Delhi Business Review Vol. 23, No. 1 (January - June 2022)

DELHI BUSINESS REVIEW

An International Journal of SHTR

Journal Homepage: https://www.delhibusinessreview.org/Index.htm
https://www.journalpressindia.com/delhi-business-review

Exploring the Growth of Indian's Foreign Direct Investment Equity Inflow amid Covid-19 Outbreak

Ravinder Rena[a]*, Ifeanyi Mbukanma[b]

[a] *Professor of Economics, NWU Business School, Faculty of Economic and Management Sciences, North-West University, Republic of South Africa*

[b] *Postdoctoral Research Fellow (Economic Sciences), NWU Business School, Faculty of Economic and Management Sciences, North-West University, Republic of South Africa*

ARTICLE INFO

**Corresponding Author:*
ravinder.rena@nwu.ac.za
ravinder.rena@gmail.com

Article history:
Received 2 May 2021
Revised 19 August 2021
24 September, 2021
Accepted 7 October, 2021

Keywords:
Covid-19 Pandemic;
Foreign Direct Investment;
Economic Growth;
India

ABSTRACT

***Purpose**: The aim of this paper is to explore the growth of Indian's Foreign Direct Investment (FDI) equity inflow amid Covid-19 outbreak.*
***Design/methodology/approach**: in-depth review of current and previous literatures from journals and periodic publications of legitimate organizations both local and international on the evolution and the trend of Covid-19 pandemic as well as it impacts on Indian's FDI was conducted.*
***Findings**: The findings however revealed a major drop in net FDI flows globally, but on the contrary, a significant increase was recorded in India. Secondly, key sectors such as services sectors, computer software and hardware, telecommunications, trading, automobile, construction development, chemicals, and pharmaceuticals was revealed to have attracted the maximum FDI inflow to India amid the Covid-19 pandemic.*
***Practical implications**: The study recommended that a cohesive policy that further strengthens FDI by identifying and creating incentives for other main industrial sectors could further promote the continued attractiveness of FDI to India.*
***Originality/value**: the current study is an original contribution in the field of FDI inflow in India amid the COVID pandemic.*

DOI: 10.51768/dbr.v23i1.231202201

Introduction

The economy of Indian is one of the recent world's top emerging economies. A decade before, it was considered one of the fragile five, but no longer. Since 2014, it has emerged as one of the world's leading international destinations with a substantial increase in FDI. However, most of the economic activities that promoted this economic growth in Indian was put to a halt, as the world experienced an unprecedented surge of Coronavirus also known as Covid-19 pandemic. Covid-19 pandemic was at first identified in Wuhan China in late 2019 and started a worldwide widespread. At first, maximum cases were initially detected in China, but the infection spread over Europe, America and the whole world. The Covid-19 pandemic is a global shock 'more than anything' involving a concurrent disruption of both demand and supply in the integrated world economy (Ifeanyi Mbukanma, 2020; Nicola et al., 2020). The virus has reduced labour availability and output on the supply side, as companies are disrupted resulting from lockdown regulations that was implemented to control the spread of the virus. On the demand side, consumer consumption and business investment are constrained by layoffs and loss of income, the burden of sickness, quarantine, unemployment and declining economic prospects.

Accordingly, India is the second most affected country on infection rate globally, with the number of infected individuals hitting above 10.8 million and death over 155,000 in January 2021. Extreme doubt about the course of the virus, duration, severity and effect of the pandemic has led to a downward cycle of a declining market and consumer morale. It has also worsened global financial conditions that have led to employment cuts and a continuous reduction in investment and economic development. As the tolls of infection and fatality escalate, global devastation is clear, representing the world's biggest economic shock in decades. Consequently, different nations have started requesting financial assistance from the International Monetary Fund (IMF) to support the financial shock that was caused by the pandemic. As a result, reserve banks around the globe have initiated aggressive policies to cut interest rate and roll out massive stimulus measures to help manage the impact of the pandemic that has rocked global economic activities and financial market (Ozili & Arun, 2020). Perhaps, it is obvious that the pandemic has affected different countries in numerous ways going by their level of vulnerability before the outbreak of Covid-19. To this end, advance, emerging and developing countries across the globe are however, evaluating and counting the cost of the pandemic as it concerns the impact it has caused in different sectors of the economy, in the strive to reactivate a cross sectional economic growth and development. Hence, the objective of this study was engineered on this context, to evaluate the impact of Covid-19 pandemic on the Indian's FDI equity inflows.

