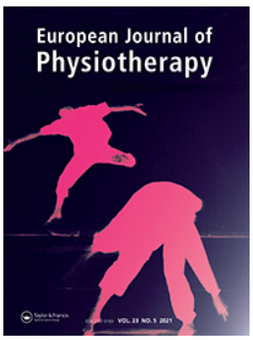

European Journal of Physiotherapy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iejp20

Mitigating the environmental impact of NSAIDs - physiotherapy as a contribution to one health and the SDGs

Srishti Banerjee & Filip Maric

To cite this article: Srishti Banerjee & Filip Maric (2021): Mitigating the environmental impact of NSAIDs - physiotherapy as a contribution to one health and the SDGs, European Journal of Physiotherapy, DOI: 10.1080/21679169.2021.1976272

To link to this article: https://doi.org/10.1080/21679169.2021.1976272

Published online: 30 Sep 2021.

EUROPEAN JOURNAL OF PHYSIOTHERAPY
https://doi.org/10.1080/21679169.2021.1976272

Taylor & Francis
Taylor & Francis Group

BRIEF REPORT

OPEN ACCESS Check for updates

Mitigating the environmental impact of NSAIDs - physiotherapy as a contribution to one health and the SDGs

Srishti Banerjee[a] and Filip Maric[b]

[a]LJ Institute of Physiotherapy, LJ University, Ahmedabad, India; [b]Department of Health and Care Sciences, UiT The Arctic University of Norway, Tromsø, Norway

ABSTRACT

Non-steroidal anti-inflammatory drugs (NSAIDs) continue to be amongst the most frequently used pharmaceutical treatments for mild to moderate musculoskeletal pain globally. In this short communication, we continue to expand the growing field of environmental physiotherapy by tracing NSAIDs journey through aquatic ecosystems, and the potential of physiotherapy to mitigate these negative environmental impacts and so contribute to achieving a range of UN Agenda 2030 Sustainable Development Goals and the aspirations of One Health. Through metabolic excretion into waterways, NSAIDs negatively impact the health and survival of various aquatic lifeforms, which, in turn, has consequences for human health. By reducing and delaying the need for pharmacotherapy for mild to moderate musculoskeletal pain, physiotherapy presents an important sustainable healthcare solution. Beyond this, however, the ecological persistence of NSAIDs also underscores the need for transformative change in healthcare and physiotherapy, towards the full recognition of the interconnected nature of human, animal, and ecosystems health and the complex questions and responsibilities this raises. For this, we need to increase our understanding of the entangled nature of health and its negotiation with human and non-human others and develop approaches to include them in our thinking, pursuit, and practice of health and care.

ARTICLE HISTORY
Received 9 April 2021
Revised 16 August 2021
Accepted 27 August 2021
Published online 28 September 2021

KEYWORDS
NSAIDs; environmental degradation; one health; sustainable development goals; posthuman healthcare

NSAIDs circular impacts on human and aquatic health

Non-steroidal anti-inflammatory drugs (NSAIDs) like diclofenac, ibuprofen, and naproxen are amongst the most frequently used pharmaceuticals used as the first line of treatment for mild to moderate musculoskeletal pain around the world. They are also among the top 10 persistent pollutants, accounting for more than 15% of all pharmaceuticals detected in aquatic environments [1–3]. With the growing need to deliver more sustainable healthcare with better effects for human health and fewer harmful consequences for the environment, continued use of NSAIDS for musculoskeletal pain is ever more questionable [4].

As orally consumed pharmaceuticals, NSAIDS are ingested, metabolised, and excreted from the human body (with excretion rates ranging from 5 to 39% mL/min for ibuprofen and diclofenac respectively) before arriving in sewage plants. Due to its accessibility and mass consumption, for example, ibuprofen concentrations in influent wastewater have been recorded to reach between 5.78 and 1673 mg/L, naproxen concentrations have been recorded to reach between 7.6 and 33.9 mg/L in various countries, and diclofenac concentrations ranging from 0.19 to 750ng/L [5–7]. Critically, such concentrations of pharmaceuticals in wastewater represent an ecological hazard and source of adverse environmental effects as 'stable chemical structure and pronounced biological activity of pharmaceuticals make them highly resistant to biodegradation, toxic (and) persistent in food chains' [8]. NSAIDs impact on the environment develops as wastewater from sewage plants is eventually released into surface water as an effluent, where it is subjected to a process of natural attenuation, which includes its dilution in surface water, absorption and adsorption into small solid particles in water and sediments, photolysis and aerobic biodegradation [9,10].

