Effects of Homogeneous and Heterogeneous Chemical Reactions on Peristaltic flow of a Micropolar Fluid through a Porous Medium with Wall Effects in the presence of Slip

Goolia. Ravi Kiran and Ganjam. Radhakrishnamacharya

Abstract — This paper investigates the effects of slip boundary condition and wall properties on the dispersion of a solute matter in peristaltic flow of an incompressible micropolar fluid through a porous medium. Long wavelength approximation, Taylor's limiting condition and dynamic boundary conditions at the flexible walls are used to obtain the average effective dispersion coefficient in the presence of combined homogeneous and heterogeneous chemical reactions. The effects of various pertinent parameters on the effective dispersion coefficient are discussed. It is observed that peristalsis enhances dispersion. It also increases with micropolar parameter, cross viscosity coefficient, Darcy number, slip parameter and wall parameters. Further, dispersion decreases with homogenous chemical reaction rate and heterogeneous chemical reaction rate.

Keywords — Dispersion, Peristalsis, Wall Properties, Chemical Reaction, Slip Condition.

I. INTRODUCTION

The dispersion of a soluble matter in fluids has many biological applications especially in the study of blood circulation. Dispersion of a solute in a viscous fluid under different conditions was studied by several authors (Taylor [1], Aris [2], Padma and Ramana Rao [3], Gupta and Gupta [4] and Ramana Rao and Padma [5]). Subsequently, Chandra and Agarwal [6], Philip and Chandra [7], Alemayehu and Radhakrishnamacharya [8], [9] extended the analysis of Taylor [1] to non-Newtonian fluids. Further, flow through porous media has various physiological applications such as the flow of blood in the micro-vessels of the lungs which may be treated as a channel bounded by two thin porous layers (Misra and Ghosh [10]). Hence, a number of authors have studied the dispersion of a solute through a porous medium under different conditions (Mehta and Tiwari [11] and Pal [12]).

Peristaltic pumping is a word used to describe a progressive wave of contraction along a channel or tube whose cross-sectional area consequently varies. Peristalsis is an inherent property of many tubular organs of the human body. The mechanism of peristaltic transport has been exploited for industrial applications like sanitary fluid transport, blood pumps in heart lung machine, transport of corrosive and noxious fluids. In view of its importance, a number of researchers investigated peristaltic transport of Newtonian and non-Newtonian fluids under different conditions (Fung and Yih [13], Shapiro, Jaffrin and Weinberg [14], Shehawey and Sebaei [15], Takagi and Balmforth [16], Radhakrishnamacharya [17], Alsaedi, Ali, Tripathi and Hayat [18] and Nadeem and Akbar [19]).

Micropolar fluid is a non-Newtonian fluid that belongs to a class of fluids with nonsymmetrical stress tensor and is referred to as polar fluid. Physically, it represents a fluid consisting of randomly oriented particles suspended in a viscous medium. It is realized that micropolar fluid accounts for the rotation of fluid particles by means of an independent kinematic vector called microrotation vector (Eringen [20]). Hence, the model of micropolar fluid may be more appropriate to analyze the behavior of lubricants, colloidal suspensions, polymeric fluids, liquid crystals and physiological fluids. Muthu, Ratiash Kumar and Chandra [21] and Sankad, Radhakrishnamacharya and Ramanamurthy [22] investigated the influence of wall properties on the peristaltic motion of micropolar fluid under different conditions. Tripathi, Chaube and Gupta [23] studied the stokes flow of micropolar fluid by peristaltic pumping through a cylindrical tube under the effect of slip boundary condition.

It is realized that fluid slips at the walls in certain physiological and engineering situations. The no slip boundary condition is a core concept in fluid dynamics in which the fluid and the boundary move with same velocity. Beaver and Joseph [24] were the first to propose slip boundary condition. The boundary condition proposed by Beaver and Joseph was simplified by Saffman [25]. The existence of slip phenomenon at the boundaries and interfaces has been observed in the flows of rarefied gases, physiological flows, hypersonic flows of chemically reacting binary mixture etc. Also flows with slip occur for certain problems in chemical engineering, for example, flows through pipes in which chemical reactions occur at the walls, certain two-phase flows and flows in porous slider bearings.

