@yahoo.com)

## **Study of the effect of *Fucus Vesiculosus* algae and relationship to thyroid hormones in rabbit serum dosed with Thiourea.**

Sara H. Oubid <sup>1</sup>

, Huda F.Ramadan <sup>2</sup> and

Sara O. Rasheed <sup>3</sup>

1,2 Biodept, College of Education for Women, University of Kirkuk .

3 Ministry of Education, General Directorate of Education, Salah al-Din, Tikrit Division.

[sarahalbayaty839@gmail.com](mailto:sarahalbayaty839@gmail.com)

[hudafeasal@gmail.com](mailto:hudafeasal@gmail.com)

[saraomran@yahoo.com](mailto:saraomran@yahoo.com)

### **Abstract**

A biochemical study was conducted to identify the effect of *Fucus Vesiculosus algae* , which is directly related to hypothyroidism in the serum of adult white rabbits dosed with the drug thiourea, by measuring the level of thyroid hormones, antioxidants, and oxidative stress in the blood serum of (28) rabbits. The animals were divided. into four groups, in the following order:

- The positive control group was dosed orally with Distil water.
- The Negative control group: - dosed orally with Thiourea at a concentration of 5 mg/cm<sup>3</sup>.
- The first group G1 :- was dosed with 5 mg/kg/day of thiourea and then 100 mg/kg/day of crude extract of *Fucus Vesiculosus algae* .
- As for group G2, they were dosed with 5 mg/kg/day of thiourea and then 150 mg/kg/day of the crude extract of *Fucus Vesiculosus algae* . The results showed the following:

The results showed that the level of TSH showed a significant decrease in all groups compared to the positive control group in the fourth week of dosing. Also the T3 hormone level showed a significant increase in all groups C1, G1, and G2 compared to the positive control in the fourth week of dosing. In addition, the T4 hormone showed a significant increase in all groups C2, G1, and G2 in the fourth week of dosing. As well as the glutathione level, it showed a significant decrease in all groups compared to the positive control group in the fourth week of dosing. Also the malondialdehyde showed a significant increase in the serum of the groups compared to the positive control group in the fourth week of dosing.

**Keywords:** *Fucus Vesiculosus algae* , Thyroid hormones, thiourea, glutathione, malondialdehyde.

### **Introduction**

Medicinal plants were and still are the basis through which the pharmaceutical and pharmaceutical industry has developed. Plants have been exploited as a source of medicines throughout human history

and in all cultures. Scientific progress has allowed us to identify a small portion of the active compounds and their mode of action, as medicinal plants continue to contribute effectively to human health and progress, especially since many voices around the world are calling for a strong return to nature in many fields related to Human health because plants were and still are a source of food and medicine for humanity. Since ancient times, man has known many medicinal plants and herbs that grow wild in his environment. He found that many of them are useful in food and a few work as medicine. He also learned about their properties and determined their benefits by using them. They use traditional medicine to treat and remove diseases <sup>(1,2)</sup>.

Algae and its extracts have also been used in various applications in various fields such as the pharmaceutical industry, environmental treatments, and biotechnology, in addition to their use as powerful naturally occurring anti-cancer compounds that have been proposed to prevent carcinogenesis and to treat many diseases, including diarrhea, lung diseases, and bladder disorders <sup>(3, 4)</sup>. In addition to the use of many herbs in regulating thyroid hormones, such as *Fucus vesiculosus* algae, which is rich in iodine, as Hameed and her group indicated that the algae has A role in regulating the level of thyroid hormones and improving its function <sup>(5)</sup>. Brown algae, widespread on rocky sea coasts in temperate and cold regions, has also been used to treat the thyroid gland because it contains high amounts of iodine <sup>(6)</sup>. Moss is a genus of brown algae and is characterized by its greenish-brown color as a result of it containing a layer of fucoxanthin, and when it dries it turns black <sup>(7)</sup>.

*Fucus Vesiculosus algae* is used to treat cancerous tumors, especially colon cancer, as a result of it containing high amounts of fibers <sup>(8)</sup>. It is considered an antioxidant due to its high ability to attack free radicals <sup>(9)</sup>. Also, algae contains large amounts of iodine that can change the levels of thyroid hormones <sup>(10)</sup>. The thyroid gland constitutes an important component of the endocrine system that regulates many physiological functions ranging from oxygen use, growth and development to cellular metabolism <sup>(11)</sup>. Thyroid hormones are considered an essential element in the growth of the body and affect the formation of many enzymatic proteins. These hormones control most of the metabolic processes in the body and any imbalance in these hormones may have a serious clinical impact on the various organs of the body <sup>(12)</sup>.

Glutathione is a non-enzymatic antioxidant that contains vital compounds and defense systems against the danger of free radicals <sup>(13)</sup>. Glutathione is involved in many metabolic processes, and its deficiency leads to cellular danger as a result of oxidative damage (14). It has multiple functions, most of which are maintaining cellular redox balance, maintaining adequate levels of cystine and removing toxins from foreign substances entering the body <sup>(15)</sup>.

MDA is an indicator of increased oxidative stress and an indicator of oxidation as well as the incidence of some diseases, as the level of MDA increases in cancer patients <sup>(16,17)</sup>. Fats are one of the most vulnerable biomolecules to oxidative stress, and MDA is the main product of fat oxidation. It is a toxic molecule and must be taken into consideration as it is not only a sign of fat peroxidation, but it can interact with proteins and DNA, leading to the occurrence of oxidative stress (18). 19), so the current research aimed to study the effect of *Fucus vesicularis* algae and its relationship with thyroid hormones in the serum of adult white rabbits dosed with the drug thiourea.

## Materials and methods

### • Animals used in the study

(28) adult local white rabbits were used in this study. Their weights ranged from (1-2) kg, and their ages were (4-6) months. The study was conducted for the period from the beginning of April until May of the year 2023, in the animal house at the university. The animals were placed in iron cages covered with metal covers, with a floor covered with sawdust, and the hygiene aspect of the cages was taken into account by replacing the sawdust two to three times a week and sterilizing the cages with disinfectants, and the animals were fed daily and regularly with ready-made feed and water.

### • Experiment design

The animals were randomly divided into four groups, with (7) rabbits for each group. The animals were dosed orally with (5 mg/kg/day) of thiourea to induce hypothyroidism, and then they were dosed with the crude extract of *Fucus vesica*, according to the following groups:

- Positive control group C1: was dosed orally with plain water.
- Negative control group C2: was dosed orally with thiourea at a concentration of 5 mg/kg/day.
- The first group, G1: was dosed orally with (5 mg/kg/day) of thiourea and then dosed with (100 mg/kg/day) of raw algae extract.
- The second group, G2: was dosed orally with (5 mg/kg/day) of thiourea and then dosed with (150 mg/kg/day) of raw algae extract.

### • Collect blood samples

After four weeks of dosing, the animals were starved for 12 hours and blood was drawn from them using the heart puncture method. Then the dosing and blood drawing continued in the same way in the fourth week of dosing, as (4) cm<sup>3</sup> of blood was collected in the fourth week of dosing. The blood was then emptied into clean, dry plastic tubes (One-time use) Free of anticoagulants. The blood was separated using a centrifuge at a speed of 2500 rpm for 10 minutes. The blood serum was obtained and stored at -20°C after dividing it into three parts in small Eppendorf tubes until the tests were performed. Biochemistry of thyroid hormones, antioxidants, and oxidative stress.

### Determination of T<sub>3</sub>,T<sub>4</sub> Hormones

It is allowed to concentrate both T<sub>3</sub>, TSH, and T<sub>4</sub> by following the steps attached to the clarity kit prepared by the American company Monobind, and specifying the manufacturer's instructions for the ELISA technology, as they are marked up to T<sub>3</sub> according to the method <sup>(20)</sup>. As for the T<sub>4</sub> level, it is determined according to method <sup>(21)</sup>, while TSH is determined according to method <sup>(22)</sup>.

### Estimation of glutathione and malondialdehyde levels in blood serum

The concentration of glutathione in serum was estimated using the modified method used by researchers (Sedlak & Lindsay; Tietz) <sup>(23)</sup>. The concentration of malondialdehyde in the serum was also estimated using the modified method used by the researchers (Guidet & Shah ) <sup>(24)</sup>.

## Statistical analysis

The Statistical analysis system - SAS 2012 was used, using Duncun's Multiple Range test to compare between the groups. The Least Significant Differences - LSD was used in the test for the importance of comparing means in this study. Special differences between the groups were also identified in The fourth week of dosing using the T.Test <sup>(25)</sup>.

## Results and discussion

Estimation of thyroid hormones for the samples under study:

Table (1) shows the mean  $\pm$  standard deviation of thyroid hormones for the samples under study

Groups Parameter	Mean $\pm$ SD			
	C1 n =28	C2 n =28	G1 n =28	G2 n =28
TSH ( $\mu$ IU /ml)	0.097 $\pm$ 0.036 a	0.023 $\pm$ 0.011c	0.047 $\pm$ 0.032b	0.036 $\pm$ 0.005c
T3 (ng/ml)	3.625 $\pm$ 0.649a	2.721 $\pm$ 0.437b	2.521 $\pm$ 0.427b	2.012 $\pm$ 0.283c
T4 ( $\mu$ g/ml)	1.352 $\pm$ 0.222c	2.254 $\pm$ 0.443b	3.704 $\pm$ 1.032a	2.649 $\pm$ 0.500b

## Thyroid hormones

The protective effect of crude *Fucus Vesiculosus* algae extract against the effect of thiourea induced hypothyroidism was studied by monitoring the level of thyroid hormones.

## Estimation of thyroid-stimulating hormone in blood serum

Table (1) shows that the hormone level for the positive control group was (0.097 $\pm$ 0.036) micro-IU/ml, while the negative control group showed (0.023 $\pm$ 0.011) micro-IU/ml treated with thiourea. As for groups G1 and G2, it reached (0.047  $\pm$ 0.032), (0.036 $\pm$ 0.005) [micro international units/ml, respectively, and treated with the crude extract of *Fucus vesica* algae.

The results indicate that the level of thyroid-stimulating hormone showed a significant decrease at the probability level ( $P \leq 0.05$ ) in the control group compared to the other groups, as in Figure (1).



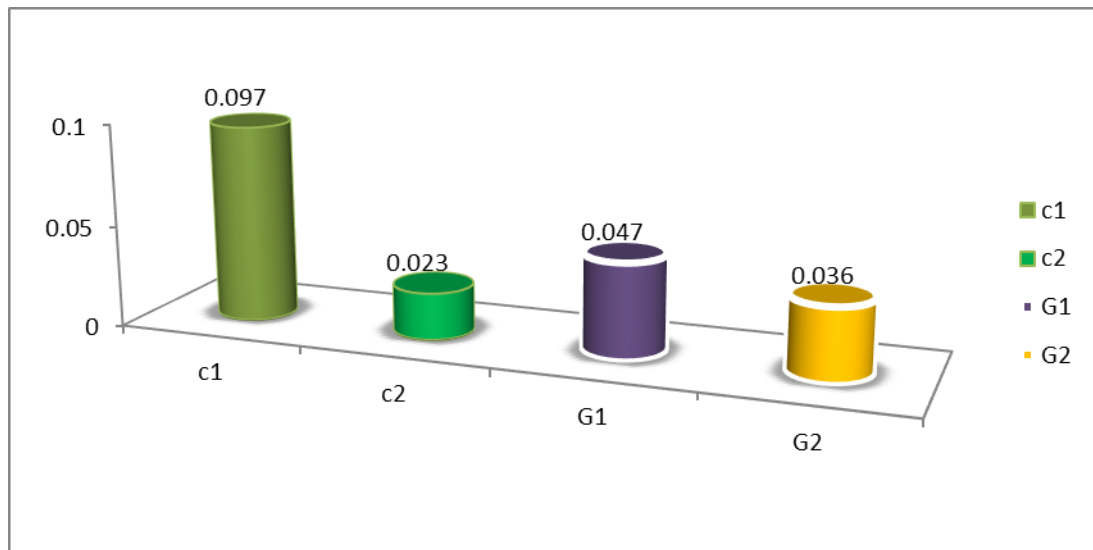


Figure (1): The level of TSH in blood serum.

Research did not indicate a therapeutic attempt for hypothyroidism using *Fucus vesicular* algae at the hormone level, but Al-Samarrai <sup>(9)</sup> The effect of raw algae may cause a decrease in the level of thyroid-stimulating hormone in the blood serum of adult white rabbits.

The low level of the hormone secreted by the pituitary gland in group G2 is due to the thyroid gland not responding to the hormone, and thus its level in the blood rises. It may sometimes cause benign hyperplasia of the thyroid gland, and at high concentrations it can cause cancer in rodents. Hyperplasia of the pituitary gland occurs as a result of the hyperfunction required to secrete the hormone TSH <sup>(26)</sup>. Also, the decrease in the hormone level in the fourth week of dosing may be due to the role of the raw moss extract in reducing the effect of thiourea, restoring the thyroid gland to its function, and blocking the harmful effect of thiourea. This is due to the properties of the moss as it contains antioxidant compounds that have enhanced the role of the immune system in eliminating toxicity. Thiourea.

### Level of T3 hormone

Table (1) shows that the T3 hormone level for the positive control group was  $(0.649 \pm 3.625)$  ng/ml, while it was  $(0.437 \pm 2.721)$  ng/ml, and the treatment with thiourea for the negative control group. As for groups G1 and G2, it reached  $(0.427 \pm 2.521)$ .  $(0.283 \pm 2.012)$  ng/ml respectively and treated with crude extract of *Fucus Vesiculosus algae* .

The results showed that the average level of the hormone decreased significantly in the negative control group compared to the positive control group. The activity of the hormone also decreased at the probability level ( $P \leq 0.05$ ) in the blood sera of the two groups treated with the crude extract compared to the negative control group. Here the effective and protective role of the crude extract against the effect of thiourea and its regulation becomes clear. The work of the gland is as shown in Figure (2).

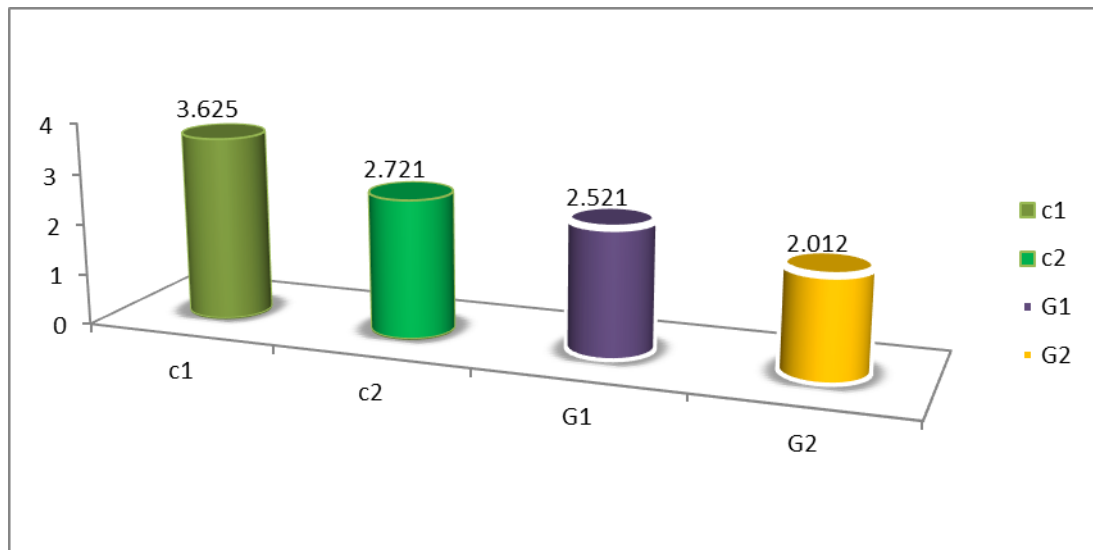


Figure (2): Level of T3 in blood serum

The reason for a decrease in the hormone level in the group treated with thiourea as a negative control group may be due to the interference that occurs due to thiourea in the path of building glandular hormones and its ability to convert iodine to the inorganic form <sup>(27)</sup>. Also, the fucus moss contains iodine, which may obscure the effect of thiourea as an additional source of iodine.

Or the reason for the decrease in the hormone may be explained by an inhibition in the activity of the 5-Monodeiodinase enzyme, which controls the conversion of the T4 hormone to T3 by thiourea, thus causing a decrease in the hormone level and an increase in the level of the T4 hormone <sup>(28)</sup>, if this result is consistent with the level of the T4 hormone that was recorded. An increase in the fourth week of dosing, and the reason for the decrease may also be due to the fact that the T3 hormone stimulated the secretion of thyroid-stimulating hormone.

TSH from the pituitary gland through a feedback mechanism, and when this cause is removed, the hormones will return to their normal levels <sup>(29)</sup>.

The T3 hormone is 3-5 times more effective in peripheral blood than T4. It also has a low affinity for plasma proteins, which makes it spread outside the vessels more easily than T4. Therefore, T3 is more important at the cellular level than T4. Therefore, it is believed that T3 is the only effective hormone and that T4 is the hormone's generator, as it is transformed in the cell into T3 after the loss of an iodine atom through the deiodenate process, and thus T3 can be considered the biologically active hormone <sup>(30)</sup>.

### Level of T4 hormone

Table (1) shows that the hormone level for the positive control group was  $(1.352 \pm 0.222)$  micrograms/cm<sup>3</sup>, while the negative control group showed  $(2.254 \pm 0.443)$  micrograms/ml and treated with thiourea. As for groups G1 and G2, it reached  $(3.704 \pm 1.032)$ .  $(2.649 \pm 0.500)$  respectively and treated with the crude extract of *Fucus vesicularis algae*.

The results showed that the average hormone level increased significantly and at the probability level ( $P \leq 0.05$ ) in the blood sera of all groups under study, C2, G1, and G3, compared to the positive control, as in Figure (3).

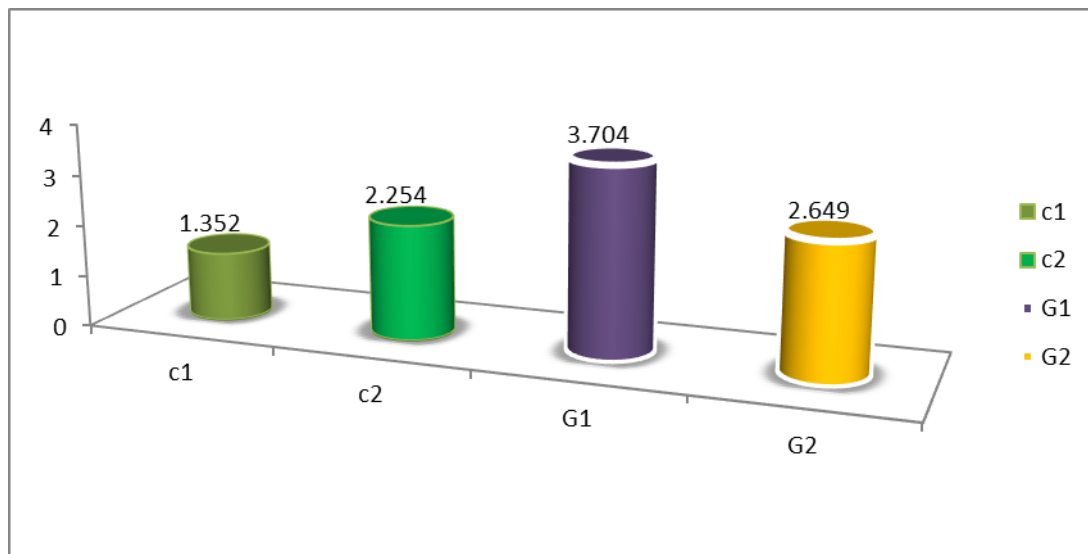


Figure (3): level of T4 in blood serum

Studies have not indicated a therapeutic attempt for hypothyroidism using *Fucus vesicularis algae* at the hormone level, but the results of Al-Samarra<sup>(9)</sup>. It indicated that raw fucus moss shows an increase in the hormone level in healthy groups treated with the moss.

The reason for the increase in the hormone in the negative control group may be due to the cessation of its conversion into T3 hormone within the tissues, which leads to an increase in its concentration in the blood<sup>(31)</sup>. Or the reason for the high T4 hormone may be due to the ability of raw algae to stimulate the secretion of thyroid hormones<sup>(32)</sup>, This is through the effect of the extracts on the receptors designated for binding to the TSH hormone, which is located on the surface of the basement membrane in epithelial cells, at the level of activation of the adenylyl cyclase enzyme located in the cell membrane, which increases the production of cAMP in the cell<sup>(30)</sup>. Thus, cAMP plays a role as a secondary carrier to activate the basic enzymatic system of thyroid cells, and this process results in a rapid increase in the secretion of thyroid hormones, including T4<sup>(28)</sup>.

- Measuring the levels of antioxidants and oxidative stress of the samples under study:

Table (2) shows the average  $\pm$  standard deviation of antioxidants and oxidative stress for the samples under study.

Groups Parameter	Mean $\pm$ SD			
	C1	C2	G1	G2
	n =28	n =28	n =28	n =28

GSH ( $\mu$ mol/l)	2.408 $\pm$ 0.219 a	1.510 $\pm$ 0.103 b	1.880 $\pm$ 0.126 c	1.756 $\pm$ 0.116 b
MDA ( $\mu$ mol/l)	1.560 $\pm$ 0.201 c	3.474 $\pm$ 0.312 a	2.282 $\pm$ 0.214 b	2.768 $\pm$ 0.259 a

#### Level of glutathione in blood serum

Table (2) shows that the mean  $\pm$  standard deviation of the glutathione level for the positive control group was (2.408 $\pm$ 0.219) micromol/L, while the negative control group showed (1.510 $\pm$ 0.103) micromol/L and treated with thiourea. As for groups G1 and G2, they reached ( 1.880 $\pm$ 0.126) and (1.756 $\pm$ 0.116) micromol/L, respectively, treated with raw vesicular focus

The results showed that the average level of glutathione decreased significantly in the negative control group compared to the positive control group, and it also decreased significantly in groups G2 and G1 compared to the positive and negative control groups and at the probability level ( $P \leq 0.05$ ), as in Figure (4).

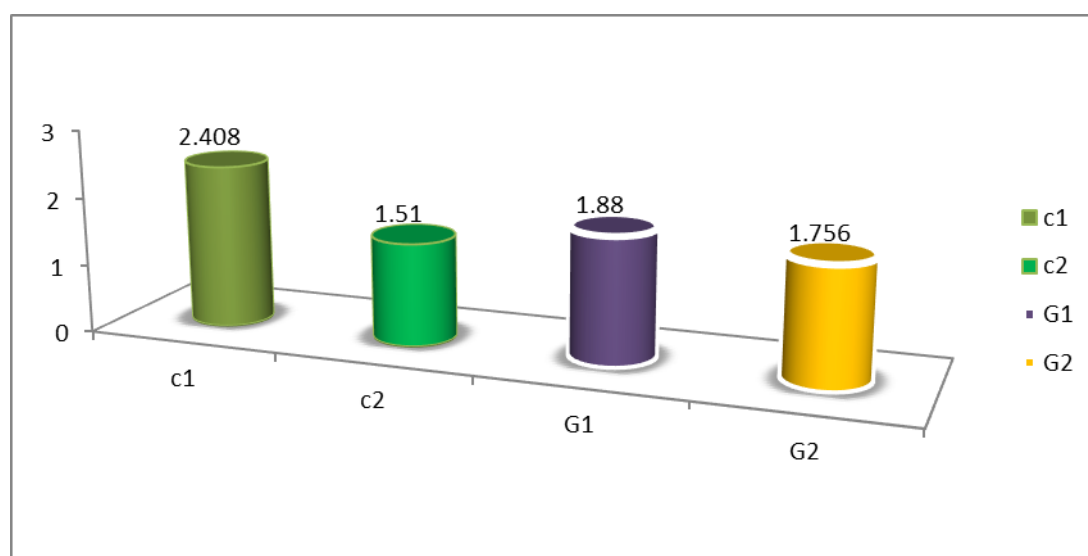


Figure (4): Level of GSH in blood serum

The literature did not indicate the effect of a treatment attempt for hypothyroidism using *Fucus vesica* algae on the level of glutathione, but the results were inconsistent with the results of <sup>(9)</sup>. While the results agree with Muhaemin <sup>(33)</sup>, who observed an increase in the level of glutathione as a result of the influence of strains of algae. *Chlorella allipsoideq*, *Scenedsmus acutus*, *Scenedesmus dimorphus*

The reason for the decrease in the level of glutathione in the negative control group may be attributed to the effect of thiourea, as it is a toxic substance to liver cells and other tissues. The reason for the decrease in the level of glutathione in group C2 compared to C1 may be attributed to the fact that thiourea may have caused a deficiency in the raw materials for its construction, especially the coenzyme. (Reduced form) Nicotinamide adenine dinucleotide phosphate (NADPH) produced by the pentose phosphate pathway Which is the catalyst for the action of the glutathione reductase enzyme,

which works to restore the active form of glutathione from the inactive form<sup>(34)</sup>. Or it may be due to the fact that thiourea led to the consumption of glutathione, which is one of the most important non-enzymatic antioxidants in removing free radicals and their products. Then it is transformed from the active form to the inactive form, glutathione disulfide. The sulfur group in the glutathione synthesis is a good reducing agent, as a hydrogen atom is blown away. Easily due to the weak bond between sulfur and hydrogen (S-H) and the strong bond between carbon and hydrogen (C-H). In free radicals, it protects cell membranes from free radical damage<sup>(35)</sup>. The reason for this decrease in the concentration of glutathione may also be attributed to the fact that hypothyroidism resulting from thiourea leads to an increase in oxidative stress and a decrease in the GSH-GSSG ratio, as well as a decrease in the effectiveness of the enzymes catalase and superoxide dismutase, as well as its possible effect on the liver, as it can cause damage to the liver cells. Causing hepatic damage, which leads to an increase in free radicals and active oxygen species (ROS) and a decrease in the concentration of glutathione in blood serum<sup>(36)</sup>.