Review of Literature

The unprecedented outbreak of Coronavirus in late 2019, leading to a global pandemic in 2020 has triggered public health crisis globally, with underlining evidence of negative impacts on social and economic activities. A detrimental effect has been felt globally from the ripple effect of Covid-19, which continue to plunge the global economy in several ways. In the quest to manage and reduce the spread globally, different economies have enforced several measures, which has on the return affected economic activities around the world (Chakraborty & Maity, 2020; Nicola et al., 2020). Consequently, FDI decisions by firms globally was disrupted significantly as a result of several measures adopted by nations to control the spread of the virus. Perhaps, the inevitable impact on FDI flows will depend on the success of both these public health and economic policy responses by the different nations (OECD, 2020). In essence, FDI is a long-term investment partnership between a resident entity and a non-resident entity, which typically includes a significant managerial impact on the investment firm by the investor (Arain et al., 2020; Ifeanyi Mbukanma, 2020; Zameer et al., 2020).

This systematic long-term investment partnerships have over the years helped in boosting economic growth and development in both advances, emerging and developing economies. It has also helped in promoting industrial revolution through transfer of technology, industrial robotization and digital advancement in production and investment across the globe (Singh, 2019). On the contrary, the surge of Covid-19 have created uncertainty on the global investment, which has continued to affect FDI inflows across economies as the global FDI collapsed in 2020, dropping 42% from \$1.5 trillion in 2019 to an estimated \$859 billion in 2020 (UNCTAD, 2021). According to the UNCTAD report, the concentration of the decline in FDI was on developing economies, where FDI equity flows dropped by -12% (an estimate of \$616 billion), while developed economies recorded a drop of -69% (an estimate of \$229 billion) and transition economies recording a drop of -77% (an estimate of \$13 billion). United State also recorded a sharp decrease of FDI flows to the tune of -49% (an estimate of \$134 billion), while China cements their lead on FDI with other Asian countries benefiting as well.

However, UK and other European countries have also experienced a heavy drop in FDI inflows. Ironically, Indian being the second most affected country by Covid-19, received an increase rate in FDI inflow hitting a rise of 13% (an estimate of $57 billion) in the year 2020, as investment in digital economy continue to witness growth (UNCTAD, 2021). Other than equity investments, there has been a major rise in the inter-corporate debt of FDI firms, which covers borrowing or leasing among affiliated direct investment firms. Consequently, the streamlining of the policy mechanism for external commercial borrowings (ECBs) since January 2019 has enabled all companies eligible for FDI to raise ECBs and other relaxations, such as widening the spectrum of end-use resources, has resulted in increased FDI flows of US$8.3 billion in 2019-20, three times the amount a year earlier (Reserve Bank of India, 2020) .

Methodology

This study utilized a literature review strategy. The choice of research strategy was informed by the objective of this study, as the key emphasis was on the survey and assessment of past works of literature to unfold logically and up to date issues as it concerns Coronavirus widespread and its impacts on Indian's FDI equity inflows. Although, they are varieties of methods of literature review in this context, which includes narrative review, vote counting, meta-analysis and descriptive analysis of literature (King & He, 2005). A descriptive analysis of literature was used for the benefit of this study. Thus, the descriptive analysis of literature mostly summarizes and synthesizes accessible studies on a specific subject field. However, due to the limited number of empirical research as it concerns up to date logical analysis on the global current information of the pandemic, a detailed descriptive analysis of previous literature was conducted, which aids in revealing current issues, challenges and impacts of Covid-19 on the Indian economy as well as the response of FDI inflows to the trend of the virus. Thus, various Covid-19 articles gathered from various significant and applicable websites, journals, newsletters, magazines were taken into consideration in extracting information for the descriptive analysis.

