Information Sciences Letters

Volume 10
Issue 2 *May 2021*

Article 17

2021

New Dynamical Behaviour of the Coronavirus (2019-Ncov) Infection System with Non-Local Operator from Reservoirs to People

P. Veeresha
Department of Mathematics, CHRIST (Deemed to be University), Bengaluru - 560029, India,
hmbaskonus@gmail.com

Wei Gao
School of Information Science and Technology, Yunnan Normal University, Yunnan, China,
hmbaskonus@gmail.com

D. G. Prakasha
Department of Mathematics, Davangere University, Shivagangothri, Davangere-577007, India,
hmbaskonus@gmail.com

N. S. Malagi
Department of Mathematics, Davangere University, Shivagangothri, Davangere-577007, India,
hmbaskonus@gmail.com

E. Ilhan
Faculty of Engineering and Architecture, Kirsehir Ahi Evran University, Kirsehir, Turkey,
hmbaskonus@gmail.com

See next page for additional authors

New Dynamical Behaviour of the Coronavirus (2019-Ncov) Infection System with Non-Local Operator from Reservoirs to People

Authors

P. Veeresha, Wei Gao, D. G. Prakasha, N. S. Malagi, E. Ilhan, and Haci Mehmet Baskonus

Inf. Sci. Lett. **10**, No. 2, 205-212 (2021)

Information Sciences Letters
An International Journal

http://dx.doi.org/10.18576/isl/100206

New Dynamical Behaviour of the Coronavirus (2019-Ncov) Infection System with Non-Local Operator from Reservoirs to People

P. Veeresha[1], *Wei Gao*[2], *D. G. Prakasha*[3], *N. S. Malagi*[3], *E. Ilhan*[4] *and Haci Mehmet Baskonus*[5,*]

[1]Department of Mathematics, CHRIST (Deemed to be University), Bengaluru - 560029, India
[2]School of Information Science and Technology, Yunnan Normal University, Yunnan, China
[3]Department of Mathematics, Davangere University, Shivagangothri, Davangere-577007, India
[4]Faculty of Engineering and Architecture, Kirsehir Ahi Evran University, Kirsehir, Turkey
[5]Department of Mathematics and Science Education, Faculty of Education, Harran University, Sanliurfa, Turkey

Received: 2 Jan. 2020, Revised: 2 Feb 2020, Accepted: 14 Mar. 2021
Published online: 1 May 2021

Abstract: The mathematical accepts while analysing the evolution of real word problems magnetizes the attention of many scholars. In this connection, we analysed and find the solution for nonlinear system exemplifying the most dangerous and deadly virus called coronavirus. The six ordinary differential equations of fractional order nurtured the projected mathematical model and they are analysed using q-homotopy analysis transform method (q-HATM). Further, most considered fractional operator is applied to study and capture the more corresponding consequences of the system, known as Caputo operator. For different fractional order, the natures of the achieved results are illustrated in plots. Lastly, the present investigation may aid us analyse the distinct and diverse classes of models exemplifying real-world problems and helps to envisage their corresponding nature with parameters associated with the models.

Keywords: 2019-nCoV, Laplace transform, Caputo derivative, q-Homotopy analysis method, Numerical solutions.

1 Introduction

The evolution of the human population rapidly is increasing in associated with new cultures and lifestyles. Mankind have developed many types of equipments to lead to their beautiful life. To lead a happy life in their own directions, humans are breaking limitations and boundaries developed by nature. Particularly, the utilization of food, vehicles, mobiles, cosmetics, electrical and petroleum equipment and many others, made the highly polluted and virus filled environment. Due to this, new type and class of virus have been developed and made a diseased environment. Particularly, from the lost three months, humans are afraid and timid to come out from their home, a due novel virus called coronavirus (2019-nCoV). The history of this virus traced back to 1965 when Tyrrell and Bynoe have acknowledged when they passage a virus named B814 [1, 2].The outbreak of a highly infected and deadly virus of the present era is a coronavirus and it is recognized on December 31, 2019 in the Wuhan (Chinese city) [3, 4]. Since then it killed over 2,75,976 on May 8 over the infected case of 40,09,291 peoples in more than 212 countries.

As from the beginning up to this day, there is no particular treatment, medicine or vaccine to completely cure infected patients and from the day by day, there is always exponential increase in the death of the deceased peoples. More precisely, the economy of each infected country is decreasing due to this cruel virus. Initially, every infected person has high fever, cough and shortness in the breath. This virus transmitted by touching the body of diseased patients to the uninfected person to his/her eyes, nose, mouth and some other parts. In order to control the spread of the virus, each country has taken all most all initializations and spends a huge amount to prevent or avoided its effects on humankind. From January to till the date many important research has been carried out by many scholars in order to illustrate it behaviour and predict its evolution [5–8].

* Corresponding author e-mail: hmbaskonus@gmail.com, pundikala.veeresha@christuniversity.in

On the other hand, in order to study, analyse, examine, predict and capture the behaviour of virus, diseases, threads and others, the mathematics is the only tool that can help us in systematic, effective and accurate manner without too much expense. This tool is considered to propose a model with some cases study and examine with the help of its constituent subjects. When the model depends on other parameters and it contains the processes of the rate of change, we should and always referred a novel concept called calculus. Even though the concept of calculus is initiated in the 16th century all most all phenomena necessitates, and the role of nature is effectively and accurately described with the help of calculus. In this paper, we considered the concept of generalization of the calculus of integer order to fractional order called fractional calculus (FC). The concept of FC is rooted in the same era of classical concept, however recently it magnetized by numerous scholars. Specifically, when we capturing and examining the behaviour of the mechanism related hereditary possessions, memory consequences, complexity, and other stimulating and essential properties, the concepts of FC are very useful and more effective [9–24, 31–56]. We hired Caputo operator in the present study and which is the foremost operator which obeys maximum needs of classical lows and corresponding properties.