### level of malondialdehyde

Table (2) shows that the average  $\pm$  standard deviation of the MDA level for the positive control group was  $(1.560 \pm 0.201)$  micromol/L, while the negative control group showed  $(3.474 \pm 0.312)$  and those treated with thiourea. As for groups G1 and G2, it amounted to  $(2.282 \pm 0.214)$  Micromol/L,  $(2.768 \pm 0.259)$  Micromol/L, respectively, treated with raw fucus.

The results showed that the average MDA level increased significantly in group C2 compared to group C1, and groups G2 and G1 recorded a significant increase at the probability level ( $P \leq 0.05$ ) compared to the positive and negative control group, as in Figure (5).

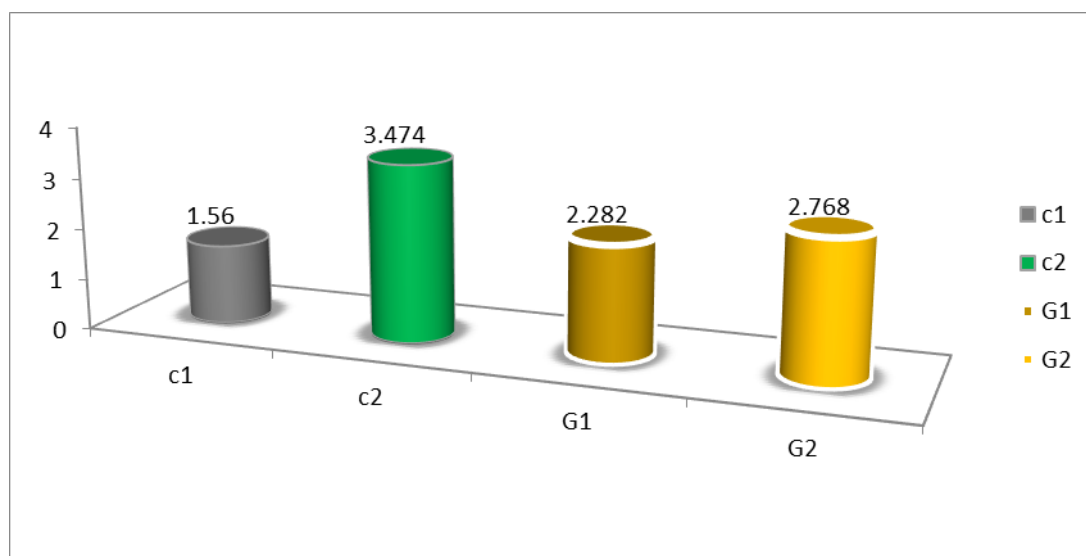


Figure (5): Level of MDA in blood serum

The literature did not indicate the effect of a treatment attempt for hypothyroidism using *Fucus vesicula* moss on the level of malondialdehyde, but the results agreed with the results of Al-Samarrai<sup>(9)</sup>.

The reason for the high concentration of malondialdehyde is attributed to the fact that thiourea may have caused an increase in the speed of consumption of antioxidant defense systems, leading to tissue damage<sup>(37)</sup>. The increase may also be due to an increase in the activity of free radicals that exceed the

ability of antioxidants to remove or neutralize them, causing an increase in lipid peroxidation and thus leading to an increase in the level of MDA and a loss of the balance between the effectiveness of free radicals and the activity of antioxidants, which leads to a loss in the elasticity of cellular membranes<sup>(38)</sup>. The reason may also be that the state of oxidative stress may affect the pancreatic  $\beta$ -cells and insulin secretion and thus lead to a decrease in the concentration of insulin in the blood. This stimulates and increases the activity of the enzyme Fatty acyl CoA oxidase, which stimulates

The process of  $\beta$ -oxidation of fatty acids and increased hydrogen peroxide formation and ultimately increased rates of lipid peroxidation and malondialdehyde production<sup>(39)</sup>.

However, the reason for the decrease in the level of malondialdehyde in the groups treated with raw moss may be due to the fact that *Fucus vesica* contains active and protective compounds that have an important role in reducing oxidative damage and its ability to scavenge free radicals, as increasing the concentration of substances is proportional to the ability to reduce levels of oxidative stress. By reducing the level of malondialdehyde<sup>(40)</sup>.

## Histological study

### Thyroid gland tissue

The results of the current study showed the effect of thiourea on the tissue of the thyroid gland, as it was observed that necrosis and rupture occurred in the colloidal vesicles of the connective tissue of the gland, with the observation of fibrin deposition in the blood vessel, as shown in Figure (6) compared to Figure (7), in which the gland cells appeared normal, as Connective tissue barriers between the colloidal follicles (normal follicle cells and blood vessels) appear normally, and part of the parathyroid gland tissue appears.

Figure (8) shows for the group treated with raw algae extract at the lower concentration, the appearance of necrosis in the colloidal vesicles and deposition of fibrin, while the cells in Figure (9) appeared almost normal and the necrosis and dehiscence disappeared, with no fibrin deposits observed in the blood vessel when treated with the higher concentration of the extract. Raw algae, which is rich in antioxidants, which work to protect thyroid cells and body cells from the danger of free radicals resulting from treatment with thiourea.

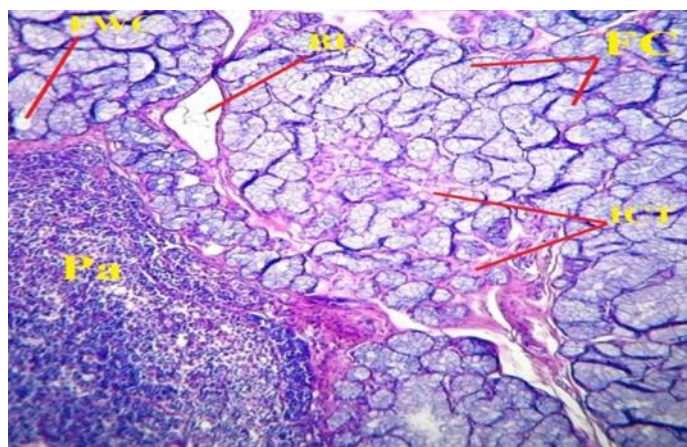


Figure (6): A cross-section of the thyroid gland showing the connective tissue barriers between the colloidal follicles (normal follicular cells) and the blood vessels normally, with part of the gland observed next to the normal thyroid gland for the positive control group (C1) x 200 (HE).

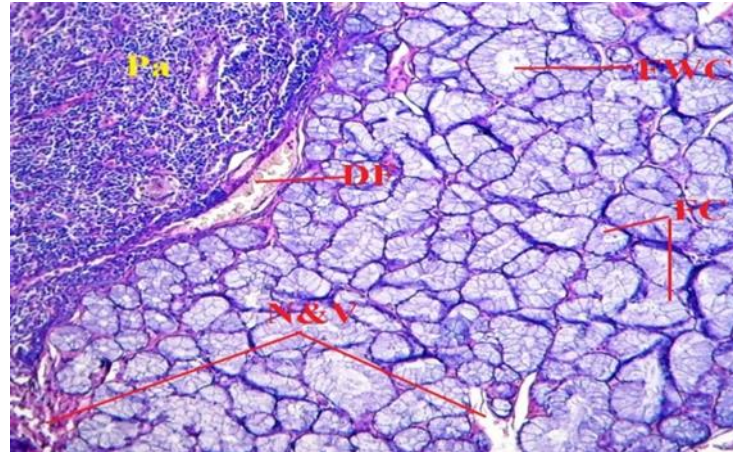


Figure (7): Cross-section showing necrosis and rupture of colloidal vesicles and connective tissue with fibrin deposition in the blood vessel of the negative control group (C2)

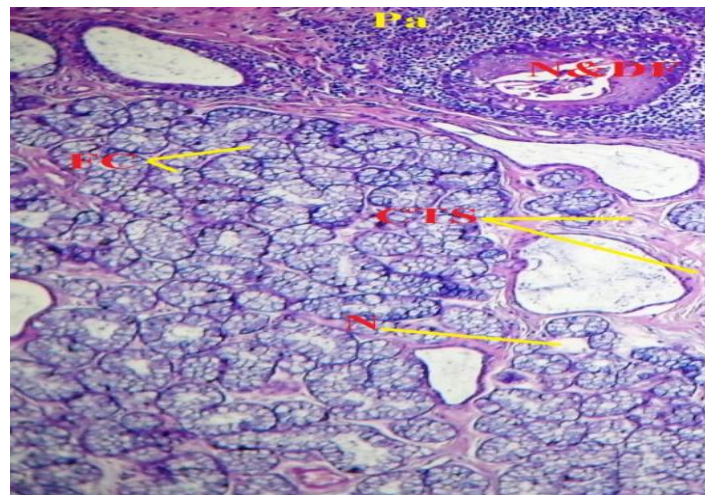


Figure (8): A cross-section showing necrosis in colloidal vesicles, noting necrosis and fibrin deposition next to the thyroid gland for group G1

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**The effect of *Allium sativum* extract and antibiotics  
against *Shewanella putterfaciens* bacteria isolated from  
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**Luma Safi Abd**

Biology Department, College of Education for pure Sciences, Tikrit University, Iraq

# The effect of *Allium sativum* extract and antibiotics against *Shewanella putterfaciens* bacteria isolated from Urinary Tract Infection

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## Abstract

The study aims to determine the extent of the effect and antibiotics on *Shewanella putterfaciens*, 90 sample were isolated from urinary tract patients who were hospitalized and admitted to AL-Alam General Hospital, five infections were diagnosed with this bacterium. The diagnosis was made based on microscopic, morphological, chemical and physiological examination and using the API 20E system, Than , a sensitivity test was conducted for both aqueous and alcoholic extracts of the garlic plant at the following concentrations (25, 50, 100)%, where the results for the aqueous extract showed (8, 10, 12)mm, respectively , while the result for the alcoholic extract showed percentages (12, 13, 15)mm at the same concentration as above.

A sensitivity test to some antibiotics was conducted, and the results of the study showed the sensitivity of bacteria to the following antibiotics (Ciprofloxacin. Ceftriaxona. Gentamicine. Azithromycin) in the rate of 100%, while the bacteria showed sensitivity to the antibiotic Amikacin in the rate of 70%, as for the Penicillin , Cefotarxime in the rates of 20% and 25% respectively, while anti Amoxicillin it was his percentage 0%.

**Keywords:** UTI, Antibiotic, *Shewanella*.

تأثير مستخلص نبات الثوم والمضادات الحيوية ضد بكتريا *Shewanella putterfaciens* المعزولة من التهاب المسالك البولية

لمى صافي عبد غنام

قسم علوم الحياة, كلية التربية للعلوم الصرفة, جامعة تكريت, العراق.

## الخلاصة

تهدف الدراسة إلى معرفة مدى تأثير كل من مستخلص نبات الثوم والمضادات الحيوية على بكتريا *Shewanella putterfaciens* . حيث تم عزل 90 عينة من مرضى المسالك البولية الراقدين والمراجعين لمستشفى العلم العام , شخصت 5 إصابات بهذه البكتريا , تم التشخيص اعتمادا على الفحص المظهري والكيميائي والفسلجي وعن طريق نظام API 20E. ثم تم إجراء اختبار الحساسية لكل من المستخلص المائي والكحولي لنبات الثوم عند التركيز (25, 50, 100)% حيث ظهرت نتائج المستخلصات المائية كما يلي (8, 10, 12) ملم على التوالي, بينما أظهرت نتائج المستخلص الكحولي النسب التالية (12, 13, 15) ملم على التوالي عند نفس التراكيز أعلاه .

تم إجراء اختبار الحساسية لبعض المضادات الحيوية , حيث أظهرت نتائج الدراسة حساسية البكتريا تجاه المضادات التالية (Ciprofloxacin . Ceftriaxona. Gentamicine. Azithromycin) بنسبة 100% , بينما أظهرت البكتريا حساسية تجاه مضاد Amikacin بنسبة 70% وتجاه مضاد Penicillin , Cefotarxime بنسبة 25% , 20% على التوالي , بينما كانت مقاومة لمضاد Amoxicillin بنسبة 0% .

## Introduction

Urinary tract infections are the second most widespread and common diseases after respiratory infection and are among the disease related to people(1). The number of people infected by it reaches millions, including males and females if all ages(2). Females are more susceptible to infection than males, because the urethra s closer to the anus, and germs are transmitted to it and cause infection(3). Studies have shown that there is an increase in antibiotic resistance due to the continued frequent and inappropriate use of antibiotics by people(4). Shewanella spp bacteria is a facultative anaerobic, heterotrophic, gram negative, rod shaped bacterium that occurs naturally in water(5). Garlic belongs to the Allium family and is closely related to onions and leeks. It has a strong, piquancy taste and is widely used (6). It consists of active compounds such as phenolic, sulfur and cytonin compounds that effect bacteria (7). The aim of the research:

Isolation and diagnosis shewanella bacteria from UTI

Knowledge effect antibiotic and Allium plant extract on growth the bacteria.

## 2-Material and Methouds

Samples were collected for a period of 3 months from people visiting and lying in Al-Alam Hospital, after explaining the method of taking the sample and mentioning the notes on the sample package, including name, age, gender and time of taking the sample (8). After that, the sample was examined microscopically to see the sediments and determine whether the sample was infected or not, we then planted it on MacConkey and Blood and EMB Agar medium and incubated at 37° degree for 24h, after bacteria growth, we isolated it and conduct the biochemical test of IMViC and the tests oxidase and catalase to diagnose it as well as the work of chromium dye to determine its shape and methods of collection and thus depends on official characteristics and biochemical tests of the diagnosis (9). Also, we used the system API 20E make sure of the diagnosis (10).

### 2-1 Antimicrobial tests

The sensitivity of this bacteria to some antibiotics was tested according to the Kirby-Bauer method on Muller Hinton agar medium depending on Clinical Laboratory Standards institute (11). The antibiotics tested in our study for which the antibiotic name and concentration are listed in table (1)

**Table 1 Antibiotic disc utilized in this study**

Antimicrobial agent (code)	Dose/Disc	Antimicrobial agent (Code)	Dose/ Disc
Penicillin (P)	10U	Azithromycin (AZM)	15mcg
Gentamicin (GM)	10mcg	Doxycycline (DO)	10 mcg
Cefotaxime (CTX)	30mcg	Amoxycillin (AMC)	25 ug
Ciprofloxacin (CIP)	10mcg	Ceftriaxone (CTR)	30 mcg

Amikacin (AK)	10 mcg		
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## 2-2 Plant extract

Allium extract (Aqueous and Alcohol) on *Shewanella putrefaciens* used to determine their effect on it, the garlic plant was placed in balanced quantities in water and another in alcohol and incubated with a humidifier for 24h at 37 degree , then filtered with a humidifying solution and placed in a centrifuge with 3000/5000 rpm

## 3- Results and Discussion

### 3-1 Collection and Diagnosis

In the current study, 90 sample were collected from the urine of people with UTI , and the bacteria appeared as 5 sample of the germs causing the disease. After examining and diagnosing the *Shewanella putrefaciens* bacteria, it showed the following characteristics:

Table 2 Biochemical characters

Gram staining	Oxidase	Catalase	Oxidative-fermentative	Motility	Methyl Red	Voges-Proskauer	Indol
-	+	+	fermentative	+	-	-	-
H <sub>2</sub> S Productase	Urease	Nitrate reductase	B-Galactosidase				
+	+	-	+				

Note: + =Positive , - = Negative

### 3-2 Antibiotics resistance

Many bacteria have many ways to resist antibiotics, and these defense methods include biofilms, capsules, and other. In our current study, we took some antibiotics CTX, CTR, P, AM , AK, AZM, GM, CIP and DO. Table 3 shows the rates of bacterial resistance to antibiotics

Table 3 show result effect resistance antibiotic on the bacteria

	AK	CIP	GM	CTX	DO	AMC	AZM
	%	%	%	%	%	%	%
<b>Anti</b>	<b>70%</b>	<b>100%</b>	<b>100%</b>	<b>20%</b>	<b>100%</b>	<b>0%</b>	<b>100%</b>
	<b>CTR</b>	<b>P</b>					
	%	%					

	<b>100%</b>	<b>25%</b>					
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The bacteria showed high sensitivity to each of the following antibiotics, GN, CIP, AZM and CTR , the results showed a sensitivity rate of 100% , this is the highest percentage, while the rate of sensitivity to an antibiotic AK was 70% , sensitivity showed low rates to each of the following antibiotics CTX and CIP was 20% and 25% , while the percentage was 0% for anti AMC, these are the lowest result that appeared to us. No similar research was available for the purpose of comparing the result.

### 3-3 Effect of plant extract

The result of the current study showed that the alcoholic extract of the garlic plant has stronger effectiveness in inhibiting bacterial growth, table 4 shows that the diameter inhibition of the alcohol extract in this bacteria, it appeared that the highest diameter of inhibition at the concentration of 100% I was reached 15mm, and less diameter of inhibition at the concentration of 25% I was reached 12mm, while the highest diameter of inhibition of bacteria in the aqueous extract was at the concentration of 100% I was reached 12mm, and less diameter of inhibition at the concentration of 25% I was reached 8mm.

**Table 4 the inhibition zone % alcohol and aqueous extract against bacteria (mm)**

<b>Aqueous extract</b>			<b>Alcohol extract</b>		
<b>Concentration (%)</b>			<b>Concentration (%)</b>		
<b>25</b>	<b>50</b>	<b>100</b>	<b>25</b>	<b>50</b>	<b>100</b>
<b>8</b>	<b>10</b>	<b>12</b>	<b>12</b>	<b>13</b>	<b>15</b>

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**Assistant teacher:Wafaa Ayoub Kissara**

Technical College of management-Baghdad

Middle Technical University

[wafaaa@mtu.edu.iq](mailto:wafaaa@mtu.edu.iq)

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[wafaaa@mtu.edu.iq](mailto:wafaaa@mtu.edu.iq)

### **Abstract:**

The research aims to activate the role of information and communication technology in improving health services in private hospitals / Baghdad. Information and communication technology represents the backbone of organizations in the current era, especially health organizations, as modern medical technologies are one of the requirements for adapting to the modern health environmental reality. Patient-related data has become digitally transferred between hospitals without the need for physical documents and transferred in the usual traditional ways, etc. The hospital only has to press a button to view the electronic medical file and the pictures and reports it needs on the health condition automatically and quickly, as it is not possible to achieve a high level of health service without the use of this information technology, as its use achieves high quality in the health service provided to patients, and this It means the necessity of correlation between the availability of medical technologies and their achievement of health service quality. The research sought to explain the role of modern information and communication technology in achieving health service quality in health organizations. The research sample was passed to 70 employees, including 28 male and 42 female employees. Coding the variables and entering them into the statistical program SPSS to analyze the data of the research under study. It was found that there is a correlation between information technology and the quality of health service, as information technology significantly affects the dimensions of health quality. The sample of the study was the International National Hospital and the International Hospital in Baghdad Governorate. The study concluded that This technology has an effective and important role in improving health services in hospitals.

**Keywords:** Information and communication technology; health service; Quality of health services.

## 1. Introduction

The human being is the goal of development, as well as its means, and health is the first human requirement and the most important component of life. The reality is that the health of the citizen is the most precious thing that societies possess, and it is a wealth that must be preserved. Therefore, it seeks Man since ancient times has sought to develop treatment and search for... Healing until medicine has reached the level of progress we have now, and researchers are still searching for further development in medicine using all available means of science, the most important of which is information and communication technology. Therefore, health institutions are among the institutions that most need to ensure and improve their services, especially after... D Progress in medical science and knowledge and successive scientific discoveries, including the development of devices and technologies, the spread of diagnostic technology and telemedicine, the spread of competition in health services between research and medical centers, and the emergence of donor institutions. ED, which sets quality standards to improve health services, and Therefore, the issue of improving and developing the service or searching for new services becomes one of the prominent features in the work of the health institution to keep pace with the speed of scientific and technological change in the field of medicine, which makes some of the health services provided obsolete over time and with the increase in the number of patients and the demand for a quick response to their requirements and needs. Accused of addition To increase the improvement of health and medical services provided to them, all of this made it necessary for those in charge of managing the quality of health services to find means and ways to meet these requests and respond to them, which led to the adoption of the use of information and communication technology in these health institutions, as Computers have become Automation and information technology are a basic means of work and management, especially in the field of health information management, storage, processing, and retrieval. With the development of health information systems and technology, it has bridged distances in a way that humans have never known before, and has enabled the storage of digital data and It also provides the ability to process this data at high speed, which helps provide extremely important information to decision makers.

### 1.1 Research problem

One of the reasons that prompted us to choose this topic:

1. The lack of applied studies that addressed the subject of information and communication technology in private health institutions and the focus of the majority of researchers on studying the institution's functions of production, marketing, and finance. Therefore, this study came as an attempt to contribute to research in the field of information and communication technology.
2. The increase in the volume of expenditures directed to the health sector, which requires thinking about ways to rationalize them by providing good service at the lowest possible costs.
3. The decline in health service, despite its importance and despite the available material and information equipment , Knowing the extent of activation of information and communications technology in health institutions and its impact on improving health services.

#### 1.2 The importance of research

This research gains an important position within the various academic research presented in this field, given that our topic affects a sensitive sector of society. The importance of this research lies in the following:

1. The importance of improving health services because of their direct impact on human health.
2. The widespread and widespread use of information and communication technology because of its impact on the time and cost factor.
3. Seeking to highlight the benefits and feasibility of using information and communication to improve health services for private sector hospitals in light of the problems facing the sector and the challenges and competition it faces.

### **1.3 Research objectives**

1. Explain the importance of information and communication technology in health institutions and its impact on health services.
2. Knowing the extent of activation of information and communications technology in health institutions and its impact on improving health services.
3. Identifying the most important needs of health institutions in order to be able to provide recommendations and suggestions that help improve the quality of health service through enhancing communication technology.
4. Providing solutions that can contribute to improving the quality of service in the sector.
5. Identify and analyze the relationship between information technology and health service quality.

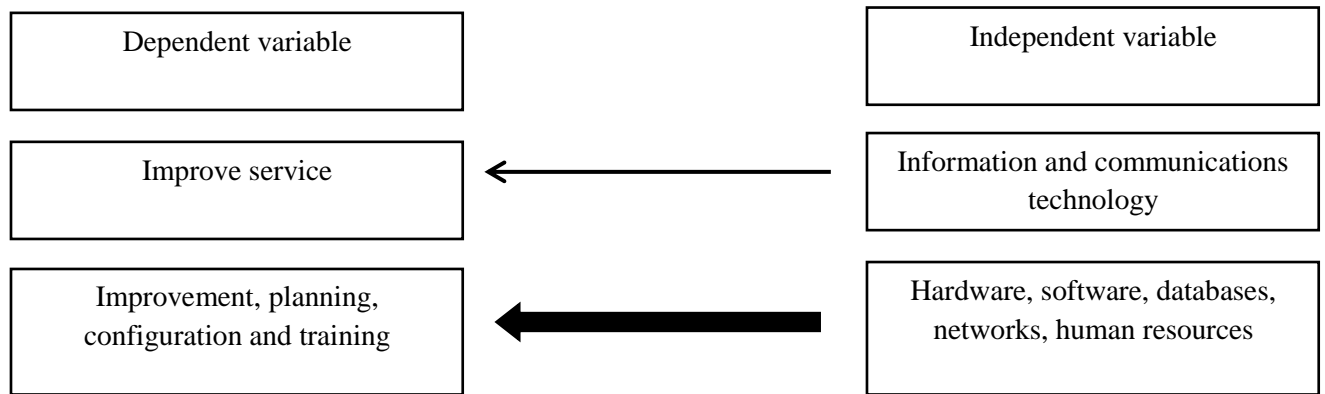
### **1.4 Research hypotheses**

The research was based on two main hypotheses:

- The first main hypothesis: There is a significant correlation between information and communication technology and the dimensions of health service quality:  
The following sub-hypotheses:
  1. There is a significant correlation between the physical equipment and the dimensions of the quality of health services.
  2. There is a significant correlation between the software and the dimensions of the quality of health services.
  3. There is a significant correlation between databases and dimensions of the quality of health services.
  4. There is a significant correlation between communication networks and the dimensions of the quality of health services.
  5. There is a significant correlation between human resources and the dimensions of the quality of health services.
- The second main hypothesis: There is a significant impact relationship between information and communication technology and the dimensions of health service quality.

