

Eyes Wide Shut: Assessments of Outdoor/ Coastal Swimming Water Quality in Ireland

Houghton, F., Treacy, J. & Moran Stritch, J.

Technological University of the Shannon, Limerick, Ireland

First received: March 2024

Accepted for publication: March 2025

Abstract: Water is one of the most important ecosystems for human survival. However, although vastly improved, bathing water quality in Ireland is still jeopardised by a range of factors, including poor sewage management. Concerns have been raised over the increasing range of pollutants that may adversely impact swimmers. This is particularly problematic, given the rising number of people engaging in wild swimming since the pandemic. Not only have numbers increased, but so has the swimming season, far beyond the traditional summer period. Swimming provides numerous health benefits; however, bathing water monitoring and certain forms of water treatment are still often confined to the summer period. This may leave members of the public, who are largely unaware of such limitations, at considerable risk. Improved public awareness of the pollution risks of wild swimming is required. Increased water quality monitoring is also suggested, alongside improved year-round waste-water treatment. Improvements in the use of sensors, as well as engagement with citizen science and satellite monitoring, may help improve the monitoring of bathing water quality into the future.

Keywords: *wild swimming, wellbeing, pollution, legislation, monitoring, water quality monitoring*

“Just keep swimming,”

DORY IN FINDING NEMO.

1.0 Introduction

This Commentary explores the chronic issue of water quality in Ireland in the context of the significant growth in outdoor, ‘wild’, swimming in recent years. It starts with an examination of the health benefits of swimming and bluescape therapeutic environments. This is followed by an examination of the adverse impacts of polluted water on the health of swimmers. The following section looks in more detail at the problematic issue of Irish bathing water quality. This is followed by an exploration of the limitations of current water monitoring practices and approaches. Finally, the discussion summarises these issues and makes several recommendations for the future.

2.0 The Health Benefits of Bathing, Swimming & Bluescapes

The health benefits of bathing and swimming have been espoused for millennia. These pastimes took on a renewed focus in Britain and Ireland during the Edwardian and Victorian eras, which saw the development of extensive railway networks servicing expanding coastal holiday destinations (Love, 2008; Andrews & Kearns, 2005). Although excluded from many other domains, research suggests that swimming was one area of activity that largely remained open to women (Parker, 2010). Further impetus to the swimming and sea-bathing movements emanated from the Romantic cult of wild nature as espoused by literary figures such as Taylor Coleridge, Keats, and Byron (Jarvis, 2019). The inter-war period continued to promote swimming as part of the open-air movement (Lencek & Bosker, 1998; Foley, 2010).

Swimming has been demonstrated to have positive impacts on physical health, as well as mental health and well-being (Swim England, 2017; Knechtle *et al.*, 2020; McDougall *et al.*, 2022). Information relating to the benefits of swimming and associated statistics as outlined by Swim Ireland are detailed in Table 1.

Table 1: Swim Ireland Strategic Plan 2022-2026.

Swimming and the Aquatics in Ireland

- Swimming is a life skill, as important as learning to read
- It is the sport that most people come back to in their adult years
- Swimming is the second most popular participation sport behind personal exercise
- Swimming improves mental health and has psychological, emotional and social benefits
- Swimming is accessible, open to all ages, all abilities
- 9% of adults participate in swimming. Over 340,000 people swam once a week in 2019.
- Swimming is the number one sport for women
- Swimming is the most participated sport across the life cycle of all sports
- Ireland is an island nation with 6000 km of coastline and 12,000 inland loughs
- Swimming is the number one sport for people with a disability
- Over 500,000 children participate in swimming lessons every year. Swimming is the fourth most popular sport for children in the Republic of Ireland and second in Northern Ireland
- Swimming forms a critical part of the €230 m sports and fitness industry which employs 9,500 people across the country
- Swimming is a gateway sport for other sporting activities

(Swim Ireland, 2022)

Writing before the outbreak of the Covid-19 pandemic, Jarvis (2019:67) discussed the recent expansion of wild swimming as part of neo-romantic '*response to the overregulation and commodification of aquatic leisure activity*'. This increase in outdoor swimming has continued in both Ireland and the UK. Foley (2022: 298) states that '*Swimming is having a zeitgeist moment... especially in the unpredictable but exciting wildness of the ocean*'. Media reports of an increase in wild swimming during the COVID-19 pandemic (e.g., Irish News, 2021; Carroll, 2021; O'Connell, 2021) are supported by both NGO reports (Water Safety Ireland, 2023) and CSO (2022) surveys. Recent estimates suggest that participation in outdoor swimming in the UK increased by between 1.5 and 3 times between 2019 and 2021 (Outdoor Swimmer, 2021). This research noted not only increased numbers of outdoor swimmers, but that those engaged in outdoor swimming increased the frequency of their outdoor swimming. Female participation rates in outdoor swimming were also noted to have increased. A temporal aspect to participation was also noted in this research; the report notes that '*Women are more attracted to winter swimming than men*' (Outdoor Swimmer, 2021: 21). Swimming in winter has been described as both 'life affirming' and 'addictive magic' in Irish media reports (Kelleher, 2019). The growth in outdoor and coastal swimming and related activities looks set to continue. The former Chief Medical Officer for England has exhorted people on this very issue:

This is not the time to tread water; we need to enrich and harness the evidence and opportunity, and to encourage more to swim, and swim regularly. We need to move as a nation to take more exercise. So do swim for pleasure, leisure, or as a sport. (Davies, 2017)

The association between water and therapeutic landscapes has long been recognised (Gesler, 1992; 1996; 1998). Ongoing research in the therapeutic landscapes field has continued to focus on this topic (Foley, 2010; Bell *et al.*, 2015; Finlay *et al.*, 2015; Smith *et al.*, 2022; Bell *et al.*, 2023), even in the field of imagined therapeutic landscapes (Houghton & Houghton, 2013). Given the growth in outdoor swimming described above it is perhaps no surprise that human geography has experienced a 'blue turn' and has focussed in far more depth on bluescape practices such as swimming, surfing and typical beachside activities such as rock pooling and sand castle building (Anderson, 2012; Ashbullby *et al.*, 2013; Britton, 2019; Britton & Foley, 2021; Foley *et al.*, 2019; Foley & Kistemann, 2015).

The academic interest in immersion and swimming has no doubt been further enhanced through both the recent sensual turn in Geography (Bell *et al.*, 2023) and the increased focus on active mobilities and health in spatial contexts (Gatrell, 2013). Ireland has been at the forefront of research on the relationship between therapeutic landscapes and water, particularly swimming, for well over a decade (e.g., Foley 2010; Foley, 2015; Foley *et al.*, 2019; Britton & Foley, 2021). Of particular importance in the context of this paper, which implicitly examines the potential impacts of extended exposure, is the work by Foley (2017) which discusses the accretive nature of the bond and its impact on individuals of therapeutic landscapes (Bell *et al.*, 2018; Britton & Foley, 2021; Foley, 2023).

Reviewing a range of bluescape activities Foley (2022: 300) acknowledges how ‘ocean spaces become both health-enabling and health endangering’. Bell *et al.* (2018) and Bell *et al.* (2019) discuss the potential dangers of beach environments, including both racism and dangerous currents and undertows that can result in drowning. Addressing safety concerns, Gibbs & Warren (2015) mention the threat of currents, rocks, and marine life, including sharks. Water Safety Ireland (2023) notes many of these threats, as well as those potentially posed by seals, swans, and weever fish. A small body of research on swimming and surfing has explored environmental health aspects of these therapeutic bluescapes and associated recreational pastimes (Attias *et al.*, 1995; Leonard *et al.*, 2018; Farrell *et al.*, 2021; Foley, 2015; Britton & Foley, 2021; Strathmann *et al.*, 2016).