The effect of combined homogeneous and heterogeneous
chemical reactions in the peristaltic motion of a micropolar fluid through a porous medium with wall properties and slip condition has not received any attention. It is realized that porosity and peristalsis may have significant effect on the dispersion of a solute in the fluid flow and this may lead to better understanding of the flow situation in physiological systems. Hence, in this paper, the effect of dispersion of a solute in persistent transport of a micropolar fluid through a porous medium under slip conditions and wall effects is investigated. Using long wavelength approximation, dynamic boundary condition and Taylor's approach, analytical expression has been obtained for the average effective dispersion coefficient, in the presence of combined homogeneous and heterogeneous irreversible chemical reactions and the effects of various relevant parameters on it are studied.

II. FORMULATION OF THE PROBLEM

Consider the dispersion of a solute in persistent flow of a micropolar fluid in an infinite uniform channel of width 2d and with flexible walls on which are imposed traveling sinusoidal waves of long wavelength. It is assumed that the channel is filled with porous material. Cartesian coordinate system (x, y) is chosen with x-axis aligned with the center line of the channel. The traveling waves are represented by

\[ y = \pm h = \pm \left[ d + a \sin \frac{2\pi}{\lambda} (x - ct) \right] \]  

(1)

where \( a \) is the amplitude, \( c \) is the speed and \( \lambda \) is the wavelength of the peristaltic wave (Fig. 1).

![Fig. 1 Geometry of the problem](image)

The governing equation of motion of the flexible wall may be expressed as (Mitra and Prasad [26])

\[ L(h) = p - p_0 \]  

(2)

where \( L \) is an operator which is used to represent the motion of a stretched membrane with damping forces such that

\[ L = -T \frac{\partial^2}{\partial x^2} + m \frac{\partial^2}{\partial t^2} + C \frac{\partial}{\partial t} \]  

(3)

Here \( T \) is the tension in the membrane, \( m \) is the mass per unit area and \( C \) is the coefficient of viscous damping force.

The equations governing the two dimensional flow of an incompressible micropolar fluid for the present problem (by neglecting body forces and body couples) are given by

\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \]  

(4)

\[ \rho \left[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} \right] = -\frac{\partial p}{\partial x} + \left( \frac{\mu + \kappa}{2} \right) \frac{\partial^2 u}{\partial y^2} - \frac{\mu}{k_0} u \]  

(5)

\[ \rho \left[ \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} \right] = -\frac{\partial p}{\partial y} + \left( \frac{\mu + \kappa}{2} \right) \frac{\partial^2 v}{\partial x^2} - \frac{\mu}{k_0} v \]  

(6)

\[ \rho \left[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} ight] + \frac{2\mu + \kappa}{2} \frac{\partial^2 u}{\partial y^2} - \frac{\mu}{k_0} u = 0 \]  

(7)

where \( u \) and \( v \) are the velocity components in the \( x \) and \( y \) directions respectively, \( g \) is the microrotation component, \( \rho \) is the density, \( p \) is the pressure, \( J \) is the microinertia coefficient, \( \mu \) is the coefficient of viscosity, \( \kappa \) and \( \gamma \) are the viscosity coefficients for the micropolar fluid. \( k_0 \) is the permeability constant of the porous medium and \( \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \)

Under long wavelength approximation, the equations (4) – (7) reduce to

\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \]  

(8)

\[ -\frac{\partial p}{\partial x} + \left( \frac{2\mu + \kappa}{2} \right) \frac{\partial^2 u}{\partial y^2} - \frac{\mu}{k_0} u = 0 \]  

(9)

\[ -\frac{\partial p}{\partial y} = 0 \]  

(10)

\[ -2\kappa g + \gamma \frac{\partial^2 g}{\partial y^2} - \kappa \frac{\partial u}{\partial y} = 0 \]  

(11)

It is assumed that \( p_0 = 0 \) and the channel walls are inextensible so that only lateral motion takes place and the horizontal displacement of the wall is zero.

The relevant slip boundary conditions for the velocity and microrotation are respectively given by (Bhatt and Sacheti [27])

\[ u = -\frac{d\sqrt{Da}}{\alpha_t} \frac{\partial u}{\partial y} \quad \text{at} \quad y = \pm h \]  

(12)

where \( Da \) is the permeability parameter (or Darcy number) and \( \alpha_t \) is the slip parameter.