The continuous flow of NSAIDS from sewage plants to water bodies is a threat to aquatic flora and fauna and, therewith, to achieving SDG14 aimed at the conservation and sustainable use of oceans, seas, and marine resources [11]. Exposure to and accumulation of NSAIDs in the plasma of exposed fish has deleterious genetic, physiological, physical, and feeding behaviour of fish populations. Modulation of genes and their expression negatively affects the immune response, kidney development, and regeneration, sexual differentiation, and leads to significant reductions in egg production and hatching. Exposure to NSAIDs also affects the cells of the gill and liver, modulates feeding behaviour, and hinders the physical development of fish through stunted growth, skeletal and cartilaginous malformation, and changes

CONTACT Srishti Banerjee srishtibanerjee5@gmail.com LJ Institute of Physiotherapy, LJ University, Ahmedabad, India

to the texture and physiochemical properties of muscles [8,12–14].

In addition to deleterious effects on fish populations, NSAIDs have also been found to have negative effects on gastropods, bivalves, and crustaceans, all of which form critical links in aquatic trophic chains. Exposure to NSAIDs has been confirmed to lead to gastropod and crustacean DNA damage, fragmentation, and transcriptional changes, and affects reproduction, hatching, larval development, and overall survival [15–18]. Disturbance in detoxification and antioxidative processes have also been noted alongside significant morphological consequences [14]. The bioaccumulation of NSAIDS in aquatic organisms like fish, molluscs, and crustaceans can also lead to transfer and concentration further up the trophic chain. Diclofenac and ibuprofen, for example, have been detected on the external surface of 18% of otter hair samples, suggesting external/dermal exposure within the aquatic medium, and in up to 54% of the extracted samples, indicating historic ingestion [19].

Oral NSAIDs are known to have a wide range of direct negative side-effects on human health, including increasing the risk of adverse events in the gastrointestinal tract (perforation, ulcers, bleeding), the cardiovascular system (myocardial infarction, heart failure, hypertension), liver and kidneys [13,20]. The effects of NSAIDs on aquatic fauna and further up the trophic chain might serve as an indication for additional, indirect negative effects for human health following their depletion of aquatic and ecosystems health. More research is needed to confirm the direct human health risks of NSAIDs following the trophic transfer, yet, their directs effects on aquatic organisms are certain, and resulting indirect effects on human health and wellbeing seem hard to avoid [21].

Insofar as NSAIDs could affect fish population sizes (*via* decreases in egg production, hatching, and overall poor health), they would have deleterious effects for SDG2, aimed at ending global hunger, achieving food security, and improving nutrition [11]. Particularly with regard to food security and improving nutrition, there is reason to assume that the effects of NSAIDs on overall fish health puts unnecessary additional stress on a food source that is already deteriorating in both quantity (due to heavy and unsustainable overfishing) and quality (*via* the ingestion of microplastic pollution and other toxins) [22]. Leaving aside the issue that overfishing, overconsumption, and degradation of aquatic health have negative effects on biodiversity and this, in turn, has drastic consequences for achieving SDG13 (climate action) and many others [23], it should be clear that reduced food security and nutritional quality have significant negative implications for achieving SDG3, aimed at good health and wellbeing for all and at all ages [11].

Physiotherapy as a sustainable alternative to NSAIDs

NSAIDs' limited pain reduction effects and their diverse negative effects on human, aquatic, and ecosystems health make evident the need for sustainable alternatives for reducing mild to moderate musculoskeletal pain. Though further research is needed in this regard, growing evidence is suggesting that physiotherapy is better tolerated and at least as effective as NSAIDs in the treatment of mild to moderate musculoskeletal pain for a variety of conditions [24–26]. For example, in a comparison of the efficacy of oral ibuprofen against neural mobilisation in the treatment of cervicobrachial pain, it was indicated that neural mobilisation was less effective in the short term but came without the side effects of its pharmacological alternative [27]. Studies comparing NSAIDs against taping as adjuncts to exercise further indicate that non-pharmacological combinations are equally effective in the treatment of subacromial impingement and knee osteoarthritis while being tolerated better and reducing or delaying the need for pharmacological supplementation [28,29].

As we have indicated before, the environmental footprint of physiotherapy needs further study and reduction [30]. However, exercise, various manual therapy approaches, health-related education, and other non-pharmaceutical interventions common to physiotherapy lack the direct and indirect negative effects on human, aquatic, and ecosystems health resulting from the use of NSAIDs.