However, despite this limited thread in the academic literature, it is important to note that in reviews of the dangers that winter swimming poses in Ireland, there is almost no mention of unclean water or faecal contamination (Butler-Eldridge, 2024). As can be seen from Table 2, attention focuses on a range of risks, with threats from the temperature, currents, and weather conditions being the most prominent.

Table 2. Warnings about Outdoor/ Wild Swimming in Ireland

English (2022)	Kelleher (2019)	Water Safety Ireland (2023)
<ul style="list-style-type: none"> ● Know your limits ● Check the weather and water temperature ● Get in slowly to avoid cold water shock ● Wear a watch to monitor time in water ● Know the signs of hyperthermia ● Plan for after 	<ul style="list-style-type: none"> ● Do not swim on your own ● Wear a bright swimming cap ● Get kitted out with the right gear ● Don't overdo it & don't spend too long in the water ● Always check the weather forecast ● Bring a tow float into the water ● Don't start at Christmas 	<ul style="list-style-type: none"> ● Weather conditions ● Currents/ Rip Currents/ Longshore/ Lateral Current ● Wave Profile ● Tidal Cut-off ● Tidal River ● Wild animals/ Stings ● Entry & Exit ● Cold Shock/ After drop/ Hypothermia ● River in flood

Similar concerns predominate in other international texts exploring outdoor swimming (Iconomidis, 2022). Concerns over water in the UK have become a routine and popular discourse in the UK (Oliver & McDougall, 2023; Oliver *et al.*, 2023; Wood *et al.*, 2022). However, there has been less of a focus on water swimming quality in the academic literature relating to Ireland.

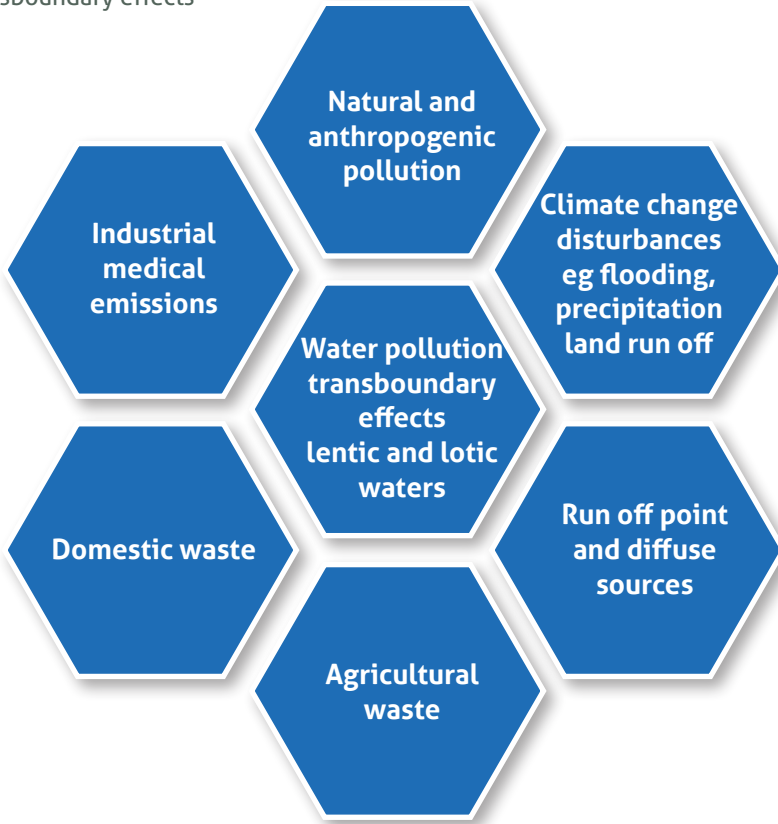
3.0 Water Pollution & Its Impacts on Human Health

Swimming in contaminated fresh or seawater can have negative health impacts, ranging from mild to serious (Halliday *et al.*, 2011). Popular swimming areas in Ireland are not immune to these risks, termed 'recreational water illnesses' (RWI) (Lee *et al.*, 2002). Sewage overflow, agricultural runoff, industrial waste, and natural factors like algal blooms are common sources of contamination leading to RWI. The most common complaints traced to swimming in contaminated water are gastrointestinal problems, including diarrhea, vomiting, nausea, and stomach cramps (Schets *et al.*, 2011; Wade *et al.*, 2010; CDC, 2022). Other complaints include skin rashes, cellulitis, conjunctivitis, and infections such as 'swimmer's ear', along with respiratory issues (Fleisher *et al.*, 1996; Natajara & Miller, 2016). These infections may be more common and potentially more serious for children and adult swimmers with pre-existing conditions or weakened immune systems (CDC, 2022; ECDC, 2022). Children under ten years of age have been noted to be at particular risk of gastrointestinal (GI) illness following exposure to sewage contamination in recreational swimming water (Wade *et al.*, 2008; Niknejad *et al.*, 2024)

The physical symptoms described above may bring the wild swimmer to the attention of their local general practitioner or pharmacist, seeking relief from acute complaints that are uncomfortable and inconvenient but not life-threatening. However, bioaccumulation of toxic substances in bodies of water through respiration, skin contact, or ingestion may pose a more serious threat in the long term (Lima *et al.*, 2022). Human exposure to pharmaceutical residues such as antibiotics and personal care products through recreational activity has been a growing topic of investigation over the last two decades (Breton & Boxall, 2003; Ziyilan & Ince, 2011; Kumar *et al.*, 2023). Contaminants of emerging concern (CEC) include a variety of products used in healthcare, pharmaceutical manufacturing, personal and domestic use, and agriculture, which find their way into bodies of water despite sophisticated waste treatment systems (Ng *et al.*, 2020). Human exposure to discharged pharmaceutical waste materials such as antibiotics, therapeutic hormones, and anti-inflammatory medications, even at trace levels, can have a toxic effect if the exposure is prolonged (Hernando *et al.*, 2006; Streck, 2009; Tahar *et al.*, 2017). There has been, however, limited attention paid to the presence or potential effects of these CECs in Irish aquatic environments to date (Rapp-Wright *et al.*, 2023) and even less on what impact these contaminants may have on the people who regularly swim in them. It should be noted that although this paper has focused specifically on swimmers, research from the UK has also explored polluted environments experienced by surfers (Evers & Phoenix, 2022). Although Ireland only has a relatively small surfing 'scene', the parallel impacts of aquatic pollution on both surfers and swimmers are obvious.

Like air pollution, water pollution can be very complex. As stated by the United Nations, water quality issues are complex and diverse (UN, 2011).

Figure 1: The complexity of water pollution, including natural and anthropogenic pollutants and transboundary effects



The complexity of water pollution, as seen in Figure 1, can be due to the partially closed loop of water within the hydrosphere and point and diffuse and transboundary effects.

