# Comments on the paper "'Concentration-dependent viscosity and thermal radiation effects on MHD peristaltic motion of Synovial Nanofluid: Applications to rheumatoid arthritis treatment' by M. G. Ibrahim, W. M. Hasona, and A. A. El-Shekhipy, Computer Methods and Programs in Biomedicine, 2019, 170: 39 - 52"

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## Abstract

This comment has been prepared from the perspective point of view that the readers of the above mentioned paper may not be aware of the several serious flawed analysis and typographical errors throughout the whole work. In the next few pages I will focus on most of these mistakes/typos, clarifying that the obtained results should be reported as fabricated results that no one can rely upon. Suggested corrections for these numerous errors will be offered to correct the literature and ensure its integrity.

**Keywords:** Peristaltic motion, Synovial nanofluid, Magnetohydrodynamics (MHD), Thermal radiation.

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## I. Introduction

Ibrahim et al. [1] aimed in their attempt to investigate the effects of concentration-dependent viscosity and thermal radiation on MHD peristaltic motion of Synovial nanofluid. The authors solved the problem for two different models. Model-(I) captures the response of the synovial fluid for both shear thinning ($-0.5 < n < 0$), and also the chemically-thickening behavior (by allowing the apparent viscosity to depend on concentration). For Model-(II), this model takes into account that the variation in concentration will influence the shear-thinning effects. Then a detailed comparison between Model-(I) and Model-(II) were made. Unfortunately, they have fallen in several severe mistakes and typos that leads to conceptual and logical flaws as listed below;

## II. Comments on Mathematical Modeling

1. In the problem modeling section Ref. [1]. The readers should be aware of the way the authors used bars on variables in expressing Eqs. (1)−(16). A case of inconsistency.

2. The authors did not clarify precisely the role of the magnetic field in the problem formulation. By regarding Eqs. (12) and (13) one can recognize that the Hall current effects were to be considered through their analysis. Contrarily, as viewing Eqs. (17), (19), (22) and (24), Ibrahim et al. [1] have considered a uniform

magnetic field transverse to the flow direction while ignoring the Hall effects leaving the readers being confused.

3. The momentum Eq. (9) in Ref. [1] page 41, is mathematically wrong and its correction is

$$\rho_f \frac{D\vec{\boldsymbol{V}}}{D\bar{t}} = -\nabla P + 2\, div(\mu(\bar{C}, D)\boldsymbol{D}) + \vec{J} \times \vec{B} + (1 - \bar{C}_0)\rho_f\, \vec{\boldsymbol{g}}\, \beta(\bar{T} - \bar{T}_0) + \left(\rho_P - \rho_f\right) \vec{\boldsymbol{g}}\, (\bar{C} - \bar{C}_0) \quad (1)$$

Here in Eq. (1) the velocity vector of the fluid is identified by $\vec{\boldsymbol{V}}$ and not $\bar{V}$ as presented by the authors. As in page 41 they have already defined the components of the velocity vector of the fluid in the fixed frame by $(\bar{U}, \bar{V})$.

- The symmetric part of the velocity gradient $\boldsymbol{D} = \frac{1}{2}(\nabla\vec{\boldsymbol{V}} + \nabla\vec{\boldsymbol{V}}^{\mathrm{T}})$ was missed on the right hand side of the second term in Eq. (9) page 41 Ref. [1]. Obviously this mistake makes that term being a scalar quantity and not in vector form as desired.
- Also the acceleration due to gravity in the last two terms on the right hand side of Eq. (9) page 41 Ref. [1], should have been written in vector form so that this equation being mathematically balanced.
- The authors have introduced $\beta$ in the Nomenclature as the Hall factor. Whilst, the same symbol $\beta$ that appeared in equation (9) page 41 Ref. [1] should be defined as the thermal expansion coefficient. The parameter $\beta^*$ in Eq. (9) page 41 Ref. [1] was not defined anywhere in the article and has to be omitted from the equation.

4. The energy Eq. (10) in Ref. [1] page 41 is wrong as it contains three typos and its correction is

$$(\rho c)_f \left(\frac{D\bar{T}}{D\bar{t}}\right) = k\, \nabla \cdot \nabla\bar{T} - \nabla \cdot \boldsymbol{q_r} + (\rho c)_P \left\{ D_B [\nabla\bar{C} \cdot \nabla\bar{T}] + \frac{D_T}{T_0} [\nabla\bar{T} \cdot \nabla\bar{T}] \right\} + \frac{1}{\sigma} \vec{J} \cdot \vec{J}, \quad (2)$$

where $\boldsymbol{q_r} = \frac{-4\, \sigma^*}{3\, k^*} \boldsymbol{\nabla}\, \bar{T}^4$ is the heat flux.