Indian's FDI Policies Framework

FDI is considered as a significant source of non-debt financial capital for economic growth and development. It is therefore becoming important to the Indian government to attract and encourage FDI in order to complement domestic resources, technology and skills for accelerated economic growth and development. Thus, over the last few decades, there have been major shifts in approaches and policies related to FDI in India, together with improvements in the country's industrial policy and foreign exchange status. These policies are embedded in a consolidated framework, updated every six months in order to monitor and keep pace with the regulatory changes. However, the policies are formulated in different phases (see Table 1), which addresses the issues as it concerns the requisite policies that will enhance the growth of FDI in India.

The early phase of the policy primarily addresses the receptive attitude that provides foundations for foreign investment attractions. However, the liberation efforts started in 1980, with industrial policy statement in 1980, 1982 and 1983. Perhaps, the procedures for formulating FDI policies in India involves a coherent contribution of Department of Industrial Policy and Promotion (DIPP) and Ministry of Commerce and Industry with procedural instructions issued by Reserve Bank of India. Thus, these policies are reviewed on an ongoing basis and measures for it further liberalization with regulatory framework, which consist of Acts, Regulations, Press Notes, Press Releases and Clarifications.

In the 1990s, when the economy was in a crucial stage and needed macro-economic stabilization and economic reform, FDI emerged as the most preferred option for the mobilization of financial resources. As a result, up to 51% of FDI's equity in specified industries was authorized by Reserve Bank of India under the automatic approval route. Indeed, since liberalization effort in third Phase of the policy, FDI flows to India have steadily increased and are an essential part of foreign capital, as FDI infuses long-term sustainable resources in the economy and contributes to technology transfer, strategic sector development, increased innovation, competition and job creation, among other benefits. Thus, the fourth and the fifth Phases of the policy framework incorporates a significant policy that have caused a long-run and the most recent attraction of foreign firms to invest in India. However, as long as a list of investment sectors exist for investment by foreign firms, investment is prohibited in gambling, lottery, business of chit fund, housing and real estate, trading in transferable development rights, atomic energy, manufacturing of cigars, cheroots, cigarillos and cigarettes, of tobacco or of tobacco substitutes to mention but few.

Phase I 1950-67	Receptive Attitude	• Non- discriminatory treatment to FDI; No restrictions on remittances; Indians having ownership and control.
Phase II 1967 -1980	Restrictions	• Restrictions on FDI without technology. More than 40 percent not allowed. FDI controlled by FERA (foreign exchange regulation act).
Phase III 1980-1990	Pro-business approach: gradual liberalization	• Export oriented units allowed higher FDI. • Liberalization in the procedure of remittance and royalty in technical fees. • Faster channels for FDI clearance created.
Phase IV 1990-Onward	Open door policy	• Liberalized policy framework for foreign trade, foreign exchange and technical collaborations. • Core and infrastructure sectors: FDI was welcomed FERA replaced with FEMA (Foreign exchange management act). • It was not necessary for FDI to be accompanied with technology. • FDI was encouraged through mergers and acquisitions in services and financial sector, non-banking financial companies and insurance, etc.
Phase V 2014 Onwards	Open door policy and promotion of selective sectors of National interest	• Promoting FDI selectively in several sectors. • Focus on FDI for job creation and domestic manufacturing. • Raising FDI in defence sector from 26 percent to 49 percent. Full Indian Management and control through FIPB route. Development of smart cities and reduction in FDI from 50,000 square meters to 20,000 square meters with a three-year post completion lock in. • FDI in manufacturing through automatic route. Manufacturers allowed to sell through retail including e commerce platforms. • Raising for FDI in the insurance sector from 26 % to 49 %., Civil aviation raised from 74 % to 100 %. FII/FPI allowed to invest in Power exchanges through primary market. • Overseas investment up to 49% in the insurance and pension sectors under the automatic route. • 100% FDI in asset reconstruction companies through the automatic route. Construction development eligible for 100 % FDI under the automatic route. • Limit for investment by foreign portfolio investors (FPIs) in central public sector enterprises, other than banks, listed in stock exchanges raised from 24 % to 49 %. • Investment limit for foreign entities in Indian stock exchanges will be enhanced from 5% to 15%.