4.0 Outdoor (Wild) Bathing Water Quality in Ireland

Recent news reports have heralded improvements in the quality of Irish bathing water (RTE, 2023a; 2023b). These reports appear to paint the image that almost all bathing water is of adequate, good, or excellent quality; *'It found that 144 out of 148 bathing waters met or exceeded the minimum required standard, with 117 of them classified as excellent or good'* (RTE, 2023a). These media reports were based on a national review of bathing water quality for the year 2022 conducted by the Environmental Protection Agency (EPA, 2023a). The key messages from this report are outlined in Table 3.

Table 3: Key Messages from the EPA Report on Bathing Water Quality for Ireland in 2022**KEY MESSAGES FOR 2022**

The majority of bathing waters have Excellent or Good quality.

- 97% of the 148 identified bathing waters met or exceeded the minimum required standard.
- 117 bathing waters (79%) were of Excellent quality.
- Two bathing waters have shown significant improvement to Excellent from a Poor classification in recent years – Portrane, The Brook Beach in Fingal and Trá na bhForbacha, Na Forbacha, Galway.
- 3 bathing waters were Poor (up 1 from 2021) and will have a swimming restriction for the 2023 season. These were Balbriggan (Front Strand Beach), Lady's Bay, Buncrana and Trá na mBan, An Spidéal

(EPA, 2023a)

Improvements in water quality are taking place as part of the gradual development of improved wastewater infrastructure in Ireland (Irish Water, n.d.). However, pollution remains an issue.

4.1 Water Pollution in Ireland

Domestic and industrial activities produce wastewater effluents containing undesirable contaminants that must be removed before the water is discharged to receptors, which can be air, water, and soil. Coastal water is a common receptor of wastewater treatment plants (EPA, 2021a). In several coastal and inland areas, untreated sewage is still being discharged into water systems (EPA, 2021b). Urban wastewater contains domestic human wastes; discharge from urban wastewater treatment plants may contain residuals of microbial pathogens, disease-causing bacteria, and viruses from human waste, and other discharges such as metals and nutrients from local industries. Diffuse pollution in coastal areas can be due to agricultural activities, septic tank run-off, and industrial activities (Novotny *et al.*, 1994; NFU, 2023).

5.0 Water Quality Monitoring in Ireland

Water quality monitoring and assessment in Ireland is guided by the Water Framework Directive (WFD) (EU, 2000). Water can be viewed in terms of the Environmental Quality Objective (EQO) and the Environmental Quality Standard (EQS) (Kolabokas *et al.*, 2002; Eur-Lex, 2023a). The standard relates to the quality requirements for the water body, and the objective relates to the use/s of the water body. Embedded within the WFD are elements such as the EU Bathing Water Directive (BWD). In synergy with the BWD is the Blue Flag Beach status, which is a global initiative. To achieve the Blue Flag status within Europe, a bathing area must adhere to the Bathing Water Quality Regulations and

implement the standards laid down in the European Union BWD (EPA, 2023c; Eur-Lex, 2023b; Irish Statute Book, 2008a). The Blue Flag status requirements and the European Union bathing water requirements must be achieved within the bathing season from June 1st to September 15th, one year prior to submission of an application for Blue Flag status. Water quality for the BWD and Blue Flag beach status is classified as excellent (highest, cleanest class), good (generally good water quality), sufficient (meets minimum quality standards), and poor (does not meet the minimum standard).

The standard requirements are mainly based on indicator parameters, namely intestinal enterococci and *Escherichia coli*. The bacteria count to give rise to excellent, good and sufficient water quality are given in Table 4. Also included in this table are the methods of analysis and testing. Poor quality water would have higher counts than the sufficient quality water level.

Table 4: Water Quality Standard and Method of Testing and Analysis

Water Type	Parameter	Excellent Quality	Good Quality	Sufficient Quality	Reference method
For Inland waters	Intestinal enterococci (cfu/100 mls)	200*	400*	330**	ISO 7899-1 or ISO 7899-2
For Inland waters	<i>Escherichia coli</i> (cfu/100 mls)	500*	1,000*	900**	ISO 9308-3 or ISO 9308-1
For coastal waters and transitional waters	Intestinal enterococci (cfu/100 mls)	100*	200*	185**	ISO 7899-1 or ISO 7899-2
For coastal waters and transitional waters	<i>Escherichia coli</i> (cfu/100 mls)	250*	500*	500**	ISO 9308-3 or ISO 9308-1

(*) (**) Denotes * 95 % probability; ** 90 % probability

Table 4 relates to Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC (EUR-Lex, 2006).

A map showing the bathing water quality and monitoring sites during the monitoring programme from June 1st to September 15th 2023, can be seen in Figure 2 (EPA, 2024a). From the monitoring results, 114 bathing waters (77 %) were of excellent quality in 2023, down from 117 bathing waters (79 %) in 2022. This report highlighted the causes of reported incidences of poor quality stemming from urban wastewater, runoff from urban areas, proliferation of both cyanobacteria and microalgae, diffuse pollution from agriculture, and contamination from animals and birds.

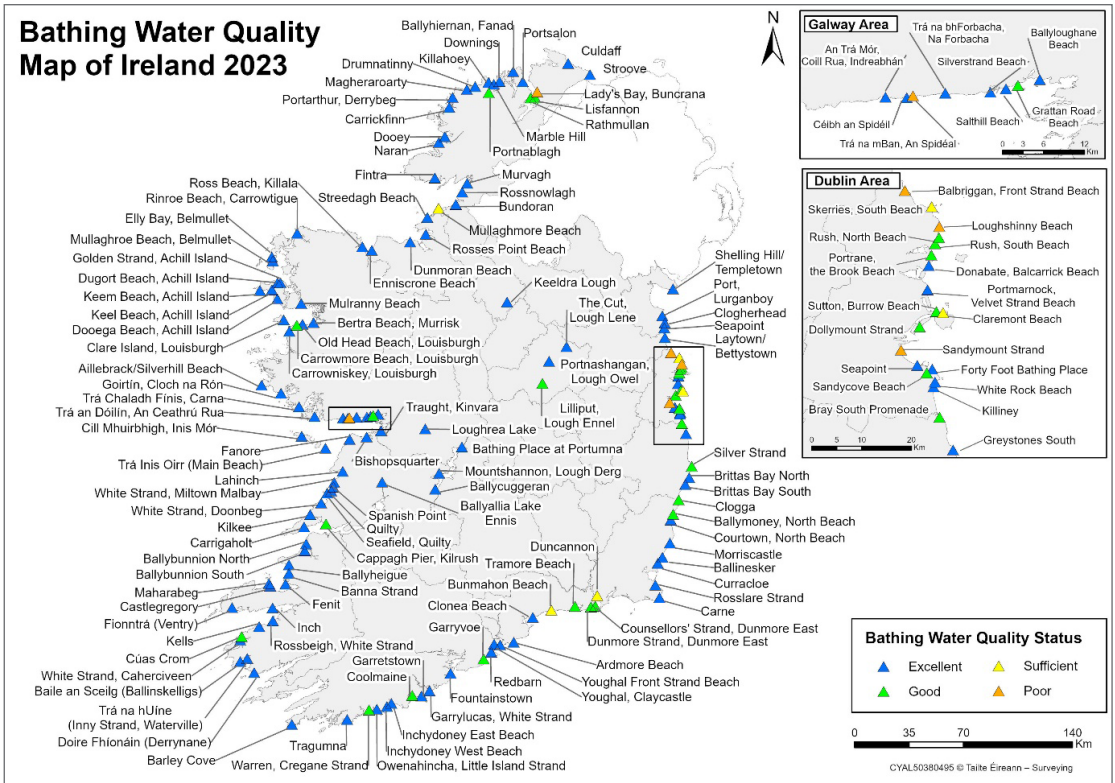


Figure 2: Bathing water quality monitoring sites and results for the 2023 season (EPA, 2024a)

Current water quality monitoring practices are out of sync with recent developments. For example, the assumption that the bathing season runs from June 1st to September 15th is no longer the norm.. The current growth in wild swimming is not simply a factor of numbers, it is also evident in the extended length of the swimming season for many. This means there is an urgent need to extend the length of the water quality monitoring season in Ireland to include all twelve months of the year to reflect new trends in recreational water use.