2 The Model

Here, we consider the epidemic model proposed by Khan and Atangana [25]. In [25], the authors derived some stimulating consequences for the hired system related practical values. In this epidemic model, the total number of people is symbolised as N. Further, the susceptible people are denoted as $S(t)$, the exposed population is symbolised by $E(t)$, total infected strength is represented by $I(t)$, the asymptotically infected peoples is presented as $A(t)$, the number of recovered humans is indicated by $R(t)$ and $M(t)$ is considered as a reservoir. Now, the non-linear differential system considering the above components is considered as follows [25]

$$\begin{aligned}
\frac{dS(t)}{dt} &= b-\gamma S-\frac{\delta S(I+\beta A)}{N}-\varepsilon SM,\\
\frac{dE(t)}{dt} &= \frac{\delta S(I+\beta A)}{N}+\varepsilon SM-(1-\vartheta)\theta E-\vartheta\mu E-\gamma E,\\
\frac{dI(t)}{dt} &= (1-\vartheta)\theta E-(\rho+\gamma)I,\\
\frac{dA(t)}{dt} &= \vartheta\mu E-(\sigma+\gamma)A,\\
\frac{dR(t)}{dt} &= \rho I+\sigma A-\gamma R,\\
\frac{dM(t)}{dt} &= \tau I+\kappa A-\omega M.
\end{aligned} \tag{1}$$

Here, b denote the rate of birth and γ is a rate ofdeath of the infected population. The symbol δ signifies the transmission coefficient, β is transmissibility multiple, α is the transmission rate becomes infected and θ is that of the incubation period, the amount of asymptomatic infection is denoted by ϑ, the disease transmission coefficient is represented as ε. In the considered system, ρ and σ are respectively defines the recovery rate of the infected and asymptotically infected population. Further, τ and κ respectively symbolise the influence of the virus to M by I and A. The parameter ω defines the rate of virus removing from M.

Table 1: The value of the Parameters cited in Eq. (1) [25]

Parameter	Value
γ	$\frac{1}{76.79\times365}$
δ	0.05
β	0.02
ε	0.000001231
ϑ	0.1243
θ	0.00047876
α	0.005
ρ	0.09871
σ	0.854302
τ	0.000398
κ	0.001
ω	0.01

In this paper, we consider the fractional order of Eq. (1) with Caputo derivative as

$$\begin{aligned}
D_t^{\mu}S(t) &= b-\gamma S-\frac{\delta S(I+\beta A)}{N}-\varepsilon SM,\\
D_t^{\mu}E(t) &= \frac{\delta S(I+\beta A)}{N}+\varepsilon SM-(1-\vartheta)\theta E-\vartheta\alpha E-\gamma E,\\
D_t^{\mu}I(t) &= (1-\vartheta)\theta E-(\rho+\gamma)I,\\
D_t^{\mu}A(t) &= \vartheta\alpha E-(\sigma+\gamma)A,\\
D_t^{\mu}R(t) &= \rho I+\sigma A-\gamma R,\\
D_t^{\mu}M(t) &= \tau I+\kappa A-\omega M.
\end{aligned} \tag{2}$$

The rest of the manuscript as presented as: In the next section we recalled fundamental notions of FC and then we illustrated the algorithm of the hired method. In Section 4, the considered system is analysed with the help of hired scheme and then we presented their corresponding consequences in Sections 5 and 6.

In this section, were called basic definitions associated to Laplace transform (LT) and FC.

Definition 1. The Riemann-Liouville fractional integral of $f(t)\in C_\delta\,(\delta=-1)\,(\mu>0)$ is defined as

$$\begin{aligned}
J^{\mu}f(t) &= \frac{1}{\Gamma(\mu)}\int_0^t (t-\vartheta)^{\mu-1}f(\vartheta)d\vartheta,\\
J^{0}f(t) &= f(t).
\end{aligned} \tag{3}$$

Definition 2. The Caputo fractional order derivative of $f \in C^n_{-1}$ is presented as follows

$$D_t^{\alpha} f(t) = \frac{d^n f(t)}{dt^n}, \qquad \mu = n \in \mathbb{N}, \tag{4}$$

$$= \frac{1}{G(n-\mu)} \int_0^t (t-\vartheta)^{n-\mu-1} f^{(n)}(\vartheta)\, d\vartheta, \tag{5}$$

$$n-1 < \mu < n, n \in \mathbb{N}.$$

Definition 3. LT of $f(t)$ with Caputo fractional derivative is

$$L\left[D_t^{\mu} f(t)\right] = s^{\mu} F(s) - \sum_{r=0}^{n-1} s^{\mu-r-1} f^{(r)}\left(0^+\right), \tag{6}$$

where $F(s)$ is LT of $f(t)$.

3 Fundamental Solution Procedure of q-HATM

In this section, we present the solution procedure of q-HATM nurtured by Singh et al. [26] by using LT with q-HAM. Soon after, it is employed by number of authors to evaluate the solution for numerous families of differential equations exemplifying diverse phenomena including economic growth, biological models, human disease, chaotic behaviour, chemical reaction, optics, fluid mechanics and others [26–30], and further derived some fascinating consequences in comparison of other modified and classical algorithms.