Table 1: Major Features of FDI Policy in India
Source: DIPP (2020a)

Growth of Indian's FDI Inflows amid Covid-19 Pandemic

FDI is widely regarded as a key component to stimulate economic growth and integrate the economy into the global environment. In develop and developing countries, it is expected to contribute to economic growth more than domestic investment (Dunning & Lundan, 2008; Ketteni & Kottaridi, 2019). It is also considered as one of the most essential platforms through which nations can access global finance. However, the surge in Covid-19 pandemic created absolute uncertainty in the investment environment, where major economic activities was put to a halt in the strive to control the spread of the virus. International borders were closed, businesses were disrupted and shutdown, investors are counting on their losses and jobs are lost. Perhaps, in this kind of hostile economic environment, FDI's are less expected because of the level of vulnerability of most economies. Many economies around the globe were experiencing contractions and projections were made on further economic contractions in both advances, developed, emerging and developing economies.

S. No.	Financial Years 2000 - 2020	Amount of FDI Equity Inflows	Percentage Growth over Previous Years
1	2000	2463	-
2	2001	4065	+65%
3	2002	2705	-33%
4	2003	2188	-19%
5	2004	3219	+47%
6	2005	5540	+72%
7	2006	12492	+125%
8	2007	24575	+97%
9	2008	31396	+28%
10	2009	25834	-18%
11	2010	21383	-17%
12	2011	35121	-64%
13	2012	22423	-36%
14	2013	24299	+8%
15	2014	29737	+22%
16	2015	40001	+35%
17	2016	43478	+9%
18	2017	44857	+3%
19	2018	44366	-1%
20	2019	49977	+13%
21	2020 (September)	30004	-
Cumulative Total (From April, 2000 To September, 2020)		500123	

Table 2: Indian's FDI Equity Inflows between 2000-2020 (US$ million)
Source: DIPP (2020b) and Reserve Bank of India (2020)

On the contrary, Indian economy received a significant growth in their FDI, attracting a percentage growth of 13% (an estimate of over $500 million), a milestone in Indian economy amid the high level of uncertainty created by Covid-19 outbreak (see Table 2).

Ranks	Sectors	2018-19 (April – March)	2019-20 (April – March)	2020-21 (April – Sept)	Cumulative Inflows (April, 00 - Sept, 20)	% of Total Inflows by sector
1	Services Sector	9158	7854	2252	84255	17%
2	Computer Software & Hardware	6415	7673	17554	62466	12%
3	Telecommunications	2668	4445	7	37278	7%
4	Trading	4462	4574	949	28543	6%

Ranks	Sectors	2018-19 (April – March)	2019-20 (April – March)	2020-21 (April – Sept)	Cumulative Inflows (April, 00 - Sept, 20)	% of Total Inflows by sector
5	Construction Development: Townships, housing, built-up infrastructure and construction development projects	213	617	118	25780	5%
6	Automobile Industry	2623	2824	417	24628	5%
7	Chemicals (Other than Fertilizers)	1981	1058	437	18077	4%
8	Construction (Infrastructure) Activities	2258	2042	377	17223	3%
9	Drugs & Pharmaceuticals	266	518	367	16868	3%
10	Hotel & Tourism	1076	2938	283	15572	3%

Table 3: Sectors Attracting Highest FDI Equity Inflows to India (US$ million)
Source: DIPP (2020b)

The increase rate of Indian's FDI inflow during this unprecedented time as presented in table 2, shows a structural growth on key sectors of Indian economy as compared to other emerging economy that has shown the highest level of vulnerably during this pandemic. However, the effort of Indian government since the year 2000, by implementing major FDI reforms have helped in ensuring that the country becomes an increasingly desirable and investor-friendly destination. Although, the growth trend as presented in table 2 seems fluctuating, but absolute consistency has been the brain behind Indian reforms that have kept the pace of FDI attractions to India even amid Coronavirus pandemic. Accordingly, the investment climate in India has changed and improved significantly since the opening up of the economy in 1991, and more improvement has been made since 2014 (Singh, 2019).

In addition, the relaxation of FDI criteria has played a crucial role in rising FDI in various sectors of the Indian economy. Perhaps, the new FDI policy framework, provides two routes for foreign companies to access the country: the government route and the automatic route. Under government route, prior investment approvals are required and must be authorized by the corresponding administrative agency or department. On the automatic route, the investor does not need an investment authorization from the government of India. However, up to 100% of FDI will be allowed on both routes. Perhaps, it could be argued that the existing FDI policy framework in India have provided couching and significant leverage on the havoc and uncertainty created by Covid-19 outbreak. As further weakening situation in FDI growth is expected in 2021 globally, greater efforts are required by the government of Indian to sustain the existing growth in FDI by further addressing individual sectors of the economy.