5.1 Water Quality & Pollutants

While all natural waters contain bacteria, some types of bacteria found in animal and human faeces can cause illness. Two organisms, *Escherichia coli* and *Intestinal Enterococci*, occur in very large numbers in the gut of warm-blooded animals and human faeces. *Escherichia coli* and *Intestinal Enterococci* are analysed to assess bathing water compliance as they are considered good ‘indicator’ organisms. The presence of these bacteria in large numbers in bathing waters is a warning of a potential health risk due to the likelihood that other pathogens, bacteria, and viruses might be present (Schets *et al.*, 2011; Rozen & Belkin, 2001).

However, other pollutants of increasing concern in the modern world involve emerging pollutants such as veterinary and pharmaceutical drugs, contraceptives, antibiotics, and nutrients (Ziylan & Ince, 2011), along with recreational drugs, cosmetics, marine oils, and grease residuals. Other bacteria and viruses of concern include avian influenza viruses (Farrell *et al.*, 2021; Irish Statute Book 2008b). There are significant concerns that current wastewater treatment plants are unable to completely remove drugs such as antibiotics and other toxic organic pollutants (Tahar *et al.*, 2017; Auberttheau *et al.*, 2016). Recent Irish research has also noted the potential contamination of waters used for recreational use by antibiotic-resistant bacteria, or so-called ‘superbugs’ (Morris *et al.*, 2024). The question that needs to be asked is: Should there be more regular monitoring of emerging parameters as well as the standard indicator parameters in order to fully understand the health risks of wild swimming?

5.2 Monitoring and Regulation of Bathing Waters

Local authorities and Uisce Eireann in Ireland are responsible for managing and monitoring identified bathing waters. discharges or oil spills. The frequency of routine sampling in a bathing area depends on the resources of the specific local authority and the population being served in a particular bathing area. With over 7,500 km of coastline, assessing the quality of coastal water in Ireland is a challenging task (EPA, 2023b; EU, 2023). Remote areas where some wild swimming takes place may not be monitored at all. From the map of bathing waters monitoring, monitoring sites can be coastal, marinas or lake habitats.

5.3 Sampling Protocols and Bathing Water

Water monitoring protocols involve a number of steps including: sampling; analysis in the field, which involves visual observations and measuring parameters such as temperature and dissolved oxygen; storage of samples; transportation of samples to the laboratory; laboratory analysis; results evaluation and the documentation of the results (Bartram & Ress, 1999). As such, it is perhaps no surprise that harmonisation of sampling protocols both within a country and internationally is a challenge (Ritabrata, 2019).

Sampling protocols require samples to be taken 30 cm below the water’s surface and in water that is at least one metre deep (EU, 2006). Deviations in the monitoring programme can occur within different local authorities in Ireland in areas such as the time of sampling and its correlation with the time of high tide (Obir-Danso *et al.*, 1999). There can be inconsistencies in the depth of sampling due to the sampler walking outwards from the shore and taking samples with a long pole. In some European countries, samples may be taken from small boats. Such methods can introduce significant discrepancies in the sampling depth when compared to the shore-based sampling pole method. However, as the US EPA (2000) notes, it is important for the sampler to ensure a consistent sampling depth. Such inconsistencies in methods are largely unknown by the general swimming

public and yet can lead to vastly differing results such as false positive and false negative recordings.

Other issues exist concerning Ireland's water sampling protocols. Local authorities in Ireland are required to take samples at least once a month. However, although some may take more samples, the actual number taken depends on the resources available, such as the number of samplers and laboratory analysts in each local authority. As such there is no real-time monitoring of bathing water quality in Ireland, and the time lag involved between contamination and the release of water quality check results can be extensive. Regular swimmers may be aware of the dangers of swimming after a major rain event, but newer wild swimmers and occasional swimmers may not be as well-informed and may therefore be at increased risk. Guiding information for the general public may be further compromised as the latest revision of the BWD states that assessments of water quality are based on testing results over the previous four years, rather than just assessing the quality of the water on the past season's information, or the information from the most recent sample analysed (Ritabrata, 2019). Such general indicators may be misleading in the short term.

5.4 Waste Treatment and Limitations

In general, conventional wastewater treatment consists of a combination of physical, chemical, and biological processes and operations to remove insoluble particles and soluble contaminants from effluents (Treacy, 2015; EU, 2023). Due to cost and lack of space around water treatment facilities, tertiary treatment is not always available at wastewater treatment plants. Tertiary UV treatment can be available in certain areas where there is a large loading capacity to the treatment plant and where the discharge can affect the bathing area where a large population reside. This treatment can also be utilised where food products namely mussels and shellfish are being aqua-farmed in the vicinity of the discharge waters.

It is interesting to note the EPA Ireland website states:

'In 2023 most of Ireland's wastewater was treated at plants designed to provide secondary treatment (58.6%) or secondary treatment with nutrient removal (39.6%).

The remainder was either conveyed to plants that provide a more basic form of treatment, known as primary treatment (0.9%) or was collected at areas that have no treatment plant and discharged directly into the water environment without any treatment (0.9%)'. (EPA 2024b)

Tertiary treatment prevents eutrophication of the receiving waters and prevent large residuals of bacteria and other pathogens in the discharge waters. Treatment across the calendar year is required in areas that have a food product such as a shellfish harbour (Irish Statute Book, 2006). However, in most bathing areas UV light treatment is only utilised during the relatively short bathing season from June to mid-September. As noted above, this seasonal approach is now an increasingly deficient given the increased numbers of wild swimmers and the temporal extension in swimming throughout the year.

5.5 Microclimatic Impacts on Water Quality

The microclimatic conditions of a region, such as temperature, light flux, humidity, wind speed and turbulence, dew, heat balance, evaporation rates, and heavy rainwater events can also affect water quality. The microclimate of the region can impact parameters such as turbidity and sediment gradients, which in turn can influence bacteria growth. The UV intensity flux can also vary within a microclimate, and this can impact the ability of UV light to diminish bacterial counts. Tidal strength and spring tides are affected by the microclimate weather at a particular location. All these factors reduce the accuracy of testing, particularly when it is a variable of intermittent nature.

5.6 Climate Change Impacts on Water Quality & Other Dangers

Climate change consequences on water systems can include extreme weather events such as drought, heavy rainfall events, and flooding. Heavy precipitation can deteriorate bathing water quality (Ordulj *et al.*, 2022). Other impacts include sediment runoff and changes in temperature gradients. In coastal areas such as beaches, heavy rainfall can lead to wastewater overflows or run-off from both urban and agricultural lands. Higher sediment loads can lead to a temporary deterioration of bathing water quality. Such sediments can accumulate bacteria, viruses, and chemicals (Wyness *et al.*, 2019). Species movement gradients due to temperature gradients and climate change, such as jellyfish species, can also be of concern (Ecowatch, 2021).