Here, to present the procedure of q-HATM we hire the following differential equation of fractional order

$$D_t^{\mu} v(x,t) + \mathscr{R}\, v(x,t) + \mathscr{N}\, v(x,t) = f(x,t), \tag{7}$$

with the initial condition

$$v(x,0) = g(x), \tag{8}$$

where $D_t^{\mu} v(x,t)$ denotes the Caputo derivative of $v(x,t)$. On employing LT on Eq. (7), we obtain

$$\mathscr{L}[v(x,t)] - \frac{g(x)}{s} + \frac{1}{s^{\mu}}\{\mathscr{L}[\mathscr{R} v(x,t)] + \mathscr{L}[\mathscr{N}\, v(x,t)] - \mathscr{L}[f(x,t)]\} = 0. \tag{9}$$

For $\varphi(x,t;q)$, $\mathscr{N}$ is contracted as follows

$$\mathscr{N}[\varphi(x,t;q)] = \mathscr{L}[\varphi(x,t;q)] - \frac{g(x)}{s} + \frac{1}{s^{\mu}}\{\mathscr{L}[\mathscr{R}\, \varphi(x,t;q)] + L[\mathscr{N} \varphi(x,t;q)] - L[f(x,t)]\}. \tag{10}$$

where $q \in \left[0, \frac{1}{n}\right]$. Then, we present homotopy with the embedding parameter q and non-zero auxiliary parameter $\hbar$by HAM as

$$(1-nq)\mathscr{L}[\varphi(x,t;q) - v_0(x,t)] = \hbar q \mathscr{N}[\varphi(x,t;q)], \tag{11}$$

where L is signifying LT. For $q=0$ and $q=\frac{1}{n}$, the following conditions satisfies

$$\varphi(x,t;0) = v_0(x,t), \quad \varphi\left(x,t;\frac{1}{n}\right) = v(x,t). \tag{12}$$

With the help of Taylor theorem, we have

$$\varphi(x,t;q) = v_0(x,t) + \sum_{m=1}^{\infty} v_m(x,t) q^m, \tag{13}$$

where

$$v_m(x,t) = \frac{1}{m!} \frac{\partial^m \varphi(x,t;q)}{\partial q^m}\Big|_{q=0}. \tag{14}$$

After differentiating Eq. (13) m-times with q and multiplying by $\frac{1}{m!}$ and substituting $q=0$, one can get

$$\mathscr{L}[v_m(x,t) - k_m v_{m-1}(x,t)] = \hbar \mathfrak{R}_m(\vec{v}_{m-1}), \tag{15}$$

where the vectors are defined as

$$\vec{v}_m = \{v_0(x,t), v_1(x,t), \ldots, v_m(x,t)\}. \tag{16}$$

Eq. (15) reduces after employing inverse LT to

$$v_m(x,t) = k_m v_{m-1}(x,t) + \hbar \mathscr{L}^{-1}[\mathfrak{R}_m(\vec{v}_{m-1})], \tag{17}$$

where

$$\mathfrak{R}_m(\vec{v}_{m-1}) = L[v_{m-1}(x,t)] + \frac{1}{s^{\mu}} L[R v_{m-1} + \mathscr{H}_{m-1}] - \left(1 - \frac{k_m}{n}\right)\left(\frac{g(x)}{s} + \frac{1}{s^{\mu}} L[f(x,t)]\right), \tag{18}$$

and

$$k_m = \begin{cases} 0, & m \leq 1, \\ n, & m > 1. \end{cases} \tag{19}$$

Here, $\mathscr{H}_m$is homotopy polynomial and presented as

$$\mathscr{H}_m = \frac{1}{m!}\left[\frac{\partial^m \varphi(x,t;q)}{\partial q^m}\right]_{q=0} \quad and \quad \varphi(x,t;q) = \varphi_0 + q\varphi_1 + q^2\varphi_2 + \ldots . \tag{20}$$

By using Eqs. (17) and (18), we get

$$v_m(x,t) = (k_m + \hbar) v_{m-1}(x,t) - \left(1 - \frac{k_m}{n}\right)\mathscr{L}^{-1}\left(\frac{g(x)}{s} + \frac{1}{s^{\mu}} L[f(x,t)]\right) + \hbar \mathscr{L}^{-1}\left\{\frac{1}{s^{\mu}} L[R v_{m-1} + \mathscr{H}_{m-1}]\right\}. \tag{21}$$

The series solution by projected algorithm is defined as

$$v(x,t) = v_0(x,t) + \sum_{m=1}^{\infty} v_m(x,t). \tag{22}$$

4 q-HATM Solution for Considered Model

In this segment, we hired the system with fractional-order defined in Eq. (2) to employ the projected scheme

$$\begin{aligned} &D_t^{\mu} S(t) - b + \gamma S - \frac{\delta S(I+\beta A)}{N} + \varepsilon SM = 0, \\ &D_t^{\mu} E(t) - \frac{\delta S(I+\beta A)}{N} - \varepsilon SM + (1-\vartheta)\theta E \\ &+\vartheta\alpha E + \gamma E = 0, \\ &D_t^{\mu} I(t) - (1-\vartheta)\theta E + (\rho+\gamma) I = 0, \\ &D_t^{\mu} A(t) - \vartheta\alpha E + (\sigma+\gamma) A = 0, \\ &D_t^{\mu} R(t) - \rho I - \sigma A + \gamma R = 0, \\ &D_t^{\mu} M(t) - \tau I - \kappa A + \omega M = 0, \end{aligned} \tag{23}$$

with initial conditions

$$S(0) = S_0,\ E(t) = E_0,\ I(0) = I_0, \\ A(0) = A_0,\ R(0) = R_0 \ and\ M(0) = M_0. \tag{24}$$