The dynamic boundary conditions at the flexible walls (Mitra and Prasad [26]) can be written as

\[ \frac{\partial}{\partial x} \left( L(h) \right) = \left( \frac{2\mu + \kappa}{2} \right) \frac{\partial^2 u}{\partial y^2} + \kappa \frac{\partial g}{\partial y} - \frac{\mu}{k_0} u \]  

(13)

where

\[ \frac{\partial}{\partial x} L(h) = \frac{\partial p}{\partial x} - T \frac{\partial^2 h}{\partial x^2} + m \frac{\partial^3 h}{\partial x^2 \partial t} + C \frac{\partial^3 h}{\partial x \partial t^2} \]
Solving equations (9) to (11) under the boundary conditions (12) and (13), we get

\[ u(y) = A'_1 \cosh(l'_1 y) + A'_2 \cosh(l'_1 y) + A'_3 \]

where

\[ A'_1 = \frac{P'k_0}{\mu} \frac{l'_{11}}{l'_1}, \quad A'_2 = -\frac{P'k_0}{\mu} \frac{l'_{12}}{l'_1}, \quad A'_3 = -\frac{P'k_0}{\mu} \]

\[ l'_1 = \frac{2\mu(2\kappa k_0 + \gamma)}{\gamma \kappa_0(2\mu + \kappa)}, \quad l'_2 = \frac{4\mu \kappa}{\gamma \kappa_0(2\mu + \kappa)}, \]

\[ l'_3 = \sqrt{\left[l'_1 + \sqrt{l'_1^2 - 4l'_2}\right]/2}, \quad l'_4 = \sqrt{\left[l'_1 - \sqrt{l'_1^2 - 4l'_2}\right]/2}, \]

and

\[ P' = -T^{\frac{\partial^2 h}{\partial x^2}} + m^{\frac{\partial^2 h}{\partial x \partial t}} + c^{\frac{\partial^2 h}{\partial x^2}}, \]

Further, the mean velocity is defined as

\[ \bar{u} = \frac{1}{2h} \int u(y)dy \]

Substituting equation (14) in equation (16), we get

\[ \bar{u} = \frac{A'_1}{h l'_1} \sinh(l'_1 h) + \frac{A'_2}{h l'_1} \sinh(l'_1 h) + A'_3 \]

If we now consider convection across a plane moving with the mean speed of the flow, then relative to this plane, the fluid velocity is given by (Gupta and Gupta [4], Alemayehu and Radhakrishnamacharya [8], [9])

\[ u_s = u - \bar{u} \]

Substituting equations (14) and (17) in equation (18), we get

\[ u_s = A'_1 \cosh(l'_1 y) + A'_2 \cosh(l'_1 y) \]

**Diffusion with Combined Homogeneous and Heterogeneous Chemical Reactions**

It is assumed that a solute diffuses and simultaneously undergoes a first order irreversible chemical reaction in peristaltic transport of micropolar fluid in a channel under isothermal conditions. Using Taylor’s approximation, i.e.,

\[ \frac{\partial^2 C}{\partial x^2} \approx \frac{\partial^2 C}{\partial y^2} \]

the equation for the concentration C of the solute is given by (Gupta and Gupta [4])

\[ \frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} = D \frac{\partial^2 C}{\partial y^2} - k_i C \]

where D is the molecular diffusion coefficient and \( k_i \) is the first order reaction rate constant.

For typical values of physiologically relevant parameters of this problem, it is realized that \( \bar{u} = c \) (Alemayehu and Radhakrishnamacharya [8], [9]). Using this condition and making use of the following dimensionless quantities,

\[ \theta = \frac{t}{T}, \quad \bar{y} = \frac{y}{\bar{h}}, \quad \eta = \frac{y}{d}, \quad \xi = \frac{x - \bar{x}}{\bar{h}}, \quad H = \frac{h}{d}, \quad P = \frac{d^2}{\mu c} \]

equations (19) and (20) reduce to

\[ u_i = \left(-\frac{d^2}{\mu}\right)[A_1 \cosh(l_i \eta) + A_2 \cosh(l_i \eta)] \]

\[ -\frac{A_1}{l_i H} \sinh(l_i H) - \frac{A_2}{l_i H} \sinh(l_i H) \]