5. The coefficient of viscosity $\mu$ (**dimensional quantity**) defined in Eq.(1) and Eq. (2) page 40 Ref [1], also appears in equations (17), (21), (22) and (26) in Ref [1] page 41-42. Obviously, in constructing equations it is not allowed to add dimensional to non-dimensional quantities. Henceforward, these mentioned equations [ (17), (21), (22) and (26) in Ref [1] page 41-42] are incorrect and all subsequent results are also incorrect. In addition to that, the authors did another severe mistake in figure (Fig. 8, page 45 Ref [1]) by plotting the influence of $\mu$ on the longitudinal pressure gradient, but this time they defined $\mu$ to be an unknown material parameter! See section 5.2 page 48 Ref [1].

6. A very strange mistake, is the appearance of the dimensional parameter $\sigma$ (which was defined to be the electrical conductivity of the base fluid) in the dimensionless Eq. (22) of Model (I) Ref [1]. One could ask, is

this be a typo! No it is not, the same mistake was repeated in Eq. (26) of Model (II) Ref [1]. The correction is to replace $\sigma$ by the dimensionless concentration $\varphi$.

7. It is clear that the two energy equations (19) and (24) presented in Ref [1] for both Models (I) and (II) are identical. Since the authors ignored the viscous dissipation effect in their study. But unfortunately this energy equation for both Models (I) and (II) is wrong. This equation as presented by the authors was given by;

$$0 = (1 + P_r\, R_n)\frac{\partial^2\theta}{\partial y^2} + B_r\, M^2 \left(\frac{\partial\psi}{\partial y} + 1\right)^2 + P_r\, N_t\, \frac{\partial\theta}{\partial y}\frac{\partial\varphi}{\partial y} + P_r\, N_b\, \frac{\partial^2\theta}{\partial y^2}\,, \qquad (3)$$

and its correction is

$$0 = (1 + P_r\, R_n)\frac{\partial^2\theta}{\partial y^2} + B_r\, M^2 \left(\frac{\partial\psi}{\partial y} + 1\right)^2 + P_r\, N_b\, \frac{\partial\theta}{\partial y}\frac{\partial\varphi}{\partial y} + P_r N_t \left(\frac{\partial\theta}{\partial y}\right)^2. \qquad (4)$$

It is clear that the places of the thermophoresis $N_t$ and the Brownian motion $N_b$ parameters were switched and that the last term to the right $P_r\, N_b \frac{\partial^2\theta}{\partial y^2}$ in equation (3), has to be replaced by $P_r\, N_t\, (\frac{\partial\theta}{\partial y})^2$.

8. In Eq. (28) page 42 Ref [1], the boundary condition for $y = h_2 = -d - b\cos(2\pi x + 1)$ is wrong and its correction is;

$$y = h_2 = -d - b\cos(2\pi x + \phi). \qquad (5)$$

9. The condition presented in Eq. (7) ref [1] page 41 is wrong and its correct form is as follows;

$$a_1^2 + b_1^2 + 2\, a_1\, b_1\, \cos\phi \le (d_1 + d_2)^2.$$ For more details see Ref. [2].

## II. Comments on Definitions

1- In the Nomenclature table, many mistakes were found. As an example,

- $\rho_P$ is defined to be current density. Regrettably it was assumed to be the density of the nanoparticles as appeared in the momentum equation (9) Ref.[1] page 41.

- $Q$ is defined as fixed frame. The right definition for $Q$ as introduced in Eq. (29) Ref. [1] is that $Q$ resembles the dimensionless mean flow over one period in the fixed frame.

- $c$ is defined to be the fluid velocity! The authors themselves define $c$ as the speed of the channel walls in last line of page 40 Ref. [1] and in equations (5) and (6). That remissness was followed by another trivial mistake as assigning to the velocity $c$ a unit of length (m).

- Introducing the Hall factor $\beta$, mass of the electron $n_e$ and the electron charge $e$, in the Nomenclature were meaningless as the Hall effect was not considered throughout the whole study.

