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Observed and Potential Environmental Impacts of COVID-19 in Africa.

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Abstract

The COVID-19 pandemic has tremendously affected the African continent and the rest of the world. Most businesses have closed and a lot of people have lost their jobs. The aviation industry has been shaken to the core with airlines losing millions of dollars and flights being cancelled. The tourism industry has consequently been affected due to restricted travel of tourists, impacting wildlife conservation and livelihoods. Schools, colleges and universities have been closed. The virus has infected millions of people and hundreds of thousands of people have died globally putting strain on health systems especially those of hard hit countries. Various countries all over the world have put measures to control the spread of the virus through lockdowns and social distancing policies. The reduced economic activities and mobility of people has resulted in improved air quality, cleaner water and beaches in some countries. However there are also negative impacts such as challenges in waste management, increased pharmaceutical and household waste and discovery of the corona virus in wastewater, a potential threat to public health. A considerable amount of research has been done on the socio-economic impacts of COVID-19 in Africa but there is still limited research on its impact on the environment. This

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paper serves to highlight the observed and potential environmental impacts of COVID-19 in Africa.

Keywords: COVID-19, SARS-CoV-2, Environment, Africa, Pandemic, Pollution

1. Introduction

The COVID-19 pandemic has affected every country in the world with 925,297 cases in Africa and 751,154 deaths globally at the time of writing (WHO, 2020a). The disease is caused by a novel Severe Acute Respiratory Corona Virus 2 (SARS-CoV-2). Symptoms of COVID-19 include headaches, fever, coughing and difficulty in breathing. The SARS-CoV-2 is spread through droplets, aerosols and contact with people or surfaces contaminated with the virus (Shi et al., 2020). There is a potential of faecal-oral transmission of the virus through wastewater and drinking contaminated drinking water (Ahmed et al., 2020; Gormley et al., 2020; Medema et al., 2020) but there is no evidence yet (La Rosa et al., 2020). The most affected countries in Africa are South Africa with more than 500 000 cases to date followed by Egypt, Nigeria, Ghana, Algeria and Morocco respectively. This novel virus is expected to have unprecedented effects compared to other infectious diseases in the world (Chakraboty and Maity, 2020). Poor health facilities in Africa affect the continent's response to the pandemic and the situation is exacerbated by poor Water, Sanitation and Hygiene (WASH). The dense population of most urban settlements in Africa make social distancing difficult hence the virus can spread quickly in overcrowded areas (Dzinamarira et al., 2020). Water scarcity in Sub-Sahara Africa can increase the spread of COVID-19 in Africa as WASH is vital in curbing the novel corona virus and other infectious diseases such as cholera, typhoid and diarrhoea (Anim and Ofori-Asenso , 2020; Haddout et al., 2020). With new cases being recorded everyday this pandemic can have

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devastating effects on the environment even for years to come especially in developing countries. Since the time the virus was discovered in December 2019 up to date there have been significant changes in the environment. The most notable change is improved air quality due to reduced industrial activities and mobility as countries worldwide enforced lockdowns to control the spread of the virus.

A majority of the African population work in the informal sector and they live from hand to mouth. COVID-19 has disrupted their form of livelihood, causing food insecurity and serious repercussions on the environment. Some of those in the formal sector have lost their jobs permanently. Some companies have laid off some of their workers or permanently closed while others will take years for their businesses to thrive again. Although some African governments have initiated food relief funds, they can only sustain people for a short time and corruption hinders people from fully benefiting from these food schemes (Dzinamarira et al., 2020; Mukiibi, 2020). Unemployment also means that people will struggle to pay for electricity bills thus they will resort for cheaper alternatives such as kerosene, charcoal and woodfuel for heating, cooking and lighting resulting in increased indoor air pollution. There is a looming threat of overexploitation of natural resources. Deforestation, illegal mining, overfishing and veld fires to clear forests for agriculture and other activities that cause environmental degradation will surge as people resort to anything for survival. The increasing number of corona virus cases has serious implications on the environment and mitigation measures need to be put in place to contain the problems caused by this virus.

Africa is already overwhelmed by many issues among them poverty, high unemployment rates, wildlife poaching, desertification, deforestation, water pollution, waste management and land degradation. The COVID-19 pandemic together with climate change exacerbates the

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problems faced by the continent. The longer this pandemic persists, the longer it will take for the environment to recover from its negative effects. The best way is to find cheap and sustainable solutions to stop further damage to the environment as well as sound environmental policies and regulations that are feasible to implement effective strategies.