Further, equation (15) reduces to

\[ A_1 = -A_3 \frac{l_{1s}}{l_{1s}}, \quad A_2 = A_3 \frac{l_{1b}}{l_{1s}}, \quad A_3 = PDa \]

\[ l_1 = l'_1 d^2 = \frac{1}{Da} \left[ M^2 \mu_1 Da + 2 \right], \]

\[ l_3 = l'_3 d^2 = \frac{M^2 N^2}{Da}, \quad l_2 = l'_3 d = \sqrt{l'_3 + (l'_3)^2 - 4l'_2}/2, \]

\[ l_4 = l'_4 d = \sqrt{l'_1 - (l'_1)^2 - 4l'_2}/2, \]

\[ l_5 = l'_5 d^2 = \frac{1}{\mu_1 Da} - \frac{l'_3}{2N^2} \sinh(l_1 H), \]

\[ l_6 = l'_6 d^2 = \frac{1}{\mu_1 Da} - \frac{l'_3}{2N^2} \sinh(l_1 H), \]

\[ l_7 = \cosh(l_1 H) + \sqrt{\frac{Da}{\alpha}} l_3 \sinh(l_1 H), \]

\[ l_8 = \cosh(l_1 H) + \sqrt{\frac{Da}{\alpha}} l_4 \sinh(l_1 H), \]

\[ l_9 = l'_3 d^3 = l_1 l_5 l_7 - l_1 l_7 l_6 \quad \text{and} \quad P = -e \left[(E_1 + E_2)(2\pi)^3 \cos(2\pi \xi) - E_1(2\pi)^2 \sin(2\pi \xi) \right] \]
Here, \( \varepsilon (= a / d) \) is the amplitude ratio, \( E_r (= -T d^3 / \lambda^3 \mu c) \) is the rigidity, \( E_v (= m c d^3 / \lambda^3 \mu) \) is the stiffness, \( E_s (= C d^3 / \mu t^2) \) is the viscous damping force in the wall, \( M (= 2d \sqrt{\mu / \gamma}) \) is the micropolar parameter, \( N (= \sqrt{\mu / (2 + \mu)}) \) is the coupling parameter, \( \mu_c (= \kappa / \mu) \) is the cross viscosity coefficient, \( Da (= k_v / d^2) \) is the Darcy number.

It is assumed that a first order irreversible chemical reaction takes place both in the bulk of the fluid (homogeneous) as well as at the walls (heterogeneous) of the channel which are assumed to be catalytic to chemical reaction. Thus, the corresponding boundary conditions at the walls (Philip and Chandra [7]) are under

\[
\frac{\partial C}{\partial y} + fC = 0 \quad \text{at} \quad y = h = [d + a \sin (\frac{2\pi}{\lambda} (x - \bar{m}))]
\]

(25)

\[
\frac{\partial C}{\partial \eta} - fC = 0 \quad \text{at} \quad y = -h = [-d + a \sin (\frac{2\pi}{\lambda} (x - \bar{m}))]
\]

(26)

If we introduce the dimensionless variables (21), the above boundary conditions become

\[
\frac{\partial C}{\partial \eta} + \beta C = 0 \quad \text{at} \quad \eta = H = [1 + \varepsilon \sin (2\pi \xi)]
\]

(27)

\[
\frac{\partial C}{\partial \eta} - \beta C = 0 \quad \text{at} \quad \eta = -H = [-1 + \varepsilon \sin (2\pi \xi)]
\]

(28)

where \( \beta = fd \) is the heterogeneous reaction rate parameter corresponding to catalytic reaction at the walls.