Applying LT on Eq. (23) and then by the assist of forgoing conditions, we get

$$\begin{aligned} &L[S(t)] - \frac{1}{s}(S_0) - \frac{1}{s^{\mu}} L\{b - \gamma S - \frac{\delta S(I+\beta A)}{N} \\ &-\varepsilon SM\} = 0, \\ &L[E(t)] - \frac{1}{s}(E_0) - \frac{1}{s^{\mu}} L\{\frac{\delta S(I+\beta A)}{N} + \varepsilon SM \\ &-(1-\vartheta)\theta E - \vartheta\alpha E - \gamma E\} = 0, \\ &L\{I(t)\} - \frac{1}{s}(I_0) - \frac{1}{s^{\mu}} L\{(1-\vartheta)\theta E - (\rho+\gamma) I\} = 0, \\ &L\{A(t)\} - \frac{1}{s}(A_0) - \frac{1}{s^{\mu}} L\{\vartheta\alpha E - (\sigma+\gamma) A\} = 0, \\ &L\{R(t)\} - \frac{1}{s}(R_0) - \frac{1}{s^{\mu}} L\{\rho I + \sigma A - \gamma R\} = 0, \\ &L\{M(t)\} - \frac{1}{s}(M_0) - \frac{1}{s^{\mu}} L\{\tau I + \kappa A - \omega M\} = 0. \end{aligned} \tag{25}$$

Now, the nonlinear operator is presented as

$$\begin{aligned} &N^1[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5,\ \varphi_6] \\ &= L[\varphi_1(t;q)] - \frac{1}{s}(S_0) - \frac{1}{s^{\mu}} L\{b - \gamma\varphi_1(t;q) \\ &- \frac{\delta\varphi_1(t;q)(\varphi_3(t;q) + \beta\varphi_4(t;q))}{N} - \varepsilon\varphi_1(t;q)\varphi_6(t;q)\}, \\ &N^2[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5,\ \varphi_6] \\ &= L[\varphi_2(t;q)] - \frac{1}{s}(E_0) \\ &- \frac{1}{s^{\mu}} L\{\frac{\delta\varphi_1(t;q)(\varphi_3(t;q) + \beta\varphi_4(t;q))}{N} \\ &+\ \varepsilon\varphi_1(t;q)\varphi_6(t;q) - (1-\vartheta)\theta\varphi_2(t;q) \\ &-\ \vartheta\alpha\varphi_2(t;q) - \gamma\varphi_2(t;q)\}, \end{aligned}$$

$$\begin{aligned} &N^3[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5, \varphi_6] \\ &= L[\varphi_3(t;q)] - \frac{1}{s}(I_0) \\ &- \frac{1}{s^{\mu}} L\{(1-\vartheta)\theta\varphi_2(t;q) - (\rho+\gamma)\varphi_3(t;q)\}, \\ &N^4[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5,\ \varphi_6] \\ &= L[\varphi_4(t;q)] - \frac{1}{s}(A_0) - \frac{1}{s^{\mu}} L\{\vartheta\alpha\varphi_2(t;q) \\ &- (\sigma+\gamma)\varphi_4(t;q)\}, \\ &N^5[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5,\ \varphi_6] \\ &= L[\varphi_5(t;q)] - \frac{1}{s}(R_0) - \frac{1}{s^{\mu}} L\{\rho\varphi_3(t;q) \\ &+\ \sigma\varphi_4(t;q) - \gamma\varphi_5(t;q)\}, \\ &N^6[\varphi_1,\ \varphi_2,\ \varphi_3, \varphi_4, \varphi_5,\ \varphi_6] \\ &= L[\varphi_6(t;q)] - \frac{1}{s}(M_0) - \frac{1}{s^{\mu}} L\{\tau\varphi_3(t;q) \\ &+\ \kappa\varphi_4(t;q) - \omega\varphi_6(t;q)\}. \end{aligned} \tag{26}$$

By applying the considered method and for $H(t) = 1$, the m-th order deformation equation is presented as

$$\begin{aligned} &L[S_m(t) - k_m S_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{1,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \\ &L[E_m(t) - k_m E_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{2,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \\ &L[I_m(t) - k_m I_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{3,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \\ &L[A_m(t) - k_m A_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{4,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \\ &L[R_m(t) - k_m R_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{5,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \\ &L[M_m(t) - k_m M_{m-1}(t)] \\ &= \hbar\mathfrak{R}_{6,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right], \end{aligned} \tag{27}$$

where

$$\begin{aligned} &\mathfrak{R}_{1,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right] \\ &= L[S_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right)\frac{1}{s}(S_0) - \frac{1}{s^{\mu}} L\{b - \gamma S_{m-1} \\ &- \frac{\delta}{N}(\sum_{i=0}^{m-1} S_i I_{m-1-i} + \beta \sum_{i=0}^{m-1} S_i A_{m-1-i}) \\ &- \varepsilon \sum_{i=0}^{m-1} S_i M_{m-1-i}\}, \\ &\mathfrak{R}_{2,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1},\ \vec{R}_{m-1},\ \vec{M}_{m-1}\right] \\ &= L[E_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right)\frac{1}{s}(E_0) \end{aligned}$$