2. Impact on Air

Satellite images have shown reduced CO_2 and NO_2 emissions in China, Europe, Africa and USA (Xu et al., 2020; Dutheli et al., 2020; Venter et al., 2020, La et al., 2020 and Muhammad et al., 2020). In Africa, the CO_2 emission levels have reduced to between 0.01-0.03mol/m^2 except in West Africa with 0.04mol/m^2 and in some areas the emission is higher than 0.05mol/m^2 (La et al., 2020). Burning of wood, fossil fuel combustion, monsoon and Saharan winds that carry sea salt and dust cause extreme air pollution in West Africa (Tito et al., 2018). NO_2 emissions were found to be generally higher in urban cities like Lagos, Accra and Kigali due to rapid urbanisation but lower in less developed urban areas in countries like Sudan and Madagascar. Despite lockdown measures there was no significant reduction in air pollution in Harare and Ouagadougou. This can be attributed to continued vehicle mobility and economic activities (Masaki et al., 2020). However as countries begin to ease lockdown measures to prevent economic collapse, CO_2, NO_2 and Particulate Matter levels will rise again. Adopting the use of renewable energy such as solar and wind energy as main sources of power generation will go long way in reducing air pollution as well as use of green fuel for vehicles.

2.2 Indoor air pollution

Whilst atmospheric air pollution has gone down, indoor air pollution has increased as people are confined to their homes. About 600 million people in Africa don't have access to

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electricity and more than 900 million use polluting sources of energy (International Energy Agency, 2019). This causes air pollution and alarming rates of deforestation in Africa. Due to travel restrictions induced by the pandemic, people are spending more time indoors resulting in increased indoor air pollution. Crowded settlements have poor air circulation and people are exposed to harmful air pollutants as they burn kerosene, charcoal and wood to cook, warm themselves and for light. Some poor households even resort to use of plastics, textile and any other materials they can find (Mbandi et al., 2020). Due to economic downturn many people who have their jobs will no longer afford to pay for power utility bills and will resort to cheaper alternatives like wood to save money for basic commodities. Africa many grapple with severe deforestation issues for time to come as wood is the most widely available and cheap source of energy. Deforestation also leads to emergence of zoonotic diseases like Ebola and COVID-19 (Ezeh et al., 2020). Outbreaks of such diseases can be prevented through intensive agriculture. African governments are urged to invest in agriculture and intensify production instead of clearing more land for farming (Ezeh et al., 2020).

3. Impact on water quality

Most dams, lakes and rivers in Africa are polluted especially those in urban and peri-urban areas hence reduced human activities due to COVID-19 do not necessarily improve water quality, but only reduces the pollution load in these aquatic bodies. Those in rural areas are considered to be cleaner as industrial activities are minimal. Common causes of water pollution are untreated industrial effluents, pesticides and fertilizers washed away from fields, discarded plastics and raw sewage from burst pipes and dysfunctional treatment plants. (Horn et al., 2020) raises concern over pharmaceutical pollution in South African water bodies by COVID-19 treatment drugs if the medication to treat the virus is found. Anti-retroviral drugs (ARVs) for

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H.I.V treatment are the main causes of pharmaceutical pollution in the country as wastewater treatment plants cannot efficiently remove them. Emerging pollutants such as discarded face masks, gloves and empty hand sanitizer's bottles and other PPE in water bodies pose threat to aquatic organisms as they mistake them for food. Face masks degrade into microplastics which can be ingested by aquatic organisms and bio accumulate in the food chain (van Niekerk and Weghmann, 2020; Silva et al., 2020; Fakare and Okkofo, 2020) in some cases they can kill them (Saadat et al., 2020). The corona virus can last for days on surfaces and in water depending on the environmental conditions (Nabi and Khan 2020, Quilliam et al., 2020). Infected PPE in aquatic systems can introduce SARS-CoV-2 into water which can be spread to humans through oral intake. There is also potential risk of the virus becoming aerosolised as sewage is pumped into sewer systems to the point where the water is discharged into the environment. Alcohol based hand sanitizers contain ethanol, isopropyl alcohol have hazardous effects on the environment if they are spilled in huge quantities, however prolonged use of these hand sanitizers also affects human health and results in antimicrobial resistance and enhances other viral diseases (Mahmood et al., 2020). Chemicals like Triclosan, triclocarbon and acrylate polymers found in hand sanitizers are also hazardous in the environment. Triclosan can form dioxins that can persist in the environment and in aquatic bodies (Anger et al., 2013).

