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On the onset of bioconvection in nanofluid containing gyrotactic microorganisms and nanoparticles saturating a non-Darcian porous medium

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ABSTRACT

This paper presents an investigation for bioconvection of nanofluid holding gyrotactic microorganism over a stretching surface implant in a porous medium by taking the model introduced by Xu and Pop (2014). The bulk matrix linear resistance applied by porous media and the inertia effect characterized by the non-linear Forchheimer term are considered in the momentum equation. Using the similarity transformation, the governing PDEs are turned into a set of five similarities non-linear ODEs. Using charts and tables, the consequences of numerous parameters on flow features are examined and resolved in whole. The present results disclose that the rate of heat transmission is reduced with permeability parameter and inertial parameter whereas the rate of mass transfer is amplified with those parameters for suction and depleted for injection.

1. Introduction

Bioconvection is a fluid dynamic phenomenon that originates in the movement of microorganism and can be formed in flagellate, bacterial and plankton cultures. These kinds of arrangement are also spotted in cultures of swimming microorganisms which are more compressed than water. In reply to outer stimuli (e.g. gravity, chemical gradients and light intensity) they boost themselves towards the upper surface of the liquid. The non-uniformity cell allocation together with the variation of density between the cells and the fluid, conduct an unbalanced stratification which produce large-scale convective flows. Observations in bioconvection have been documented on earlier occasions in various studies [1–3].

There has been improved devotion in the study of transport phenomena in porous media due to its impact in various field of engineering. Some significant developments have been done in fluid flow modelling through a porous medium. A major chunk of work has come to the front on flow and heat transmission in Darcian porous media. But, Darcy's law is admissible only where slow flow through porous media with low penetrability is concerned, it cannot be presumed in umpteenth number of practical situations. Thus for the convective transport in a porous medium, the insertion of non-Darcian terms is necessary. Much of the study in porous media are already used in the by gone days which is now widely identified as the Darcy-Forchheimer, Brinkman–Forchheimer extended model [4–6]. Mabood and Khan [7] analytically studied the boundary layer flow and heat transfer over a radiative plate in a Darcian porous medium. Gireesha et al. [8] discussed MHD flow of dusty fluid over an unsteady stretching surface through a non-Darcy porous medium. Heat and mass stratification on a plate submerge in a fluid soaked by non-Darcy porous medium was studied by Srinivasacharya and Surender [9]. Recently, Srinivasacharya et al. [10] inspect the impact of thermophoresis on convection flow over a wavy surface and Mabood et al. [11] clarify the heat source/sink and Soret effects of micropolar fluid past a vertical plate embedded in a non-Darcian porous medium.

In industry, an alternative method for improving the convection heat transfer characteristics is to use porous medium with nanofluid. Therefore, nanofluid flow in porous media has been put under the scanner and given a significant consideration. A rich oeuvre of published papers on nanofluid and porous medium can be found in the open literature [12–14]. Buongiorno's model was applied by various research workers [15–16] to study the uncertainty of flow problem of nanofluid through a porous medium. A numerical study on nanofluid flow surrounded by porous media was conveyed by Ahmad and Pop [17]. Other associated studies on thermal variability in a porous medium inundated by nanofluid contain those by Nield and Kuznetsov [18] & Chand and Rana [19]. Shaw and Sibanda [20] was further studied the work of Nield and Kuznetsov [18] by considering a non-Darcy porous medium. Nanofluid flow over a vertical plate soaked by non-Darcy porous medium was carefully studied by Murthy et al. [21].

Bioconvection has numerous applications in oil refinery. Many researchers have immersed themselves for the intense scrutiny of

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