$$- \frac{1}{s^{\mu}} L\{ \frac{\delta}{N} \left(\sum_{i=0}^{m-1} S_i I_{m-1-i} + \beta \sum_{i=0}^{m-1} S_i A_{m-1-i} \right)$$
$$+ \varepsilon \sum_{i=0}^{m-1} S_i M_{m-1-i} - (1-\vartheta)\theta E_{m-1} - \vartheta \alpha E_{m-1}$$
$$- \gamma E_{m-1}\},$$
$$\mathfrak{R}_{3,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1}, \vec{R}_{m-1}, \vec{M}_{m-1}\right]$$
$$= L[I_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right) \frac{1}{s}(I_0) - \frac{1}{s^{\mu}} L\{(1-\vartheta)\theta E_{m-1}$$
$$- (\rho + \gamma) I_{m-1}\}, \tag{28}$$
$$\mathfrak{R}_{4,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1}, \vec{R}_{m-1}, \vec{M}_{m-1}\right]$$
$$= L[A_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right) \frac{1}{s}(A_0) - \frac{1}{s^{\mu}} L\{\vartheta \alpha E_{m-1}$$
$$- (\sigma + \gamma) A_{m-1}\},$$
$$\mathfrak{R}_{5,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1}, \vec{R}_{m-1}, \vec{M}_{m-1}\right]$$
$$= L[R_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right) \frac{1}{s}(R_0) - \frac{1}{s^{\mu}} L\{\rho I_{m-1}$$
$$+ \sigma A_{m-1} - \gamma R_{m-1}\},$$
$$\mathfrak{R}_{6,m}\left[\vec{S}_{m-1}, \vec{E}_{m-1}, \vec{I}_{m-1}, \vec{A}_{m-1}, \vec{R}_{m-1}, \vec{M}_{m-1}\right]$$
$$= L[M_{m-1}(t)] - \left(1 - \frac{k_m}{n}\right) \frac{1}{s}(M_0) - \frac{1}{s^{\mu}} L\{\tau I_{m-1}$$
$$+ \kappa A_{m-1} - \omega M_{m-1}\}.$$

On employing inverse LT on Eq. (27), it simplifies to

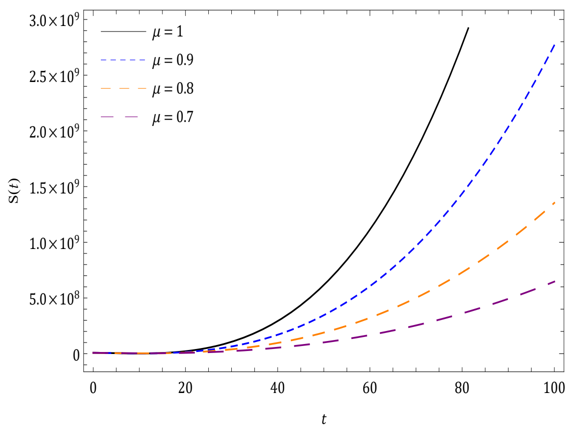
$$\begin{aligned}
S_m(t) &= k_m S_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{1,m}\},\\
E_m(t) &= k_m E_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{2,m}\},\\
I_m(t) &= k_m I_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{3,m}\},\\
A_m(t) &= k_m A_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{4,m}\},\\
R_m(t) &= k_m R_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{5,m}\},\\
M_m(t) &= k_m M_{m-1}(t) + \hbar L^{-1}\{\mathfrak{R}_{6,m}\}.
\end{aligned} \tag{29}$$

By using initial values and then solving the for going equations, we can obtained the terms of

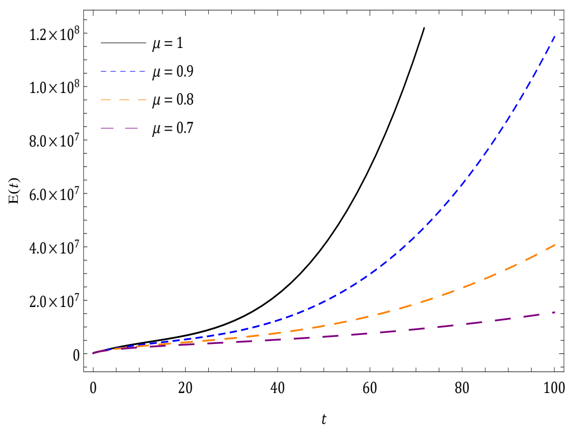
$$\begin{aligned}
S(t) &= S_0(t) + \sum_{m=1}^{\infty} S_m(t) \left(\frac{1}{n}\right)^m,\\
E(t) &= E_0(t) + \sum_{m=1}^{\infty} E_m(t) \left(\frac{1}{n}\right)^m,\\
I(t) &= I_0(t) + \sum_{m=1}^{\infty} I_m(t) \left(\frac{1}{n}\right)^m,\\
A(t) &= A_0(t) + \sum_{m=1}^{\infty} A_m(t) \left(\frac{1}{n}\right)^m,\\
R(t) &= R_0(t) + \sum_{m=1}^{\infty} R_m(t) \left(\frac{1}{n}\right)^m,\\
M(t) &= M_0(t) + \sum_{m=1}^{\infty} M_m(t) \left(\frac{1}{n}\right)^m.
\end{aligned} \tag{30}$$

