Dynamics of SIR mathematical model for COVID-19 outbreak in Pakistan under Fractal-fractional derivative

ABSTRACT

There are still mathematical predictions in the fight against epidemics. Speedy expansion, ways and procedures for the pandemic control require early understanding when solutions with better computer-based mathematical modeling and prognosis are developed. Despite high uncertainty in each of these models, one of the important tools for public health management system is epidemiology models. The fractional order is shown to be more effective in modeling epidemic diseases, in relation to the memory effects. Notably, recently founded calculus tools, called fractal-fractional calculus, having a fractional order and fractal dimension, enable us to study the behavior of a real-world problem under both fractal and fractional tools. This paper is about the dynamical behavior of a new mathematical model of novel corona disease (COVID-19) under the fractal-fractional Atangana–Baleanu derivative. The considered model has three compartments, namely, susceptible, infected and recovered or removed (SIR). The existence and uniqueness of the model's solution will be proved via Krasnoselskii's and Banach's fixed point theorems, respectively. The stability of the solution in the sense of Hyers–Ulam (HU) will be built up by nonlinear functional analysis. Moreover, the numerical simulations for different values of isolation parameters corresponding to various fractal-fractional orders are analyzed using fractional Adams–Bashforth (AB) method with two-step Lagrange polynomial. Finally, the obtained simulation results are applied to the real data of disease spread from Pakistan. The graphical interpretations demonstrate that increasing the isolation parameters which is caused by strict precautionary measures will reduce the disease infection transmission in society.

Keyword: Coronavirus pandemic disease; Fractal-Fractional Atangana–Baleanu Derivative; Existence theory; HU stability; Fractional Adams–Bashforth (AB) Method; Numerical simulation