### **1.5 Hypothetical outline of the research**

The following diagram shows the hypothetical diagram of the research, as it indicates the relationship between the variables, if the independent variable (information and communication technology) and the dependent variable (quality of service) are determined, as shown in Figure (1).



**Figure No. (1) Hypothetical diagram of the research**

Source: - Researcher

### 1.6 Research methodology

In order to reach the specific objectives, reliance has been placed on the descriptive and analytical approach that is compatible with this type of studies, which is based on collecting apparent quantitative facts and data to be studied, by defining the theoretical framework for the subject of the study and reviewing the studies that dealt with this subject and the experimental approach through the applied chapter on The method of case study, which enables one to delve deeper into the various aspects of the subject and reveal its dimensions through field visits to the institution under study. As for the research and study tools, we relied on a number of diverse sources and references. We also used observation as a means of research, in order to directly diagnose the reality of the institution to know The reality of applying information and communication technology in health institutions and the extent of its contribution to improving health services. We then analyzed the results of the interview we conducted.

### 1.7 Research limitations

- ✓ Spatial boundaries: The research was applied in hospitals in the private sector (International Hospital, International Hospital).
- ✓ Time limits: which is represented by the period for starting the preparation of the theoretical and applied aspects of the research from the date (12/15/2022 to the date (5/28/2023).

### 1.8 Research population and sample

1. The research community: The private health sector was chosen to implement the applied aspect of the research, as the community was represented by the International National Hospital and the International Hospital in Baghdad Governorate.
2. Research sample: A random sample consisting of (70) individuals from the hospital staff in all departments was selected. Table (1) shows the characteristics of the research sample members in terms of (gender, age group, number of years of service).

Table (1) shows the characteristics of the research sample members

percentage	the number	Category	Properties
40 %	28	male	Gender
60%	42	female	
100%	70	the total	
%27	19	Less than 30 years old	Age group
%49	34	30-40 years	
%24	17	More than 40 years	
% 100	70	the total	
%29	20	Less than 5 years	Years of service
%33	23	6-10 years	
%38	27	More than 10 years	
% 100	70	the total	

### 1.9 Statistical methods used in data analysis

The ready-made statistical program (SPSS) was used to analyze the data in the practical side of the research, as follows:

1. The arithmetic mean to determine the level of answers in the research sample.
2. Standard deviations to measure the degree of dispersion of the sample's answers from their arithmetic means.
3. Correlation coefficient to determine the degree of relationship between variables.
4. Simple regression analysis to measure the effect.

### 1.10 Previous studies

Many studies included the concept and application of the role of information and communication technology in improving the quality of services in different countries of the world. The researchers reviewed previous studies and research related to the topic of research with the aim of identifying the most important results and general indicators that resulted from those researches and studies. The following is a review of some of these. Studies:-

1. A study by Dr. Alaa Farag Hassan Radwan (2021), entitled: "The role of patient dealing skills in improving the level of health service quality" (an applied study on patients dealing with Menoufia University hospitals). This study aimed to measure the effect of the skills of dealing with patients, verbal communication, non-verbal communication, listening, and persuasion on

the quality of health service (responsiveness, reliability, empathy, material aspects, assurance). The study was applied to a sample of (264) individual patients. Visitors to Menoufia University Hospitals. The field data necessary to conduct the study was collected using a survey list, and the stability and validity of the measures used in the study were confirmed by relying on confirmatory factor analysis and the Cronbach coefficient. The study concluded: There is a positive moral effect for all skills in dealing with patients. The results showed that there is a significant positive effect for all dimensions of skills in dealing with patients, and there is also a positive moral effect for communication skills, whether verbal or verbal, for the health service. On the physical aspects dimension of health service quality dimensions, and finally, the results showed that there is a positive moral effect for each dimension of patient dealing skills on the assurance dimension as one of the dimensions of health service quality.

2. A study by Ammar Muhammad Zuhair Tinawi (2019), entitled: "The role of the use of information technology in improving the quality of services provided at the telecommunications company (MTN & Syriatel)." The study reached a number of results, the most important of which is the existence of a significant relationship between the use of information technology and the dimensions of quality. The service represented by (the dimension of tangible physical aspects, the dimension of reliability or credibility, the dimension of speed of response and customer assistance, the dimension of trust and security (warranty), the dimension of empathy with the customer), whether partially with each dimension alone, or with all dimensions combined.
3. Study by Yahyaoui Elham et al. (2016), entitled: "The importance of using information and communication technology in improving the quality of higher education at the Algerian university." The study aimed to use information and communication technology to improve the quality of higher education at the Algerian university, leading to the spread of education and improving its level, reducing costs, continuous improvement of the role of the professor, teaching methods, and artificial intelligence for education, and achieving the highest possible levels in practices and processes, including obtaining highly efficient outcomes.
4. Study by Muammar Muhammad Ambia Al-Toumi (2017), entitled: (The impact of information and communications technology on improving the quality of banking services for Libyan commercial banks: a field study). The study aimed to identify the impact of information and communications technology on the quality of services provided to clients of Libyan commercial banks, and to identify At the level of information and communications technology used, the study concluded that there is a statistically significant impact of information and communications technology on the quality of services provided to clients of Libyan commercial banks.

## **2. The theoretical framework of the research**

This aspect addresses the theoretical framework of research from all aspects, as recent times have witnessed rapid and unprecedented developments in all aspects of life. The most prominent of these developments that have distinguished our current time is the dynamism that the technological field has known, especially those related to processing and disseminating information, or what has become known as information technology, and it is considered According to current developments, information and communication technology is a new form of means that keeps pace with developments and many paths.

## 2.1. Information and communication technology

The concept of information and communication technology is a somewhat overlapping concept due to the development it has witnessed, as most of this technology has been around for the past thirty years or more. Information and communications technology has become linked to the development of societies in our present era, as it is considered the most important means of transferring developing societies to more developed societies. The term Information and Communication Technology (TIC) is not a concept with a single meaning and specialization. It is the concern of several disciplines: mathematics, automated media, communication, literature, sociology, psychology, communications engineering, medicine... etc., and its concept has emerged. Original in USA as "Media Technologies". (Chubakumzuk Jamir : 2021)

Rowley defines information and communication technology as: "collecting, storing, processing, and transmitting information using information. This is not limited to hardware equipment or software, but also to the importance of the role of man and the goals he seeks from the application and use of these technologies and the values and principles he resorts to to achieve." His experiences. (Yasser Abd. Djawad: 2018)

Communications are important for the success and achievement of understanding and cooperation between communicating individuals and groups. The communication process represents one of the basic elements in human interaction. Through communication systems, institutions have been able to achieve tangible progress in various aspects (socially, economically, etc.). (Abdul Hadi, K: 2018).

## 2.2 Characteristics of information and communication technology:

Information technology has distinguished itself from other technologies by a number of characteristics, the most important of which are the following:( Ogungbade:2022)

1. Interactivity: This means that the one who uses these technologies is independent and a transmitter at the same time, and that the parties in the communication process can exchange roles, and this is due to a kind of effectiveness between people, institutions and other groups.
2. Not limited by time: This means that messages can be received at any time, such as in the case of e-mail (E-MAIL).
3. Decentralization: It is a characteristic that allows the independence of new NTIC technologies, such as the case of the Internet, which has continuity of operation in all cases. It is impossible for any party to stop the Internet because it is a communication network between people and institutions.
4. Mobility: This means that the user can benefit from services during his movements, such as a laptop computer and a mobile phone.
5. Globalization: It is the environment that activates these technologies because it uses more space in any part of the world and allows the flow of information capital in the information capital. Its decentralization has allowed it to flourish in the global environment, especially in trade exchange, which allows it to transcend the problem of time and space. (Dr. Qassim N:2020).



### 2.3 IT Infrastructure:

“The term ICT infrastructure in its traditional definition refers to communications networks that specifically provide traditional fixed-line telephone service, and which meet a basic human need, which is the need for remote communication. However, in the twenty-first century, the amazing development of technology and the accompanying growth of the system The needs of the modern era have raised the term and deepened the concept of IT infrastructure and given it dimensions that were not known or even imaginable in the past.

Laudon and Laudn also define IT infrastructure as: “the shared technological resources that provide the basis for information system applications in the company.” (Saleem, Farrukh:2020)

### 2.4 The concept of health service

Defined by Bitner and Zeitaml, they are all activities whose outputs are not physical products. They are generally consumed at the time of their production and provide added value such as comfort, health, and time saving, and they are essentially intangible.

The health service can be defined by dividing it into two parts:

a. Therapeutic health services represent health services directly related to an individual’s health and include diagnostic services and treatment services, whether this is done through direct drug treatment at home or through supportive health services that require clinical care inside hospitals in addition to health care services until recovery occurs. These services are services Medical treatment aimed at relieving the individual of his illness or alleviating the individual’s suffering from the pain of the disease.

B. Preventive health services, or what can be called environmental health services, as these categories are related to protection from infectious diseases and epidemics, and protection from health deterioration resulting from the behavior of individuals and projects that engage in environmentally polluting activities. (Musleh, Attia:2017)

### 2.5 Characteristics of health services:

Like other services, they have a set of characteristics that distinguish them from other products by intangibility, meaning they cannot be touched, their production coincides with their consumption, variability, meaning the inability to provide the same level of quality, perishability, meaning they cannot be stored, and lack of ownership. In addition, health services are distinguished by the characteristics next:

1. Health services are personal.
2. Health services often require speed in their performance, and this requires their spatial and temporal spread.
3. Health services consist of elements that complement each other. (Musleh, Attia:2017)

❖ In the field of health care, specialists in this field believe that there are two basic elements by which the quality of health services is measured:( DR MARGARET CHAN:2020)

✓ The technical element: It relates to the application of knowledge, information, medical techniques and other sciences in treating medical problems. The degree of quality in this element is measured by the extent of the ability to provide the maximum health benefits to the patient without this leading to an increase in the risks to which he is exposed.

✓ The human element: It represents the management of social and psychological interaction between health service providers and patients in accordance with the social values and

rules that govern interaction between individuals in general and in disease situations in particular. The degree of quality in this element is measured by the extent to which health service providers meet expectations. And the needs of patients, and also in terms of comfort and pleasure requirements in the stay, as they complement the social and psychological aspects. The service can be measured from non-measurable aspects, by directing survey lists to customers, and the questions are easy, simple, and closely related to the subject of the service, as It can be analyzed appropriately, and ensuring service quality may be more than ensuring quality for tangible goods and products, due to the characteristics of the service.

## 2.6 Health Gap Scale

It is called the (Servqual) scale and is based on health service quality as the appropriate and suitable performance for measuring quality in service hospitals by measuring patient satisfaction. This scale was developed by (Parasuraman et al 1988 and Perry). This approach starts from the premise that the quality of service provided is determined conclusively. In the difference between the patient's expectations and his perceptions of the service provided, here the quality of service can be defined as (the gap), which is equal to the extent of the patient's perception of the quality of the service. (Chimango Nyasulu:2018)

Or his evaluation of the overall service provided to him as excellent or superior, and it is considered the cornerstone in measuring the quality of health service. Accordingly, the gap takes three basic forms:

✓ If the patient's perception of the service actually provided is superior to the service that the patient expects, then the gap here is positive, which means that the patient gets more health services than he expects from the hospital. .

✓ If the quality of the health service provided (the perceived gap) is equal to the patient's expectations, then the gap will be equal to zero, which means that the hospital has paid attention to the patient's expectations for the quality of health services, and has developed its health services towards customers in a way that matches their expectations.

✓ If the expected quality (gap) is negative, this means that what the patient gets from health services is different from what he expected from the hospital, which means that the hospital failed to anticipate the patients' desires for the quality of health services, and therefore did not provide them with the services they desired. (Al-Zubaidi:2018) (Gargvanshi, Prasenjit:2020)

## 2.7 The impact of information and communication technology on the health service: (Hammadi, Majed:2018)

The introduction of information and communications technology into the health sector has a significant impact on various aspects of health service provision, from improving quality to achieving effectiveness and ease of access. This is in addition to the advantages and benefits that accrue to the organization, the citizen, and public health more broadly. However, this does not mean that there are no obstacles that hinder application, in addition to negatives about it.

❖ Advantages of applying information and communication technology in the health field: (Sittig, Dean: 2015)

Information and communication technology plays an increasingly important role in providing health services. These advantages benefit the doctor, the patient, health care workers, and citizens in general alike. Each of them benefits from this technology, and perhaps the most important advantages are the following: -

1. Increase work efficiency and effectiveness.

2. Improving communication between partners in the health service.
  3. Enhancing cooperation and improving the relationship between partners in the health service.
  4. Converging distances
  5. Improve sharing of information and knowledge.
  6. Improving the decision-making process.
  7. Reduce wasted time efforts.
  8. Reducing costs.
  9. Reducing medical errors.
  10. Reduce repetition of information
  11. Improving medical research and statistical processes.
  12. Improving administrative processes.
- ❖ Obstacles to the application of information and communication technology in the health field: (Sittig, Dean: 2015) (Yassir, Ali, Hameed:2016)

There are many obstacles that stand in the way of the success of the process of implementing ICT in the health sector. Satallife has identified three main obstacles:

1. Connecting to the network
2. Content
3. Capabilities.

Madanmohan added five other elements:

1. Community
2. Trade.
3. Culture.
4. Cooperation
5. Capital.

3. The practical aspect

This shows the practical aspect of the research variables, which includes passing the questionnaire form to 70 employees, including 28 male and 42 female employees. The variables were coded and entered into the statistical program SPSS to analyze the research data under study, and the conclusions shown below were reached:

### **3.1 Testing the level of importance of the research variables:**

3.1.1 Testing the level of importance of the independent variable (information and communication technology) from the point of view of the sample members

This paragraph includes the presentation and analysis of the responses of the research sample members regarding the independent variable (information and communication technology), relying on a five-point Likert scale, which is represented.

Table (2): Description and diagnosis of the individuals in the research sample for the independent variable (information and communication technology)

N	the question	mean	standard deviation	Relative importance%
Hardware				
1	Providing computer connectivity between various departments and units within the hospital.	4.65	0.662	93%
2	The hospital has an infrastructure equipped to use information technology well.	4.4	0.545	88%
3	The hospital uses information and communication technology and modern means of communication to receive patient inquiries.	3.75	1.103	75%
4	The hospital has telemedicine technology.	4.57	0.675	91%
Software				
5	The hospital is working to develop capabilities in the field of information technology with the aim of improving performance	4.2	0.911	84%
6	Information technology provides the doctor with knowledge of the analysis available in the hospital while he is present in his department and is able to determine the analysis required to be performed on his patient.	4.60	0.671	%92
7	The hospital provides all information about new services on an ongoing basis thanks to information and communication technology.	4.6	0.671	92%
8	Information and communication technology contributes to overcoming the difficulties faced by the patient.	4.17	0.902	83.50%
9	The hospital works to quickly transfer information between different departments and administration based on information technology.	4.67	0.525	93.50%
Database				
10	The hospital maintains accurate electronic records about patients' medical reviews and consultations.	4.6	0.671	92%
11	Information and communication technology contributes to the possibility of organizing work with patients and managing relationships well.	4.55	0.714	91%
12	The hospital works to organize dealing with patients and managing relationships with them using elements of information and	4.75	0.493	95%

	communication technology to reduce effort and cost.			
13	Providing a database to facilitate booking and appointments with patients.	4.52	0.678	90%
Networks				
14	Laboratory tests are sent electronically to patients	4.35	0.735	87%
15	Medical consultations and drug prescriptions are given electronically	4.17	1.174	83%
16	The communication services provided by the hospital have helped improve health services provided to patients	4.62	0.667	92%
17	The hospital provides Internet service on an ongoing basis	4.42	0.747	88%
18	Ability to receive medical inquiries 24 hours a day.	4.5	0.716	90%
Human resource				
19	The hospital administration seeks to develop human resources (administrative and medical) through education and training in the field of information and communication technology	4.42	0.812	88%
20	The communication process between the patient and the doctor is carried out with ease through the information and communication technology available in the hospital	4.37	0.925	87%
21	Hospital workers have the knowledge and experience to answer all referral inquiries.	4.27	0.846	85%
22	Individuals working in the hospital in the field of computers and electronics have self-development capabilities.	4.75	0.438	95%
23	There is conviction and support from the hospital's senior management for the use of information technology.	4.42	0.675	88%

### 3.1.2 Testing the level of importance of the dependent variable (improving health services) from the point of view of the research sample

This paragraph includes the presentation and analysis of the responses of members of the research sample on the dependent variable (improving health services), relying on a five-point Likert scale.

Table (3): Description and diagnosis of the individuals in the research sample for the dependent variable (improving health services )

N	the question	mean	standard deviation	Relative importance%
<b>Dependability</b>				
24	Information and communication technology contributes to the speed and quality of service provided	4.32	0.828	86%
25	The hospital and its employees are committed to providing the best services to patients	4.27	1.061	85%
26	Patients place their trust in medical specimen skills confidently and safely	4.6	0.671	92%
27	Hospital workers have the knowledge and experience to answer all referral inquiries	4.27	0.846	85%
28	There is interest on the part of the hospital and its employees in the manner and form of work clothing that is appropriate to the level of service provided	4.47	0.816	89%
<b>Response</b>				
29	The hospital administration works to resolve complaints quickly and effectively	4.45	0.932	89%
30	The hospital pays attention to cleanliness, lighting, air conditioning, the necessary medical equipment, and providing an appropriate physical environment	4.2	0.822	84%
31	There is a sufficient number of doctors and nurses who provide services to patients	4.32	0.944	86%
32	The service provided is at the level that the patient expects	4.00	0.905	%80
33	The hospital cooperates with patients when a problem occurs	4.27	0.715	85%
34	The hospital administration sympathizes with patients when they submit complaints as you expect in your mind	4.27	0.846	85%
<b>Location</b>				
35	The interior design of the hospital provides a comfortable atmosphere for patients	4.55	0.749	91%
36	The hospital administration is interested in providing services in a limited time, quickly and accurately	4.32	0.693	86%
37	The hospital administration is committed to its promises to patients in the field of therapeutic health services and providing the appropriate	4.3	0.686	86%

environment as you expect			
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### 3.2 Testing the correlation and influence between the dimensions of information and communication technology and improving health services.

Testing the first main hypothesis (there is a significant relationship (correlation) between information and communication technology in general and improving health services for the research sample by (73%)).

3.2.1 Analyzing the correlation of the research variables from the point of view of the research sample  
The relationship between the research variables will be found by calculating the Spearman correlation coefficient for the correlation of ranks between both information and communication technology and improving health services through the ready-made statistical program (SPSS), as shown in Table No. (4), and the interpretation of the results is as follows:

Table (4) Spearman correlation matrix from the point of view of the research sample

Information and communication technology	B <sub>5</sub>	B <sub>4</sub>	B <sub>3</sub>	B <sub>2</sub>	B <sub>1</sub>	B
improving health services	0.794	0.694	0.736	0.731	0.564	0.737

The results of Table No. (4) showed that the value of the Spearman correlation coefficient reached (0.737) between information and communication technology and the improvement of health services in general, which is represented by (B), and from it it is clear that there is a significant correlation between information and communication technology and the improvement of health services from the point of view The research sample. The value of the Spearman correlation coefficient was (0.564) between the dimension (physical devices) and the improvement of health services (B<sub>1</sub>), and from it it is clear that there is a significant correlation between the physical devices and the improvement of health services, and this means accepting the first sub-hypothesis from the point of view of the research sample. The value of the Spearman correlation coefficient was (0.731) between the dimension (software) and improving health services (B<sub>2</sub>), and from it it is clear that there is a significant correlation between software and improving health services, and this means accepting the second sub-hypothesis from the point of view of the research sample. The value of the Spearman correlation coefficient was also (0.736) between the database dimension (B<sub>3</sub>) and improving health services, and from it it is clear that there is a significant correlation between databases and the improving health services, and this means accepting the third sub-hypothesis from the point of view of the research sample. The table also reflects (4) The correlation between the dimension of communication networks (B<sub>4</sub>) and the quality of health services, where the value of the Spearman correlation coefficient reached (0.694), and from it it is clear that there is a significant correlation between communication networks and the quality of health services, and this means accepting the fourth sub-hypothesis from the point of view of the sample. Research: Table (4) reflects the correlation between the human resource dimension (B<sub>5</sub>) and the improving health services, where the value of the Spearman correlation coefficient was (0.794), and from it it is clear that there is a significant correlation between the human resource and the quality of

health services, and this means accepting the hypothesis. The fifth subscale from the point of view of the research sample.

Since all the values of the correlation coefficients were between the two values (0.564 and 0.794), which means that all the relationships between information and communication technology and the quality of health services were between medium and strong, as we notice from the results in the table above that the highest strength of correlation was between the supplier and The human and improving health services, where the correlation coefficient reached 0.794, while the lowest degree of correlation was between the physical devices and the quality of health services with a degree of 0.564. This reflects the close interrelation between the various dimensions of information and communication technology and the improving health services. Therefore, the institution must focus on the dimensions of information and communication technology and not focus on One after another.

3.2.2 Analyzing the impact relationship of the research variables from the point of view of the research sample

Testing the second main hypothesis (there is a statistically significant relationship (effect) between information and communication technology and the improving health services).

Analysis of the levels of influence of research variables:

A- The impact of information and communication technology on the improving health services in general

Table (5) Analysis of the impact of information and communication technology on the improving health services in general from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.694	.48	35.328	0.001	0.655	0.001	Information and communication technology

It is clear from Table (5) that information and communication technology, as an independent variable, has a significant impact on the improving health services as a dependent variable, as shown by the (F) test, as its value was (35.328), and the coefficient of determination (R2) had a value of (48). The regression coefficient (B) had a value of (0.655) and at a significance level of (0.001) less than (0.05). This means that information and communication technology as an independent variable explains and interprets (48%) of the changes occurring in the dependent variable, and this means that (52%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample, and this means accepting the second main hypothesis, which states: "There is a significant relationship (effect) between information and communication technology and the improving health services in the hospital under investigation."

B- The impact of physical equipment on the improving health services



Table (6) The impact of physical devices on the improving health services from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.613	38.	23.300	0.002	0.382	0.002	(physical devices)

It is clear from Table (6) that information and communication technology (physical devices) as an independent variable has a significant impact on the improving health services as a dependent variable, as shown by the (F) test, as its value was (23.300), noting that the coefficient of determination (R<sup>2</sup>) was Its value was (38) and the regression coefficient (B) had a value of (0.382) and at a significance level of (0.001) less than (0.05). This means that information and communication technology as an independent variable explains and explains (38%) of the changes occurring in the dependent variable. This means (62%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample, and this means accepting the first sub-hypothesis, which states: "There is a significant relationship of influence between physical equipment and the quality of health services."

H- The impact of software on the improving health services

Table (7) The impact of software on the improving health services from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.711	.50	38.890	0.000	0.478	0.000	Software

It is clear from Table (7) that information and communication technology (software) as an independent variable has a significant impact on the improving health services as a dependent variable, as shown by the (F) test, as its value was (38.890), noting that the coefficient of determination (R<sup>2</sup>) was Its value is (0.50) and the regression coefficient (B) was valued at (0.478) and at a significance level (0.000) less than (0.05). This means that information and communication technology as an independent variable explains and explains (50%) of the changes occurring in the dependent variable. This means that (50%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample. This means accepting the second sub-hypothesis, which states, "There is a significant relationship of influence between software and the improving health services."