5 Results and discussion

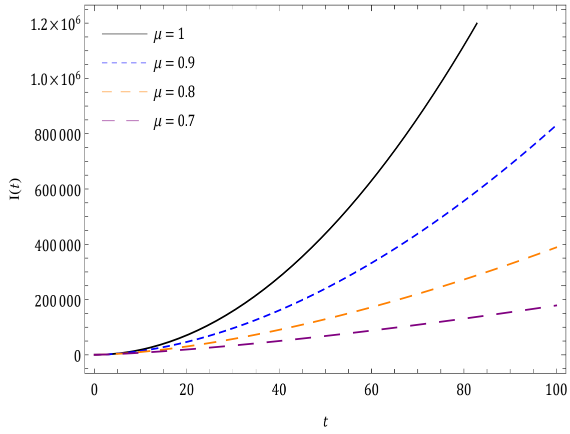
In the present framework, for the projected epidemic we consider the initial conditions model as $S(0) = S_0 = 8065518$, $E(t) = E_0 = 200000$, $I(0) = I_0 = 282$, $A(0) = A_0 = 200$, $R(0) = R_0 = 0$ and $M(0) = M_0 = 50000$ and we consider parameters value with the aid of Table 1.We find third-order series solution to present the nature of the considered system. Figure 1describesthe nature of achieved solution by considered procedure for $S(t)$, $E(t)$, $I(t)$, $A(t)$, $R(t)$ and $M(t)$for diverse arbitrary order (μ) with time (t). From the captured figures we can see that the considered system exceptionally be contingent on the order and gives huge degree of freedom. Further, the hired operator offers more stimulating significances to predict and analyse the future of the projected system.



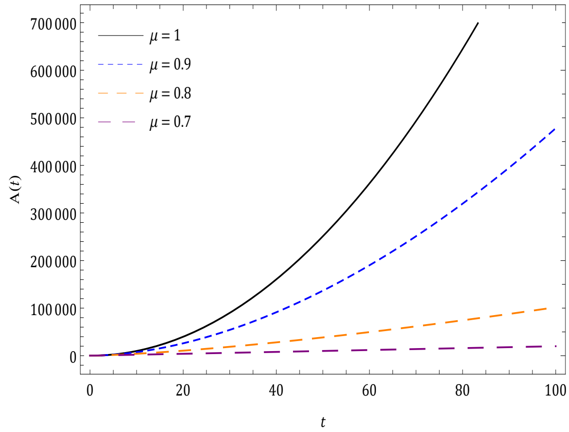
(i)



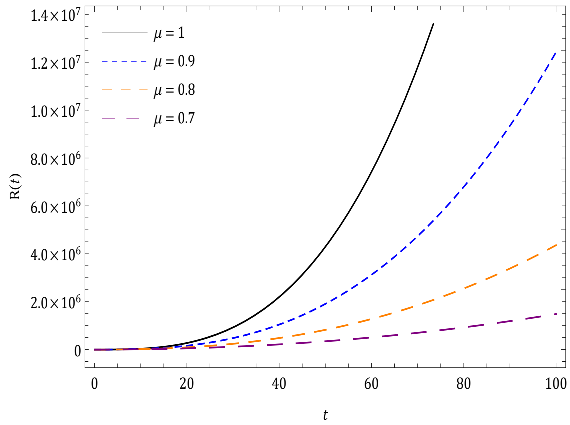
(ii)



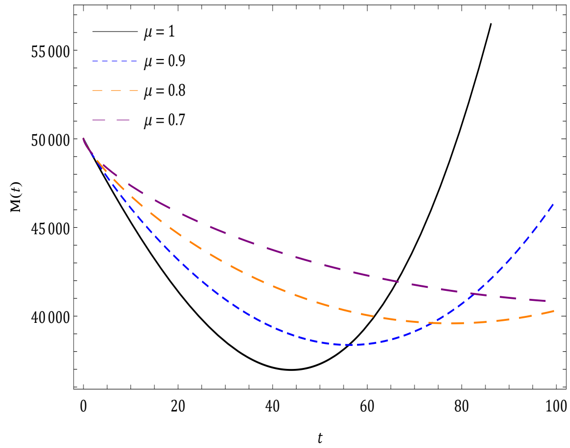
(*iii*)



(*iv*)



(*v*)



(*vi*)

Fig. 1: Nature of obtained solution for $(i)S(t),(ii)E(t),(iii)I(t),(iv)A(t),(v)R(t)$ and $(vi)M(t)$ for different μ at $\hbar=-1,n=1$ and using Table 1.

6 Conclusion

The dynamic model of coronavirus is effectively analysed using q-HATM in the present investigation within the frame of a fractional operator and captured the behaviour of achieved results in terms of 2D plots. The projected model has described the evolution of the deadly disease and highly effective virus in the current period due to which more than 2,75,976 peoples are dead till May 8, 2020, and day by day it is continuously and exponentially increasing. The obtained consequences show that both projected fractional operator and technique are noticeably methodical and effective to analyse real-world problems. Moreover, the projected solution procedure reduces computational time and it does not require any perturbation and new polynomial to find the solution for the non-linear systems. Finally, we can conclude that, the projected method can be employed in any complex and non-linear systems exemplifying chemical, biological and others.

Acknowledgement

This projected work was partially (not financial) supported by Harran University with the project HUBAP ID: 20124.

Competing interests

The authors declare that they have no competing interests.

References

[1] D. A. Tyrrell, M. L. Bynoe, Cultivation of viruses from a high proportion of patients with colds, Lancet, **1** (1966), 76-77.
[2] J. S. Kahn, K. McIntosh, History and recent advances in coronavirus discovery, The Pediatric Infectious Disease Journal, **24(11)**, 223-227 (2005).

[3] Is the World Ready for the Coronavirus?. Editorial. The New York Times. 29 January 2020. Archived from the original on 30January 2020.

[4] China virus death toll rises to 41, more than 1,300 infected worldwide. CNBC. 24 January 2020. Archived from the original on 26 January 2020. Retrieved 26 January 2020. Retrieved 30January 2020.