6.0 Discussion

Wild swimming has grown dramatically in recent years, particularly since the COVID-19 pandemic. At the same time, although there have been improvements in water quality, many areas continue to discharge untreated sewage into water systems. A lack of public awareness of the risks related to bathing areas that are not being monitored must be highlighted, as should the limitations of current monitoring (Farrell *et al.*, 2021; Oliver & McDougall, 2023). Irish health information systems are poorly developed and are effectively unable to monitor most potential impacts of adverse bathing water quality.

Water quality can be difficult to monitor adequately and regulate given the complex interplay between human pollution, pollution caused by birds and animals, the impacts of climate change, tidal impacts, temperature gradients and thermoclines, sediment and soil erosion, and extreme precipitation and flooding events. The challenge of Ireland's increasing population and its impacts on water quality, the sustainability of our water systems, our waste management practices, and the changing nature of discharges also need to be continuously evaluated. The impacts of climate change on water quality and bathing water quality also need consideration in the long run.

All water ecosystems require strong monitoring and assessment of the stresses on water quality (EEA, 2023). However, bathing water monitoring in Ireland can be regular,

intermittent, sporadic, or non-existent, as well as highly inconsistent. Harmonisation of protocols for bathing water sampling needs to be addressed, as does the issue of resourcing of local authorities to facilitate increased monitoring. Murray (2022) has explored the importance of promoting year-round monitoring of bathing waters. Real-time monitoring is absent, and measures of bathing water quality can be highly misleading. Routine assessments should be considered for an increasing range of potential threats, including viruses, bacteria, metals, toxic pollutants, and veterinary, pharmaceutical, and recreational drugs (Wu, 2020; Holcomb & Stewart, 2020). Current practice in Ireland not only restricts bathing water quality assessments to the summer season but UV treatment of sewage discharges as well. Tertiary treatment of sewage discharge, especially UV light treatment, throughout the year is important, not just during the traditional summer bathing season (Grennan, 2023). This challenge was highlighted in the media during the 2024 Olympic Games in France in terms of the quality of the River Seine during the open-water swimming events (Eurosport, 2024).

Increased monitoring is required. The potential of wild swimmers to engage in citizen science to assist in pollution monitoring should be considered in the future (Fraisl *et al.*, 2022). This could involve for example the use of a developed app that could be used by wild swimmers to log observations of water quality such as colour at the site linked with a register of complaints and even the use of basic sensors by swimmers to access the quality of the water. Satellite images to assess water quality are also currently underutilised (Copernicus, 2023). Investigations into the potential use of real-time sensors and artificial intelligence to better understand and evaluate water quality are opportunities for future exploration. Innovative technologies such as EOMAP include maps of water turbidity caused by particles and sediments in the water; diatoms and chlorophyll levels should be integrated more in bathing water monitoring (ESA, 2023). These technologies, currently deployed by the European Space Agency, are vital in understanding the loading values of sediment plumes from dredging, dumping activities, and sediment run-off due to weather events (ESA, 2023; Richards *et al.*, 2023). To support the increase and expansion across the year in wild swimming in coastal waters, which has been embraced by the Irish public, new technologies, more regular monitoring, and communication of results must be introduced to preserve the health benefits of swimming for all.

In summary, it is important to mention some focused research activity needs arising from this Commentary:

- Using qualitative and quantitative analysis to address the challenges in the growth of coastal swimming and other open water swimming, such as inland rivers and lakes, and the dangers of water pollution;
- Research the present narrow scientific basis for assessing the water quality in regulated bathing areas;
- Research the potential of integrating citizen science, satellite imagery, and AI technologies to understand water quality and pollution;
- Investigate necessary policy developments around restricted swimming in areas that currently and historically have not undergone monitoring;

- Investigate and deploy the use of cheap indicator sensors such as turbidity for understanding microbial water quality;
- Design a public awareness program on advice to minimise swimming in non-regulated areas to reduce the risk of health issues.

References

- Anderson, J., 2012.** Relational places: the surfed wave as assemblage and convergence. *Environment and Planning D: Society and Space*, 30, 570–587.
- Andrews, G. J., & Kearns, R. A., 2005.** Everyday health histories and the making of place: The case of an English coastal town. *Social Science and Medicine*, 60, 2697–2713. Ashbullby, K. J., Pahl, S., Webley, P., & White, M., (2013). The beach as a setting for families' health promotion: A qualitative study with parents and children living in coastal regions in southwest England. *Health and Place*, 23, 138–147.
- Attias, L., Bucchi, A. R., Maranghi, F., Holt, S., Marcello, I., & Zapponi, G.A., 1995.** Crude oil spill in sea water: an assessment of the risk for bathers correlated to benzo(a)pyrene exposure. *Central European Journal of Public Health*, 3(3), 142–5.
- Aubertheau, E., Stalder, T., Mondamert, L., Ploy, M. C., Dagot, C., & Labanowski, J., 2016.** Impact of wastewater treatment plant discharge on the contamination of river biofilms by pharmaceuticals and antibiotic resistance. *Science of the Total Environment*, 579, 1387–1398.
- Bartram, J., & Rees, G., 1999.** *Monitoring Bathing Waters A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes*. London: E & FN Spon.
- Bell, S. L., Foley, R., Houghton, F., Maddrell, A., & Williams, A., 2018.** From therapeutic landscapes to healthy spaces, places and practices: A scoping review. *Social Science & Medicine*, 196, 123–130.
- Bell, S., Hickman, C., & Houghton, F., 2023.** From therapeutic landscape to therapeutic 'sensescape' experiences with nature? A scoping review. *Wellbeing, Space & Society*, 4, 100126.
- Bell, S. L., Hollenbeck, J., Lovell, R., White, M., & Depledge, M., 2019.** The shadows of risk and inequality within salutogenic coastal waters. In R. Foley, R. Kearns, T.
- Bell, S. L., Leyshon, C., Foley, R., & Kearns, R., 2018.** The healthy dose of nature: A cautionary tale. *Geography Compass*, 13, e12415.
- Bell, S. L., Phoenix, C., Lovell, R., & Wheeler, B. W., 2015.** Seeking everyday wellbeing: The coast as a therapeutic landscape. *Social Science & Medicine*, 142, 56–67.
- Bretton, R., & Boxall, A., 2003.** Pharmaceuticals and Personal Care Products in the Environment: Regulatory Drivers and Research Needs. *Molecular Informatics*, 22(3), 399–409.
- Britton, E., 2019.** Duchas: Being and belonging on the borderlands of surfing, senses and self. In R. Foley, R. Kearns, T. Kistemann, & B. Wheeler (Eds.), *Blue space, health and wellbeing: Hydrophilia unbounded* (pp. 95–116). Routledge.
- Britton, E., & Foley, R., 2021.** Sensing Water: Uncovering Health and Well-Being in the Sean and Surf. *Journal of Sport and Social Issues*, 45(1), 60–87.
- Butler-Eldridge, T., 2024.** Swimming, confusion, and plenty of brews: Negotiating ambivalence within Windermere's fragile waters. *Health & Place*, 89, 1–8.
- Carroll, R., 2021.** Lockdown has made us fall in love with the sea. *The Irish Examiner*, 31/08/2021. <https://www.irishexaminer.com/lifestyle/healthandwellbeing/arid-40370333.html>
- Centers for Disease Control and Prevention, 2022.** Swimming-Related Illnesses. <https://www.cdc.gov/healthywater/swimming/swimmers/rwi.html>
- Central Statistics Office, 2022.** Pulse Survey April–May 2022 – Our Lives Outdoors: Spending Time Outdoors. <https://www.cso.ie/en/releasesandpublications/fp/fp-olodsto/pulsesurveyapril-may2022-ourlivesoutdoorsspendingtimeoutdoors/keyfindings/>.
- Copernicus, 2023.** Copernicus European eyes on Earth Marine. https://defence-industry-space.ec.europa.eu/document/download/67e3d2d0-53d4-4ef8-893a-c43da0f140a4_en?filename=Copernicus%20General%20EN.pdf

