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# Channel flow of non-Newtonian fluid due to peristalsis under external electric and magnetic field

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## Abstract

The overall objective of the current analysis is to examine how electroosmotic flow combined with peristaltic pumping phenomenon could ably contribute to intracellular fluid flow. The biofluid is taken as non-Newtonian Couple stress fluid, while micro-passage is approximated as two-dimensional inclined channel comprehending complex peristaltic walls. Following a traditional approach of peristaltic fluid flow problem balance of mass and momentum is utilized. Beside channel waves, flow is also generated by Lorentz force triggered by electric and magnetic fields. To integrate electric potential term Poisson-Boltzmann and Nernst Planck equation are utilized. Finally, a sixth order BVP in term of stream function is obtained by employing creeping flow, long wavelength and Debye-Hückel assumptions. A numerical solution is calculated and analyzed by plotting fluid velocity and level curves in MATLAB 2021b. It is observed that couple stress fluid flows with greater speed (in central region of the channel) as compared to Newtonian fluid. Moreover, electro-osmotic parameter and Debye-Hückel length are assistive factors to the fluid velocity in the lower half of the passage.

## Keywords

Couple stress fluid, Poisson-Boltzmann equation, Nernst Planck equation, Debye-Hückel assumptions, complex peristaltic walls

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## Introduction

The role of fluid dynamics in the developmental biology is already recognized. Biofluid mechanics introduce interminable possibilities to integrate concepts of fluid mechanics into certain biological marvels. Out of these possibilities peristaltic transport (rises via wave train propagation) is one of the most miscellaneous mechanism. It is observed in physiology of pharyngeal motion,[1] morphogenesis of lung,[2] stomach pumping,[3] vasomotion in the bat wing,[4] bacterial gliding motility,[5–9] self-propulsion of human sperm,[10–17] medical endoscope designing,[18] and earthworm propulsion.[19,20] The manufacturing of soft microrobots with complicated electro-hydraulic designs focused on replicating (natural occurring) peristaltic motions.[21,22] Peristaltically driven flow of complex rheological liquid is the key mechanism for most of physiological process inside human body. The pumping problem of viscoplastic models (with all its limiting cases) is presented by Tripathi and Bég.[23] Bertuzzi et al.[24] investigated the urine activity and functions of erythrocytes within wavy micro passages.[24] Fluid-structure interaction (FSI) combined with hydroelectric forces is expounded by Lin et al.[25] They utilized factual spring model to explain the said process in micro-pumps. Jaffrin,[26] Fauci,[27] Natarajan and Dehghan[28] and Berg et al.[29] have all communicated additional analysis of various pumping devices and their design.

Transporting of fluids under the influence of electro-osmosis or electrophoresis has significance implication in the fabrication of microfluidic devices and thus in biomedicine and micro-electromechanical systems. Obvious examples are separation and lap-on-a-chip devices. Electrokinetic[30] transport has evolved as a thriving field in modern fluid mechanics. It is utilized in a wide range of medical applications, including blood circulation, chromatography, hemoglobin separation, and the creation and manipulation of colloidal suspensions. Electrokinetic mechanism incorporates electro-osmosis, electrophoresis,

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