However, the importance of addressing individual sectors of the economy was presented in the report of (UNCTAD, 2021) and (Reserve Bank of India, 2020) as they emphasised that the increase in Indian's FDI equity inflows was attributed to the investment in the service sector and digital economy, which includes communication services, retail and wholesale trade, financial services, computer and business services and the manufacturing sector. Perhaps, a cross-border M&A sales was increased by 87% (an estimate of $27 billion). A significant record deal on the acquisition of 10% of Jio Platform by Jaadhu, owned by Facebook (United States) with a value worth $5.7 billion (UNCTAD, 2021). Thus, Table 3 presents 10 top sectors of Indian economy that attracts the highest FDI's equity inflow 2018-2020.

Accordingly, the investment in the service sectors also reported a rise in the cross-border M&A as well as the digital sector, which also recorded a significant rise. Indeed, the sectorial attraction of FDI's represents the quality of multinational investment that a country attracts. Similarly, the sectorial share of investment also indicates the direction of growth in host nation as it concerns productivity capacity and local economic development. Although, it is clearly shown in table 3 that there is a significant shift of FDI's from manufacturing sectors to services sectors. These developments are majorly attributed to the interest of foreign firms, which represents their focus of investment areas that have more optimal benefits to them. However, a share of

29% of the Indian's FDI came through the Mauritius route, followed by Singapore 21%, the US, Netherlands, Japan each 7% and the UK 6% (DIPP, 2020b). However, as the Covid-19 pandemic continue to spread across the globe with lesser optimism in the vaccines from fewer companies, incentives on different sectors of Indian economy that will attract more FDI needs to be sustained. Hence, the sustainability of the relationship and attraction of these foreign firms is key to a long-term growth in FDI, which also attracts a comprehensive economic growth and development.

Key Findings

The global economy has experienced several ups and downs in recent time, struggling with the devastating economic situation that resulted from the outbreak of Covid-19 with lots of uncertainty in the investment environment. However, globalization has helped most economies to survive, as greater benefits exist in an increase relationship in economic activities and investment between nations. Similarly, FDI have played greater role in leveraging most economies by attracting multinational firms to invest in key economic sectors. Thus, in evaluating the growth of Indian's FDI amid Covid-19 outbreak, key findings were identified with policy recommendations.

The Indian economy has recently been described as one of the most attractive developing economies in the world. In line with globalization, trading partners with India have grown significantly over the last decades, providing more opportunities for a variety of sectors of the economy. Reflecting closely, India's half-trillion-dollar FDI is an indicator of foreign investors' deep confidence in India's strong economic fundamentals, stable political outlook, and sustainable economic growth that generated returns for investors even during the global recession of 2007-2008.

The increase trend in FDI attraction presents optimism in the future economic growth of India. In addition to capital inflows that FDI attracts, it also brings technological flows, know-how, management ideas and operational practices that lead to boosting economic development. Although, foreign investors introduce new methods of operating within the sector invested, but new technology and procedures that improve the productivity of work and the efficiency of employees are incorporated.

Sectorial attraction of FDI in India have shown a significant shift from the manufacturing sector to the service and digital economic sections. This has helped to create competitiveness and boost the productivity of the business and has expanded across the whole network of firms engaged in the production of goods or services that need to be updated to satisfy current consumer demands.

As India battle with the increase rate of Covid-19 pandemic, existing structural economic policies have helped in leveraging them from significant economic contraction. Indeed, the global economy has undergone a sharp contraction since the Covid-19 outbreak, and more contractions are expected in 2021, but the Indian economy has demonstrated a positive degree of resilience that poses a non-vulnerable economic policy and

A significant cross-border M&A sale was also recorded in Indian's economy amid Covid-19 outbreak, which was less expected considering the backdrop in economic activities around the globe. This has however, shown the level of FDI attraction even in the period of pandemic, multinational firms were still interested in acquisition of investment shares in India.