Presence of SARS-Co-v2 in wastewater has raised concerns of cross-contamination of water sources and human infection as Africa has poor wastewater and water treatment facilities to effectively remove pathogens. To date there are no cases of COVID-19 infections through drinking and usage of contaminated water (La Rosa et al., 2020). However precautions should be taken as the effects of this pandemic are still evolving. Considering that outbreaks of diseases such as cholera and diarrhoea result from drinking contaminated water, COVID-19 can also

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become a water-borne disease. (Street et al., 2020; Arslan et al., 2020 Adelodun et al., 2020) recommend regular wastewater monitoring to be able to identify COVID-19 hotspots and implement measures to avoid water contamination. People are encouraged to use chlorine tablets and also boiling water before drinking, especially water from open sources or unclean tap water.

Literature on the impact of COVID-19 on Africa's water quality especially the African Great lakes remains anecdotal. Just like other water sources in Africa, these water bodies are also laden with pollutants from anthropogenic activities (Mayoma et al., 2019; Dalameh et al., 2019; Abdel-Satar et al., 2017; Plisnier et al., 2018). The lakes are also under threat of overfishing. There is general perception that fish species have had the opportunity to replenish their numbers as fishing activities declined together with pollution from industrial activities (Mantur, 2020).

4. Impact on land

Africa already has a waste management crisis and with the introduction of COVID-19 related waste into the environment, the situation only worsens (Saba, 2020; Godfrey et al., 2019). Manufacturing of single use plastics have increased to meet consumer demands and hygiene purposes resulting in drawbacks of single use plastic ban and management regulations (Silva et al., 2020; Klemes et al., 2020; Kalina and Tilley, 2020). The average Municipal Solid Waste (MSW) collection in Africa is 55% and only 44% in Sub-Sahara. Most of the waste is disposed in open dumps and other indiscriminate methods of disposal such as burning and incineration are applied. About 29% of waste is placed in landfills and only 4% is recycled (UNEP Africa Waste Management Outlook, 2018). Open dumps pose problems of underground water pollution as there is no leachate collection like in the case of engineered landfills. Some of the waste is washed into drainage systems and waterways causing floods and creating breeding grounds for

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diseases. Plastics also affect crop production, soil fertility and also damages vegetation (Silva et al., 2020; Kubanzi and Simatele, 2019). Facemasks, gloves and empty hand sanitizer bottles are being thrown into dumps and others are being discarded in the streets (Fakare and Okoffo, 2020). Improper disposal and reuse of contaminated PPE could also spread the virus (Arslan et al., 2020). Recycling activities have been disrupted in some countries like Nigeria by the Nigeria Centre for Disease Control (NCDC) amid fears that handing of waste especially by waste pickers may result in exposure to the virus (Nzediegwu and Chang, 2020; Nzeadibe and Ejike-Aliey, 2020). The NCDC also recommends the use of special collection buckets to dispose face masks gloves and other PPE in hospitals, buildings and public areas to avoid littering. Regular clean up of surrounding environments by communities can help contain the hazardous waste. Zimbabwe has a national clean up day every first Friday of the month and this has helped keep the streets and environment clean. Small children have a tendency of picking up litter and playing with it. Playing with infected PPE puts them at risk. Regular cleaning of surroundings can go a long way in fighting this pandemic as well as combating the prevalent waste management crisis.

(Nzediegwu and Chang, 2020) estimated that approximately 700 million single-use face masks would be used in Africa on a daily basis. Fortunately many people have adopted the use of reusable cloth face masks as they are cheaper thereby reducing the pollution load of disposed PPE. Some people are now hesitant to use medical masks after reports that the masks were being resold in Mozambique and Nigeria. Hospitals and quarantine centres continue to generate a lot of medical waste as COVID-19 cases increase. Some hospitals in Africa have dysfunctional incinerators like Queen Elizabeth Hospital in Malawi and hospital staff and patients complain of respiratory problems as medical waste is burnt outside the incinerator (Tilley and Kalina, 2020). Improper disposal of medical waste by hospitals and quarantine centres have serious implications

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on the environment and human health. In countries like Zimbabwe the economic crisis is worsening by each passing day, nurses and doctors always on strike because of poor wages throwing the healthcare system in a crisis. This greatly affects handling of the pandemic in the country as new confirmed cases are rising each day, with more than 4000 cases to date.

