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Analysis of MHD Bioconvection Flow of a Hybrid Nanofluid Containing Motile Microorganisms over a Porous Stretching Sheet

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Abstract

This paper presents a numerical investigation of steady two-dimensional bioconvective MHD flow along with the heat and mass transfer phenomena of a water-based hybrid nanofluid containing motile microorganisms over a porous stretching sheet. The study considers effects of various physical parameters, such as thermal radiation, chemical reactions, Joule heating, and heat generation, on the flow and transport characteristics of the system. Copper (Cu) and alumina (Al_2O_3) nanoparticles are used with water (H_2O) as the base fluid. The governing equations are transformed into a set of nonlinear ordinary differential equations using a standard similarity transformation. The reduced equations are solved numerically using the Keller-box method. The impact of different parameters on the velocity, temperature, concentration, and microorganism concentration profile is illustrated graphically, while their influence on the skin-friction coefficient, local Nusselt number, local Sherwood number, and local density number of motile microorganisms is tabulated. This study provides an excellent agreement with previously published works. The results of the study show that the presence of motile microorganisms significantly enhances the heat transfer rate and mixing efficiency of the nanofluid. The analysis demonstrates that the chemical reaction and thermal radiation play crucial roles in controlling the concentration and temperature distributions of the nanofluid, respectively.

Keywords Thermal radiation · Chemical reactions · Stretching sheet · Hybrid nanofluid · Motile microorganism · Joule heating

Nomenclature

a, b	Constant
x, y	Cartesian coordinates along the surface and normal to it, respectively (m)
u, v	Velocity component along x-axis and y-axis respectively (m s^{-1})
T	Temperature (K)
C	Nanoparticle concentration (mol l^{-1})
N	Concentration of the microorganism
B_o	Magnetic field (T)
k_o	Porous term (m^2)
Q_o	Coefficient of heat generation
C_p	Specific heat at constant pressure (J kg^{-1} K^{-1})
q_r	Radiative heat flux
D_m	Mass diffusion coefficient
D_n	Microorganisms' diffusion coefficient
Kr	First-order chemical reaction coefficient
W_c	Maximum cell swimming speed
k^*	Mean absorption coefficient
M	Magnetic parameter
Ec	Eckert number
Q	Heat generation/absorption
K_p	Permeability parameter
Pr	Prandtl number
Rd	Radiation parameter
Sc	Schmidt number
Sb	Bioconvection Schmidt number
Pe	Bioconvection Peclet number
Cf_x	Skin-friction coefficient
Nu_x	Nusselt number
Sh_x	Sherwood number
Nn_x	Density number of motile microorganism
Re_x	Reynold number

Greek symbols

ν	Kinematic viscosity (m^2 s^{-1})
μ	Dynamic viscosity (kg m^{-1} s^{-1})
σ	Electrically conductivity (S m^{-1})

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