By reducing, or at least delaying pharmacotherapy demands, physiotherapy effectively constitutes a hitherto underappreciated contribution to a variety of SDGs even beyond SDG3. Building on what we have outlined here, these include SDG2 (zero hunger), SDG6 (clean water and sanitation), SDG14 (life below water), and even SDG15 (life on land) if we consider NSAIDs effect on humans and other species [31]. Through its potential contribution to the improvement of life on land and below water, physiotherapy thus equally constitutes a One Health intervention, that is, a healthcare intervention that simultaneously contributes to better health of humans, animals, and ecosystems alike. More explicitly than its sibling developments (planetary health, ecosystems health, and sustainable healthcare), One Health focuses on the complex interactions between animals, ecosystems, and human health as a critical nexus for understanding and ensuring health around the world [32]. One Health has a strong focus on managing and preventing zoonotic diseases – transmitted between animals and humans – like the current COVID-19 pandemic, for human health benefits. But One Health also implies care for the health of animals and ecosystems, beyond anthropocentric concerns. It is in this way that physiotherapy could be argued to constitute a One Health intervention in the way we are suggesting here, as an intervention that simultaneously contributes to better health of humans, animals, and ecosystems [33,34].

To our knowledge, physiotherapy's possible contribution to One Health is entirely unexplored to date and its possible contributions to achieving the SDGs in the earliest stages of exploration [35,36]. Further work in these directions seems highly pertinent for two reasons: Firstly, because UN Agenda 2030 emphasises the need for the involvement of all sectors [11]; and, secondly, because both the UN SDGs and One Health clearly highlight that we can no longer address health

and health care without integrating other humans, animals, ecosystems and more into our thinking and doing.

As physiotherapists gradually come to grips with the central interconnected nature of today's social, environmental, and health crisis, the contribution we make to SDG3, SDG14, and beyond *via* the reduction of pharmacotherapy should be widely promoted and pursued. However, to achieve the transformative societal change called for in the UN Agenda 2030, which, necessarily, encompasses the transformative change of physiotherapy, we should not rest on the laurels of a contribution that merely requires us to do more of what we are used to doing (i.e. exercise, touch, education, etc.), but seek to go further to think and practice physiotherapy and healthcare in ways responsive to today's changed and highly entangled world. In the following section, we outline the conceptual foundations for one element of this transformative change as an invitation for further research and innovation in physiotherapy and the healthcare professions at large.

Towards inclusive health cares for life on land and underwater

The story of NSAIDs journey through human and other-than-human bodies highlights the need for more careful deliberation of the future role of healthcare professionals and, in doing so, presents a challenge to physiotherapy, One Health, and SDG implementation alike. In the first instance, the brief journey of NSAIDs through humans, aquatic ecosystems, and back onto land presented here is a perfect allegory of today's environmental, social, and health crisis. Intimately bound up with the stories of different kinds of waste and human-driven pollution, NSAIDs remind us that the products we produce, consume, and discard as waste do not just go away. As eco-philosopher Timothy Morton has argued, 'there is no "away" to flush it to absolutely, so that our toilet waste phenomenologically sticks to us, even when we have flushed it' [37].

This is a story that has very much repeated itself through the ongoing COVID-19 pandemic. Massive amounts of plastic and carbon emissions have been generated and used for single-use personal protective equipment and then discarded as waste that further affects waterways and life in oceans around the world [38,39]. Apart from exacerbating the ongoing climate and plastic pollution crises and their consequences for global health, 'hyperobjects' like pharmaceuticals, plastics, PPE pollution, and carbon emissions – phenomena that are too large to be observed or comprehended as a whole, but are everywhere and operate at all kinds of scales [40] – further evidence a quintessential characteristic of our time: We have and continue to fundamentally change the world we live in, its geological composition, atmospheric conditions, and the diverse existences we share it with, in ways that will not just be flushed or even exercised away [41,42].

If this first message exemplified in the story of NSAIDs we presented is a hard-to-hear truth, the second implicit message is one that the physiotherapy profession, but also healthcare in general has been largely oblivious to so far, if not reticent to hear: It is that human life and health are gained, maintained, negotiated and improved on the back of countless other-than-humans that we are inseparably entangled with. As repeatedly pointed out in recent thinking on our current condition and overwhelming evidence in One Health research, the other-than-humans involved in the making of health include plants, ecosystems, microbes, bacteria, viruses, and animals on land, underwater, and in the air. But they now also include NSAIDs, carbon emissions, global warming, antibiotics, pollution, plastic, and many more hyperobjects and phenomena that we evoke, produce, and try to discard in vain while they participate in and change our world, bodies, organs, and all others that share them [43–46].