Solving (23) under the boundary conditions (27) and (28) by assuming that \( \partial C / \partial \xi \) is independent of \( \eta \) at any cross section, we get the solution for the concentration of the solute \( C \) as

\[
C(\eta) = \left[ \frac{d^6}{\lambda \mu D} \frac{\partial C}{\partial \xi} \right] \left[ \frac{A_1}{L} \cosh (\alpha \eta) - \left( \frac{A_1}{l_i^2 - \alpha^2} \right) \cosh (l_i \eta) - A_1 \right]
\]

(29)

where

\[
A_1 = \left( \frac{A_1}{l_i^2 - \alpha^2} \right) \sinh (l_i H) + \left( \frac{A_1}{l_i \alpha^2 H} \right) \cosh (l_i H) + \left( \frac{A_1 l_i}{l_i^2 - \alpha^2} \right) \sinh (l_i H)
\]

\[
A_2 = \left( \frac{A_2}{l_i \alpha^2} \right) \sinh (l_i H) + \left( \frac{A_2}{l_i \alpha^2 H} \right) \cosh (l_i H)
\]

and

\[
A_3 = \frac{1}{\alpha^2} \left[ \frac{A_3}{l_i H} \cosh (l_i H) + \frac{A_3}{l_i \alpha^2 H} \right]
\]

The volumetric rate \( Q \) at which the solute is transported across a section of the channel of unit breadth is defined by

\[
Q = \int_{-H}^{H} C \, d\eta 
\]

(30)

Substituting equations (23) and (29) in equation (30), we get the volumetric rate \( Q \) as

\[
Q = -2 \frac{d^6}{\mu \lambda D} \frac{\partial C}{\partial \xi} G(\xi, \alpha, \beta, \varepsilon, \mu, M, Da, \alpha_i, E_i, E_s)
\]

(31)

where

\[
2G(\xi, \alpha, \beta, \varepsilon, \mu, M, Da, \alpha_i, E_i, E_s) = \left( \frac{A_1 A_1}{L} \right)
\]

\[
\left[ \frac{2l_i \cosh (\alpha H) \sinh (l_i H) - 2\alpha \cosh (l_i H) \sinh (\alpha H)}{l_i^2 - \alpha^2} \right] \left[ \frac{A_1^2}{l_i^2 - \alpha^2} \right] \sinh (2l_i H) - \frac{A_1 A_1}{l_i^2 - \alpha^2} + \frac{A_1 A_1}{l_i^2 - \alpha^2}
\]

\[
\left[ \frac{2l_i \cosh (\alpha H) \sinh (l_i H) - 2\alpha \cosh (l_i H) \sinh (\alpha H)}{l_i^2 - \alpha^2} \right] \left[ \frac{2l_i \cosh (\alpha H) \sinh (l_i H) - 2\alpha \cosh (l_i H) \sinh (\alpha H)}{l_i^2 - \alpha^2} \right] - \left( \frac{A_1 A_1}{l_i^2 - \alpha^2} \right) \left[ \frac{2l_i \cosh (\alpha H) \sinh (l_i H) - 2\alpha \cosh (l_i H) \sinh (\alpha H)}{l_i^2 - \alpha^2} \right]
\]

(32)

Now comparing the equation (31) with Fick's first law of diffusion, the effective dispersion coefficient \( D' \) with which the solute disperses relative to a plane moving with the mean speed of the flow, is obtained as,

\[
D' = 2 \frac{d^6}{\mu^2 \lambda D} G(\xi, \alpha, \beta, \varepsilon, \mu_i, M, Da, \alpha_i, E_i, E_s)
\]

(33)

Let the average of \( G \) be \( \bar{G} \), and is defined by

\[
\bar{G} = \int_{0}^{1} G(\xi, \alpha, \beta, \varepsilon, \mu_i, M, Da, \alpha_i, E_i, E_s) \, d\xi
\]

(34)

III. NUMERICAL RESULTS AND DISCUSSION

The equation (34) gives the dispersion coefficient \( D' \) through the function \( \bar{G} \), which has been computed numerically using MATHEMATICA software and the results are presented graphically. The dimensionless quantities involved in the discussion are: the amplitude ratio \( \varepsilon \), the homogeneous reaction rate \( \alpha \), the heterogeneous reaction rate \( \beta \), the cross viscosity coefficient \( \mu_c \), the micropolar
parameter $M$, the Darcy number $Da$, the slip parameter $\alpha$, and the wall parameters $E_1, E_2, E_3$. Further, from the equations (13) and (22) we may note that $E_1, E_2$ and $E_3$ cannot be taken as zero simultaneously.