G - The impact of databases on the improving health services

Table (8) The impact of databases on the improving health services from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.745	.55	47.398	0.000	0.402	0.000	Database

It is clear from Table (8) that information and communication technology (databases) as an independent variable has a significant impact on improving of health services as a dependent variable, as shown by the (F) test, as its value was (47.398), noting that the coefficient of determination (R2) was Its value was (0.55) and the regression coefficient (B) had a value of (0.402) and at a significance level of (0.000) less than (0.05). This means that information and communication technology as an independent variable explains and explains (55%) of the changes occurring in the dependent variable. This means (45%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample. This means accepting the third sub-hypothesis, which states: "There is a significant influence relationship between databases and the improving health services."

#### D- The impact of communication networks on the improving health services

Table (9) The impact of communication networks on improving health services from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.731	.53	43.576	0.000	0.449	0.000	communication networks

It is clear from Table (9) that information and communication technology (communication networks) as an independent variable has a significant impact on the quality of health services as a dependent variable, as shown by the (F) test, as its value was (43.576), noting that the coefficient of determination (R2) was Its value was (0.53) and the regression coefficient (B) had a value of (0.449) and at a significance level of (0.000) less than (0.05). This means that information and communication technology as an independent variable explains and explains (53%) of the changes occurring in the dependent variable. This means (47%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample. This means accepting the fourth sub-hypothesis, which states: "There is a significant relationship of influence between communication networks and the quality of health services."

#### I- The impact of the human resource on the quality of health services

Table (10) The impact of the human resource on the quality of health services from the point of view of the research sample

Improving health services						Variables
R	R2	F		B		
		F	Sign	B	Sign	
From the point of view of the research sample						
0.752	.56	49.585	0.000	0.529	0.000	human resource

It is clear from Table (10) that information and communication technology (human resource) as an independent variable has a significant impact on the quality of health services as a dependent variable, as shown by the (F) test, as its value was (49.585), noting that the coefficient of determination (R2) was its value was (0.56) and the regression coefficient (B) had a value of (0.529) and at a significance level of (0.000) less than (0.05). This means that information and communication technology as an independent variable explains and explains (56%) of the changes occurring in the dependent variable. This means (44%) of the variables are due to other variables that are not shown in the research model from the point of view of the research sample. This means accepting the fifth sub-hypothesis, which states: "There is a significant influence relationship between the human resource and the quality of health services."

After analyzing the questionnaire data using the statistical program - SPSS, we found that there is a statistically significant relationship between information and communication technology as an independent variable on the one hand and the quality of health services as a dependent variable on the other hand, as there is a positive autocorrelation between information and communication technology and the quality of health services, and this is sufficient, To confirm and explain the relationship between the independent and dependent variables. It was also shown through the study of the one-way analysis of variance (ANOVA) test that there is a significant significant effect between the variables of the study, which are mainly represented in information and communication technology and the quality of health services in the studied community.

### Conclusions

1. Through statistical analysis of the research sample in the international hospital and the international hospital affiliated with the private sector, it appears that there is an awareness of the improving health service provided in hospitals.
2. The hospital's interest in working on using appropriate software to analyze, classify, and summarize data to prepare the information it requires at the present time.
3. The hospital's interest in using databases, recording all patient information on a daily basis, and providing the Internet in order to provide information in real time.
4. It has been shown that there is a correlation between information technology and the improving health services, as information technology has a significant impact on the dimensions of health quality. This indicates that investment in information and communication technology components contributes to a high level of the health service provided.
5. Hospitals' interest in the improving health service and working to reach a high level of quality. This was clearly evident through the research sample's answers to questions related to the improving health service provided.

## Recommendations

1. Developing the electronic communication system between the various hospital departments and thinking about alternative solutions in the event of a breakdown.
2. Developing the capabilities and skills of all employees by having health institutions conduct training courses and study days on various information technology applications in the hospital .
3. The necessity of coordination between private sector hospitals and foreign hospitals that use health service quality systems in order to exchange experiences in the field of health service quality.
4. It is necessary to include laws and regulations that control the use of this technology in order to maintain the confidentiality and security of information.
5. Activating communication between citizens and health institutions through developing their websites.

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## **Hiding Secret Data in Color Video Applying Modify RSA for Cryptography with Randomly Select Frame and Pixel to Steganography**

**Hatem Nahi Mohaisen <sup>1</sup>, Mohammed Q. Mohammed <sup>2</sup>, Mustafa Hatem Nahi <sup>3</sup>**

1 Ministry of High Education and Scientific Research/Minister's office, Baghdad, Iraq.

2 University of Information Technology and Communications, Baghdad, Iraq.

3 Al-Esraa University, Baghdad, Iraq.

[ha19652010@yahoo.com](mailto:ha19652010@yahoo.com)

[dr.mohammed@uoitc.edu.iq](mailto:dr.mohammed@uoitc.edu.iq)

[mustafa1234432111@gmail.com](mailto:mustafa1234432111@gmail.com)

# Hiding Secret Data in Color Video Applying Modify RSA for Cryptography with Randomly Select Frame and Pixel to Steganography

Hatem Nahi Mohaisen<sup>1, a)</sup>, Mohammed Q. Mohammed<sup>2,3, b)</sup> Mustafa Hatem Nahi<sup>3, c)</sup>

<sup>1</sup> Ministry of High Education and Scientific Research/Minister's office, Baghdad, Iraq.

<sup>2</sup> University of Information Technology and Communications, Baghdad, Iraq.

<sup>3</sup> Al-Esraa University, Baghdad, Iraq.

[ha19652010@yahoo.com](mailto:ha19652010@yahoo.com)

[dr.mohammed@uoitc.edu.iq](mailto:dr.mohammed@uoitc.edu.iq)

[mustafa1234432111@gmail.com](mailto:mustafa1234432111@gmail.com)

## Briefly:

In this study paper, we will explain how to conceal sensitive notification in a color movie by selecting a frame at random and then using a mathematical calculation to split the frame into (R G B) and random pixels from that frame. This method goes through five basic stages, the first stage, transform the video to frames, which represents the number of frames that make up the video, the second stage choice one frame from this frames randomly, after that transform the frame to digital and separating the frame to three matrix (R, G, B), third stage transform secret message the encryption using the RSA. The number of pixels choose dependent on the length encryption secret message. Fourth stage hiding the encryption message in the frame randomly in (R, G, B). Then we return the selected pixels to their original positions in the frame. The five stages, return the frame in original place in video and send the video to the recipient. The statistical measures were used the Structural Similarity Index Measure (SSIM), peak signal to noise ratio (PSNR), histogram and mean square error (MSE). The outcomes achieved are excellent. The recipient to extract the secret message follows the same secure keys to arrive the hid secret and same steps from the first four stages.

**Keywords:** Information concealing, Video, SSIM, PSNR, MSE, and Modified RSA cryptography, Seed number, Histogram.

## INTRODUCTION

These days, information security is crucial to the storage and transmission of data, particularly when high levels of anonymity are needed. The video or images are rentals in considerable part in many businesses. Because of this, it's important to protect video and image data from prohibitive arrival or from being decrypted by an unexpected user. Attackers and other intruders interfere with the majority of systems globally, altering or tampering with critical data that is transmitted through those systems. The secrecy of digital videos has become more important in today's technological and connected society. Numerous researchers have come up with numerous strategies to avoid these issues and stop them from disclosing or altering information in order to tackle these concerns. The most well-known techniques for preserving crucial data while it is being sent are cryptography and steganography. An inclusion technique for hiding encrypted messages in random and non-contiguous pixel locations along borders and in smooth areas of pictures [1]. Steganography is a technique for concealing information in media, whereas cryptography encrypts data and uses an appropriate key [2, 3, 4]. Utilizing a hash function to generate a modality for data hiding into the carrier media's LSB of RGB pixel values [5]. In the temporal domain, a mixed steganography and encryption technique is used. First, the secret handwritten signature's image is encrypted using RSA; the final three bits are then randomly entered based on mathematical randomized [6]. By integrating many cryptography phases—the DNA algorithm, GZIP algorithm, AES and image, multiplying by worker along the last step of DNA encryption, and LSB image steganography technology—the encrypted letter is disguised in a high-quality image steganography [7]. An innovative asymmetric picture encryption method relied on the Arnold transformation and RSA algorithm. First, the quantum logistic chart's prime values are

generated using the RSA algorithm's asymmetric public key. Secondly, the Arnold chart's parameters are computed. The process of investigating the rough concealing of picture information on a typical image is called the Arnold creeping operation. Third, the image's columns and rows are each assigned different units, and exclusive-OR (XOR) diffusion is then used [8]. Combining the human skin-color offer with the LSB algorithm—which can choose the inclusion zones—is an additional choice. This theory is based on the observation that the Human Vision System (HVS) tends to concentrate its attention on selecting specific visual sight structures rather than the entire image [9]. Secret data was concealed in a grayscale digital image using a different technique. Combining RSA encryption with steganography has advantages. This method relies on looking for two-by-two congruence bits between the values of the image pixels and the secret data bits. The confidential data bits are hidden at the drag (LSB) least significant bits in the event that the bits are not congruent. To apply the steganography technique, two types of images are used: a bright grayscale image and a dark grayscale image [10]. Arnold Mapping is utilized to guarantee extreme jumbleness in both copartner pixels and random spreading, hence excluding any potential interaction with the main picture placate, architecture enlarged visual cryptography design for color images and increased security [11]. A mix of three techniques to increase the system's overall security level: altered RSA cryptography, steganography-encrypted text, and random pixel selection from an image [12]. Use a mathematical equation to randomly pick the number of bytes in a color image that contains confidential information. The long of the confidential message determines how many randomly chosen bytes will be included in the digital picture once it has been transformed [13]. Combining cryptography and steganography results in a strong system that can use the RSA technique to encode a secret message. The sophisticated LSB approach is utilized to disguise the message [14]. This work uses the affine transformation approach as a display steganography method to hide data. The coefficients of the video frames' integer wavelet transform include the secret data. The affine transformation is used to disperse the pixel values during embedding [15]. This article illustrates the two approaches' various applications. A communication is encrypted while it is being transferred over a network from one source to another using steganography and cryptography. These methods are frequently employed to ensure the security and privacy of data. While stenography is used to conceal the cover medium, such as audio, photos, or videos, cryptography keys conceal information using a private key or public key, preventing third party from accessing the data. These methods have been applied to entity authentication, basic authentication, confidentiality, and security of data[16]. Suggested encrypting images with second-order equations and embedding the resultant encrypted image within the movie. To strengthen the security layer, the image is embedded based on the equations rather than sequentially. The experimental findings indicate that a high embedding ability is achieved by the suggested strategy. Additionally, as compared to alternative information-hiding techniques, the suggested system is more secure and resilient due to encryption and non-sequential frame and bit-hiding location selection [17]. In order to conceal data in video files, this project presents the Least Significant Bit Substitution approach using elliptical curve cryptography. Data hiding, a type of cryptography used in this research, inserts data into digital media for identification and annotation purposes [18]. This study looks at the histogram that forms inside the frame as well as the forecast error that arises between two consecutive frames of a video binder. The resulting stego\_file's frame count and composition remain unchanged despite these updated forecast inaccuracies [19]. Video frames can be encrypted and conceal into a cover video binder using one of two techniques. First, a wide variety of distinct keys were generated for encryption using two keys and the XOR bit operation. Second, to provide two security levels, a improve version of the least significant bit (LSB) technique was used to hide bitmap color, high quality video frames in specific cover video frames. Encryption and data masking techniques were successfully tested on numerous classified recordings, including Traffic, Secret Medicine, and Ad Eye videos [20].

This study offers a novel approach to stop hackers, intruders, and cryptanalysis from accessing, changing, or tampering with sensitive data. Using five methods, video splitting, RSA modification, unspecified of the chosen frame from color video, selection of pixels from a single frame based on the length of the secret message, and concealment technique employing (LSB).



**FUNDAMENTALS****RSA Cryptography**

One of the earliest and most commonly employed methods for public-key encryption is the RSA algorithm. This cryptographic technique was introduced in 1977 by a team of MIT-affiliated researchers led by Ron Rivest, Adi Shamir, and Leonard Adelman. RSA is frequently utilized for creating public and private key pairs [21]. The RSA algorithm operates in an asymmetric manner, involving the use of two keys: one for the public and another for the private. Next, it proceeds with the key generation procedure in five steps:

1. Select (p and q) two huge prime numbers.
2. Determine  $n = p * q$ .
3.  $\Phi(n) = (p - 1) * (q - 1)$  must be calculated.
4. Select a number e such that  $1 < e < \Phi(n)$ , and:
  - (a) Ascertain that  $\text{gcd}(e; \Phi(n)) = 1$ .
  - (b) Make sure  $\Phi(n)$  and e are coprime.
5. Calculate an integer d such that  $d = e^{-1} \text{ mod } \Phi(n)$ .

Both the produced asymmetric keys and the decryption process can use them. The public key is made up of (n, e), whereas the private key is made up of (d, n).  $K_{\text{private}} = (d, n)$ ,  $K_{\text{public}} = (e, n)$  [22].

**Pseudo-random number generator**

For computers, creating unspecific numbers for cryptography is a difficult process. A function for pseudo-random number creation, after receiving a starting seed, produces a series of digits that appear random to an observer without knowledge of the seed value [23]. The linear congruential random number generator (LCRNG) is used to create a unspecific set from pixels, initially put forth by Lehmer [24], is used. One of the most popular methods for creating a series of unspecific numbers is the LCRNG ( $x_0, x_1, \dots$ ) within range  $[0, n-1]$ . The number of seeds is  $x_0$ . Any successive random number  $x_{i+1}$ , can be get using the following formula:

$$x_{i+1} = w * x_i + s \text{ mod } m \quad (1)$$

Where m is the modulus, s is the increment, and w is the constant multiplier.

**LSB Concealing**

The purpose of concealing is to hide sensitive information within the transmission medium so that an adversary cannot detect the presence of the hidden message. Steganography can be used with various forms of data such as audio, video, and images, and has the ability to hide a wide range of digital content. The least significant bit, or LSB, is one of the most straightforward techniques for cancelation of spatial domain images [8]. The following algorithm makes hiding easier and easier to implement. The goal of data embedding is to obliquely add a message to each pixel's least significant bit on the bearer medium. View the following example:

Bitmap picture file: 10101101 11001010 10111010 01011001

Piece of Information: 0010

Stego Picture: 10101100 11001010 10111011 01011000

Later, other researchers proposed and put into practice some expanded versions of this technique. According to a study [25], bit replacement can also be performed on the sixth, seventh, eighth, and even on their combination.

**Dedication Measure**

The degree of change between the original image and the stego-image is estimated using these kinds of measurements. The following are the most well-known measurements [26]:

**Equation of (MSE)**

It is the average of two photos' square errors:

$$MSE = \frac{1}{RC} \sum_{y=1}^C \sum_{x=1}^R (f_0(x, y) - f_e(x, y))^2 \quad (2)$$

### Equation of (PSNR)

The PSNR values, which assess the ratio of distortion and are derived from equation (3) for color images, are used to compare the original and stego-image:

$$PSNR = 10 \text{Log}_{10} \left( \frac{(\text{Max}_{xy} f_0(x, y) - \text{Min}_{xy} f_e(x, y))^2}{MSE} \right) \quad (3)$$

And in gray scale is:

$$PSNR = 10 \text{Log}_{10} \left( \frac{255^2}{MSE} \right) \quad (4)$$

Where  $\text{Min}_{xy} f_e(x, y) = 0$ , and  $\text{Max}_{xy} f_0(x, y) = 255$  denoted the original and embedded images, respectively,  $f_0$  and  $f_e$ .

### Equation of (SSIM)

Together with MSE and PSNR, a more recent metric like the structural similarity index metric (SSIM) can provide a comparison. Greater similarity is indicated by a high SSIM around one. SSIM can be computed using:

$$SSIM(x, y) = \frac{(\mu_x \mu_y + n_1)(2\sigma_{xy} + n_2)}{(\mu_x^2 + \mu_y^2 + n_1)(\sigma_x^2 + \sigma_y^2 + n_2)} \quad (5)$$

The constants  $n_1$  and  $n_2 > 0$  are employed to ensure stability when other parameters are approximated to zeros, where  $\sigma$  is the standard deviation and  $\mu$  is the mean intensity.

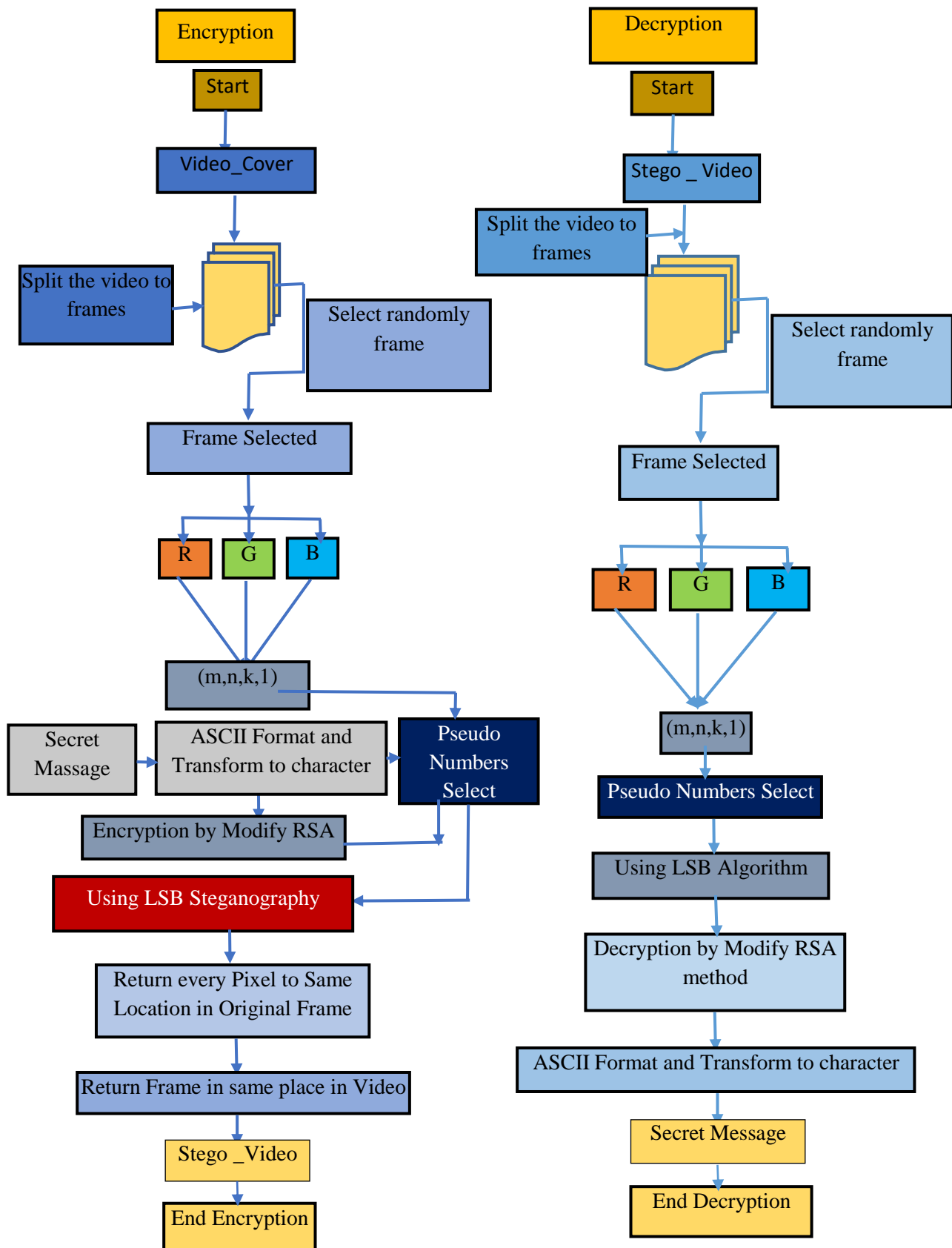
## ENHANCED RSA AND THE SYSTEM'S STRUCTURE

The suggested system introduces an enhanced to the RSA formula, involving multiplication of the typical RSA formula by an integer for encryption and division by the same integer for decryption. This integer incorporates any additional keys included in both the private and public keys. This adjustment results in a modified RSA equation for encryption, with 'E' representing the cipher text. Now, the equation of RSA becomes:

$$E = (M_e \text{ mod } n) * I \quad (6)$$

Where the integer, I is positive. Equation (7) represents the decryption equation.

$$M = \left( \frac{E}{I} \right)^d \text{ mod } n \quad (7)$$



**PROPOSED METHOD**

The suggested approach through two algorithms: one for encryption and one for decryption. When this algorithm is employed on a color video, it involves the following steps: splitting the video into individual frames, randomly selecting one or more frames,

FIGURE 1. The encryption and decryption flowchart

separating the chosen frame(s), performing encryption, embedding secure data, and finally, decrypting and extracting the secure data. Algorithms 1 and 2 elaborate on each of these phases.

Algorithm 1 (transmitter portion)

Input: video cover, message, seed number, p, q, and integer I.

Output: stego\_video.

- A. Utilize the cover video
- B. Divide the video into individual frames.
- C. Randomly choose a frame using equation (1).
- D. - Convert the message into ASCII format.
- E. Employ equation (6) for message encryption.
- F. Calculate the length of the ciphertext.
- G. Split the selected frame into a 1-dimension ( $m * n * 3, 1$ ), giving every pixel an index.
- H. Using the equation (1) with a seed number to obtain a unspecific pixel from step (F) based on the long of the ciphertext.
- I. Utilize LSB cancellation to hide the information in the randomly chosen pixel from (G).
- J. Restore each pixel to its original position based on the frame's index.
- K. Convert the one-dimensional representation of the selected frame back into a three-dimensional format ( $n, m, 3$ ) to reconstruct the original frame.
- L. Return the chosen frame to its original location in the video.
- M. Transmit the video to the recipient as "Stego\_video."

Algorithm 2 (recipient portion)

Input: video cover, message, seed number, p, q, and integer I.

Output: confidential message.

- A. The Stego\_video.
- B. Divide the Stego\_video into individual frames.
- C. Randomly choose a frame using equation (1).
- D. Transform the selected frame into a one-dimensional format ( $m * n * 3, 1$ ).
- E. Utilize equation (1) and input the message length together with the transmitter seed number.
- F. Utilize LSB to extract the secure data from the pixels selected in step (E).
- G. The ASCII form of the message can be obtained by applying equation (7) with the same values for I, p, and q.
- H. Transform the ASCII characters into the original message.
- I. The concealed confidential message.

### TRIALS AND OUTCOMES

The suggested solution was put into practice on an HP PC running Windows 7 with an Intel(R) Core (TM) I5-7200U processor, 2.5 GHz CPU, 4.00 GB of RAM, and MATLAB 2014a software. The program was used on video file type (VIA), and the frame BMP type as cover video. The split of video shown that in Figure (2). The Figure (3A, 3B) depicts the façade of the proposed system apparenting the methods of encryption and decryption. The outcomes demonstrate that the suggested algorithm accomplishes a significant security. The findings demonstrate that the recommended method satisfies a significant security note, as indicated by figures 4 through 9 and the fidelity measure values listed in Table 1. The frame from figure (4), shown as a random numbers selection made from the frame following the message's encryption, and figure (5) represented of the frame 25 represent original and stego-frame and histogram (R, G, B) to the random frame selected, and frames from figures (6, 7, 8, 9) represented the frames (56,126,187,377) with the original frame and stego-frame and histogram caparison between original and stego-frame. The histogram of the original frame with the same length message is compressed when different frames are taken; the viewer is not aware of the subtle change in the histogram's form. A sample of choose random number from color frame of size  $400 \times 300$  of message" hello hatem how are you i hope you are good health", Figure (4) displays the results for 88 generation of pixels.

The suggested approach can be used with color video and is described through two algorithms: one for encryption and one for decryption. When this algorithm is employed on a color video, it involves the following steps: splitting the video into individual frames, randomly selecting one or more frames, separating the chosen frame(s), performing encryption, embedding secure data, and finally, decrypting and extracting the secure data. Algorithms 1 and 2 elaborate on each of these phases.

Algorithm 1 (transmitter portion)

Input: video cover, message, seed number, p, q, and integer I.

Output: stego\_video.

- A- Utilize the cover video
- B- Divide the video into individual frames.
- C- Randomly choose a frame using equation (1).
- D- - Convert the message into ASCII format.
- E- Employ equation (6) for message encryption.
- F- Calculate the length of the ciphertext.
- G- Split the selected frame into a 1-dimension ( $m * n * 3, 1$ ), giving every pixel an index.
- H- Using the equation (1) with a seed number to obtain a unspecific pixel from step (F) based on the long of the ciphertext.
- I- Utilize LSB cancellation to hide the information in the randomly chosen pixel from (G).
- J- Restore each pixel to its original position based on the frame's index.
- K- Convert the one-dimensional representation of the selected frame back into a three-dimensional format ( $n, m, 3$ ) to reconstruct the original frame.
- L- Return the chosen frame to its original location in the video.
- M- Transmit the video to the recipient as "Stego\_video."