- Davies, S.C., 2017.** Foreword. In Swim England (ed.) *The Health and Wellbeing Benefits of Swimming*. <https://www.swimming.org/swimengland/health-and-wellbeing-benefits-of-swimming/>
- Ecowatch, 2021.** Jellyfish may benefit from climate change. <https://www.ecowatch.com/jellyfish-climate-change-2651367971.html>
- EEA, 2023.** Water quality and water assessment. European Environment Agency. <https://www.eea.europa.eu/themes/water/european-waters/water-quality-and-water-assessment>
- English, G., 2022.** Dodge hypothermia and stay safe with these 6 winter sea swimming tips. Evoke.ie. <https://evoke.ie/2022/01/19/wellness/winter-sea-swimming-tips>
- EPA, 2021a.** Environmental Protection Agency. Code of Practice for Domestic Wastewater Treatment Systems. https://www.epa.ie/publications/compliance--enforcement/waste-water/2021_CodeofPractice_Web.pdf
- EPA, 2021b.** Environmental Protection Agency. Urban Waste Water Treatment in 2021. <https://www.epa.ie/publications/monitoring--assessment/waste-water/Urban-Waste-Water-Treatment-in-2021-report.pdf>
- EPA, 2023a.** Environmental Protection Agency. Bathing Water Quality in Ireland
- A report for the year 2022.** EPA. <https://www.epa.ie/publications/monitoring--assessment/freshwater--marine/Bathing-Water-Quality-in-Ireland-2022.pdf>
- EPA, 2023b.** Environmental Protection Agency. National Marine Monitoring Programme. <https://www.epa.ie/our-services/monitoring--assessment/freshwater--marine/estuaries-and-coastal/>
- EPA, 2023c.** Beaches and bathing water directive. Environmental Protection Agency. <https://www.epa.ie/our-services/monitoring--assessment/bathing-water/>
- EPA (US), 2023.** Climate Impacts on Water Quality. United States Environmental Protection Agency. <https://www.epa.gov/arc-x/climate-impacts-water-quality>
- EPA, 2024a.** Bathing Water Quality in Ireland A report for the year 2023 online <https://www.epa.ie/publications/monitoring--assessment/freshwater--marine/Bathing-Water-Quality-in-Ireland-2023.pdf>
- EPA, 2024b.** Urban wastewater treatment in Ireland. Environmental Protection Agency. <https://www.epa.ie/our-services/compliance--enforcement/waste-water/urban-waste-water/>
- EPA (US), 2000.** Sampling and Consideration of Variability (Temporal and Spatial) for Monitoring of Recreational Waters. Environmental Protection Agency. <https://www.epa.gov/sites/default/files/2015-11/documents/sampling-consideration-recreational-waters.pdf>
- ESA, 2023.** World water quality App hits the web. European Space Agency. https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Worldwide_water_quality_app_hits_the_web
- EU, 2000.** Water Framework Directive. European Union. https://environment.ec.europa.eu/topics/water/water-framework-directive_en
- EU, 2006.** Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC.
- EU, 2023.** Proposal for a Directive Of The European Parliament And Of The Council. https://environment.ec.europa.eu/system/files/2022-10/Proposal_for_a_Directive_concerning_urban_wastewater_treatment%28recast%29.pdf
- EUR-Lex., 2006.** Directive – 2006/7 – EN – EUR-Lex (europa.eu) accessed October 7th 2024
- EUR-Lex., 2023a.** Consolidated text: Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0105-20130913&qid=1695125683606>
- EUR-Lex., 2023b.** online EUR-Lex – 32006L0007 – EN – EUR-Lex (europa.eu) Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC
- EUR-Lex., 2023c.** The precautionary principle online. <https://eur-lex.europa.eu/EN/legal-content/summary/the-precautionary-principle.html>
- European Centre for Disease Prevention and Control, 2024.** STEC infection. In: ECDC. Annual epidemiological report for 2022. Stockholm: ECDC.

- Eurosport, 2024.** Paris 2024 Olympic Games: Is the River Seine really clean? What has Emmanuel Macron said? Which events will be in it? https://www.tntsports.co.uk/olympics/olympic-games-paris-2024/2024/is-river-seine-really-clean-emmanuel-macron-triathlon-practice-cancelled-events_sto20011971/story.shtml#welcome=eurosport
- Evers, C. & Phoenix, C., 2022.** Relationships between Recreation and Pollution When Striving for Wellbeing in Blue Spaces. *International Journal of Environmental Research and Public Health*, 19(7), 4170.
- Farrell, M. L., Joyce, A., Duane, S., Fitzhenry, K., Hooban, B., Burke, L. P., & Morris, D., 2021.** Evaluating the potential for exposure to organisms of public health concern in naturally occurring bathing waters in Europe: A scoping review. *Water Research*, 206, 117711.
- Finlay, J., Franke, T., McKay, H., & Sims-Gould, J., 2015.** Therapeutic landscapes and wellbeing in later life: Impacts of blue and green spaces for older adults. *Health Place*, 34, 97–106.
- Fleisher, J. M., Kay, D., Salmon, R. L., Jones, F., Wyer, M. D., & Godfree, A. F., 1996.** Marine waters contaminated with domestic sewage: nonenteric illnesses associated with bather exposure in the United Kingdom. *American Journal of Public Health*, 86(9), 1228–1234.
- Foley, R., 2010.** *Healing Waters: Therapeutic landscapes in historic and contemporary Ireland.* Abingdon: Routledge.
- Foley, R., 2015.** Swimming in Ireland: Immersions in therapeutic blue space. *Health & Place*, 35, 218–225.
- Foley, R., 2017.** Swimming as an accretive practice in healthy blue space. *Emotion, Space and Society*, 22, 43–51.
- Foley, R., 2022.** Swimming: Immersive encounters in the ocean. In K. Peters, J. Anderson, A. Davies & P. Steinberg (Eds.) *The Routledge Handbook of Ocean Space*, pp. 298–310. London: Routledge.
- Foley, R., 2023.** Theorising therapeutic accretion: swimming as a health-enabling practice across the lifecourse. *Irish Geography*, 56(1), 21–36.
- Foley, R., Kearns, R., Kistemann, T., & Wheeler, B. (Eds.), 2019.** *Blue Space, Health and Wellbeing: Hydrophilia Unbounded.* London: Routledge.
- Foley, R., & Kistemann, T., 2015.** Blue space geographies: Enabling health in place. *Health & Place*, 35, 157–165.
- Fraisl, D., Hager, G., Bedessem, B., Gold, M., Hsing, P., Danielsen, F., Hitchcock, C. B., Hulbert, J. M., Piera, J., Spiers, H., Thiel, M., & Haklay, M., 2022.** Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers*, 2, 64.
- Gatrell, A.C., 2013.** Therapeutic mobilities: walking and ‘steps’ to wellbeing and health. *Health & Place*, 22, 98–106.
- Gesler, W., 1992.** Therapeutic landscapes: Medical issues in light of the new cultural geography. *Social Science & Medicine*, 34(7), 735–746.
- Gesler, W., 1996.** Lourdes: Healing in a place of pilgrimage. *Health & Place*, 2, 95–105.
- Gesler, W., 1998.** Bath’s reputation as a healing place, in R. Kearns and W. Gesler (eds.) *Putting Health into Place.* Syracuse: Syracuse University Press, pp. 17–35.
- Gibbs, L., & Warren, A., 2015.** Transforming shark hazard policy: Learning from ocean-users and shark encounter in Western Australia. *Marine Policy*, 58, 116–124.
- Grennan, D., 2023.** Dollymount Dames taking Housing Minister to task on E Coli ridden bathing waters. *Dublinlive*, 12 April 2023. <https://www.dublinlive.ie/news/dublin-news/dollymount-dames-taking-housing-minister-26638785.amp>
- Halliday, E., Rebecca, J., & Gast, R. J., 2011.** Bacteria in Beach Sands: An Emerging Challenge in Protecting Coastal Water Quality and Bather Health *Environmental Science & Technology*, 45(2), 370–379.
- Hernando, M. D., Mezcuca, M., Fernández-Alba, A.R., & Barceló, D., 2006.** Environmental risk assessment of pharmaceutical residues in wastewater effluents, surface waters and sediments. *Talanta*, 69, 334–342.
- Holcomb, D. A., & Stewart, J. R., 2020.** Microbial Indicators of Fecal Pollution: Recent Progress and Challenges in Assessing Water Quality. *Current Environmental Health Reports*, 7(3), 311–324.
- Houghton, F., & Houghton, S., 2013.** Exploring Imagined Therapeutic Landscapes: Trainee Social Care Practitioners in Ireland. *Irish Geography*, 46(1–2), 79–90.
- Inconomidis, N., 2022.** *Cold Water Swimming: Health Benefits and Risks.* Nordersteht, Germany: BoD.
- The Irish News, 2021.** Immersion in beauty: the lure of open water swimming. *The Irish News*, 28/10/2021. <https://www.irishnews.com/lifestyle/health/2021/10/28/news/immersion-in-beauty-the-lure-of-open-water-swimming-2484912/>