[5] N. Zhu, D. Zhang, W. Wang, et al., A novel coronavirus from patients with pneumonia in China, N. Engl. J. Med.,**382**, 727-733 (2020).

[6] A. E. Gobalenya, S. C. Baker, et al., The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nature Microbiology, **5(4)**, 536-544 (2020).

[7] M. S. Kiran, et al. Evolution and analysis of COVID-2019 through a fractional mathematical model, Numerical Methods for Partial Differential Equations, **37 (2)**, 1282-1298 (2021).

[8] Z. Liu, P. Magal, O. Seydi, G. Webb, Understanding unreported cases in the COVID-19 epidemic outbreak inwuhan, china, and the importance of major public health interventions, Biology, **9(50)**, (2020), DOI: 10.3390/biology9030050.

[9] M. Caputo, Elasticita e Dissipazione, Zanichelli, Bologna, (1969).

[10] K. S. Miller, B. Ross, An introduction to fractional calculus and fractional differential equations, A Wiley, New York, (1993).

[11] I. Podlubny, Fractional Differential Equations, Academic Press, New York, (1999).

[12] A. A. Kilbas, H.M. Srivastava, J.J. Trujillo, Theory and applications of fractional differential equations, Elsevier, Amsterdam, (2006).

[13] D. Baleanu, Z.B. Guvenc, J.A. Tenreiro Machado, New trends in nanotechnology and fractional calculus applications, Springer Dordrecht Heidelberg, London New York, (2010).

[14] S. Kumar, R. Kumar, J. Singh, K.S.Nisar, D. Kumar, An efficient numerical scheme for fractional model of HIV-1 infection of $CD4^+$ T-cells with the effect of antiviral drug therapy, Alexandria Eng. J., (2020), DOI: 10.1016/j.aej.2019.12.046.

[15] P. Veeresha, D.G. Prakasha, Solution for fractional Zakharov-Kuznetsov equations by using two reliable techniques, Chinese J. Phys. **60**, 313-330 (2019).

[16] S. W. Yao, E. Ilhan, P. Veeresha, H. M. Baskonus, A powerful iterative approach for quintic complex Ginzburg-Landau equation within the frame of fractional operator, Fractals, (2021), DOI: /10.1142/S0218348X21400235.

[17] P. Veeresha, D. G. Prakasha, Solution for Fractional Kuramoto-Sivashinsky Equation Using Novel Computational Technique, Int. J. Appl. Comput. Math., **7(33) (2021)**, DOI: 10.1007/s40819-021-00956-0,

[18] H. M. Srivastava, D. Kumar, J. Singh, An efficient analytical technique for fractional model of vibration equation, Appl. Math. Model., **45**, 192-204 (2017).

[19] A. Atangana, B. T. Alkahtani, Analysis of the Keller-Segel model with a fractional derivative without singular kernel, Entropy **17**, 4439-4453 (2015).

[20] B. Ghanbari, S. Kumar, R. Kumar, A study of behaviour for immune and tumor cells in immunogenetic tumour model with non-singular fractional derivative, Chaos Solitons Fractals, **133** (2020), DOI: 10.1016/j.chaos.2020.109619.

[21] J. Singh, D. Kumar, Z. Hammouch, A. Atangana, A fractional epidemiological model for computer viruses pertaining to a new fractional derivative, Appl. Math. Comput. **316**, 504-515 (2018).

[22] P. Veeresha, D. G. Prakasha, Solution for fractional generalized Zakharov equations with Mittag-Leffler function, Results Eng., **5** (2020), DOI: 10.1016/j.rineng.2019.100085.

[23] J. Singh, D. Kumar, D. Baleanu, New aspects of fractional Biswas-Milovic model with Mittag-Leffler law, Math. Model. Nat. Phenom. **14(3)**, 1-23 (2019). DOI: 10.1051/mmnp/2018068.

[24] D. G. Prakasha, P. Veeresha, Analysis of Lakes pollution model with Mittag-Leffler kernel, **5(4)**, 310-322 (2020).

[25] M. A. Khan, A. Atangana, Modeling the dynamics of novel coronavirus (2019-nCov) with fractional derivative, Alexandria Eng. J., **59(4)** 2379-2389 (2020).

[26] J. Singh, D. Kumar, R. Swroop, Numerical solution of time- and space-fractional coupled Burgers equations via homotopy algorithm, Alexandria Eng. J., **55(2)** 1753-1763, (2016).

[27] P. Veeresha, D. G. Prakasha, Z. Hammouch, An efficient approach for the model of thrombin receptor activation mechanism with Mittag-Leffler function, Nonlinear Analysis: Problems, Applications and Computational Methods, 44-60, (2020).

[28] P. Veeresha, D. G. Prakasha, D. Baleanu An efficient technique for fractional coupled system arisen in magneto-thermoelasticity with rotation using Mittag-Leffler kernel, J. Comput. Nonlinear Dynam., **16(1)**, (2021), DOI: 10.1115/1.4048577.

[29] A. Prakash, P. Veeresha, D.G. Prakasha, M. Goyal, A homotopy technique for fractional order multi-dimensional telegraph equation via Laplace transform, Eur. Phys. J. Plus, **134(19)**, 1-18 (2019), DOI:10.1140/epjp/i2019-12411-y.

[30] D. Kumar, R. P. Agarwal, J. Singh, A modified numerical scheme and convergence analysis for fractional model of Lienard's equation, J. Comput. Appl. Math. **399**, 405-413 (2018) .

[31] W. Gao, H. M. Baskonus, L. Shi, New investigation of Bats-Hosts-Reservoir-People coronavirus model and apply to 2019-nCoV system, Advances in Difference Equations, **391**, 1-11 (2020).