5. Impact on wildlife

The pandemic has affected the tourism industry worldwide and Africa has suffered a devastating loss as most economies thrive on tourism. Wildlife conservation, anti-poaching programmes and indigenous communities surrounding nature reserves are sustained by tourism revenues. Disruption of cash flow as tourism activities decline has thwarted conservation and anti-poaching efforts in several countries such as Namibia (Lendelvo et al., 2020) and several other African countries. In Uganda local wildlife parks have reported a surge in bush meat poaching (Maron, 2020b). Bush meat poaching cases have doubled compared to last year as people struggle to fend for their families with 367 cases reported between February and May since the lockdown began. The snares laid are meant to catch antelopes and wild pigs for household consumption and for sale but unfortunately other animals such as lions, giraffes and gorillas fall victim to these traps. Surprisingly the Uganda Wildlife Authority (UWA) said that ivory poaching is low as most of the poaching seems to be for bush meat. Pilgrim Africa has donated $100, 000 to UWA to help with conservation efforts in the Bwindi Mgahinga Conservation Area. The money will sustain the park for ten months (UWA, 2020). Wildlife rangers and other staff recently received food donations in an effort to boost their morale to continue patrols and safeguard the park. Kenya has also seen a surge in bush meat poaching. Wildlife rangers have confiscated giraffe meat and snares around its parks and conservancies.

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Some rangers have been laid off as nature reserves can no longer pay salaries as tourism revenues dry up. In Democratic Republic of Congo, Virunga National Park closed its gates for tourism in an effort to prevent gorillas from contracting the deadly SARS-CoV-2 through human interaction (Newsome, 2020). Bwindi Impenetrable Forest Park in Uganda also followed suit.

In Southern Africa, Botswana and South Africa have dehorned their rhinos to combat poaching of the endangered species although it only reduces the chances of poaching but does not totally eliminate it. The horns also grow back so it's a process that has to be carried out regularly. In the midst of concerns in upsurge of poaching around the continent, South Africa have seen a decline in rhino poaching over the past years since 2007 (Eikelboom et al., 2020) as well as Namibia (Mogomotsi and Madigele, 2017). However in neighbouring Botswana six rhinos have been killed since the pandemic began. Black rhinos have been relocated amid fears that the species could become extinct by next year at the current rate of poaching (Maron, 2020b). Namibia has also reported a drastic drop in elephant and rhino poaching over the past three years and has attributed this to their anti-poaching initiatives with various stakeholders. (The Namibian, 2020) states that only seventeen rhinos and two elephants have been killed this year compared to one hundred and sixty seven cases of poached rhinos and elephants respectively in the past two years. In Madagascar, poaching of endangered green turtles has increased. Poachers were caught with sixty kilograms of turtle meat and twenty eight bodies of dead turtles were found on a lying on a beach (Marshall, 2020). During a crisis like this, use of drones and engagement of military personnel in wildlife conservation is crucial. Drones monitor large areas and can identify wildlife trafficking routes and poachers' operations (Bergenas et al., 2013). Soldiers can fill in the gap that has been left by dismissed wildlife rangers so that patrols and anti poaching programmes operate efficiently. The pandemic is still evolving and so are its

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impacts across all facets of society. As time passes more environmental impacts of COVID-19 will be revealed. (Zambrano-Monserrate et al., 2020) warns that the pandemic may cause long term environmental problems that will be hard to resolve if we underestimate its impact. (Paital, 2020) suggests regular lockdowns post COVID-19 for sustainable environmental management.

6. Conclusion

A lot of information on the environmental impacts of COVID-19 in Africa remains anecdotal and a huge research gap still remains. As the pandemic prolongs the extent of its impact on our lives and the environment is constantly changing. More research is required to evaluate its impact on our continent and feasible measures that individuals, communities, organisations and the government can take to sustain livelihoods as well as the environment.