2- The authors have switched the definitions of $\varphi$ and $\phi$ several times through the whole work, see the Nomenclature, the paragraph following Eq. (6) page 41, Fig. 13, Section 5.3 and Section 5.4.

3- Eq. (3) page 40 Ref. [1] representing the magnitude of the rate of deformation tensor contains two typos, and its correction is

$$|\boldsymbol{D}| = D = \left[ 2\left(\frac{\partial \bar{U}}{\partial \bar{X}}\right)^2 + 2\left(\frac{\partial \bar{V}}{\partial \bar{Y}}\right)^2 + \left(\frac{\partial \bar{U}}{\partial \bar{Y}} + \frac{\partial \bar{V}}{\partial \bar{X}}\right)^2 \right]^{1/2} \quad (6)$$

4- The Eckert number presented by the authors in Eq. (16) page 41 ( $E_c = \frac{c^2}{(T_1 - T_0)}$ ) is wrong. As it becomes dimensional quantity as follows; here $c^2$ $(\mathbf{m^2/s^2})$ is the square of the wave speed and $(T_1 - T_0)(\mathbf{K})$ the difference between the temperatures at the lower and upper walls respectively. The correction to the Eckert number is given by $E_c = \frac{c^2}{c_f(T_1 - T_0)}$ where $c_f(\mathbf{K^{-1} s^{-2}\, m^2})$ is the specific heat.

5- In the set of the dimensionless parameters in Eq. (16) page 41 Ref [1]. It is observed that there are eight of these parameters that contains the viscosity term in their definition. Five of these parameters namely $P$, $R_e, M^2, P_r$ and $N_t$ involves the expression $\mu_0$. On the other hand the remaining three parameters namely $G_c$, $G_t$ and $R_n$ involves the expression $\mu$. The authors in page 40 Ref. [1] defined $\mu_0$ as an unknown material parameter which is wrong. As we can see from Eqs. [1] and [2] page 40 Ref. [1] that the expression $\mu_0$ is the constant viscosity case as $\gamma \to 0$ and $\alpha \to 0$. While $\mu$ is the variable viscosity. So, another confusing case is reported here.

6- The term $v = -\delta \frac{\partial \psi}{\partial y}$ presented in Eq. (16) is wrong and its correction is $v = -\frac{\partial \psi}{\partial x}$. In the this corrected expression the partial derivative is with respect to $x$. The parameter $\delta$ was omitted as the authors defined the non-dimensional velocity component in $y$- direction in the moving frame by $v = \frac{\bar{v}}{c\,\delta}$ , where $\delta = \frac{d_1}{\lambda}$ that was not defined also by the authors. Otherwise the continuity Eq. (8) will not be satisfied as the authors claimed.

7- I would like to infer that the authors gave a wrong definition for the parameter $d$ as they defined $d$ in the Nomenclature to be half width of the channel (i.e. $d = \frac{d_1 + d_2}{2}$). Whereas, the correct definition should be $d = \frac{d_2}{d_1}$.

## III. Comments on Figures

Despite of the wrong equations presented in the modeling section that led to incorrect results. The way the authors did comparisons between Model (I) and (II) in Figures 11, 12, 13, 14, 15, 16 17, 18 are wrong as the $y$ −scale values in each comparison are not the same. Besides, they did not present the caption of the figures at all.

In addition to these numerous mistakes, more careful review is required for other undiscussed conceptual mistakes in Ibrahim et al. [1] that were not referred to in this comment.

## IV. Conclusion

Taking into account all the above discussions the study presented by Ibrahim et al. [1] contained a lot of mistakes in defining, modeling and demonstrating the problem. Consequently this led up to totally unreliable work and results.

## References

[1] Ibrahim M. G., Hassona W. M. and El-Shekhipy A. A. (2019), Concentration-dependent viscosity and thermal radiation effects on MHD peristaltic motion of Synovial Nanofluid: Applications to rheumatoid arthritis treatment. Computer Methods and Programs in Biomedicine **170**, 39−52.

[2] Elogail M. A. (2019), "Comments on 'Combined effects of magnetohydrodynamic and temperature dependent viscosity on peristaltic flow of Jeffrey nanofluid through a porous medium : Application to oil refinement'", International Journal of Heat and Mass Transfer **128**, 976–979.