Critically, it has been pointed out that the manifold non-human contributions made to human life, health, and well-being made have thus far 'been completely silenced and occluded behind institutional walls. Unseen, unthought' [47]. As [48] have recently argued, we must become more aware of the way that health, functioning, and health care always involve complex relationships, contestations, contributions, and consequences with and for human and more-than-human others if we are to develop the more sustainable, interconnected and inclusive approaches health cares aspired to in One Health and the SDGs. Because physiotherapy has not engaged with the entangled nature and consequences of health care very much so far, a critical task in the pursuit of more inclusive physiotherapy and health futures will be to tell and hear more stories of ecological entanglement like the one we have presented here.

The more difficult task building on our increasing ecological awareness will be to deal with the complex questions and responsibilities it raises [48]. Since so much of the ways in which the world has changed are here to stay and involve so many other previously marginalised humans and non-human others, the questions to be answered cannot just revolve around waste management. In Morton's terms, 'How to care for the neighbour, the strange stranger, and the hyperobject, are the long-term problems posed by the ecological thought' [49]. Beyond doing the immediately feasible, familiar, and necessary, and learning more about the complex nature of health, we must develop new ways of thinking and doing health care and physiotherapy in entirely new ways, for entirely new reasons and in collaboration with entirely new others.

Implications for future research and practice

Given that we only outline a field that has not yet been at the forefront of physiotherapy research and practice, there is much that remains to be done to develop its full potential and implications for practice. Specifically, we need much more research into the potential of physical therapy modalities like exercise, touch, and communication as alternatives to medication in the treatment of musculoskeletal pain, as much as virtually any condition for which alternatives or adjuncts to pharmacological treatments are in use.

Regarding NSAIDs, this kind of research might be additionally complicated because their ubiquitous use and availability make it particularly difficult to control for them.

Though we have focussed on NSAIDs as a kind of exemplary case here, more research into the different health benefits and ecological impacts of pharmacological versus non-pharmacological interventions is needed in general. Other types of medication also have significant effects on ecosystems and medicines are one of the major contributing factors to the carbon footprint of health care systems [50]. The first large-scale consideration of allied health professions' potential in reducing the carbon footprint of health care systems will become available through the 'Greener AHPs Hub' that will be published by NHS England soon. Yet more research and advocacy are needed to further shift health care systems promotion and use of more environmentally friendly low-carbon approaches and modalities.

Finally, it is critical that future research is not limited to clinical and empirical studies only, but includes significant amounts of conceptual work towards novel understandings of physiotherapy that do justice to the complex social and ecological realities of health and care. Philosophically rigorous conceptual research remains woefully underdeveloped in physiotherapy. It will be essential, however, if we are to have a sufficiently solid foundation for our meaningful contribution to the interconnected health of humans, animals, and our planetary ecosystem alike.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Srishti Banerjee http://orcid.org/0000-0001-8653-5919
Filip Maric http://orcid.org/0000-0002-1265-6205