Algorithm 2 (recipient portion)

Input: video cover, message, seed number, p, q, and integer I.

Output: confidential message.

- A- The Stego\_video.
- B- Divide the Stego\_video into individual frames.
- C- Randomly choose a frame using equation (1).
- D- Transform the selected frame into a one-dimensional format ( $m * n * 3, 1$ ).
- E- Utilize equation (1) and input the message length together with the transmitter seed number.
- F- Utilize LSB to extract the secure data from the pixels selected in step (E).
- G- The ASCII form of the message can be obtained by applying equation (7) with the same values for I, p, and q.
- H- Transform the ASCII characters into the original message.
- I- The concealed confidential message.

## TRIALS AND OUTCOMES

The suggested solution was put into practice on an HP PC running Windows 7 with an Intel(R) Core (TM) I5-7200U processor, 2.5 GHz CPU, 4.00 GB of RAM, and MATLAB 2014a software. The program was used on video file type (VIA), and the frame BMP type as cover video. The split of video

shown that in Figure (2). The Figure (3A, 3B) depicts the façade of the proposed system apparenting the methods of encryption and decryption. The outcomes demonstrate that the suggested algorithm accomplishes a significant security. The findings demonstrate that the recommended method satisfies a significant security note, as indicated by figures 4 through 9 and the fidelity measure values listed in Table 1. The frame from figure (4), shown as a random numbers selection made from the frame following the message's encryption, and figure (5) represented of the frame 25 represent original and stego-frame and histogram (R, G, B) to the random frame selected, and frames from figures (6, 7, 8, 9) represented the frames (56,126,187,377) with the original frame and stego-frame and histogram caparison between original and stego-frame. The histogram of the original frame with the same length message is compressed when different frames are taken; the viewer is not aware of the subtle change in the histogram's form. A sample of choose random number from color frame of size  $400 \times 300$  of message" hello hatem how are you i hope you are good health", Figure (4) displays the results for 88 generation of pixels.



FIGURE 3 B. The frontage of the suggested system to decryption



FIGURE 3 A. The frontage of the suggested system to encryption

```

The value of (N) is: 7663
The public key (e) is: 5
The value of (Phi) is: 7488
The private key (d)is: 4493
ASCII Code of the entered Message:
Columns 1 through 17
 104 101 108 108 111 32 104 97 116 101 109 32 104 111 119 32 97
Columns 18 through 34
 114 101 32 121 111 117 32 105 32 104 111 112 101 32 121 111 117
Columns 35 through 50
 32 97 114 101 32 103 111 111 100 32 104 101 97 108 116 104
Cipher Text of the entered Message:
Columns 1 through 8
 41478 28842 42090 42090 28272 34908 41478 37248
Columns 9 through 16
 42948 28842 4236 34908 41478 28272 26322 34908
Columns 17 through 24
 37248 408 28842 34908 6348 28272 7968 34908
Columns 25 through 32
 28992 34908 41478 28272 20724 28842 34908 6348
Columns 33 through 40
 28272 7968 34908 37248 408 28842 34908 6498
Columns 41 through 48
 28272 28272 43362 34908 41478 28842 37248 42090
Columns 49 through 50
 42948 41478
    
```

FIGURE 4. After the message has been encrypted, a random number is chosen from the frame.

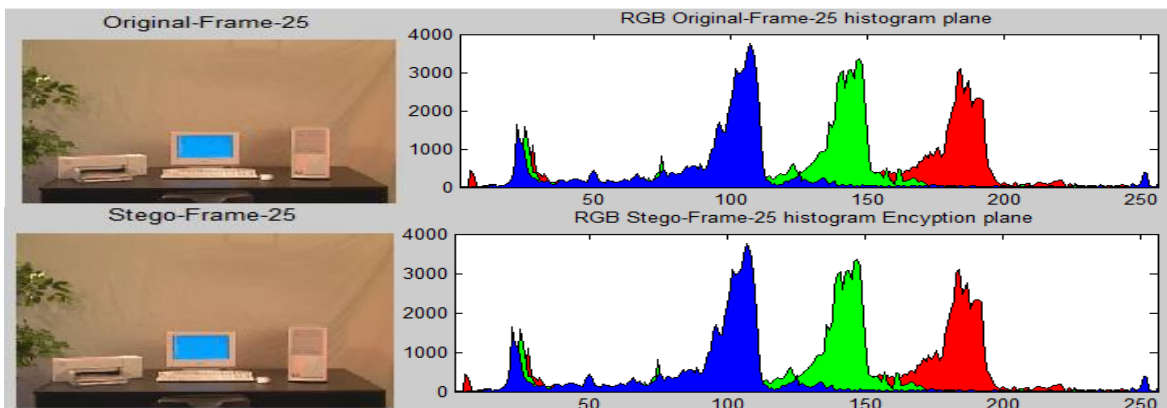


FIGURE 5. Frame 25 represent original and stego and histogram (R, G, B)

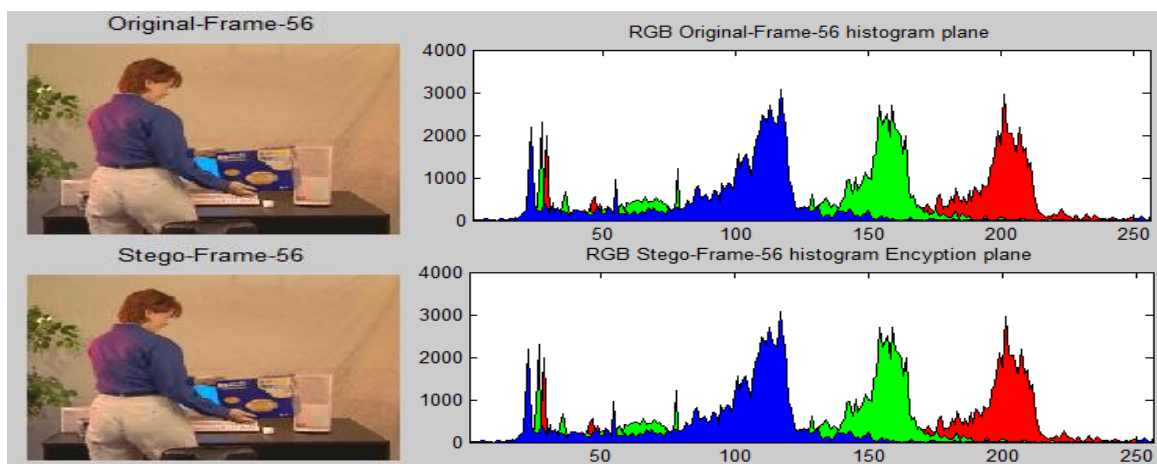


FIGURE 6. Frame 56 represent original and stego and histogram (R, G, B)

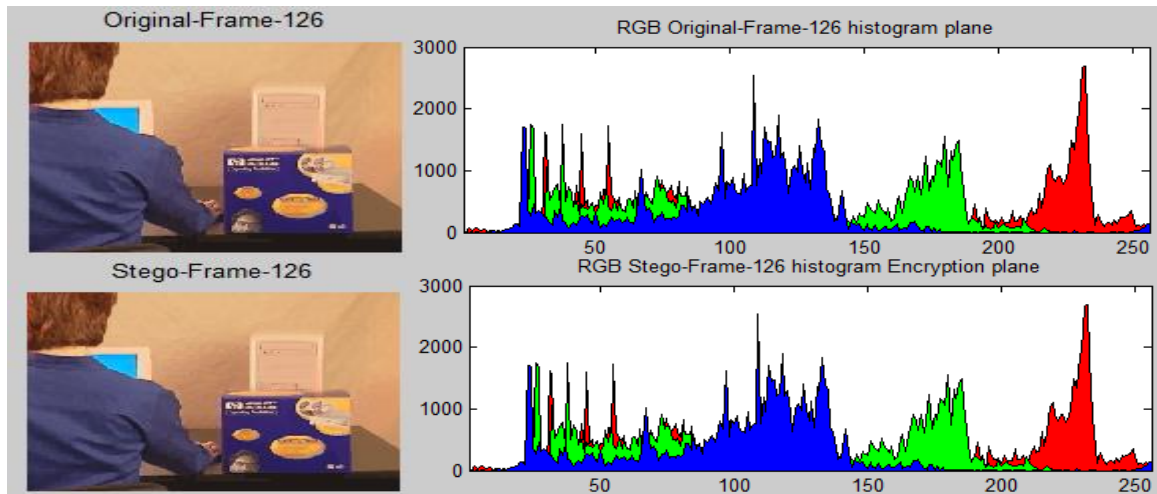


FIGURE 7. Frame 126 represent original and stego and histogram (R, G, B)

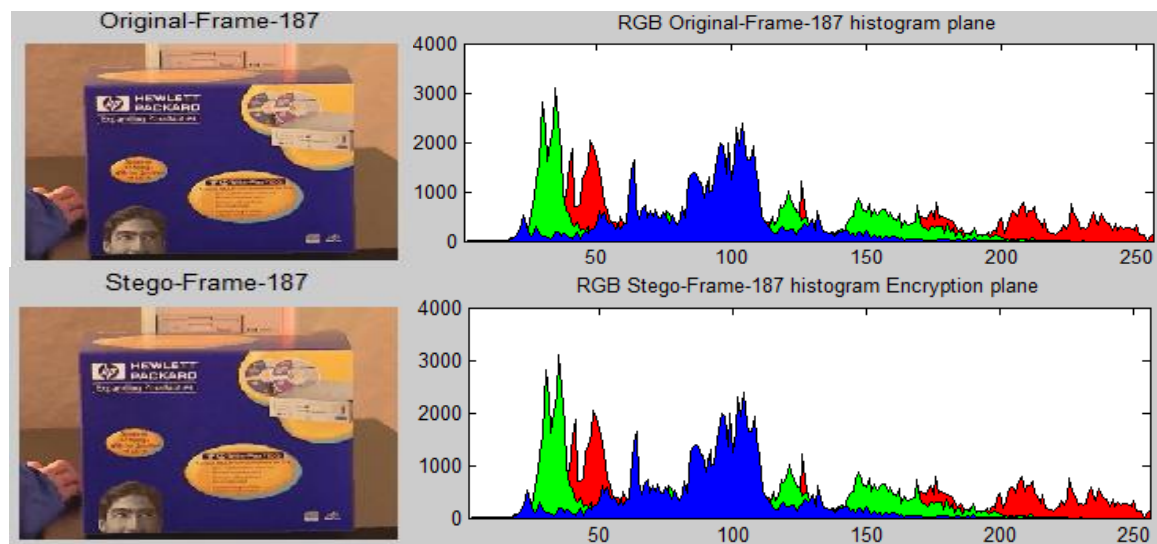


FIGURE 8. Frame 187 represent original and stego and histogram (R, G, B)

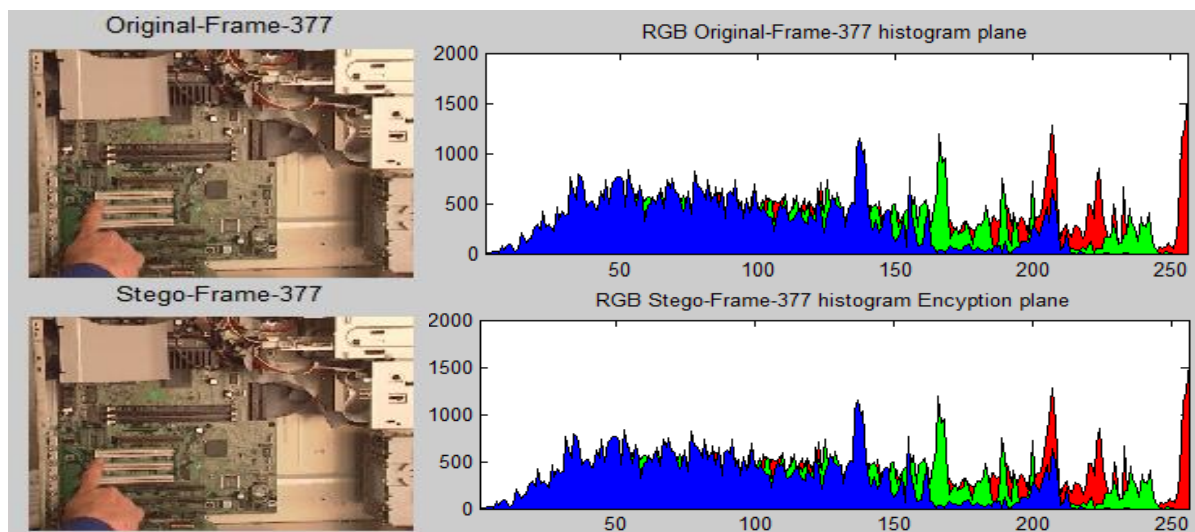


FIGURE 9. Frame 377 represent original and stego and histogram (R, G, B)



**TABLE 1.** Represent the variation value statistical measure for different frames

No.Frame	MSE	PSNR	SSIM	Histogram_Error
25	0.001675	75.8898	0.999997	5.8119E-07
56	0.001588	76.1208	0.999998	1.50553E-07
126	0.001684	75.8673	0.999997	4.8828E-08
187	0.0017231	75.7677	0.999998	1.8344E-07
377	0.0016666	75.9123	0.999999	9.0533E-08

## IN CONCLUSION

Observes that by using video frames with strong color intensity and frame-to-frame differentiation, the following findings are made:

- A- The (SSIM) is very near to 1, the MSE is very tiny, and the PSNR values are very high.
- B- The original and stego-frame histograms are nearly the same.
- C- A unique approach that can stop any attackers or intruders was created by combining randomized pixel selection from the frame with LSB steganography and altering RSA.
- D- By using cryptography to tweak the RSA method and provide an alternative, an attacker or intruder will find it extremely difficult to predict the factor that adds to the RSA algorithm—particularly when adding a new element.
- E- In order to avoid repeating the amount of pixels, it is preferable to select appropriate values for the seed number, p, q, and I.
- F- The suggested system receives the algorithm, which is safe to hide any sensitive information and ensures that the video is not altered—even in the event that hackers or attackers try to access it.
- H- The suggested system functions efficiently, rapidly, and well.
- I- Using video in the process of hiding information gives you more space and flexibility, in addition to the possibility of revealing confidential information easily.

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## **A NEW TYPE OF NON-ADJACENCY TOPOLOGICAL SPACES ON UNDIRECTED GRAPHS**

**Zahraa Lateef Hadi <sup>1\*</sup>** , **Asmhan Flich Hassan <sup>2</sup>**

<sup>1,2</sup>Department of Mathematics, faculty of education for girls, University of Kufa, Iraq

\*Corresponding author:

<sup>1</sup>E-mail: [zahraal.alshamarti@student.uokufa.edu.iq](mailto:zahraal.alshamarti@student.uokufa.edu.iq)

<sup>2</sup>E-mail: [asmhanf.alzuhairy@uokufa.edu.iq](mailto:asmhanf.alzuhairy@uokufa.edu.iq)

## A NEW TYPE OF NON-ADJACENCY TOPOLOGICAL SPACES ON UNDIRECTED GRAPHS

Zahraa Lateef Hadi <sup>1\*</sup> , Asmhan Flieh Hassan <sup>2</sup>

<sup>1,2</sup>Department of Mathematics, faculty of education for girls, University of Kufa, Iraq

\*Corresponding author:

<sup>1</sup>E-mail: [zahraal.alshamarti@student.uokufa.edu.iq](mailto:zahraal.alshamarti@student.uokufa.edu.iq)

<sup>2</sup>E-mail: [asmhanf.alzuhairy@uokufa.edu.iq](mailto:asmhanf.alzuhairy@uokufa.edu.iq)

### ABSTRACT:

In this work, we associate a topology to undirected graph  $G = (V, E)$ , we named it non-adjacency-  $P_3$ -topology (briefly  $NP_3$  - topology) of undirected graph  $G$ . A sub-basis family will generate the non-adjacency -  $P_3$  – topology, and it is introduced on the set of vertices  $V$ . Then we investigate some properties and discuss it on certain few important types of undirected graphs. Our motivation is to give fundamental steps toward investigation of some properties of simple undirected graphs by their corresponding  $NP_3$  - topology.

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**Key words and phrases:** undirected graphs,  $NP_3$  - topology,  $NP_3$  -topological spaces.

### 1. Introduction

Numerous applications have utilized the relationship between topology and graph to generate many new types of a topology generated by graph, because of the importance of topological graph theory as It is part of graph theory that has a great role and illustrious history in mathematics. The sources [1-4] include several great introductions to graph theory, topological graph theory, and a few applications.

On the basis of vertices or edges, some topological models are developed or based. In the undirected graphs and directed graphs. In 2013, Jafarian et al. began using a graphic topology for any locally finite without isolated vertices [5]. 2018 [6] saw kilicman and Abdulkalek define a sub-basis family as a set of vertices associated with an Incidence Topology for any simple graph without an isolated vertex sets containing the edge  $e$  of each incident vertex. A revised definition of the term “Family of sub-basis” was introduced in 2020. This definition created independent Topology of any un-digraph via vertices that are not adjacent to the Zainab and Asmhan introduce vertex  $v$  [7]. Asmhan and Zainab in 2022, give the topology of independent compatible edges [8], which is described as the topology connected to the group of edges. Asmhan and Iman authored an Independent in 2022. Digraph-based incompatible Edges topology with specific applications [9], the reader can also see [10,11]. In 2023, non-incidence topology was founded by Asmhan and Jafar, in [12]

Accordingly, in our new paper, we define a new kind of topological spaces associated with simple undirected graph  $G$ , which we named it non-adjacency -  $P_3$ - topological space. In basic kinds of graphs, we will investigate some of the advantages that are achieved with the non-adjacent -path of length two-topology of the undirected graph.

section 2: involve fundamental definitions of graphs and topologies. Definition of a  $NP_3$  -topological spaces associated with simple undirected graph  $G$ , in the section 3: We will discuss some preliminary

result in the fourth section of this paper. In the fourth section of our paper: several main conclusions of  $NP3$  -topology are introduced.

### 2. Preliminaries

Basic definitions and introductions to topology and graph theory are covered in the part. Ideas are all often utilized and can be found in books like [1,13,14].

Typically, a graph consists of two sets,  $G = (V, E)$ , where  $V$  is set of vertices and  $E$  is set of edges, an edge of the form  $(v, v)$  is loop. Parallel edges are those with the identical end vertices. If a graph contains no parallel edges or loop, it is considered simple. If the vertex  $v$  and  $u$  are connected by edge then they are adjacent. All of these ideas are well-known and are available in books mentioned above. We use the symbols  $K_n$  for the complete graph with  $n$  vertices and  $C_n$  is cycle graph on  $n$  vertices and  $P_n$  is path on  $n$  edges and  $K_{n1,n2}$  is a whole bipartite graph of size partite  $n1$  and  $n2$ .

An open family of subsets to the non-empty set  $X$  is said to be a topology if the following conditions are hold:  $X, \emptyset \in \tau$ , for every  $E, D \in \tau$ ,  $E \cap D \in \tau$  and

$\bigcup_{\alpha \in \Delta} A_\alpha \in \tau$  for every sub – combination  $A_\alpha$  of  $\tau$ , then  $(X, \tau)$  is called a topology on space, an open set is sub set of  $X$ . Indiscrete topology is defined as  $\tau = \{\emptyset, X\}$  on  $X$  while discrete topology is def.  $\tau = P(X)$  on  $X$ .

Now, the introducing of non-adjacency - $P_3$ - topological spaces ( $NP3$  -Topological Space), which associated with undirected graph  $G$ .

### 3. NP3 -Topological Space

This section consists of the definition of a non-adjacency - $P_3$ -topological space ( $NP3$  -Topological Space) associated with simple undirected graph  $G$  and some examples on basic undirected graphs.

**3.1. Definition:** Let  $G = (V, E)$  be any undirected graph. The  $NP3$ -topological space, briefly the topology named as  $\tau_{NP3}$ , which is a topology relates to the vertices set  $V$  of vertices for  $G$ , and brought on by sub-basis  $S_{NP3}$  whose components are the sets  $U \subseteq V$ ,  $|U| \leq 2$  s. t. if  $v \in U$  and  $w$  is non-adjacent with  $v$ , then  $w \in U$ , i.e,  $w \in U$  if  $w$  is non-adjacent with  $v$  and form with  $v$  a two-length path.

**3.2. Example:** Let a graph  $G = (V, E)$  be as in figure (1) below s. t.  $V(G) = \{v_1, v_2, v_3, v_4\}$ ,  $E(G) = \{e_1, e_2, e_3\}$ , by the definition (3.1) of the  $NP3$  - topology ( $\tau_{NP3}$ ) above, we can find our new topology via the following;

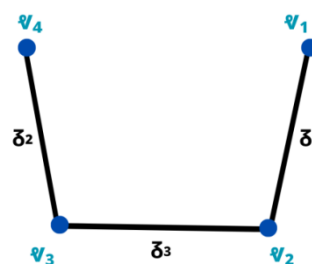


Fig. 3.1.

$\mathcal{T}_{NP3}$  has a sub-basis;  $\mathcal{S}_{NP3} = \{ \{v_1, v_3\}, \{v_2, v_4\} \}$ . Then by using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \{v_1, v_3\}, \{v_2, v_4\}, \emptyset \}$

Then, utilizing all unions, will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_1, v_3\}, \{v_2, v_4\} \}$$

**3.3 Remark:** Let  $\mathcal{T}_{NP3}$  be a topological space on the vertices set  $\mathcal{Y}$  of the un-directed graph  $C_n$  s.t.  $n = 4$ , then  $\mathcal{T}_{NP3}$  is not discrete topology, but if  $n > 4$  then  $\mathcal{T}_{NP3}$  is discrete, notice the following e.g.

**3.4 Example:** Consider  $G = (\mathcal{Y}, E)$  be the cycle  $C_4$  shown in the fig. (2), then:

$$\mathcal{Y}(G) = \{v_1, v_2, v_3, v_4\}, E(G) = \{\delta_1, \delta_2, \delta_3, \delta_4\},$$

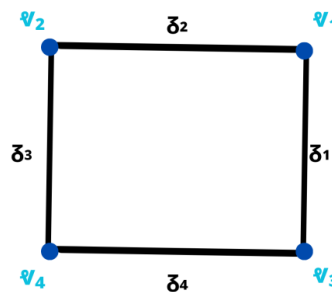


Fig. 3.2.

$\mathcal{T}_{NP3}$  has a sub-basis

$\mathcal{S}_{NP3} = \{ \{v_2, v_3\}, \{v_1, v_4\} \}$ . By using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \{v_2, v_3\}, \{v_1, v_4\}, \emptyset \}$

Then, utilizing all union, will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_2, v_3\}, \{v_1, v_4\} \},$$

it is clear that  $\mathcal{T}_{NP3}$  is not discrete topology.

**3.5. Example:** Consider  $G = (\mathcal{Y}, E)$  be the cycle  $C_5$  as shown in the fig. (3), then:

$$\mathcal{Y}(G) = \{v_1, v_2, v_3, v_4, v_5\}, E(G) = \{\delta_1, \delta_2, \delta_3, \delta_4, \delta_5\},$$

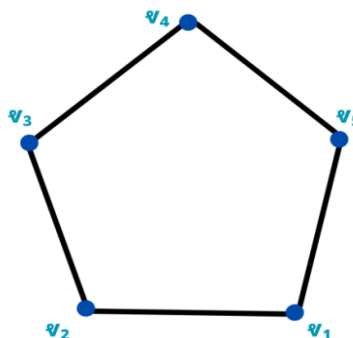


Fig. 3.3

$\mathcal{T}_{NP3}$  has a sub-basis

$\mathcal{S}_{NP3} = \{ \{v_1, v_3\}, \{v_1, v_4\}, \{v_2, v_4\}, \{v_2, v_5\}, \{v_3, v_5\} \}$ . Then using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \emptyset, \{v_1, v_3\}, \{v_1, v_4\}, \{v_2, v_4\}, \{v_2, v_5\}, \{v_3, v_5\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\} \}$

Then, utilizing each unions, will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_1, v_3\}, \{v_1, v_4\}, \{v_2, v_4\}, \{v_2, v_5\}, \{v_3, v_5\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\}, \{v_1, v_2\}, \{v_2, v_3\}, \{v_4, v_5\}, \{v_1, v_3, v_5\}, \{v_3, v_4\}, \{v_1, v_5\}, \{v_1, v_3, v_4\}, \{v_1, v_2, v_3\},$$

$$\{v_1, v_2, v_4\}, \{v_1, v_2, v_5\}, \{v_2, v_4, v_5\}, \{v_2, v_3, v_4\}, \{v_1, v_4, v_5\}, \{v_2, v_3, v_5\},$$

$$\{v_3, v_4, v_5\}, \{v_1, v_2, v_3, v_4\}, \{v_2, v_3, v_4, v_5\}, \{v_1, v_3, v_4, v_5\}, \{v_1, v_2, v_4, v_5\},$$

$$\{v_1, v_2, v_3, v_5\} \},$$
 it is clear that  $\mathcal{T}_{NP3}$  is discrete topology.