[32] E. Ihan, I. O. Kiymaz, A generalization of truncated M-fractional derivative and applications to fractional differential equations, Applied Mathematics and Nonlinear Sciences, **5(1)**, 171-188 (2020).

[33] C. Cattani, G. Pierro, On the Fractal Geometry of DNA by the Binary Image Analysis, Bulletin of Mathematical Biology, **75(9)**, 1544-1570 (2013).

[34] W. Gao, P. Veeresha, D. G. Prakasha, H.M. Baskonus, Novel dynamical structures of 2019-nCoV with nonlocal operator via powerful computational technique, Biology, **9(5)**, (2020).

[35] H. Durur, E. Ilhan, H. Bulut, Novel Complex Wave Solutions of the (2+1)-Dimensional Hyperbolic Nonlinear Schrodinger Equation, Fractal and Fractional, **4(3)**, (2020).

[36] W. Gao, P. Veeresha, H. M. Baskonus, D. G. Prakasha, P. Kumar, A New Study of Unreported Cases of 2019-nCOV Epidemic Outbreaks, Chaos Solitons Fractals, **138**, 1-6 (2020).

[37] P. Veeresha, D. G. Prakasha, D. Kumar, Fractional SIR epidemic model of childhood disease with Mittag-Leffler memory, Fractional Calculus in Medical and Health Science, 229-248, (2020).

[38] C. Cattani, Haar wavelet-based technique for sharp jumps classification, Mathematical and Computer Modelling, **39(2-3)**, 255-278, (2004).
[39] W. Gao, G. Yel, H.M. Baskonus, C. Cattani, Complex Solitons in the Conformable (2+1)-dimensional Ablowitz-Kaup-Newell-Segur Equation, AIMS Mathematics, **5(1)**, 507-521, (2020).
[40] K. S. Al-Ghafri, H. Rezazadeh, Solitons and other solutions of (3+1)-dimensional space-time fractional modified KdV-Zakharov-Kuznetsov equation, Applied Mathematics and Nonlinear Sciences, **4(2)**, 289-304, (2019).
[41] J. Singh, D. Kumar, Z. Hammouch, A. Atangana, A fractional epidemiological model for computer viruses pertaining to a new fractional derivative, Applied Mathematics and Computation, **316**, 504-515, (2018).
[42] D. Kumar, J. Singh, D. Baleanu, Analysis of regularized long-wave equation associated with a new fractional operator with Mittag-Leffler type kernel, Physica A, **492**, 155-167 (2018).
[43] A. Atangana, Fractional discretization: the African's tortoise walk, Chaos Solitons and Fractals, **130** (2020), 109399.
[44] C. Cattani, H. M. Srivastava, X. J. Yang, Fractional Dynamics, De Gruyter, 1-5, (2015).
[45] A. Atangana, Fractal-fractional differentiation and integration: connecting fractal calculus and fractional calculus to predict complex system, Chaos Solitons Fractals, **102**, 396-406 (2017).
[46] Z. Odibat, D. Baleanu, Numerical simulation of initial value problems with generalized Caputo-type fractional derivatives, Appl. Numerical Math., **156**, 94-105 (2020).
[47] J. Dananea, K. Allalia, Z. Hammouch, Mathematical analysis of a fractional differential model of HBV infection with antibody immune response. Chaos, Solitons Fractals, **136**, 109787 (2020).
[48] O. K. Abdullaev, Some problems for the degenerate mixed type equation involving Caputo and Atangana-Baleanu operators fractional order, Progress in Fractional Differentiation and Applications, **6(2)**, 101-114 (2020).
[49] A. Atangana, Blind in a commutative world: simple illustrations with functions and chaotic attractors, Chaos Solitons Fractals, **114**, 347-363 (2018).
[50] C. Cattani, A review on Harmonic Wavelets and their fractional extension, Journal of Advanced Engineering and Computation, **2 (4)**, 224-238 (2018).
[51] J. Singh, D. Kumar, Z. Hammouch, A. Atangana, A fractional epidemiological model for computer viruses pertaining to a new fractional derivative. Applied Mathematics and Computation, **316**, 504-515 (2018).
[52] A. Boudaoui, Y. E. Moussa, Z. Hammouch, S. Ullah, A fractional-order model describing the dynamics of the novel coronavirus (COVID-19) with nonsingular kernel, Chaos Solitons Fractals, (2021), DOI: 10.1016/j.chaos.2021.110859.
[53] J. Danane, K. Allali, Z. Hammouch, K. S. Nisar, Mathematical analysis and simulation of a stochastic COVID-19 Levy jump model with isolation strategy, Results in Physics, (2021), DOI: 10.1016/j.rinp.2021.103994.
[54] P. Veeresha, D. G. Prakasha, M. Magesh, A. J. Christopher, D. U. Sarwe, Solution for fractional potential KdV and Benjamin equations using the novel technique, Journal of Ocean Engineering and Science, (2021), DOI: 10.1016/j.joes.2021.01.003.
[55] M. Zamir, F. Nadeem, T. Abdeljawad, Z. Hammouch, Threshold condition and non pharmaceutical interventions's control strategies for elimination of COVID-19, Results in Physics, 20 (2021), DOI: 10.1016/j.rinp.2020.103698.
[56] G. Rahman, K. S. Nisar, B. Ghanbari, T. Abdeljawad, On generalized fractional integral inequalities for the monotone weighted Chebyshev functionals, Adv. Differ. Equ. 368 (2020), DOI: 10.1186/s13662-020-02830-7.