Declaration of competing interest

None.

REFERENCES

1. Abdel-Star, A.M., Ali, M.H., Goher, M.E., 2017. Indices of water quality and metal pollution of Nile River, Egypt. Egyptian Journal of Aquatic Research 43, 21-29.

2. Adelodun, B., Ajibade, F.O., Ibrahim, R.G., Bakare, H.O., Choi, K., 2020. Snowballing transmission of COVID-19 (SARS-Co-V-2) through wastewater: Any sustainable preventive measures to curtail the scourge in low-income countries? Science of the Total Environment. 742, 140680.

3. Ahmed, W., Angel, N., Edson, J., Bibby, K., Bivins, A., O' Brien, J.W., Choi, P.M., Kitama, M., Simpson, S.L., Li, J., Tscharke, B., Verhagen, R., Smith, W.J.M., Zaugg, J., Dierens, L., Hugenholtz, P., Thomas, K.V., Mueller, J.F., 2020. First confirmed detection of SARS-CoV-2 in untreated wastewater Australia: A proof of concept for the wastewater surveillance of COVID-19 in the community. Science of the Total Environment 728, 138764.

4. Anger, C.T., Sueper C, Blumentritt D.J., Mcneill K., Engstrom, D.R., Arnold W.A., 2013.Quantification of triclosan, chlorinated triclosan derivatives, and their dioxin photoproducts in lacustrine sediment cores. Environ Sci Technol. 47:1833–1843.

5. Anim, D.O., Ofori-Asenso, R., 2020. Water scarcity in sub-Sahara Africa. Journal of Infection. htpps://doi.org/10.1016/j.jinf.2020.05.032.

6. Arslan, M., Xu, B., El-Din, G., 2020. Transmission of SARS-CoV-2 via fecal-oral and aerosols-borne routes: Environmental dynamics and implications for wastewater management in underprivileged societies. Science of the Total Environment 743, 140709.

7. Bergenas, J., Stohl, R., Georgiff, A., 2013. The other side of drones: saving wildlife in Africa and managing global crime. Conflict Trends Issue 3, 3-9.

8. Chakraboty, I., Maity, P., 2020. COVID-19 outbreak: Migration, effects on society, global environment and prevention. Science of the Total Environment. 728, 138882.

9. Dalameh, S., Bjornberg, E., Elenstrom, A., Niwagaba, C.B., Komakech, A.J., 2019. Pharmaceutical pollution of water resources in Nakivubo wetlands and Lake Victoria, Kampala, Uganda. https://doi.org/10.1016/j.scitotenv.2019.136347.

10. Dutheli, F., 2020. COVID-19 as a factor influencing air pollution. Environmental Pollution 263, 114466.

11. Dzinamarira, T., Dzobo, M., Chitungo, I., 2020. COVID-19: A perspective on Africa's response. *J Med Virol*, 1-8.

12. Eikelboom, J.A.J., Nuijten, R.J.M., Wang, Y.X., Schroder, B., Heitkonig, I.M.A., Mooji, W.M., van Langevelde, F., Prins, H.H.T., 2020. Will legal international rhino horn trade save wild rhino populations? Global Ecology and Conservation. 23, e01145.

13. Ezeh, C.U., Ragatoa, D.S., Sanou, C.L., Emeribe, C.N., 2020. A review of the impacts of COVID-19: Lessons for Africa. Parana Journal of Science and Education. 6(4), 65-70.

14. Fadare, O.O., Okoffo, E.D., 2020. COVID-19 facemasks: A potential source of microplastics fibers in the environment. Science of the Total Environment. 737,140279.

15. Godfrey, L., Ahmed, T.M.T., Gebremedhin, K.G., Katima, J.H.Y., Oleofse, S., Osibanjo, O., Ritcher, U.H., Yonli, A.H., 2019. Solid Waste Management in Africa: Governance failure or Development Opportunity? DOI:http://dx.doi.org/10.5772/intechopen.86974.

16. Gormley, M., Aspray, T.J., Kelly, D.A., 2020. COVID-19: mitigating transmission via wastewater plumbing systems. www.thelancey.com/lancetgh Vol 8, May 2020.

17. Haddout, S., Priya, K.L., Hoguane, A.M., Ljubenkov, I., 2020. Water Scarcity: A big challenge to slums in Africa to fight against COVID-19. Science and Technology Libraries. http://doi.org/10.1080/0194262X.2020.1765227.