References

[1] Green GA. Understanding NSAIDs: from aspirin to COX-2. Clin Cornerstone. 2001;3(5):50–59.
[2] Santos JL, Aparicio I, Callejón M, et al. Occurrence of pharmaceutically active compounds during 1-year period in wastewaters from four wastewater treatment plants in seville (Spain). J Hazard Mater. 2009;164(2–3):1509–1516.
[3] Vidal-Dorsch DE, Bay SM, Maruya K, et al. Contaminants of emerging concern in municipal wastewater effluents and marine receiving water. Environ Toxicol Chem. 2012;31(12):2674–2682.
[4] van der Gaag WH, Roelofs PD, Enthoven WT, et al. Non-steroidal anti-inflammatory drugs for acute low back pain. Cochrane Database Syst Rev. 2020;4:1–151.
[5] Al-Rifai JH, Gabelish CL, Schäfer AI. Occurrence of pharmaceutically active and non-steroidal estrogenic compounds in three different wastewater recycling schemes in Australia. Chemosphere. 2007;69(5):803–815.
[6] Xu C, Niu L, Guo H, et al. Long-term exposure to the non-steroidal anti-inflammatory drug (NSAID) naproxen causes thyroid disruption in zebrafish at environmentally relevant concentrations. Sci Total Environ. 2019;676:387–395.
[7] Żur J, Piński A, Marchlewicz A, et al. Organic micropollutants paracetamol and ibuprofen-toxicity, biodegradation, and genetic background of their utilization by bacteria. Environ Sci Pollut Res Int. 2018;25(22):21498–21524.
[8] Tyumina EA, Bazhutin GA, Cartagena Gómez ADP, et al. Nonsteroidal anti-inflammatory drugs as emerging contaminants. Microbiology. 2020;89(2):148–163.
[9] Luo Y, Guo W, Ngo HH, et al. A review on the occurrence of micropollutants in the aquatic environment and their fate and removal during wastewater treatment. Sci Total Environ. 2014;473-474:619–641.
[10] Dougherty JA, Swarzenski PW, Dinicola RS, et al. Occurrence of herbicides and pharmaceutical and personal care products in surface water and groundwater around liberty Bay, Puget sound, Washington. J Environ Qual. 2010;39(4):1173–1180.
[11] United Nations/UN. Transforming our world, the 2030 agenda for sustainable development. General assembly resolution. A/RES/70/1. New York: United Nations Publishing; 2015.
[12] Fent K, Weston AA, Caminada D. Ecotoxicology of human pharmaceuticals. Aquat Toxicol. 2006;76(2):122–159.
[13] He B, Wang J, Liu J, et al. Eco-pharmacovigilance of non-steroidal anti-inflammatory drugs: necessity and opportunities. Chemosphere. 2017;181:178–189.
[14] Świacka K, Michnowska A, Maculewicz J, et al. Toxic effects of NSAIDs in non-target species: a review from the perspective of the aquatic environment. Environ Pollut. 2020;273:115891.
[15] Aguirre-Martínez GV, Del Valls TA, Martín-Díaz ML. Identification of biomarkers responsive to chronic exposure to pharmaceuticals in target tissues of carcinus maenas. Marine Environmental Research. 2013;87–88:1–11.
[16] Milan M, Pauletto M, Patarnello T, et al. Gene transcription and biomarker responses in the clam *Ruditapes philippinarum* after exposure to ibuprofen. Aquat Toxicol. 2013;126:17–29.
[17] Munari M, Matozzo V, Gagne F, et al. Does exposure to reduced pH and diclofenac induce oxidative stress in marine bivalves? A comparative study with the mussel *Mytilus galloprovincialis* and the clam *Ruditapes philippinarum*. Environ Pollut. 2018;240:925–937.
[18] Serrano MAS, Gonzalez-Rey M, Mattos JJ, et al. Differential gene transcription, biochemical responses, and cytotoxicity assessment in *Pacific oyster Crassostrea gigas* exposed to ibuprofen. Environ Sci Pollut Res Int. 2015;22(22):17375–17385.
[19] Richards NL, Cook G, Simpson V, et al. Qualitative detection of the NSAIDs diclofenac and ibuprofen in the hair of eurasian otters (lutra lutra) occupying UK waterways with GC–MS. Eur J Wildl Res. 2011;57(5):1107–1114.
[20] Machado GC, Abdel-Shaheed C, Underwood M, et al. O. Non-steroidal anti-inflammatory drugs (NSAIDs) for musculoskeletal pain. BMJ. 2021;372:n104.
[21] Cizmas L, Sharma VK, Gray CM, et al. Pharmaceuticals and personal care products in waters: occurrence, toxicity, and risk. Environ Chem Lett. 2015;13(4):381–394.
[22] Smith M, Love DC, Rochman CM, et al. Microplastics in seafood and the implications for human health. Curr Environ Health Rep. 2018;5(3):375–386.
[23] Pires APF, Srivastava DS, Marino NAC, et al. Interactive effects of climate change and biodiversity loss on ecosystem functioning. Ecology. 2018;99(5):1203–1213.
[24] Babatunde OO, Jordan JL, Van Der Windt DA, et al. Effective treatment options for musculoskeletal pain in primary care: a systematic overview of current evidence. PLOS One. 2017;12(6):e0178621.
[25] Bendtsen L, Evers S, Linde M, et al. EFNS guideline on the treatment of tension-type headache - report of an EFNS task force. Eur J Neurol. 2010;17(11):1318–1325.
[26] Holsgaard-Larsen A, Christensen R, Clausen B, et al. The effect of neuromuscular exercise compared with instruction in analgesic use on knee function in patients with early knee osteoarthritis – one year outcome of the exerpharma randomized trial. Osteoarthritis and Cartilage. 2017;25:S49.
[27] Sanz DR, Solano FU, López DL, et al. Effectiveness of median nerve neural mobilization versus oral ibuprofen treatment in