Conclusion and Recommendations

The objective of this paper was to evaluate theoretically and unveil the growth of Indian's FDI equity inflows amid Covid-19 outbreak. For this purpose, a concise literature review was conducted. From the literature analysis, evidence was unveiled on the growth of Indian's FDI inflows as FDI was found to be an engine that has promoted economic advancement in India. However, Covid-19 pandemic was found to have disrupted major economic activities across the globe, as different nations implement measures to control the spread of the virus. Secondly, the growth trend of Indian's FDI equity inflows amid Covid-19 outbreak was revealed, as Indian's FDI was identified to have attracted a 13% rise from the previous year. Which was on the contrary view from many economists in the wake of the Coronavirus pandemic, as both advance, developed, emerging and developing economies were on the verge of collapsing.

Perhaps, some school of thought suggested that the attraction of FDI flows in different countries amid the Covid-19 pandemic is highly attributed to the ways and manner individual countries have managed the pandemic. Besides, the service sector, computer software and hardware, telecommunication services, retail and wholesale trade, financial services, construction development, automobile and chemical industries were the highest recipients of FDI, which triggered the rise amounting to over $500 billion. In essence, the existing FDI policy in India was identified as the bedrock that has provided resilience and sustainable attraction of FDI growth during this period of global economic contraction. As such, it was recommended that further strengthening of the FDI policy by identifying and creating openings for other key industrial sectors will further sustain the continuous attraction of FDI to India.

References

- Arain, H., Han, L., Sharif, A., & Meo, M. S. (2020). Investigating the effect of inbound tourism on FDI: The importance of quantile estimations. *Tourism Economics*, *26*(4). https://doi.org/10.1177/1354816619859695
- Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. *Science of The Total Environment*, *728*. https://doi.org/10.1016/j.scitotenv.2020.138882
- Dunning, J. H., & Lundan, S. M. (2008). Institutions and the OLI paradigm of the multinational enterprise. *Asia Pacific Journal of Management*, *25*(4), 573–593. https://doi.org/10.1007/s10490-007-9074-z
- Ifeanyi Mbukanma, R. R. L. U. I. (2020). Surviving Personal Financial Strain Amid Covid-19 Outbreak: A Conceptual Review of South African Context. *Acta Universitatis Danubius. Œconomica*, *16*(2), 176–191.
- Ketteni, E., & Kottaridi, C. (2019). The impact of regulations on the FDI-growth nexus within the institution-based view: A nonlinear specification with varying coefficients. *International Business Review*, *28*(3), 415–427. https://doi.org/10.1016/j.ibusrev.2018.11.001
- King, W. R., & He, J. (2005). Understanding the Role and Methods of Meta-Analysis in IS Research. *Communications of the Association for Information Systems*, *16*. https://doi.org/10.17705/1CAIS.01632
- Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, M., & Agha, R. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International Journal of Surgery*, *78*. https://doi.org/10.1016/j.ijsu.2020.04.018
- OECD. (2020). *Foreign direct investment flows in the time of COVID-19*. https://www.oecd.org/coronavirus/policy-responses/foreign-direct-investment-flows-in-the-time-of-covid-19-a2fa20c4/
- Ozili, P. K. T. A., & Arun, T. (2020). Spillover of COVID-19: Impact on the Global Economy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3562570
- Reserve Bank of India. (2020). *Annual Report on Economic Review*. https://m.rbi.org.in/Scripts/AnnualReportPublications.aspx?Id=1315
- Singh, S. (2019). The fourth industrial revolution, women engineers and SDGs: an exploratory study with special reference to India. *APNN19, September*, 22. https://www.researchgate.net/profile/Seema_Singh23/publication/337136765_The_fourth_industrial_revolution_women_engineers_and_SDGs_an_exploratory_study_with_special_reference_to_India/links/5dc653914585151435f7fbe3/The-fourth-industrial-revolution-women-e
- UNCTAD. (2021). *Investment Trends Monitor*. https://unctad.org/system/files/official-document/diaeiainf2021d1_en.pdf
- Zameer, H., Yasmeen, H., Zafar, M. W., Waheed, A., & Sinha, A. (2020). Analyzing the association between innovation, economic growth, and environment: divulging the importance of FDI and trade openness in India. *Environmental Science and Pollution Research*, *27*(23). https://doi.org/10.1007/s11356-020-09112-5