18. Horn, S., Vogt, B., Pieters, R., Bouwman, H., Bezuidenhout, C., 2020. Impact of potential COVID-19 treatment on South African water sources already threatened by pharmaceutical pollution. Environmental Toxicology and Chemistry. 39, 1305-1306.

19. International Energy Agency. 2019. Africa Energy Outlook. World Energy Outlook Special Report, EA Publications. www.iea.org

20. Kalina, M., Tilley, E., 2020. "This is our next problem": Cleaning up from the COVID-19 response. Waste Management 108, 202-205.

21. Klemes, J.J., Fin, Y.V., Tan, R.R., Jiang, P., 2020. Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19. Renewable and Sustainable Energy Reviews. 127, 109883.

22. Kubanza, N.S., Simatele, M.D., 2019. Sustainable solid waste management in developing countries: a study of institutional strengthening for solid waste management in Johannesburg, South Africa. Journal of Environmental Planning and Management. DOI: 10.1080/09640568.2019.1576510.

23. La, P., Kumar, A., Kumar, S., Kumari, S., Saikia, D., Dayanandan, A., Adhikari, D., Khan, M.I., 2020. The Dark cloud with a silver lining: assessing the impact of the SARS COVID-19 pandemic on the global environment. Science of the Total Environment. 732, 139297.

24. La Rosa, G., Bonadonna, L., Lucentini, L., Kenmoe, S., Suffredini, E., 2020. Coronavirus in water environments: occurrence, persistence and concentration methods- a scoping review. Water Res. 179, 115899.

25. Lendelvo, S., Pinto, M., Sullivan, S., 2020. A perfect storm? The impact of COVID-19 On community- based conservation in Namibia. Namibian Journal of Environment 4B, 1-15.

26. Mahmood, A., Eqan, M., Pervez, Alghamadi, H.A., Tabinda, A.B., Yasar, A., Brindadhevi, K., Pugazhendi, A., 2020. COVID-19 and the frequent use of hand sanitizers; human health and environmental hazards by exposure pathways. Science of the Total Environment. 742, 140561.

27. Mantur, N.G., 2020. Impact of COVID-19 on Environment. Mukt Shabd Journal. Vol IX (6), 1545-1552.

28. Maron, D.F., 2020. Botswana is evacuating black rhinos amid poaching threat. www.nationalgeographic.com [Accessed 1 May 2020].

29. Maron, D.F., 2020. Pandemic –induced poaching surges in Uganda. www.nationalgeographic.com [Accessed 9 July 2020].

30. Marshall, M., 2020. Conservation in crisis. New Scientist, 8-9.

31. Masaki, T., Nakamura, S., Newhouse, D., 2020. How is the COVID-19 crisis affecting Nitrogen Dioxide emission in Sub-Sahara? Poverty and Equity Notes. Number 21. www.worldbank.org/ poverty.

32. Mayoma, B.S., Mjumira, I.S., Efudala, A., Syberg, K., Khan, F.R., 2019. Collection of Anthropogenic Litter from the shores of the Lake Malawi: Characterisation of plastic debris and implications of public involvement in the African Great Lakes. Toxics 7, 64. doi: 10.3390/toxics7040064.

33. Mbandi, A.M., 2020. Air pollution in Africa in the time of COVID-19: THE air we breathe indoors and outdoors. Clean Air Journal 30, 1-3.

34. Medema, G., Heijnen, L., Elsinga, G., Italiaander, R., 2020. Presence of SARS-Coronavirus-2 in sewage. http://doi.org/10.1101/2020.03.29.20045880

35. Mogomotsi, G.E.J., Madigele, P.K., 2017. Live by the gun, die by the gun: Botswana's 'shoot to kill policy as an anti-poaching strategy. SA Crime Quarterly 60, 51-59.

36. Muhammad, S., Long, X., Salman, M., 2020. COVID-19 pandemic and environmental pollution: A blessing in disguise? Science of the Total Environment. 728, 138820.

37. Mukiibi, E., 2020. COVID-19 and the state of food security in Africa. Agriculture and Human Values. https://doi.org/10.1007/s10460-020-10079-9.