- Irish Statute Book, 2006.** SI No 268 of 2006 European Communities (Quality of Shellfish Waters) Regulations 2006. <https://www.irishstatutebook.ie/eli/2006/si/268/made/en/print>
- Irish Statute Book, 2008a.** S.I. No. 79/2008 – Bathing Water Quality Regulations 2008 (irishstatutebook.ie)
- Irish Statute Book, 2008b.** S.I. No. 17/2008 – European Communities (Avian Influenza) (Control on Imports) Regulations 2008 S.I. No. 17/2008 – European Communities (Avian Influenza) (Control on Imports) Regulations 2008 (irishstatutebook.ie)
- Irish Water, (n.d.).** Kilkee Sewerage Scheme. <https://www.water.ie/projects/local-projects/kilkee-sewerage-scheme/>
- Jarvis, R., 2019.** Hydromania: The social history and literary significance of Romantic swimming. In M. Cohen & K. Quigley (Eds) *The Aesthetics of the Undersea*. London: Routledge.
- Kelleher, P., 2019.** The addictive magic of swimming in the sea in winter: 'It's life affirming'. *The Irish Times*, 23/11/2023. <https://www.irishtimes.com/life-and-style/the-addictive-magic-of-swimming-in-the-sea-in-winter-it-s-life-affirming-1.4074180>
- Knechtle, B., Waśkiewicz, Z., Sousa, C. V., Hill, L., & Nikolaidis, P. T., 2020.** Cold Water Swimming—Benefits and Risks: A Narrative Review. *International Journal of Environmental Research and Public Health*, 17(23), 8984.
- Kumar, S., Yadav, S., Kataria, N., Chauhan, A.K., Joshi, S., Gupta, R., Kumar, P., Chong, J.W.R., Khoo, K.S., & Show, P.L., 2023.** Recent Advancement in Nanotechnology for the Treatment of Pharmaceutical Wastewater: Sources, Toxicity, and Remediation Technology. *Current Pollution Reports*, 9(2), 110–142.
- Kalabokas, P. D., Nikolaos Christolis, M., & Markatos, N. C., 2002.** Environmental Quality Standards. In: *Encyclopedia of Life Support Systems*. UNESCO.
- Lee, S. H., Levy, D. A., Craun, G. F., Beach, M. J., & Calderon, R. L., 2002.** Surveillance for waterborne-disease outbreaks—United States, 1999–2000. *MMWR Surveillance Summary*, 51, 1–47.
- Lencek, L., & Bosker, G., 1998.** *The beach: The history of paradise on earth*. London: Secker and Warburg.
- Leonard, A. F., Singer, A., Ukoumunne, O. C., Gaze, W. H., & Garside, R., 2018.** Is it safe to go back into the water? A systematic review and meta-analysis of the risk of acquiring infections from recreational exposure to seawater. *International Journal of Epidemiology*, 47(2), 572–586.
- Lima, M. W., de Pereira, W. V., da Souza, E. S., de Teixeira, R. A., Palheta, D., da Faial, K., Costa, H. F., & Fernandes, A. R., 2022.** Bioaccumulation and human health risks of potentially toxic elements in fish species from the southeastern Carajás Mineral Province, Brazil. *Environmental Research*, 204(Pt B), 112024–112024.
- Love, C., 2008.** *A Social History of Swimming in England, 1800–1918*. London: Routledge.
- Macler, B. A., & Merkle, J. C., 2000.** Current knowledge on groundwater microbial pathogens and their control. *Hydrogeology Journal*, 8, 29–40.
- McDougall, C. W., Foley, R., Hanley, N., Quilliam, R. S., & Oliver, D. M., 2022.** Freshwater Wild Swimming, Health and Well-Being: Understanding the Importance of Place and Risk. *Sustainability*, 14, 6364.
- Morris, D., Cahill, N., Burgess, C., Cummins, E., Leonard, F., Hooban, B. et al., 2024.** Research 448: Antimicrobial Resistance and the Environment – Sources, Persistence, Transmission and Risk Management (AREST). Wexford: Environmental Protection Agency.
- Murray, S., 2022.** Government wants year-round water quality research for sea swimmers. *Irish Examiner*, 26/8/2022. <https://www.irishexaminer.com/news/arid-40948262.html>
- Natarajan, P., & Miller, A., 2016.** Recreational Infections. *Infectious Diseases*, 643–646.
- Ng, K. T., Rapp-Wright, H., Egli, M., Hartmann, A., Steele, J. C., Sosa-Hernández, J. E., Melchor-Martínez, E. M., Jacobs, M., White, B., Regan, F., Parra-Saldivar, R., Couchman, L., Halden, R. U., & Barron, L. P., 2020.** High-throughput multi-residue quantification of contaminants of emerging concern in wastewaters enabled using direct injection liquid chromatography-tandem mass spectrometry. *Journal of Hazardous Materials*, 398, 122933.