**3.6. Remark:** For every undirected path  $\mathcal{P}_n$ , the topology  $\mathcal{T}_{NP3}$  isn't discrete topology as in e.g.3.2.

**3.7. Remark:** For each undirected tree, we satisfy that  $\mathcal{T}_{NP3}$  is discrete topology, notice the following e.g. 3.8.

**3.8. Example:** Consider  $G = (\mathcal{Y}, \mathcal{E})$  be the undirected tree as shown in the fig.(4), then:  $\mathcal{Y}(G) = \{v_1, v_2, v_3, v_4, v_5, v_6\}$ ,  $\mathcal{E}(G) = \{\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6\}$ ,

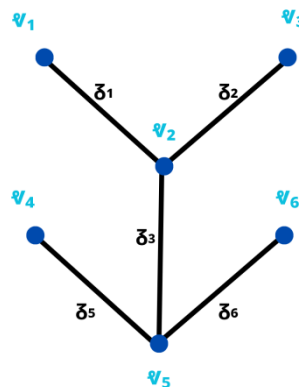


Fig. 3.4.

$\mathcal{T}_{NP3}$  has a sub-basis  $\mathcal{S}_{NP3} = \{ \{v_1, v_3\}, \{v_1, v_5\}, \{v_2, v_6\}, \{v_2, v_4\}, \{v_3, v_5\}, \{v_4, v_6\} \}$ . Then using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \emptyset, \{v_1, v_3\}, \{v_1, v_5\}, \{v_2, v_6\}, \{v_2, v_4\}, \{v_3, v_5\}, \{v_4, v_6\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\}, \{v_6\} \}$

Then, utilizing each unions will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_1, v_3\}, \{v_1, v_5\}, \{v_2, v_6\}, \{v_2, v_4\}, \{v_3, v_5\}, \{v_4, v_6\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\}, \{v_6\}, \{v_1, v_2\}, \{v_2, v_3\}, \{v_2, v_5\}, \{v_4, v_5\}, \{v_1, v_6\}, \{v_3, v_6\}, \{v_5, v_6\}, \{v_3, v_4\}, \{v_1, v_4\}, \{v_1, v_3, v_4\},$$

$$\{v_1, v_2, v_4\}, \{v_1, v_2, v_5\}, \{v_2, v_4, v_5\}, \{v_2, v_3, v_4\}, \{v_1, v_4, v_5\}, \{v_2, v_3, v_5\}, \{v_1, v_2, v_3\},$$

$$\{v_1, v_2, v_6\}, \{v_1, v_3, v_6\}, \{v_2, v_4, v_6\}, \{v_2, v_3, v_6\}, \{v_1, v_4, v_6\}, \{v_2, v_5, v_6\}, \{v_1, v_5, v_6\},$$

$$\{v_3, v_4, v_6\}, \{v_3, v_5, v_6\}, \{v_1, v_2, v_3, v_6\}, \{v_2, v_3, v_4, v_6\}, \{v_1, v_3, v_4, v_6\}, \{v_1, v_2, v_4, v_6\}$$

$\{v_1, v_2, v_5, v_6\}, \{v_2, v_3, v_5, v_6\}, \{v_1, v_3, v_5, v_6\}, \{v_1, v_2, v_5, v_6\}, \{v_3, v_4, v_5, v_6\}$   
 $\{v_3, v_4, v_5\}, \{v_1, v_3, v_5\}, \{v_1, v_2, v_3, v_4\}, \{v_2, v_3, v_4, v_5\}, \{v_1, v_3, v_4, v_5\}, \{v_1, v_2, v_4, v_5\},$   
 $\{v_1, v_2, v_3, v_4, v_6\}, \{v_2, v_3, v_4, v_5, v_6\}, \{v_1, v_3, v_4, v_5, v_6\}, \{v_1, v_2, v_4, v_5, v_6\}, \{v_1, v_2, v_3, v_5, v_6\},$   
 $\{v_1, v_3, v_4, v_5, v_6\}, \{v_1, v_2, v_4, v_5, v_6\}, \{v_1, v_2, v_3, v_4, v_5\}, \{v_2, v_3, v_4, v_5, v_6\}$

It is clear that  $\tau_{NP3}$  is a discrete topology.

**3.9. Remark:**  $\tau_{NP3}$  be a **NP3** -topology space with a set of vertices  $Y$  of a complete undirected graph  $K_n$  is discrete topology for each  $n \geq 3$  , Notice the following e.g.

**3.10. Example:** Consider  $G = (Y, E)$  be a complete un-digraph  $K_3$  , as shown in the fig. (5), s. t.  $Y(G) = \{v_1, v_2, v_3\}$  ,  $E(G) = \{\delta_1, \delta_2, \delta_3\}$ .

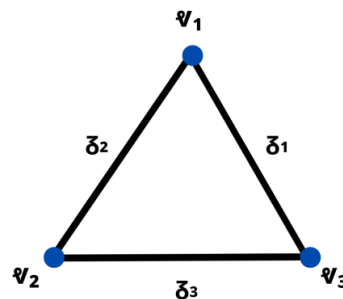


Fig. 3.5

$\tau_{NP3}$  has a sub-basis  $S_{NP3} = \{\{v_1\}, \{v_2\}, \{v_3\}\}$ . Then via using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{\emptyset, \{v_1\}, \{v_2\}, \{v_3\}\}$  . Then, utilizing each unions generate a topology  $\tau_{NP3}$  as the following:  $\tau_{NP3} = \{\emptyset, Y, \{v_1\}, \{v_2\}, \{v_3\}, \{v_1, v_3\}, \{v_1, v_2\}, \{v_2, v_3\}\}$  , clearly a discrete topology.

**3.11 Example:** Consider  $G = (Y, E)$  be complete un-directed graph  $K_4$  , as shown in the fig. (6) s.t.  $Y(G) = \{v_1, v_2, v_3, v_4\}$  ,  $E(G) = \{\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6\}$ , then;

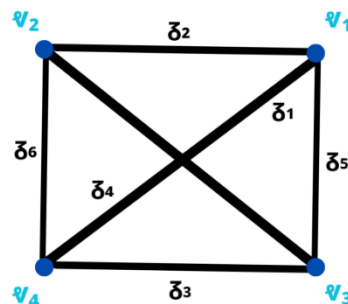


Fig. 3.6



$\mathcal{T}_{NP3}$  has a sub-basis  $\mathcal{S}_{NP3} = \{ \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\} \}$ .

Then via using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \emptyset, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\} \}$ .

Then, utilizing each unions will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_1, v_3\}, \{v_1, v_2\}, \{v_2, v_3\}, \{v_1, v_4\}, \{v_2, v_4\}, \{v_3, v_4\}, \{v_1, v_3, v_4\}, \{v_1, v_2, v_3\}, \{v_1, v_2, v_4\}, \{v_2, v_3, v_4\} \},$$

**3.13. Remark:**  $\mathcal{T}_{NP3}$  of complete bi-partite undirected graph  $K_{n1,n2}$  is discrete topology if  $n1 \geq 3$  and  $n2 \geq 3$ , Notice the following example.

**3.14. Example:** Consider  $G = (\mathcal{Y}, E)$  be a complete bi-partite undirected graph  $K_{3,3}$ , as shown in the figure (7), s.t.  $\mathcal{Y}(G) = \{v_1, v_2, v_3, v_4, v_5, v_6\}$ ,  $E(G) = \{\mathfrak{z}_1, \mathfrak{z}_2, \mathfrak{z}_3, \mathfrak{z}_4, \mathfrak{z}_5, \mathfrak{z}_6\}$ ,

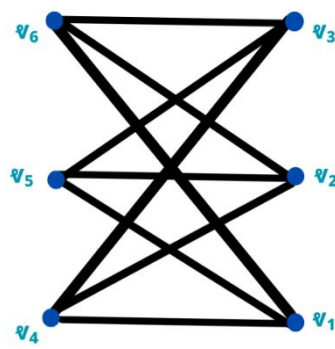


Fig. 3.7

$\mathcal{T}_{NP3}$  has a sub-basis

$\mathcal{S}_{NP3} = \{ \{v_1, v_2\}, \{v_2, v_3\}, \{v_1, v_3\}, \{v_4, v_5\}, \{v_4, v_6\}, \{v_5, v_6\} \}$ . Then via using finite intersection, the following base  $\beta_{NP3}$  is produced  $\{ \emptyset, \{v_1, v_2\}, \{v_2, v_3\}, \{v_1, v_3\}, \{v_4, v_5\}, \{v_4, v_6\}, \{v_5, v_6\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\}, \{v_6\} \}$

Then, utilizing each unions will generate a topology  $\mathcal{T}_{NP3}$  as the following:

$$\mathcal{T}_{NP3} = \{ \emptyset, \mathcal{Y}, \{v_1, v_2\}, \{v_2, v_3\}, \{v_1, v_3\}, \{v_4, v_5\}, \{v_4, v_6\}, \{v_5, v_6\}, \{v_1\}, \{v_2\}, \{v_3\}, \{v_4\}, \{v_5\}, \{v_6\}, \{v_1, v_4\}, \{v_2, v_4\}, \{v_2, v_5\}, \{v_2, v_6\}, \{v_3, v_5\}, \{v_3, v_6\}, \{v_3, v_4\}, \{v_1, v_5\}, \{v_1, v_6\},$$

$$\{v_1, v_3, v_5\}, \{v_1, v_3, v_4\}, \{v_1, v_2, v_3\}, \{v_1, v_2, v_4\}, \{v_1, v_2, v_5\}, \{v_2, v_4, v_5\},$$

$\{v_1, v_3, v_6\}, \{v_2, v_3, v_4\}, \{v_1, v_4, v_5\}, \{v_2, v_3, v_5\}, \{v_3, v_4, v_5\}, \{v_4, v_5, v_6\}, \dots, \dots$ , ... and so on). Clearly  $\mathcal{T}_{NP3}$  forms a discrete topology.

#### 4. Preliminary Results:

We show in this section some main properties and results of a new type of topology **NP3**-topology, in addition we show that a **NP3**-topological space is an Alexandroff space.

**4.1. Remark:** Let  $G = (Y, E)$  be un-directed graph, for any  $v \in Y$ , a set containing all non-adjacent vertices  $v$  in construct with  $v$  a path of length two is represented by  $\tilde{A}_{NP3}(v)$ .

**4.2. Proposition:** Let  $\mathcal{T}_{NP3}$  be a non-adjacency (**NP3**) topological space to undirected graph  $G = (Y, E)$ . For any  $v \in Y$ , If  $|\tilde{A}_{NP3}(v)| \geq 2$ . Or  $\tilde{A}_{NP3}(v) = \emptyset$ , then  $\{v\} \in \mathcal{T}_{NP3}$ .

Proof: Let  $|\tilde{A}_{NP3}(v)| = 2$ . Then (by using remark 4.1) there are two vertices  $v_1, v_2 \in Y$  such that each of them is non-adjacent  $v$  and construct with  $v$  a two-length path. Hence there exist two open set  $\{v, v_1\}, \{v, v_2\} \in \mathcal{S}_{NP3}$  (by using the definition of  $\mathcal{T}_{NP3}$ ), this signifies  $\{v\}$  is a part of the basis of  $\mathcal{T}_{NP3}$ . Same way if  $|\tilde{A}_{NP3}(v)| > 2$ .

If  $\tilde{A}_{NP3}(v) = \emptyset$ , afterward, there is an open set  $\{v\} \in \mathcal{S}_{NP3}$  (by using the definition of  $\mathcal{T}_{NP3}$ ), then  $\{v\} \in \mathcal{T}_{NP3}$ .

**4.3. corollary:** Let  $G = (Y, E)$  be any un-directed graph, If  $|\tilde{A}_{NP3}(v)| \geq 2$  Or  $\tilde{A}_{NP3}(v) = \emptyset, \forall v \in Y$ , then  $\mathcal{T}_{NP3}$  is a discrete topology.

Proof: Assume  $|\tilde{A}_{NP3}(v)| \geq 2$ , then  $\{v\} \in \mathcal{T}_{NP3}, \forall v \in Y$  (by using prop. 4.2).

Now, if  $\tilde{A}_{NP3}(v) = \emptyset$ , then  $\{v\} \in \mathcal{T}_{NP3}, \forall v \in Y$  (by using proposition 4.2).

therefor  $\mathcal{T}_{NP3} = P(Y)$  (a power set for  $Y$ ). Thereupon  $\mathcal{T}_{NP3}$  is discrete topology (def. of discrete topology).

**4.4. Definition [15]:** Alexandroff spaces are topological space that contain any arbitrary or random intersection of open sets.

**4.5. Proposition:** Let  $G = (Y, E)$  be a graph. A **NP3** - topological space of  $G$  is an Alexandroff space.

Proof: We must to prove that  $(Y, \mathcal{T}_{NP3})$  is a space of Alexandroff, it is enough to prove that a random intersection for each elements of  $\mathcal{S}_{NP3}$  is open, because  $|\omega| \leq 2, \forall \omega \in \mathcal{S}_{NP3}$ , hence either  $\bigcap_{j=1}^{\infty} \omega_j = \emptyset$  for every  $j \geq 2$  is open set, or  $\bigcap_{j=1}^{\infty} \omega_j = \omega$  s. t.  $\omega_j = \omega, \forall j$  a set is open since  $\omega \in \mathcal{S}_{NP3}$ . Alternatively,  $\bigcap_{j=1}^{\infty} \omega_j = \{v\}$  s. t.  $v \in \omega_j, \forall j \geq 2$ , because of  $\{v\} \in \mathcal{T}_{NP3}$  (by proposition 4.2). Then  $\{v\}$  is open set. Accordingly,  $(Y, \mathcal{T}_{NP3})$  is an Alexandroff space.

**4.6. Remark [15]:** Because  $(Y, \mathcal{T}_{NP3})$  is a space of Alexandroff in any un-directed graph  $G = (Y, E)$ . For all  $v \in Y$ , the smallest set that is both open and contains  $v$  and intersects all open sets that contains  $v$ , is represented by  $\mathcal{D}_{NP3}(v)$ . Furthermore, the collection  $\mathcal{D}_{NP3} = \{\mathcal{D}_{NP3}(v) \mid v \in Y\}$ , represent the minimal (smallest) basis of  $(Y, \mathcal{T}_{NP3})$ .

**4.7. Proposition:** In any undirected graph  $G = (Y, E)$ ,  $\mathcal{D}_{NP3}(v) = \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i$  such that  $v \in \omega_i, \forall i \geq 1$ .

Proof: Because  $\cup_{NP3}(\vartheta)$  is the smallest set of all open sets with intersections that contain  $\vartheta$  (using def. of  $\cup_{NP3}(\vartheta)$  and  $\mathcal{S}_{NP3}$  is a sub-basis of  $\mathcal{T}_{NP3}$ , then

$$\cup_{NP3}(\vartheta) \subseteq \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i \text{ s. t. } i \geq 1 \text{ -----(1)}$$

Then,  $\vartheta \in \omega_i, \forall i$ , so  $\vartheta \in \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i, \forall i \geq 1$ .

$$\text{Hence } \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i \subseteq \cup_{NP3}(\vartheta) \text{ -----(2)}$$

By (1) and (2)  $\cup_{NP3}(\vartheta) = \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i, \forall i \geq 1$ .

**4.8. Remark:** Consider  $G = (Y, E)$  be any undirected graph. For any  $\vartheta \in Y$ ,

1. If  $|\tilde{A}_{NP3}(\vartheta)| \geq 2$ . Or  $\tilde{A}_{NP3}(\vartheta) = \emptyset$ , then  $\cup_{NP3}(\vartheta) = \vartheta$

Because if  $|\tilde{A}_{NP3}(\vartheta)| \geq 2$ , then  $\bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i = \{\vartheta\}$  s.t.  $\vartheta \in \omega_i, \forall i \geq 2$

Since  $|\omega_i| \leq 2, \forall i$ . Hence  $\cup_{NP3}(\vartheta) = \{\vartheta\}$  (by using prop. 4.7)

Now, if  $\tilde{A}_{NP3}(\vartheta) = \emptyset$  then, there exists open set  $\omega \in \mathcal{S}_{NP3}$  s.t.  $\omega = \{\vartheta\}$ . Since  $\omega$  of the family is the only open set in  $\mathcal{S}_{NP3}$  which contains  $\vartheta$ , so  $\cup_{NP3}(\vartheta) = \{\vartheta\}$  (by prop. 4.7)

2. If  $|\tilde{A}_{NP3}(\vartheta)| = 1$ , then  $\exists$  an open set  $\omega = \{\vartheta, w\}$  in  $\mathcal{S}_{NP3}$  s.t.  $\tilde{A}_{NP3}(\vartheta) = \{w\}$ , and because  $\omega$  is only open set in the family  $\mathcal{S}_{NP3}$  which include  $\vartheta$ , (by using prop.4.7)  $\cup_{NP3}(\vartheta) = \{\vartheta, w\}$

**4.9. Corollary:** Let  $G = (Y, E)$  to be the graph, then  $\forall \vartheta, w \in Y$  in  $G$ , we have  $w \in \cup_{NP3}(\vartheta) \Leftrightarrow \tilde{A}_{NP3}(\vartheta) = \{w\}$

Proof: Using remark 4.8 makes it evident.

**4.10. Corollary:** For any  $\vartheta \in Y$  in the graph  $G = (Y, E)$ ,  $\cup_{NP3}(\vartheta) \subseteq \omega_i$  and so  $\overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}, \forall i$ , s. t.  $\vartheta \in \omega_i, \forall i$ .

Proof: since  $\cup_{NP3}(\vartheta) = \bigcap_{\omega_i \in \mathcal{S}_{NP3}} \omega_i$  (by using prop. 4.7) s. t.  $\vartheta \in \omega_i, \forall i \geq 1$ . So,  $\cup_{NP3}(\vartheta) \subseteq \omega_i, \forall i$

Now, to prove  $\overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}, \forall i$ . Let  $w \in \overline{\cup_{NP3}(\vartheta)} \rightarrow \mathcal{M} \cap \cup_{NP3}(\vartheta) \neq \emptyset, \forall \mathcal{M} \in \mathcal{T}_{NP3}$ , s. t.  $w \in \mathcal{M}$ . Since  $\cup_{NP3}(\vartheta) \subseteq \omega_i \rightarrow \mathcal{M} \cap \omega_i \neq \emptyset \forall \mathcal{M} \in \mathcal{T}_{NP3}$  s. t.  $w \in \mathcal{M}$ ,

This implies  $w \in \overline{\omega_i}$  and so,  $\overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}, \forall i$ .

**4.11. Corollary:** Let  $G = (Y, E)$  to be the graph  $\vartheta \in Y, \overline{\{\vartheta\}} \subseteq \overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}, \forall i$  s. t.  $\vartheta \in \omega_i, \forall i$ .

Proof: Let  $w \in \overline{\{\vartheta\}} \rightarrow \mathcal{M} \cap \{\vartheta\} \neq \emptyset, \forall \mathcal{M} \in \mathcal{T}_{NAV}(G)$  s. t.  $w \in \mathcal{M}$ , But  $\{\vartheta\} \in \cup_{NP3}(\vartheta)$ , so  $\mathcal{M} \cap \cup_{NP3}(\vartheta) \neq \emptyset, \forall \mathcal{M} \in \mathcal{T}_{NP3}$  s. t.  $w \in \mathcal{M}$ . Hence  $w \in \overline{\cup_{NP3}(\vartheta)}$ .

Since  $\overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}$  (by using corollary 4.10), then,  $\overline{\{\vartheta\}} \subseteq \overline{\cup_{NP3}(\vartheta)} \subseteq \overline{\omega_i}, \forall i$ .

**4.12. Corollary:** Let  $G = (Y, E)$  be any undirected graph. For any  $w, v \in Y$ , We have  $w \in \overline{\{v\}} \Leftrightarrow \tilde{A}_{NP3}(w) = \{v\}$ .

Proof:  $\Rightarrow$ ) If  $w \in \overline{\{v\}}$ , then  $\mathbb{U}_{NP3} \cap \{v\} \neq \emptyset, \forall \mathbb{U}_{NP3} \in \mathcal{T}_{NP3}$  s. t.  $w \in \mathbb{U}_{NP3}$  this means  $w \in \mathbb{U}_{NP3}$ . Hence  $\tilde{A}_{NP3}(w) = \{v\}$  (by using corollary 4.9)

$\Leftarrow$ ) suppose  $\tilde{A}_{NP3}(w) = \{v\}$  this implies  $v \in \mathbb{U}_{NP3}(w)$  (by using corollary 4.9)

Then,  $\mathbb{U}_{NP3} \cap \{v\} \neq \emptyset, \forall \mathbb{U}_{NP3} \in \mathcal{T}_{NP3}$  s. t.  $w \in \mathbb{U}_{NP3}$ .

Hence  $w \in \overline{\{v\}}$ .

**4.13. Remark [15]:** Every Alexandroff topological space  $(X, \mathcal{T})$  be the  $\mathcal{T}_1$ -space if and only if  $\mathbb{U}_{NP3}(x) = \{x\}$ . Consequently, because  $X$  is discrete, the topological space  $(Y, \mathcal{T}_{NP3})$  is  $\mathcal{T}_1$ -space  $\Leftrightarrow$  it is discrete. Now, if  $(Y, \mathcal{T}_{NP3})$  is a space of Alexandroff, then it is  $\mathcal{T}_0$ -space if and only if  $\mathbb{U}_{NP3}(v) = \mathbb{U}_{NP3}(w)$  implies  $v = w$ , i.e.  $\mathbb{U}_{NP3}(v) \neq \mathbb{U}_{NP3}(w), \forall$  distinct vertices  $v, w \in Y$ . Also, a non-adjacency (path of length tow) topological space  $\mathcal{T}_{NP3}$  is  $\mathcal{T}_0$ -space if and only if  $\tilde{A}_{NP3}(v) \neq \{w\}$  or  $\tilde{A}_{NP3}(w) \neq \{v\}, \forall w, v \in Y$  s. t.  $w \neq v$  (by using corollary 4.9).

**4.14. Proposition:** Let  $G = (Y, E)$  be any un-directed graph, Afterward  $(Y, \mathcal{T}_{NP3})$  is  $\mathcal{T}_2$ -space  $\Leftrightarrow (Y, \mathcal{T}_{NP3})$  is  $\mathcal{T}_1$ -space.

Proof:  $\Rightarrow$ ) intelligible.

$\Leftarrow$ ) Assume  $(Y, \mathcal{T}_{NP3})$  is  $\mathcal{T}_1$ -space, then  $(Y, \mathcal{T}_{NP3})$  is discrete (using remark (4.13)).

This implies  $\forall v \in Y, \{v\} \in \mathcal{T}_{NP3}$ . So  $\forall v, w \in Y, \text{s.t. } v \neq w, \exists \{v\}, \{w\} \in \mathcal{T}_{NP3}$  s.t.  $w \in \{w\}$  and  $v \in \{v\}$  and  $\{w\} \cap \{v\} = \emptyset$ .

Hence  $(Y, \mathcal{T}_{NP3})$  is  $\mathcal{T}_2$ -space.

## 6. conclusions

We introduced a new type of non-adjacency topology on undirected graph which called a **NP3**-topology, that relates the topology for a set of vertices. This space is the Alexandroff space, which indicated that some topological features examined in some fundamental graphs. This topology can solve a variety of undirected graph dependent problems in Global Positioning System GPS. We may consider the applications of using it in other research in the future.