38. Nabi, G., Khan, S., 2020. Risk of COVID-19 pneumonia in aquatic mammals. Environmental Research. 188, 109732.

39. Newsome, D., 2020. The collapse of tourism and its impact on wildlife tourism destinations. Journal of Tourism Futures. DOI.10.1108/JTF-04-2020-0053.

40. Nzeadibe, T.C., Ejike-Alieji, A.U.P., 2020. Solid waste management during COVID-19 pandemic: policy gaps and prospects for inclusive waste governance in Nigeria. Local Environment. http://dpi.org/10.1080113549839.2020.1782357.

41. Nzediegwu, C., Chang, S.X., 2020. Improper solid waste management increases potential for COVID-19 spread in developing countries. Resources, Conservation and Recycling. 161, 104947.

42. Paital, B., 2020. Nurture to nature via COVID-19, a self- regenerating environmental strategy of environment in global context. Science of the Total Environment. 729, 139088.

43. Plisner, P., Nshombo, M., Mgona, H., Ntakimazi, G., 2018. Monitoring climate change and anthropogenic pressure at Lake Tanganyika. Journal of Great Lakes Research. 44, 1194-1208.

44. Quilliam, R.S., Weidmann, M., Moresco, V., Purshouse, H., O' Hara, Z., Oliver, D.M., 2020. COVID-19: the environmental implication of shedding SARS-Co-V-2 in human faeces, Environment International. doi: htpps://doi.org/10.1016/ envmt.2020.105790.

45. Saadat, S., Rawtani, D., Hussain, C.M., 2020. Environmental perspective of COVID-19. Science of the Total Environment. 728, 138870.

46. Saba, C.K.S., 2020. COVID-19: Implications for food, water, hygiene, sanitation and environmental safety in Africa. A case study in Ghana. doi: 10.209441preprints202005.0369.v1.

47. Shi, P., Dong, Y., Yan, H., Zhao, C., Li, X., Liu, W., He, M., Tang, S., Xi, S., 2020. Impact of temperature on the dynamics of COVID-19 outbreak in China. Science of the Total Environment. 728,138890.

48. Silva, A.L., Prata, J.C., Walker, T.R., Campos, D., Duarte, A.C., Soares, A.M.V.M., Barceló, D., Rocha-Santos, T., 2020. Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment. http://doi.org/10.1016/j.scitotenv.2020.

49. Street, R., Malema, S., Mahlangeni, N., Mathee, A., 2020. Wastewater surveillance for Covid-19: An African perspective. Science of the Total Environment. https://doi/10.1016/ scitotenv.2020.140719.

50. The Namibian: rhino, elephant poaching cases down. 10 July 2020. africasustainableconservation.com

51. Tilley, E., Kalina, M., 2020. “We are already sick”. Infectious Waste Management and Inequality in the Time of COVID-19, A Reflection from Blantyre, Malawi. Worldwide Waste: Journal of Interdisciplinary Studies. 3(1), 3, 1-10.

52. Tito, A., Messan, F., Nsompi, F., Tito, A.M., Lawan, M.M., Ahonnon, A., 2018. State Of Atmospheric Pollution In West Africa: Health impact. International Journal of current research 10(9), 73970-73975.

53. Uganda Wildlife Authority. https://www.facebook.com. [Accessed 20 July 2020]

54. UNEP Africa Waste Management Outlook. 2018.

55. van Niekerk, S., Weghmann, V., 2019. Municipal Solid Waste Management Services in Africa.

56. Venter, Z.S., Kristin, A, Chowdhury, S., Lelieveld, J., 2020. COVID-19 lockdowns cause global air pollution declines with implications for public health risk. https://doi.org/10.1101/2020.04.10.20060673.

57. WHO, 2020a. htpps://www.who.int/emergencies/diseases/novel-coronavirus-2019. [Accessed: 2 August 2020]

58. Xu, K., Cui, K., Young, L., Hsieh, Y., Wang, Y., Zhang, J., Wan, S., 2020. Impact of COVID-19 Event on Air Quality in Central China. Aerosol and Air Quality Research. 20, 915-929.

 doi:10.20944/preprints202008.0442.v1

59. Zambrano-Monserrate, M.A., Ruano, M.A., Sanchez-Alcalde, L., 2020. Indirect effects of COVID-19 on the environment. Science of the Total Environment. 728, 13881.