- Niknejad, H., Hoseinvandtabar, S., Panahandeh, M., Gholami-Borujeni, F., Janipoor, R., Sarvestani, R. A., Saeedi, R., Arani, M. H., Abtahi, M., & Rafiee, M., 2024.** Quantitative microbial risk assessment of gastrointestinal illness due to recreational exposure to *E. coli* and enterococci on the southern coasts of the Caspian Sea. *Heliyon*, 10(9), e29974.
- NFU, 2023.** Diffuse Water Pollution Guidance – NFU online accessed July 25th 2023
- Novotny, V., 1994.** Water Quality: Prevention, Identification and Management of Diffuse Pollution. New York: Van Nostrand-Reinhold Publishers. ISBN 978-0442005597
- Obiri-Danso, K., Jones, K., & Nigel, P., 1999.** The effect of the time of sampling on the compliance EU Directive on Bathing water quality. *Journal of Coastal Conservation*, 5(1), 51–58.
- O’Connell, S., 2021.** Taking the plunge when it comes to open-water swimming. *The Irish Times*, 5/07/2021. <https://www.irishtimes.com/special-reports/get-active/taking-the-plunge-when-it-comes-to-open-water-swimming-1.4605879>
- Oliver, D., & McDougall, C. W., 2023.** Benefits and risks of wild swimming in Scotland. Version 1.1. Faculty of Natural Sciences, University of Stirling. Dataset. <http://hdl.handle.net/11667/211>
- Oliver, D. M., McDougall, C. W., Robertson, T., Grant, B., Hanley, N., & Quilliam, R. S., 2023.** Self-reported benefits and risks of open water swimming to health, wellbeing and the environment: Cross-sectional evidence from a survey of Scottish swimmers. *PLOS ONE*, 18(8), e0290834.
- Ordulj, M., Jozić, S., Baranovi´, M., & Krželj, M., 2022).** The Effect of Precipitation on the Microbiological Quality of Bathing Water in Areas under Anthropogenic Impact. *Water*, 14, 527.
- Outdoor Swimmer, 2021.** Trends Report. https://outdoorswimmer.com/wp-content/uploads/2022/04/TrendsReport_Full_LR.pdf
- Parker, C., 2010.** Swimming: The ‘Ideal’ Sport for Nineteenth-century British Women. *The International Journal of the History of Sport*, 27(4), 675–689.
- Rapp-Wright, H., Regan, F., White, B., & Barron, L.P., 2023.** A year-long study of the occurrence and risk of over 140 contaminants of emerging concern in wastewater influent, effluent and receiving waters in the Republic of Ireland. *The Science of the Total Environment*, 860, 160379.
- Richards, C.E., Tzachor, A., Avin, S. Fenner, R., 2023.** Rewards, risks and responsible deployment of artificial intelligence in water systems. *Nature Water*, 1, 422–432.
- Ritabrata, R., 2019)** An Introduction to water quality analysis. *International Journal for Environmental Rehabilitation and Conservation*, IX(1), 94–100.
- Rozen, Y., & Belkin, S., 2001.** Survival of enteric bacteria in seawater, *FEMS Microbiology Reviews*, 25(5), 513–529.
- RTE, 2023a.** Most swimming sites ‘excellent’, three deemed poor – EPA. 12/05/2023. <https://www.rte.ie/news/environment/2023/0512/1383133-bathing-water-epa/>
- RTE, 2023b.** 94 Irish beaches and marinas awarded Blue Flag for 2023. 19/05/2023. <https://www.rte.ie/news/2023/0519/1384550-blue-flag/>
- Schets, F. M., De Roda Husman, A. M., & Havelaar, A. H., 2011.** Disease outbreaks associated with untreated recreational water use. *Epidemiology & Infection*, 139, 1114–25.
- Smith. N., Foley, R., Georgiou, M., Tiegies, Z., & Chastin, S., 2022.** Urban Blue Spaces as Therapeutic Landscapes: “A Slice of Nature in the City”. *International Journal of Environmental Research & Public Health*, 19(22):15018.
- Strathmann, M., Horstkott, M., Koch, C., Gayer, U., & Wingender, J., 2016.** The River Ruhr – an urban river under particular interest for recreational use and as a raw water source for drinking water: The collaborative research project “Safe Ruhr” – microbiological aspects. *International Journal of Hygiene & Environmental Health*, 219(7 Pt B):643–661.
- Streck, G., 2009.** Chemical and biological analysis of estrogenic, progestagenic and andro-genic steroids in the environment. *TrAC Trends in Analytical Chemistry*, 28, 635–652.
- Swim England, 2017.** The health and wellbeing benefits of swimming. Swim England. <https://www.swimming.org/swimengland/health-and-wellbeing-benefits-of-swimming/>
- Swim Ireland, 2022.** Strategic Plan 2022-2026. Swim Ireland. <https://swimireland.ie/wp-content/uploads/sites/2/2023/02/Swim-Ireland-Strategic-Plan-2022-2026.pdf>
- Tahar, A., Tiedeken, E.J., Clifford, E., Cummins, E., & Rowan, N., 2017.** Development of a semi-quantitative risk assessment model for evaluating environmental threat posed by the three first EU watch-list pharmaceuticals to urban wastewater treatment plants: An Irish case study. *The Science of the Total Environment*, 603–604, 627–638.

- Treacy, J., 2015.** Wastewater Operation Requirements and Distribution Systems. In S. Eslamian (ed.) *Urban Water Reuse Handbook*. Boca Raton, FL: CRC Press. DOI: 10.1201/b19646-47
- UN, 2011.** water quality online waterquality_policybrief.pdf accessed Jan 30th 2025
- Wade, T. J., Calderon, R. L., Brenner, K. P., Sams, E., Beach, M., Haugland, R., Wade, T. J., Sams, E., Brenner, K. P., Haugland, R., Chern, E., Beach, M., Wymer, L., Rankin, C. C., Love, D., Li, Q., Noble, R., & Dufour, A. P., 2010.** Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: a prospective cohort study. *Environmental Health: a global access science source*, 9, 66. Water Safety Ireland., 2023). WSI Open Water Swimming: Safety first! <https://watersafety.ie/wp-content/uploads/2023/05/WSI-Open-Water-information.pdf>
- Wood, L. E., Vimercati, G., Ferrini, S., & Shackleton, R. T., 2022.** Perceptions of ecosystem services and disservices associated with open water swimming. *Journal of Outdoor Recreation and Tourism*, 37, 100491.
- Wu, B., 2020.** Chapter 6 – Human health hazards of wastewater. In Hongqiang Ren, & Xuxiang Zhang (eds.) *High-Risk Pollutants in Wastewater*. Pages 125-139. Amsterdam: Elsevier.
- Wyer, M. D., Kay, D., Morgan, H., Naylor, S., Clark, S., Watkins, J., Davies, C. M., Francis, C., Osborn, H., & Bennett, S., 2018.** Within-day variability in microbial concentrations at a UK designated bathing water: Implications for regulatory monitoring and the application of predictive modelling based on historical compliance data, *Water Research X*, 1, 100006.
- Wyness, A. J., Paterson, D. M., Rimmer, J. E. V., Defew, E. C., Stutter, M. I., & Avery, L. M., 2019.** Assessing Risk of *E. coli* Resuspension from Intertidal Estuarine Sediments: Implications for Water Quality. *International Journal of Environmental Research & Public Health*, 16, 3255.
- Ziylan, A., & Ince, N. H., 2011.** The occurrence and fate of anti-inflammatory and analgesic pharmaceuticals in sewage and fresh water: Treatability by conventional and non-conventional processes. *Journal of Hazardous Materials*, 187(1-3), 24–36.