subjects who suffer from cervicobrachial pain: a randomized clinical trial. Archives of Medical Science. 2018;14(4):871–879.
[28] Devereaux M, Velanoski KQ, Pennings A, et al. Short-Term effectiveness of precut kinesiology tape versus an NSAID as adjuvant treatment to exercise for subacromial impingement: a randomized controlled Trial. Clin J Sport Med. 2016;26(1):24–32.
[29] Hayati M, Yazdi Z, Abbasi M. Comparison of non-steroidal anti-inflammatory drugs and knee kinesio taping in early osteoarthritis pain: a randomized controlled trial. J Bodyw Mov Ther. 2019;23(3):666–670.
[30] Maric F, Groven KS, Banerjee S, et al. Essentials for sustainable physiotherapy: introducing environmental reasoning into physiotherapy clinical decision-making. Fysioterapeuten (online). 2021. https://fysioterapeuten.no/fagfellevurdert-sustainable-physiotherapy/essentials-for-sustainable-physiotherapy-introducing-environmental-reasoning-into-physiotherapy-clinical-decision-making/1317
[31] Richards N, Hall S, Scott K, et al. First detection of an NSAID, flunixin, in sheep's wool using GC-MS. Environ Pollut. 2011;159(5):1446–1450.
[32] Amuasi JH, Lucas T, Horton R, et al. Reconnecting for our future: the lancet one health commission. Lancet. 2020;395(10235):1469–1471.
[33] Lerner H, Berg C. A comparison of three holistic approaches to health: one health, ecohealth, and planetary health. Front Vet Sci. 2017;4:163.
[34] Rock MJ, Degeling C, Adams CL. From more-than-human solidarity to multi-species biographical value: insights from a veterinary school about ethical dilemmas in One Health promotion. Sociol Health Illn. 2020;42(4):789–808.
[35] Maric F, Nicholls DA. Paradigm shifts are hard to come by: looking ahead of COVID-19 with the social and environmental determinants of health and the UN SDGs. Eur J Physiother. 2020;22(6):379–381.
[36] Narain S, Mathye D. Do physiotherapists have a role to play in the sustainable development goals? A qualitative exploration. S Afr J Physiother. 2019;75(1):466.
[37] Morton T. Dark ecology: for a logic of future coexistence. New York: Columbia University Press; 2016.
[38] Farrier D. Hand in glove: the false promise of plastics. Orion Magazine; 2020.
[39] Grover N. PPE use in England generated 'colossal' amount of carbon. *The Guardian*. 2021. Retrieved from https://www.theguardian.com/environment/2021/mar/17/ppe-use-in-england-generated-colossal-amount-of-carbon.
[40] Morton T. Hyperobjects. Minneapolis: University of Minnesota Press; 2013.
[41] Crutzen PJ. The anthropocene. In E. Ehlers & T. Krafft (Eds.), Earth system science in the anthropocene. Berlin: Springer; 2006. p. 13–18.
[42] Steffen W, Richardson K, Rockstrom J, et al. Sustainability. Planetary boundaries: guiding human development on a changing planet. Science. 2015;347(6223):1259855–1259855.
[43] Akomolafe B. I, Coronavirus: Mother, Monster, Activist. 2020. https://bayoakomolafe.net/project/i-coronavirus-mother-monster-activist/.
[44] Bennett J. Vibrant matter: a political ecology of things. Durham and London: Duke University Press; 2010.
[45] Nicholls DA. What's real is immaterial: what are we doing with new materialism? Aporia. 2020;11(2):4–14.
[46] Rock MJ, Degeling C. Public health ethics and more-than-human solidarity. Soc Sci Med. 2015;129:61–67.
[47] Morton T, Boyer D. Hyposubjects: on becoming human. London: Open Humanities Press; 2021.
[48] Maric F, Nicholls DA. Environmental physiotherapy and the case for multispecies justice in planetary health. Physiother Theory Pract. 2021;1–12. DOI:10.1080/09593985.2021.1964659
[49] Morton T. The ecological thought. Cambridge: Harvard University Press; 2012.
[50] NHS England. Delivering a 'Net Zero' National Health Service. England.nhs.uk. 2021. 2020 [cited 14 August 2021]. Available from: https://www.england.nhs.uk/.