NOMENCLATURE

a, b	first and second order velocity slip parameter (-)
$\tilde{b}$	chemotaxis constant (m)
c	thermal slip parameter (-)
C	nanoparticle volume fraction (-)
d	mass slip parameter (-)
D_1	variable thermal slip factor (m)
$(D_1)_0$	constant thermal slip factor (m)
D_B	Brownian diffusion coefficient (m^2s^{-1})
D_n	diffusivity of microorganisms (m^2s^{-1})
D_T	thermophoretic diffusion coefficient (m^2s^{-1})
e	microorganism slip parameter (-)
E_1	variable mass slip factor (m)
$(E_1)_0$	constant mass slip factor (m)
F_1	variable microorganism slip factor (m)
$(F_1)_0$	constant microorganism slip factor (m)
$f(\eta)$	dimensionless stream function (-)
g	acceleration due to gravity (ms^{-2})
h	dimensionless pressure (-)
$\bar{j}$	vector flux of microorganism (kgm^{-2} s^{-1})

k thermal conductivity ($Wm^{-1}K^{-1}$)

L characteristic length (m)

Lb bioconvection Lewis number (-)

Le Lewis number (-)

n volume fraction of motile microorganisms (-)

N_1 variable first order velocity slip factor (sm^{-1})

$(N_1)_0$ constant first order velocity slip factor (sm^{-1})

N_2 variable second order velocity slip factor (sm^{-1})

$(N_1)_0$ constant second order velocity slip factor (sm^{-1})

Nb Brownian motion parameter (-)

$Nn_{\bar{x}}$ local density number of the motile microorganisms (-)

Nt thermophoresis parameter (-)

Nr buoyancy ratio parameter (-)

$Nu_{\bar{x}}$ local Nusselt number (-)

Pe bioconvection Péclet number (-)

Pr Prandtl number (-)

$\bar{p}$ pressure (Pa)

q_m wall mass flux (ms^{-1})

q_n wall motile microorganisms flux (ms^{-1})

q_w wall heat flux (Wm^{-2})

Ra Rayleigh number (-)

$Ra_{\bar{x}}$ local Rayleigh number (-)

Rb bioconvection Rayleigh number (-)

s Stefan blowing parameter (-)

$Sh_{\bar{x}}$ local Sherwood number (-)

T nanofluid temperature (K)

$\bar{u}, \bar{v}$ velocity components along $\bar{x}-$ and $\bar{y}-$axes (ms^{-1})

U_r reference velocity (ms^{-1})

$\bar{u}_w$ velocity of the plate (ms^{-1})

$\tilde{\bar{u}}, \tilde{\bar{v}}$ average directional swimming velocity of microorganisms along the axes (ms^{-1})

W_c constant maximum cell swimming speed (ms^{-1})

$\bar{x}, \bar{y}$ Cartesian coordinates ($\bar{x}-$axis is aligned along and $\bar{y}-$axis is normal to the plate) (m)

Greek symbols

α effective thermal diffusivity (m^2s^{-1})

β volumetric expansion coefficient of nanofluid (K^{-1})

γ density of motile microorganisms ($kg\ m^{-3}$)

δ_C nano-particle concentration boundary layer

δ_m momentum boundary layer

δ_n micro-organism concentration boundary layer

δ_T thermal boundary layer

η similarity variable (-)

$\theta(\eta)$ dimensionless temperature (-)

μ dynamic viscosity of the fluid ((Nsm^{-2}))

ν kinematic viscosity of the fluid (m^2 s^{-1})

ρ_f fluid density (kg m^{-3})

ρ_p nanoparticle mass density (kg m^{-3})

$(\rho c)_f$ heat capacity of the fluid (J kg^{-3} K^{-1})

$(\rho c)_p$ heat capacity of the nanoparticle material (J kg^{-3} K^{-1})

τ ratio between the effective heat capacity of the nanoparticle material and heat capacity of the fluid (-)

$\phi(\eta)$ rescaled nanoparticle volume fraction (-)

$\chi(\eta)$ rescaled density of motile microorganisms (-)

ψ stream function (-)

Subscripts/superscripts

w condition at the wall

∞ free stream condition

' differentiation with respect to η