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## Attacking The RSA Algorithm on Gaussian Integers by Using Continued Fractions

Wael Mahmood Abbas 1<sup>st</sup> Ghufran A. Ghadhban 2<sup>nd</sup> and Hind A. majeed 3<sup>nd</sup>

1 Department of Mathematics, college of science, University of Diyala, Diyala, Iraq.

2 Department of Mathematics, college of science, University of Diyala, Diyala, Iraq.

3 Mustansiriyah University College of Science, Physics department

<sup>1</sup>E-mail: [w\\_alhayat@yahoo.com](mailto:w_alhayat@yahoo.com)

<sup>2</sup>E-mail: [ghofran\\_ali@uodiyala.edu.iq](mailto:ghofran_ali@uodiyala.edu.iq)

<sup>3</sup>E-mail: [hind88.hh@gmail.com](mailto:hind88.hh@gmail.com)

# Attacking The RSA Algorithm on Gaussian Integers by Using Continued Fractions

Wael Mahmood Abbas 1<sup>st</sup> Ghufraan A. Ghadhban 2<sup>nd</sup> and Hind A. majeed 3<sup>rd</sup>

1 Department of Mathematics, college of science, University of Diyala, Diyala, Iraq.

2 Department of Mathematics, college of science, University of Diyala, Diyala, Iraq.

3 Mustansiriyah University College of Science, Physics department

<sup>1</sup>E-mail: [w\\_alhayat@yahoo.com](mailto:w_alhayat@yahoo.com)

<sup>2</sup>E-mail: [ghofran\\_ali@uodiyala.edu.iq](mailto:ghofran_ali@uodiyala.edu.iq)

<sup>3</sup>E-mail: [hind88.hh@gmail.com](mailto:hind88.hh@gmail.com)

## Abstract

In this paper, we will study the method of attacking RSA on gaussian integer Since  $d$  is the inverse of  $e \bmod \phi(N)$ , we can figure out  $d$  if we know and the public key (the modulus  $n$  and the encryption exponent  $e$ ) We can use the Extended Euclidean algorithm Knowing now is comparable to knowing  $P$  and  $Q$ , the two prime factors of  $N$ , mathematically speaking using continued fraction, The Wiener attack against the RSA cryptosystem with a small secret exponent is an application of this finding. Then, we show that regardless of the choice of  $N$ , there exists an attack based on continued fractions that recovers the secret exponent.

## Introduction

A new method of attacking RSA, known as the modified Wiener's attack, has been proposed. This method operates in the domain of integers and converts the problem to the domain of Gaussian integers. By finding the appropriate starting asymptote, a new continuous fraction is used for estimating the trace from encoding and decoding messages.

If the secret exponent ( $d$ ) contains at most one-fourth as many bits as the modulus ( $N$ ), it is possible to crack a typical RSA cryptosystem efficiently. In this scenario,  $P$  and  $Q$  are Gaussian integers of the same size, and the public exponent ( $e$ ) is less than  $N$ .

The basic relationship between exponents is used as the starting point for the Wiener's attack. If  $N(P) < N(Q) < 2N(P)$ ,  $e < N$ , and  $d$  is the denominator of a convergent from the continued fraction expansion of  $e/N$ , then there exists an integer  $k$  such that  $e*d - k*\varphi(N) = 1$ .

Approximately,  $\varphi(N)$  is equal to  $N$ , which implies that  $(k/d)$  is approximately equal to  $e/N$ . More precisely, we have the inequality  $\mathcal{N} - 3\sqrt{N} < \varphi(N) < \mathcal{N}.1$ . Continued fraction:

The fraction  $\frac{A}{B}$  can be expressed as a simple continued fraction

$$a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \frac{1}{a_3 + \frac{1}{a_4 + \dots + \frac{1}{a_n - 1 + \frac{1}{a_n}}}}}}$$

Where,  $a_0, a_1, a_2, \dots, a_n$  be real numbers. is called a finite continued fraction and is denoted by  $[a_0, a_1, a_2, \dots, a_n]$ . A simple continued fraction can either finite or infinite the following example shows how to use Euclidian Algorithm.

**Example 1:** Let us find the continued fraction expansion for  $\frac{67}{29} = [2, 3, 4, 2]$

$$= 2 + \frac{1}{3 + \frac{1}{4 + \frac{1}{2}}} = \frac{67}{29}$$

**2.convegent:**

In some sense, the convergent are the best possible approximations for a given nonnegative real:

**Definition 1.** We call  $[q_0, \dots, q_m]$  (for  $0 \leq m \leq n$ ) the  $m^{th}$  convergent to  $[q_0, \dots, q_n]$ . In our example, the convergent are

$$A_0 = \frac{P_0}{Q_0}$$

$$A_1 = \frac{P_1}{Q_1} = \frac{q_0 q_1 + 1}{q_1}$$

$$A_2 = \frac{P_2}{Q_2} = \frac{q_2 P_1 + P_0}{q_2 Q_0 + Q_1} \dots\dots$$

$$A_k = \frac{P_k}{Q_k} = \frac{q_k P_{k-1} + P_{k-2}}{q_k Q_{k-1} + Q_{k-2}}, \text{ for } k \geq 2$$



### 3. Wiener's attack on RSA with Gaussian Integer

If the secret exponent  $d$  contains at most one-fourth as many bits as the modulus  $n$ , a polynomial time approach for cracking a typical (i.e.,  $p$  and  $q$  are gaussian integer of the same size and  $e < N$ ) RSA cryptosystem has been given. Typically, the Wiener's attack is explained as follows:

If  $N(P) < N(Q) < 2 N(P)$ ,  $e < N$  and  $d$  is the denominator of a convergent of the continued fraction expansion of  $\frac{e}{N}$ . The basic relationship between exponents serves as the starting point. This means that there is an integer  $k$  such that  $ed - k \phi(N) = 1$ . Now,  $\phi(N) \approx N$  implies  $\frac{k}{d} \approx \frac{e}{N}$ . More precisely, we have  $N - 3\sqrt{N} < \phi(N) < N$ .

### 4. The most popular public-key

Shamir, and Adleman, is currently the most widely used public-key cryptographic system. Its security is based on the intractable problem of factoring large numbers. The modulus  $N$  of the RSA cipher is the product of two Gaussian integers  $P$  and  $Q$ . The public exponent  $e$  and the secret exponent  $d$  are mathematically related, such that  $e * d \equiv 1 \pmod{\phi(N)}$ , where  $\phi(N) = N(P-1)(Q-1)$ . In a typical RSA cipher scheme,  $P$  and  $Q$  have similar numbers of bits, while  $e$  is smaller than  $N$ . The encryption and decryption algorithms in RSA are defined as  $C = m^e \pmod{N}$  and

$$m = C^d \pmod{N}, \text{ respectively.}$$

In 1990, Weiner described a polynomial algorithm for breaking a typical RSA cipher system where  $P$  and  $Q$  have the same size and  $e < N$ , if the secret exponent  $d$  has at most one-fourth as many bits as the modulus  $N$ .

To improve RSA decryption speed, one might consider using a small secret exponent  $d$ . This choice is particularly advantageous in scenarios like communication between a smart card and a larger computer. In this case, it is desirable for the smart card to have a small secret exponent, while the larger computer has a small general exponent to minimize processing requirements on the smart card.

**Example 2:** Let  $p = 379$ ,  $q = 239$  using Wiener's attack on RSA with Integer Continued fraction expansion of

**Solution:**

$$N = PQ \rightarrow N = 379 \times 239$$

$$N = 90581$$

$$\phi(N) = (P-1)(Q-1) \rightarrow \phi(N) = 89964$$

$$1 < e < N \rightarrow \gcd(e, \phi(N)) = 1 \rightarrow e = 17993$$

$$de \equiv 1 \pmod{\phi(N)} \rightarrow d = 17993^{-1} \pmod{89964} = 5$$

continued fraction:

$$\frac{e}{N} = \frac{17993}{90581} = [0, 5, 29, 4, 1, 3, 2, 4, 3].$$

According to the continued fraction expansion of  $\frac{e}{N}$ . All convergent  $\frac{k}{d}$ .

$$\frac{k}{d} = 0, \frac{1}{5}, \frac{29}{146}, \frac{117}{589}, \frac{146}{735}, \frac{555}{2794}, \frac{1256}{6323}, \frac{5579}{28086}, \frac{17993}{90581}, \quad d = 5$$

## 5. Gaussian Integer $G[i]$

### Definition 2.

A gaussian integer is a complex number of the form  $A + Bi$  where both  $A$  and  $B$  are integers. We often denote the set of Gaussian integers by  $G[i]$

### Definition 3. NORM

The norm of a Gaussian integers  $\alpha = A + Bi$ , denote  $N(\alpha)$  or  $N(A + Bi)$  is a real number defined by  $N(A + Bi) = (A + Bi)(A - Bi) = A^2 + B^2$

### The Euclidean Algorithm 4:

A greatest comm divisor (gcd) of  $P$  and  $Q$  is  $P$  common divisor with maximum norm  $P, Q \in G[i]$  and  $P, Q$  are non-zero.

### Theorem (Euclid's algorithm).

Let  $P, Q \in G[i]$  be non-zero. Recursively apply the division theorem, starting with this pair, and make the divisor and remainder in one equation the new dividend and divisor in the next, provided the remainder is not zero:

$$P = Q\gamma_1 + \rho_1, \quad N(\rho_1) < N(Q)$$

$$Q = \rho_1\gamma_2 + \rho_2, \quad N(\rho_2) < N(\rho_1)$$

$$\rho_1 = \rho_2\gamma_3 + \rho_3, \quad N(\rho_3) < N(\rho_2) \dots$$

The last non-zero remainder is divisible by all common divisors of  $P$  and  $Q$ , and is itself a common divisor, so it is a greatest common divisor of  $P$  and  $Q$ .

**Euler’s congruence in G [i] 5:**

for non-zero P in G [i] , set  $\phi(P) = |(G [i] / p)x|$  When P =  $\pi$  is prime , every non-zero gaussian integer modulo  $\pi$  is invertible ,so  $\phi(P) = N(P) - 1$

**6. The RSA Algorithm on Gaussian Integer G[i]:**

**Key Generation**

- 1- Select P, Q where P & Q both prime,  $P \neq Q$  in  $Z[i]$  , prime  $(4K + 3)$
- 2- Calculate  $N = N(P) N(Q)$
- 3- Calculate  $\phi(N) = (N(P)-1) (N(Q)-1)$
- 4- Select integer e such that  $\gcd(\phi(N), e) = 1; 1 < e < \phi(N)$
- 5- Calculate  $d = e^{-1} \text{ mod } \phi(N)$
- 6- public key:  $PU = \{e, N\}$
- 7- private key  $PR = \{d, N\}$

Encryption:  $C = M^e \text{ mod } N$ , Decryption:  $M = C^d \text{ mod } N$

**1.Table**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
<b>integer</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>Gaussin integer</b>	1	1+i	3	2+i	1+2i	6	7	2+2i	3i	10	11	12	2+3i	14	15	4i

Q	R	S	T	U	V	W	X	Y	Z
17	18	19	20	21	22	23	24	25	26
1+4i	3+3i	19	20	21	22	23	24	5i	1+5i

**6. Proposed method:**

In this section, we propose a new type of Wiener paired RSA attack modification that operates in the domain of integers. Since it is converted to a gaussian integer after finding the appropriate starting asymptote, this new continuous fraction is also used for trace estimates from encoding and decoding messages.

**Example 3.** Perform Encryption and Decryption using Wiener's attack on RSA with Gaussian Integer  $p = 3$ ,  $q = 3+2i$  message: KWATT

**Solution:**

$$N(P) < N(Q) < 2 N(P)$$

$$N = N(P)N(Q) \rightarrow N = N(3)N(3+2i)$$

$$N = 9 \times 13 = 117$$

$$\phi(N) = (N(P) - 1)N(Q) - 1 \rightarrow \phi(N) = 96$$

$$1 < e < N \rightarrow \gcd(e, \phi(N)) = 1 \rightarrow e = 55$$

$$de \equiv 1 \pmod{\phi(N)} \rightarrow d = 55^{-1} \pmod{96} = 7$$

continued fraction:

$$\frac{e}{N} = \frac{55}{117} = [0, 2, 7, 1, 6].$$

$$\text{Convergent: } A_0 = \frac{P_0}{Q_0} = 0, A_1 = \frac{P_1}{Q_1} = \frac{q_0 q_1 + 1}{q_1} = \frac{2(0) + 1}{2} = \frac{1}{2}$$

$$A_2 = \frac{P_2}{Q_2} = \frac{q_2 P_1 + P_0}{q_2 Q_1 + Q_0} = \frac{7}{15}$$

$$A_3 = \frac{8}{17}, A_4 = \frac{117}{55}$$

$$\frac{K}{d} = [0, 2, \frac{15}{7}, \frac{17}{8}, \frac{117}{55}] \rightarrow \frac{K}{d} = \frac{15}{7}$$

Message: KWATT

Encryption:  $C = M^e \pmod{N}$

$$C_1 = 11^{55} \pmod{117} = 2$$

$$C_2 = 23^{55} \pmod{117} = 23$$

$$C_3 = 1^{55} \pmod{117} = 1$$

$$C_4 = 20^{55} \pmod{117} = 110$$

$$C_5 = 20^{55} \pmod{117} = 110$$

Decryption:  $M = C^d \pmod{N}$

$$M_1 = 2^7 \pmod{117} = 11$$

$$M_2 = 23^7 \pmod{117} = 23$$

$$M_3 = 1^7 \bmod 117 = 1$$

$$M_4 = 110^7 \bmod 117 = 20$$

$$M_4 = 110^7 \bmod 117 = 20$$

**Example 4.** Perform Encryption and Decryption using Wiener's attack on RSA with Gaussian Integer  $p = 1+i$ ,  $q = 1+4i$  message: STEVEN

**Solution:**

$$N = N(P)N(Q) \rightarrow N = N(1+i) N(1+4i)$$

$$N = 34$$

$$\phi(N) = (N(P) - 1) (N(Q) - 1) \rightarrow \phi(N) = 16$$

$$1 < e < N \rightarrow \gcd(e, \phi(N)) = 1 \rightarrow e = 13$$

$$de \equiv 1 \pmod{\phi(N)} \rightarrow d = 13^{-1} \pmod{16} = 5$$

continued fraction:

$$\frac{e}{N} = \frac{13}{34} = [0, 2, 1, 1, 1, 1, 2].$$

Convergent:

$$A_0 = \frac{P_0}{Q_0} = 0$$

$$A_1 = \frac{P_1}{Q_1} = \frac{q_0 q_1 + 1}{q_1} = \frac{0(2) + 1}{2} = \frac{1}{2}$$

$$A_2 = \frac{P_2}{Q_2} = \frac{q_2 P_1 + P_0}{q_2 Q_0 + Q_1} = \frac{1}{3}$$

$$A_3 = \frac{2}{5}, \quad A_4 = \frac{3}{8}, \quad A_5 = \frac{5}{13}, \quad A_6 = \frac{13}{34}$$

$$\frac{K}{d} = [0, 2, 3, \frac{5}{2}, \frac{8}{3}, \frac{13}{5}, \frac{34}{13}]. \rightarrow \frac{K}{d} = \frac{13}{5}$$

Message: STEVEN

Encryption:  $C = M^e \bmod N$

$$C_1 = 19^{13} \bmod 34 = 15$$

$$C_2 = 20^{13} \bmod 34 = 12$$

$$C_3 = (1+i)^{13} \bmod 34 = (1+6i)$$

$$C_4 = 22^{13} \bmod 34 = 20$$

$$C_5 = (1+i)^{13} \bmod 34 = (1+6i)$$

Decryption:  $M = C^d \bmod N$

$$M_1 = 15^5 \bmod 34 = 19$$

$$M_2 = 12^5 \bmod 34 = 20$$

$$M_3 = (1+6i)^5 \bmod 34 = (1+i)$$

$$M_4 = 20^5 \bmod 34 = 22$$

$$M_5 = (1+6i)^5 \bmod 34 = (1+i)$$

**Example 5.** Perform Encryption and Decryption using Wiener's attack on RSA with Gaussian Integer  $P = 1+2i$ ,  $Q = 2+3i$  message: BIRD

**Solution:**

$$N = N(P)N(Q) \rightarrow N = N(1+2i)N(2+3i)$$

$$N = 5 \times 13 = 65$$

$$\phi(N) = (N(P) - 1)(N(Q) - 1) \rightarrow \phi(N) = 48$$

$$1 < e < N \rightarrow \gcd(e, \phi(N)) = 1 \rightarrow e = 7$$

$$de \equiv 1 \pmod{\phi(N)} \rightarrow d = 7^{-1} \pmod{48} = 7$$

continued fraction:

$$\frac{e}{N} = \frac{7}{65} = [0, 9, 3, 2].$$

Convergent:

$$A_0 = \frac{P_0}{Q_0} = 0$$

$$A_1 = \frac{P_1}{Q_1} = \frac{q_0 q_1 + 1}{q_1} = \frac{0(9) + 1}{9} = \frac{1}{9}$$

$$A_2 = \frac{P_2}{Q_2} = \frac{q_2 P_1 + P_0}{q_2 Q_0 + Q_1} = \frac{3}{28}$$

$$A_3 = \frac{7}{65}$$

$$\frac{K}{d} = [0, 9, \frac{28}{3}, \frac{65}{7}]. \rightarrow \frac{K}{d} = \frac{65}{7}$$

Message: BIRD

Encryption:  $C = M^e \pmod N$

$$C_1 = (1 + i)^7 \pmod{65} = 8 - 8i$$

$$C_2 = (3i)^7 \pmod{65} = 42i$$

$$C_3 = (3+3i)^7 \pmod{65} = 11-11i$$

$$C_4 = (2i)^7 \pmod{65} = 2i$$

Decryption:  $M = C^d \pmod N$

$$M_1 = (8 - 8i)^7 \pmod{65} = 1 + i$$

$$M_2 = (42i)^7 \pmod{65} = 3i$$

$$M_3 = (11-11i)^7 \pmod{65} = 3+3i$$

$$M_4 = (2i)^7 \pmod{65} = 2i$$

### Conclusion

Through the results above within attack RSA defined on the Gaussian integer in a way continued fraction by modifying Wiener's attack The modified method has proven effective in attacking the algorithm's encryption system RSA on gaussian integer

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# **Modification of the rheological properties of chlorinated asphalt by treatment with Degraded Polystyrene**

***Mahmood K. Saleem***<sup>1</sup>

[mahmoodsaleem@ntu.edu.iq](mailto:mahmoodsaleem@ntu.edu.iq)

***Huda A. Younis***<sup>2</sup>

[hudaa.younis@ntu.edu.iq](mailto:hudaa.younis@ntu.edu.iq)

<sup>1</sup> Northern Technical University, Mosul, Iraq

<sup>2</sup> Northern Technical University, Mosul, Iraq



## **Modification of the rheological properties of chlorinated asphalt by treatment with Degraded Polystyrene**

*Mahmood K. Saleem*<sup>1</sup>

[mahmoodsaleem@ntu.edu.iq](mailto:mahmoodsaleem@ntu.edu.iq)

*Huda A. Younis*<sup>2</sup>

[hudaa.younis@ntu.edu.iq](mailto:hudaa.younis@ntu.edu.iq)

<sup>1</sup> Northern Technical University, Mosul, Iraq

<sup>2</sup> Northern Technical University, Mosul, Iraq

### **Abstract**

This study explores the possibility of modifying the rheological properties of chlorinated asphalt by introducing pyrolyzed polystyrene. Pyrolyzed polystyrene was introduced into the asphalt mixture, resulting in three distinct samples, each containing varying proportions of pyrolyzed polystyrene blended with chlorinated asphalt. Subsequent laboratory tests, conducted included evaluations of ductility, penetration, and softening point. The results indicated significant changes in asphalt properties due to the introduction of pyrolyzed polystyrene. Additionally, the chlorination process also was affected on the thermal properties of the original asphalt.

This study has obtained asphaltic samples with rheological properties suitable for various asphalt application, including paving, platinating and mastic accordance to the standard specifications.

Keywords: Asphalt, Rheological properties, Modify, Chlorination of asphalt, Processing with polystyrene.

### **Introduction**

Asphalt is a highly viscous liquid material whose viscosity increases with temperature. It is a complex mixture of various hydrocarbon materials with different molecular weights, typically ranging from 400 to 500 [1,2]. Asphalt's constituents are bound together through physical and chemical forces, providing a homogeneous appearance and making it seem like a single substance.

Asphalt possesses stable rheological properties crucial for engineering and construction applications, widely used in road construction, airport runways, bridge building, and more [3,4]. However, to develop asphalt with distinctive properties suitable for applications beyond traditional asphalt, numerous researchers have undertaken experiments [5].

Moskopedis and Speight [6] conducted research involving the addition of chlorine to asphalt, using iron chloride as a chlorination aid. The goal was to obtain halogenated derivatives of asphalt with dark color and resistance to solubility in various solvents such as benzene, nitrobenzene, and carbon tetrachloride.

Makarckiuk and Antonistn [7] studied the impact of heat on chlorinated asphalt derivatives. The results indicated that high temperatures facilitate HCL particle removal, resulting in a easily breakable

solid material. These transformations occurred due to the formation of high-carbon olefinic structures, deviating from typical asphalt properties and developing quasi-coal systems.

Shaymaa AL-Mutalq and others [8] evaluates the fuel resistance and morphology of asphalt that has been physicochemically modified using waste polymers, specifically high-density polyethylene and chlorine gas. The high-density polyethylene waste polymer and chlorine gas are utilized to modify the asphalt. The asphalt is modified through a physicochemical process involving the blending of the waste polymer and chlorine gas with the original asphalt. The objective of the research is to investigate the impact of these modifications on the fuel resistance of the asphalt and analyze the resulting changes in its composition and morphology.

While numerous studies have explored the modification of asphalt with various polymers such as rubber, research involving the incorporation of broken polystyrene into asphalt remains relatively limited. Hailong et al. attempted to enhance the stability of stored asphalt by adding styrene-butadiene-styrene (SBS) with sulfur to the mix [9]

In 2005, AL-Dubony and Ahmad [10] successfully prepared asphalt modified with polystyrene and sulfur, resulting in a homogenous blend of asphalt, polystyrene, and sulfur.

Mousa Bani Baker et al. [11] added polystyrene waste by volume to bitumen in ratios of 0%, 5%, 10%, and 15%. Tests measuring penetration, softening point, ductility, flash point, and ignition point were conducted. The results showed that increasing the polystyrene ratio in asphalt directly affected bitumen properties by reducing penetration and ductility while increasing softening point, flash point, and ignition point. Modified asphalt could be used in hot climate areas for various construction purposes such as waterproofing materials for basements, retaining walls, surfaces, or as a material for paving garage floors, car parks, sidewalks, playgrounds, and gardens.

As mentioned by Korshat Yeldiz et al. [12], waste polymers are widely used in asphalt modification, especially to mitigate their environmental impact. This research discusses the possibility of using expanded polystyrene (EPS) waste foam in asphalt modification. EPS foam waste produced during production and use was mixed with bitumen in weight ratios of 2%, 4%, 6%, and 8%, using the dry modification method. The physical and mechanical properties of the original bitumen were compared with asphalt modified by EPS foam waste. A strong relationship between the physical properties of the modified asphalt and the EPS foam ratio was observed. Decreases in penetration and ductility values were noted. Additionally, statistical analyses indicated that a 2% increase in the additive ratio was not sufficient to make a significant difference in the physical properties of bitumen.

Nader Nciri et al. [13] introduced wastes EPS foam into asphalt mixtures used in road construction. Different ratios of waste from EPS foam, such as 2%, 4%, 6%, and 8% by weight were mixed with asphalt binder. The physical and mechanical properties of the modified asphalt mixtures were then evaluated.

Khaled Ramadan et al. [14] collected polystyrene in its wastes form, shredded it, washed it, and then dried it before mixing it with original asphalt. A 70-80 penetration grade asphalt binder was used and

mixed with processed wastes polystyrene. The mixing ratios between polystyrene and asphalt (S/A) were: 0.0% (reference sample), 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, 1.2%, and 2% by weight of the asphalt binder.

Building on previous research, this study aims to investigate the dual impact of chlorine and polystyrene on the rheological properties of asphalt binder.

## **Materials and Methods:**

### **Thermal degradation of polystyrene :**

The thermal degradation of polystyrene was achieved by direct heat exposure, breaking down the polymer into approximately 60% of its original weight in the form of styrene.

This resulting product has potential applications as a car fuel improver or could be used in reprocessing the same polymer.

Additionally, the remaining styrene, once ground into fine particles, was blended into chlorinated asphalt at three different ratios (1%, 2%, and 3%) while maintaining a temperature at 150 degrees Celsius for two hours.

Here are the experimental methods [15,16,17,18,19]:

- Ductility: ASTM (D6-70)
- Penetration: ASTM (D5-83)
- Softening point: ASTM (D36-83)
- Thin Film Oven Test (TFOT): ASTM (D6-80)

### **Chemical materials used :**

The chlorination process of asphalt was facilitated by iron chloride as a catalyst. Different temperature levels were used during the chlorination process, as outlined in Table 1.