Fig. 2 Effect of $E_1$ on $G$ ($\dot{\alpha} = 0.2, \alpha = 0.5, E_2 = 0.0, E_3 = 0.0, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Fig. 3 Effect of $E_1$ on $G$ ($\beta = 5, \alpha = 0.5, E_2 = 4.0, E_3 = 0.0, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Fig. 4 Effect of $E_1$ on $G$ ($\beta = 5, \epsilon = 0.2, E_2 = 4.0, E_1 = 0.06, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Figs. 5 – 7 show that the dispersion coefficient increases as the stiffness in the wall ($E_1$) increases for both the cases of perfectly elastic wall ($E_1 = 0$) (Fig. 6) and dissipative wall ($E_1 \neq 0$) (Figs. 5 and 7).

Fig. 5 Effect of $E_1$ on $G$ ($\dot{\alpha} = 0.2, \alpha = 0.5, E_1 = 0.1, E_3 = 0.06, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Fig. 6 Effect of $E_2$ on $G$ ($\beta = 5, \alpha = 0.5, E_1 = 0.1, E_3 = 0.0, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Fig. 7 Effect of $E_1$ on $G$ ($\beta = 5, \epsilon = 0.2, E_2 = 0.1, E_3 = 0.06, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)

Fig. 8 Effect of $E_1$ on $G$ ($\alpha = 0.5, \epsilon = 0.2, E_1 = 0.1, E_3 = 4.0, \mu = 0.04, M = 10, Da = 0.002, \alpha_i = 0.01$)
The effect of the rigidity parameter \( E_i \) on the effective dispersion coefficient is shown in Figs. 2 - 4. It is observed that the dispersion increases with the rigidity parameter in the cases of (i) no stiffness in the wall \( (E_2 = 0) \) and perfectly elastic wall \( (E_i = 0) \) (Fig. 2); (ii) stiffness in the wall \( (E_2 \neq 0) \) and perfectly elastic wall \( (E_i = 0) \) (Fig. 3); (iii) no stiffness in the wall \( (E_i = 0) \) and dissipative wall \( (E_i \neq 0) \) (Fig. 4).

It is seen from Figs. 8 - 10 that the average effective dispersion coefficient increases with viscous damping force \( (E_j) \) for both the cases of stiffness in the wall \( (E_j \neq 0) \) (Figs. 8 and 9) and no stiffness in the wall \( (E_j = 0) \) (Fig. 10).
It is observed that the effective dispersion coefficient increases with micropolar parameter $M$ (Figs. 11 and 12) and cross viscosity coefficient $\mu_1$ (Figs. 13 and 14). These are true for the cases of (i) stiffness in the wall ($E_2 \neq 0$) and perfectly elastic wall ($E_2 = 0$) (Figs. 12 and 14) (ii) no stiffness in the wall ($E_2 = 0$) and dissipative wall ($E_2 \neq 0$) (Figs. 11 and 13); but the variation in case (i) is not significant.

Further, it is noticed that the average effective dispersion coefficient increases with amplitude ratio $\varepsilon$ (Figs. 3, 6, 9, 12, 14, 16 and 18). This implies that the peristalsis enhances dispersion of a solute in fluid flow. It is also noticed that dispersion increases with Darcy number $Da$ (Figs. 15 and 16) and slip parameter $\alpha_1$ (Figs. 17 and 18) but decreases with homogeneous chemical reaction rate $\alpha$ (Figs. 4, 7 and 10) and heterogeneous chemical reaction rate $\beta$ (Figs. 2, 5, 8, 11, 13, 15 and 17). The result that dispersion decreases with $\alpha$ and $\beta$ agrees with those of Padma and Ramana Rao [3], Gupta and Gupta [4], Ramana Rao and Padma [5] and Alemayehu and Radhakrishnamacharya [8], [9].

IV. CONCLUSION

The effect of combined homogeneous and heterogeneous chemical reactions on peristaltic motion of a micropolar fluid through a porous medium with wall effects and slip condition has been studied under long wavelength approximation and Taylor's limiting condition. It is observed that peristaltic motion enhances dispersion and dispersion decreases with homogeneous and heterogeneous chemical reaction rates. It is also observed that the effective dispersion coefficient increases with micropolar parameter, cross viscosity coefficient, rigidity, stiffness, viscous damping, Darcy number and slip parameter.

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