Degraded Polystyrene.

Devices Used:

- Softening point (ring and ball)
- Penetration
- Ductility
- Simple distillation apparatus for crushing
- Oven for Thin Film Oven Test (TFOT)

### **Sample Preparation :**

Polystyrene was subjected to thermal degradation through direct heating, breaking down the polymer into approximately 60% of its original weight in the form of styrene, the main component of the polymer. The remaining material was then ground into fine particles and added to chlorinated asphalt at three different ratios (1%, 2%, and 3%), with the process conducted at a temperature of 150 degrees Celsius for 2 hours.

### **Testing Methods:**

Asphalt binder samples were tested using penetration tests at 25 degrees Celsius (ASTM D6), softening point tests (ASTM D36), ductility tests at 25 degrees Celsius (ASTM D113), and Thin Film Oven Test (TFOT) ASTM (D6-80) to determine the optimal polymer content.

### **Results and Discussion:**

The thermal cracking process was implemented due to the polystyrene's difficulty in dissolving within asphalt systems and its lack of compatibility with them. Consequently, partial cracking was employed using heat and direct heating. In this process, the polystyrene is subjected to high temperatures to break down its chemical bonds and convert it into smaller, less-ordered molecules. This is achieved by heating the polystyrene to a temperature above its melting point, causing it to crack into smaller, more reactive components. This procedure enhances the polystyrene's ability to blend with asphalt and improves its mechanical properties and adhesion to other materials within the asphalt system.

Chlorinated asphalt is a modified type of asphalt that is enhanced by adding chlorinated compounds to it. Through this modification, asphalt acquires improved properties and additional benefits. Here are some key characteristics of chlorinated asphalt:

**Chemical resistance:** Chlorinated asphalt enhances resistance to chemical corrosion resulting from asphalt's reactions with harmful chemicals, such as acids and bases. This makes it suitable for use in applications exposed to strong chemical substances, such as chemical industries and water treatment plants.

**Thermal resistance:** Chlorinated asphalt is known for its resistance to thermal corrosion caused by high temperatures and sudden temperature changes. Therefore, it can be used in applications exposed to extreme thermal conditions, such as thermal industries and tropical regions.

**Durability and flexibility:** Chlorinated asphalt improves the durability of asphalt and its resistance to cracking and deterioration. It also increases its flexibility, allowing it to withstand movements and vibrations without rapid deterioration. As a result, chlorinated asphalt is used in road, pavement, and sidewalk applications to provide a durable and corrosion-resistant surface.

**Water resistance:** Chlorinated asphalt has good resistance to water and moisture. It forms a water-resistant layer on the surface, maintaining its stability and preventing water from penetrating into the

underlying asphalt. This makes it ideal for use in road, pavement, and plaza applications that require water protection[19].

Table 1 presents the physical properties of chlorinated asphalt using 1.5% from ferric chloride at different temperatures. Meanwhile, Table 2 compares the physical properties of chlorinated asphalt before and after adding 1% powdered polystyrene.

**Table (2):Physical properties of chlorinated asphalt after adding (1%) of crushed polystyrene**

Sample Number	The Chlorinated asphalt in different Temperatures			The Chlorinated asphalt after adding (1%) of polystyrene		
	Softening point oC	Penetration (0.1mm/ 5 sec, 25°C)	Ductility (Cm, 25 °C)	Softening point °C	Penetration (0.1mm/5 sec , 25 °C)	Ductility (Cm, 25 °C)
<b>1 (25 oC)</b>	45	52	+100	45	52	+100
<b>2 (90 oC)</b>	58	38	+ 100	61	32	70
<b>3 (130 oC)</b>	63	30	65	65	20	30
<b>4 (160 oC)</b>	76	16	0	77	3	0

The data reveals the impact of adding polystyrene on the properties of chlorinated asphalt. With an increase in polystyrene ratio as a solid substance, the asphalt's softening point rises while penetration decreases. This result can be attributed to the increased hardness of the asphalt due to higher polystyrene content, affecting penetration values and softening point. Furthermore, high temperatures adversely affect asphalt models, stimulating reactions that remove HCl particles and begin forming olefinic systems and double bonds, resulting in the development of more solid structure.

The comparison of results confirms the significant effect of polystyrene on the properties of chlorinated asphalt, especially in terms of flexibility. Adding 1% polystyrene reduces flexibility to 70 cm, indicating that polystyrene reduces the adhesive properties of asphalt. Additionally, the impact of high temperatures encourages the removal of HCl particles, making samples (1 and 2) suitable for use as gap-filling and roof covering materials.

When asphalt systems are exposed to heat and over time, oxidation reactions occur. These reactions result in the removal of hydrogen from asphalt molecules and the formation of olefinic bonds between the remaining molecules. As a result, the hydrogen-to-carbon ratio in asphalt systems decreases, and their hardness increases.

Over time, the oxidation and hydrogen removal process continues in asphalt systems, leading to a decrease in the hydrogen content relative to carbon. The molecules become more intertwined and bonded as more olefinic bonds are formed, thereby increasing the hardness of asphalt systems.

In general, heat and time affect asphalt systems through oxidation reactions and chemical changes that occur. These processes result in a reduction in the hydrogen-to-carbon ratio and an increase in the hardness of asphalt systems.

Conversely, Table 3 shows that adding 2% and 3% degraded polystyrene to chlorinated asphalt leads to an increase in softening point and a decrease in penetration and flexibility. This change occurs due to prolonged exposure to high temperatures, leading to the removal of HCl particles and leaving a higher proportion of olefinic structures in the presence of polystyrene.

This, in turn, results in the formation of more complex and rigid structures compared to chlorinated asphalt alone.

Due to the extreme hardness and susceptibility to fracture at low temperatures, these asphalt systems cannot be effectively used for other purposes such as paving.

When temperatures decrease, the rigid asphalt transforms into a brittle form that is prone to breaking. This means that it may crack and fracture under pressure or load. Consequently, it is not suitable for use in paving applications that require withstanding traffic movement and mechanical stresses.

It is important to note that there are different types of asphalt systems used in paving, each with varying compositions and properties. Flexible asphalt systems, specifically designed to withstand low temperatures and accommodate expansion and contraction, are commonly employed in regions with cold climates where temperatures are low.

Choosing the appropriate type of asphalt system is crucial for specific operating conditions.

In the case of chlorinated asphalt treated with 2% and 3% degraded polystyrene (samples 1 and 2), the significant changes in penetration, ductility and softening point make them suitable for use as waterproofing and thermal insulation materials.

**Table (3) :Physical properties of chlorinated asphalt after adding (2% and 3%) of crushed polystyrene**

Sample Number	The chlorinated Asphalt before adding the Polystyrene			The Chlorinated Asphalt and 2% Polystyrene			The Chlorinated Asphalt and 3% Polystyrene		
	Softening	Penetration	Ductility	Softening	Penetration	Ductility	Softening	Penetration	Ductility

	point oC	(0.1mm/, 5 sec , 25 oC)	( Cm, 25 oC)	point oC	(0.1mm/, 5 sec , 25 oC)	( Cm, 25 oC)	point oC	(0.1mm/, 5 sec , 25 oC)	( Cm, 25 oC)
<b>1</b>	45	52	+ 100	45	52	+ 100	45	52	+ 100
<b>2</b>	58	38	+ 100	64	28	35	67	17	10
<b>3</b>	63	30	165	68	15	20	73	6	0
<b>4</b>	76	16	0	80	0	0	82	0	0

Figure 3 illustrates with greater precision that, with an increase in the poly-styrene ratio, the properties of asphalt change significantly, especially when exposed to higher temperatures. This alteration is attributed to the formation of olefinic systems, leading to a reduction in oil and resin content in the model. As a result, the values for permeability and flexibility reach zero (5.6).

Polystyrene is a type of solid polymer material with a high melting point compared to asphalt. It has a molecular structure characterized by strong bonds between the particles, resulting in increased hardness and rigidity of the models made from it.

The solid nature and high melting point of polystyrene enhance the hardness and stiffness of the models. Polystyrene exhibits high resistance to corrosion and mechanical impacts, making it an ideal material for applications that require strength and rigidity.

However, it's important to note that polystyrene and asphalt are completely different materials in terms of composition and properties. The hardness and stiffness of the models are not solely determined by one component but can also be influenced by other factors, such as the chemical composition of the materials, operating conditions, and manufacturing processes.

In summary, polystyrene with its high melting point and hardness contributes to increased hardness and rigidity of the models. However, it is necessary to consider other factors that may affect the hardness and rigidity in asphalt applications.

Figure 1 visually demonstrates an increase in the softening point for various asphalt samples, including regular asphalt, chlorinated asphalt, and chlorinated asphalt treated with 1%, 2%, and 3% of shattered poly-styrene. Conversely, Figure 2 shows a decrease in penetration for chlorinated asphalt after treatment with different proportions of poly-styrene, comparing it to natural asphalt.

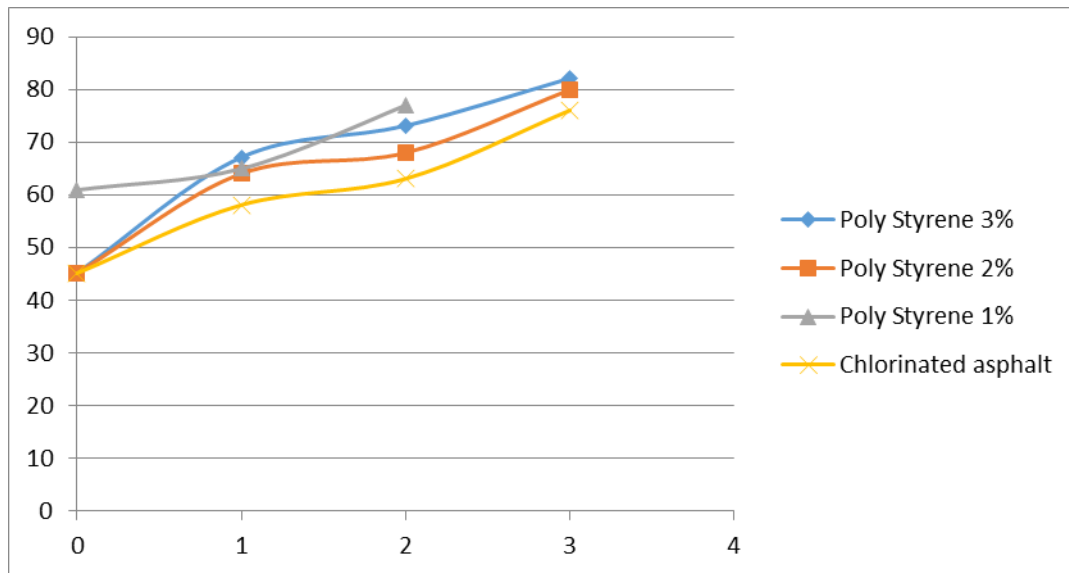


Figure 1: The softening point for the different types of asphalt.

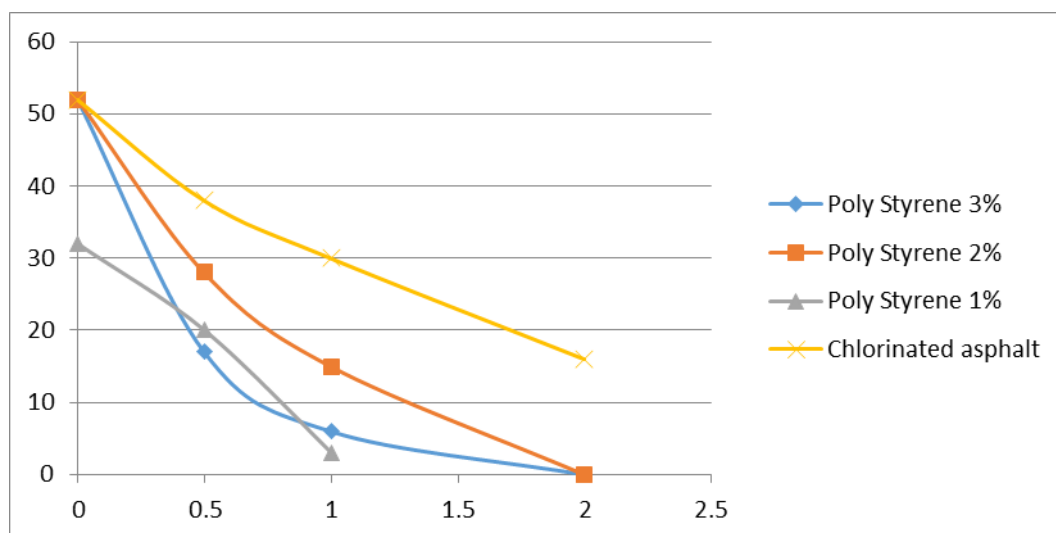


Figure 2: penetration values for the different types of asphalt

**Conclusion**

Adding chlorine to asphalt increases its melting point, and the degree of this impact is directly related to the temperature used in the chlorination process. Simultaneously, the penetration and flexibility of asphalt decrease, and the extent of this change depends on the temperature increase. Suitable asphalt for road paving in high-temperature areas can be obtained by chlorination at lower temperatures. Substituting hydrogen atoms with chlorine atoms allows asphalt to maintain its properties across a range of temperatures. Chlorinating asphalt at high temperatures leads to an increase in the double bond ratio, primarily due to the removal of HCl particles from the interconnected asphalt formation. This, in



turn, enhances cross-linking, resulting in a more rigid form of asphalt applicable in various fields, such as filling gaps in different construction contexts. Adding shattered poly-styrene to chlorinated asphalt raises its melting point while reducing penetration and flexibility. The decrease in flexibility values becomes more pronounced when the poly-styrene content exceeds 1%, eventually reaching zero.

Treating chlorinated asphalt with poly-styrene yields more complex and rigid results compared to chlorinated and regular asphalt. These outcomes present promising samples suitable for use as construction materials in tasks such as gap filling, water insulation, and thermal insulation.

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## **On Linearization of Differential Algebraic Equations**

**Eman A. Mansour**

Department of Electrical Technologies, Southern Technical University / Technical, Institute, Nasiriyah,  
Iraq.

[iman.am73@stu.edu.iq](mailto:iman.am73@stu.edu.iq)

## On Linearization of Differential Algebraic Equations

Eman A. Mansour

Department of Electrical Technologies, Southern Technical University / Technical, Institute, Nasiriyah, Iraq.

[iman.am73@stu.edu.iq](mailto:iman.am73@stu.edu.iq)

### Abstract

The unstable nature of differential-algebraic equations leads mathematicians to invest their time and efforts in investigating different methods to stabilize them and studying the effectiveness of these methods in providing the required stable solution to the differential-algebraic equations.

In this paper, an approach has been proposed and studied to use linearization that depends on the Hurwitz criterion as a stabilization method to solve the differential algebraic equations.

**Keywords:** Stabilization; Linearization; Differential algebraic equation; Hurwitz criterion.

### 1. Introduction:

The differential-algebraic equation is an equation that consists of two parts, differential and algebraic; the algebraic part of the equation is called the dominant restriction of the equation [1]. The origins of differential-algebraic equations theory can be traced back to the work of K. Wein and L. Kronecker, who parameterized families of bilinear forms in 1868 [2].

Differential algebraic systems like multibody systems control theory and electrical network analysis can model many systems in science and engineering. Applications of differential-algebraic equations are also found in chemistry, magnetohydrodynamics,

neutral networks, fault diagnosis model identification, observer design, and robotics. Differential algebraic equations also arise from problems in other branches of mathematics, such as the discretization of partial differential equations, root-finding, or optimization [1,2].

The general formula of a differential algebraic equation is [3-8]:

$$F[t, x, x^0] = 0 . \#(1)$$

With  $F: I \times D_x \times D_x^0 \rightarrow C^M$ , where  $I \in R$  is a consolidated interval and  $D_x, D_x^0 \subseteq C^n$  are open,  $m, n \in N$ .

There are two cases for the partial derivative  $\frac{\partial F}{\partial x^0}$ ; the first is when  $\frac{\partial F}{\partial x^0}$  is nonsingular, then it becomes possible to solve equation (1) for  $X^0$  and obtain an ordinary differential equation. However, if  $\frac{\partial F}{\partial x^0}$  is singular, then finding the solution for equation (1) is no longer possible, and the solution  $x$  has to satisfy certain algebraic constraints.

## 2. Differential Algebraic Equations Linearization

The dependency that differential algebraic equations and ordinary differential equations, in which the former depends on the derivatives of the signal that is inserted into the system while the latter depends on the signal itself, deemed that the ordinary differential equations are more useful in various scientific fields than the differential algebraic equations due to their stability issues [9].

The stability issues related to the structure of the differential algebraic equations deemed linearization important much more than the same processes are essential in ordinary differential equations.

However, it is possible to convert the differential algebraic equations into systems of differential equations through linearization reduction [10].

The differential-algebraic equation's linearized dynamic expression is as follows [9,10].

The semi-explicit formula, as mentioned earlier, is:

$$X^0 = I[x, y], 0 = y[x, y] . \#(2)$$

The linearization for equation (2) can be represented as:

$$\begin{bmatrix} x^0 \\ 0 \end{bmatrix} = J_u \begin{bmatrix} x \\ y \end{bmatrix}.$$

$J_u$  is the unreduced Jacobian matrix, and its formula is:

$$J_u = \begin{bmatrix} f_x & f_y \\ g_x & g_y \end{bmatrix}.$$

Considering that the  $\det(g_y)^0$  to the Jacobian matrix  $J_u$ , then it is possible to reduce the Jacobian matrix to  $J_r$  via linearization process. That reduction can be represented as:

$$X^0 = J_r x, \quad \text{where } J_r = f_x - f_y g_y^{-1} g_x.$$

### 3. Stability Of Differential Algebraic Equation

This section will demonstrate and study the effectiveness of linearization that depends on Hurwitz's criterion over the stability of differential-algebraic equations.

In this section, we will study the stability of differential algebraic equation by using linearization and depended on Hurwitz criterion.

#### 3.1 Hurwitz Criterion

The conditions of the Hurwitz stability criterion for a polynomial's coefficients can be written as [6,10]:

$$\left. \begin{aligned} a_0 \lambda^n + a_1 \lambda^{n-1} + \dots + a_{n-1} \lambda + a_n = 0. \\ \text{where all } a\text{'s are real values} \end{aligned} \right\} \#(3)$$

The condition that all  $a$ 's must be real quantities should be satisfied to ensure all the roots have negative real parts (not positive imaginary or zero). The insurance to the positive real criteria in all roots required the positivity of all coefficients. The mentioned condition is a necessity; however, it is not practical [6,10].

By considering all coefficients of the polynomial are positive, it is possible to arrange these coefficients in a determinant as:

$$\Delta_n = \begin{vmatrix} a_1 & a_3 & a_5 & \dots & 0 & 0 & 0 \\ a_0 & a_2 & a_4 & \dots & 0 & 0 & 0 \\ 0 & a_1 & a_3 & \dots & a_n & 0 & 0 \\ 0 & a_0 & a_2 & \dots & a_{n-1} & 0 & 0 \\ \cdot & \cdot & \cdot & \dots & \cdot & \cdot & \cdot \\ \vdots & \vdots & \vdots & \dots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & a_{n-a} & a_{n-2} & a_n \end{vmatrix}$$

In the previous determinant, zeros have been substituted for a's for all  $s > n$ , or where  $s$  is the number of a's.

$$\Delta_n^T = \begin{vmatrix} a_1 & a_0 & 0 & 0 & \dots & 0 & 0 \\ a_3 & a_2 & a_1 & a_0 & \dots & 0 & 0 \\ a_5 & a_4 & a_3 & a_2 & \dots & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & a_n & a_{n-1} & a_{n-2} & a_{n-3} & a_{n-4} \\ 0 & 0 & 0 & 0 & a_n & a_{n-1} & a_{n-2} \\ 0 & 0 & 0 & 0 & 0 & 0 & a_0 \end{vmatrix}$$

For stability purposes, aka (all the roots to have negative real parts),  $\Delta_n$  successive principal minors must be positive values, as shown below:

$$\Delta_i = \begin{vmatrix} a_1 & a_3 & \dots & a_{2i-1} \\ a_0 & a_2 & \dots & a_{2i-3} \\ 0 & a_1 & \dots & a_{2i-3} \\ \cdot & \cdot & \dots & \cdot \\ \cdot & \cdot & \dots & \cdot \\ \cdot & \cdot & \dots & \cdot \\ 0 & 0 & \dots & a_1 \end{vmatrix} = \begin{vmatrix} a_1 & a_0 & \dots & 0 \\ a_3 & a_2 & \dots & 0 \\ a_5 & a_4 & \dots & 0 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ a_{2i-1} & a_{2i-2} & \dots & a_i \end{vmatrix}$$

$(i = 1, 2, \dots, n)$

In the above determinant, the same conditions are applied to the lower-order determinants and upper-order determinants. The system is considered equilibrium (asymptotically stable) if all determinants are positive and  $a_0 > 0$ , and the system characteristic is given by equation (3). It should be noted that only the signs in the above determinant must be taken into consideration during the solving process [6,9,10].

As a demonstration of the discussed matter, let's consider the following characteristic polynomial:

$$L(\lambda) = \det(J_r - \lambda I) = a_0\lambda^4 + a_1\lambda^3 + a_2\lambda^2 + a_3\lambda + a_4 = 0.$$

$$\Delta_2 = \begin{vmatrix} a_1 & a_3 \\ a_0 & a_2 \end{vmatrix} = a_1a_2 - a_0a_3 > 0.$$

$$\begin{aligned} \Delta_3 &= \begin{vmatrix} a_1 & a_3 & 0 \\ a_0 & a_2 & a_4 \\ 0 & a_1 & a_3 \end{vmatrix} = a_1(a_2a_3 - a_1a_4) - a_0a_3^2 \\ &= a_3(a_1a_2 - a_0a_3) - a_1^2a_4 > 0. \end{aligned}$$

The asymptomatic stability conditions mentioned earlier in which all a's are positive values,  $\Delta_2 > 0$ , and  $\Delta_3 > 0$  are satisfied. That will cause all the roots of the given polynomial to be real and negative.

#### 4. Stabilizing Method to the Differential Algebraic Equations

This section presents our proposed approach to studying the stability in differential algebraic equations using linearization and depending on the Hurwitz criterion.

Consider equation (2) if  $\det(g_y) \neq 0$ , then linearization can be applied for reduced Jacobin matrix for:  $n^0 = J_r n$ .

To apply the stability studying suggested method, let us take the characteristic polynomial to the differential-algebraic equation with a reduced Jacobian matrix:

$$L(\lambda) = \det(J_r - \lambda I) = 0. \#(4)$$

Where  $I$  represents the identity matrix and  $J_r$  is the reduced Jacobian matrix.

So,

$$\det\left(\left(f_x - f_y g_y^{-1} g_n\right) - \lambda I\right) = 0,$$



$$\lambda^2 - T\lambda + D = 0 .$$

$T$  is the matrix trace, and  $D$  is the determinant with the condition  $T < 0$ .

The entirety of the coefficients (a's) are positive, and assuming that  $D > 0$  will result in all the roots of the given characteristic polynomial having negative real parts, giving asymptomatic stability to the characteristic polynomial.

The following application is to clarify the proposed approach through the use of actual numbers:

Let:

$$L(\lambda) = 2\lambda^4 + 3\lambda^3 + 4\lambda^2 + \lambda + 1 = 0 ,$$

$$a_0 = 2, a_1 = 3, a_2 = 4, a_3 = 1, a_4 = 1 .$$

$$D_2 = \begin{vmatrix} 3 & 1 \\ 2 & 4 \end{vmatrix} = 12 - 2 = 10 > 0 ,$$

$$D_3 = \begin{vmatrix} 3 & 1 & 0 \\ 2 & 4 & 1 \\ 0 & 3 & 1 \end{vmatrix} = 3(4 - 3) - 1(2) = 3 - 2 = 1 > 0 .$$

The conditions for asymptomatic stability are that all of the a's are positive and  $D_2$  and  $D_3 > 0$  are applied. Therefore, all the roots of the given example have negative real parts. Furthermore, that gives stability to the system.

## 5. Conclusions

The superiority of ordinary differential equations comes from their ease and stability, which gave them popularity among mathematicians, who use them to solve many problems in many fields. On the contrary, the stabilization issues related to the structure of the differential algebraic equations make them harder to invest in various fields.

This work studies the stability of the resulting ordinary differential equations that result from converting differential-algebraic equations into them and how much the resulting equations abide by predefined conditions. A new transforming method that uses

linearization and, depending on the Hurwitz criterion, is proposed, and its results are studied and prove its ability to provide a stable ordinary differential equation via practical application.

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