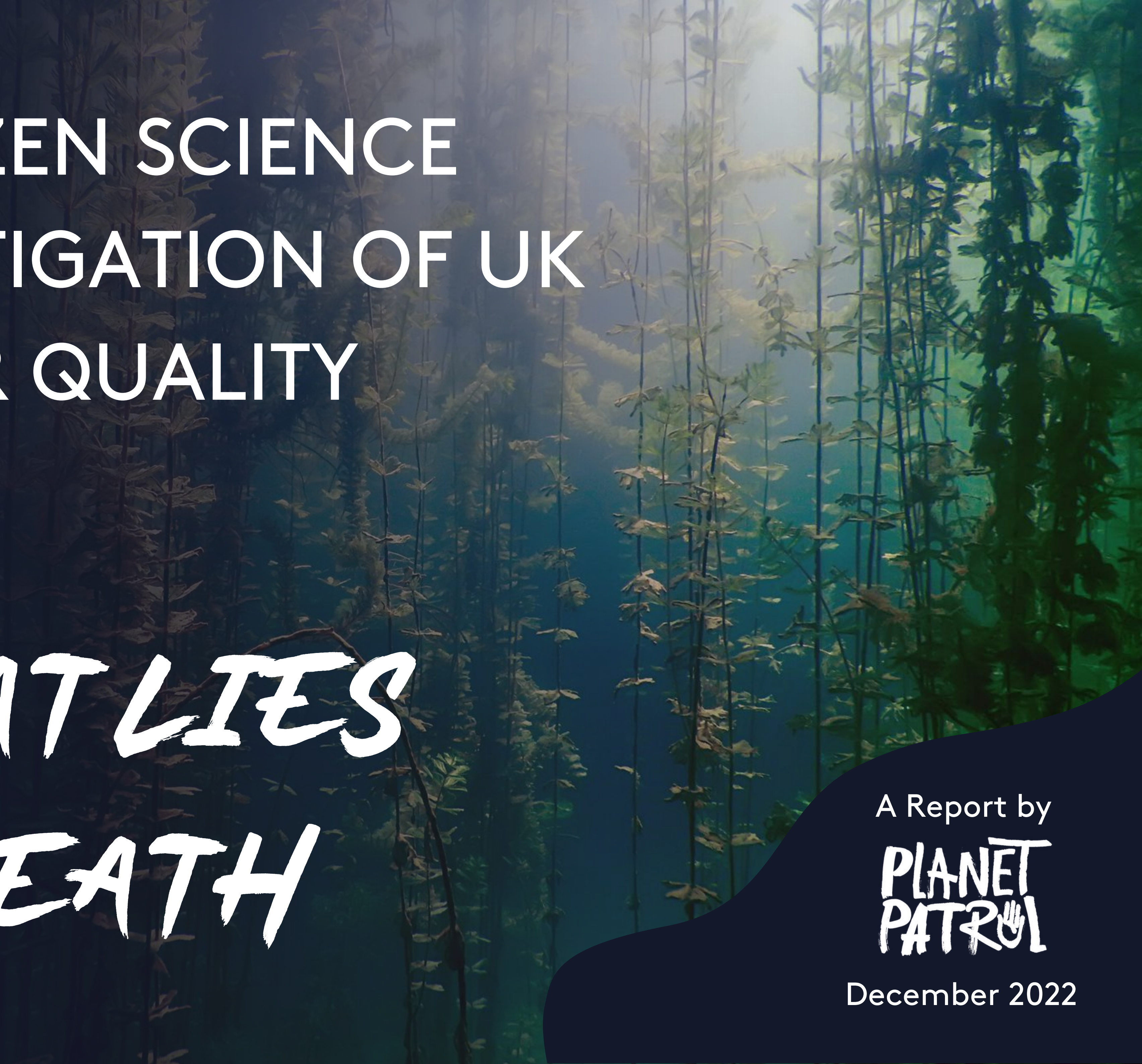
A CITIZEN SCIENCE INVESTIGATION OF UK WATER QUALITY

WHAT LIES BENEATH



A Report by

PLANET PATROL

December 2022

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FOREWORD

We are all connected by the same waters. It is critical to life on earth but this essential part of the climate discussion is often overlooked. More than 1 billion people worldwide still lack basic access to clean water and it has been predicted that by 2025, two-thirds of the world's population will be facing water shortages. We are witnessing more intense and frequent storms globally and record droughts across the northern hemisphere have hit this summer.

I've paddleboarded all over the world to bring attention to environmental issues and how they affect our waterways. It doesn't matter where I am, witnessing pollution and its impact is inescapable. Often it is visible in the form of plastic and other litter, spillages and odours but, sometimes, it's far more insidious. It's the subtle and gradual signs of pollution, largely unrecognisable to the naked eye, but with catastrophic and long lasting effects.
In 2018, whilst training for a paddleboarding expedition on the River Trent, I fell ill from ingesting river water. At the time, I put my illness down to misfortune but now I know it was not an isolated incident.

Poor water quality is as much a human health hazard as it is an ecological one.

It was this experience, and hearing many more like it from other water users, that prompted me to start investigating water quality and its true impact on both human health and aquatic environments.

By 2019, I'd completed three world firsts on my paddleboard and had written a guidebook of the UK's waterways. Planet Patrol, the non-profit I set up in 2016, had grown into a nationwide network of paddleboarding clean-ups to capture litter data through citizen science. I was actively encouraging people to get on the water - the place that had restored my health after a cancer diagnosis a few years earlier - and I felt duty bound to do more. Not only to make people better informed, but to act on the increasingly urgent issue of poor water quality to help restore the health of our precious waterways.

This year we widened the citizen science opportunities at Planet Patrol. We ran the first ever observational survey looking into the state of UK waterways launched in October 2022. Autumn Water Watch invited participants to collect data about visible signs of pollution in and around freshwater environments. The findings reinforced the clear disconnect that exists between public perception and the reality of the water quality crisis - because so much of the damage is hidden below the water's surface.

But, through our growing community of citizen scientists we've started to uncover what lies beneath to highlight a stark reality: the widespread, poor condition of our freshwater environments. The results have been disturbing.

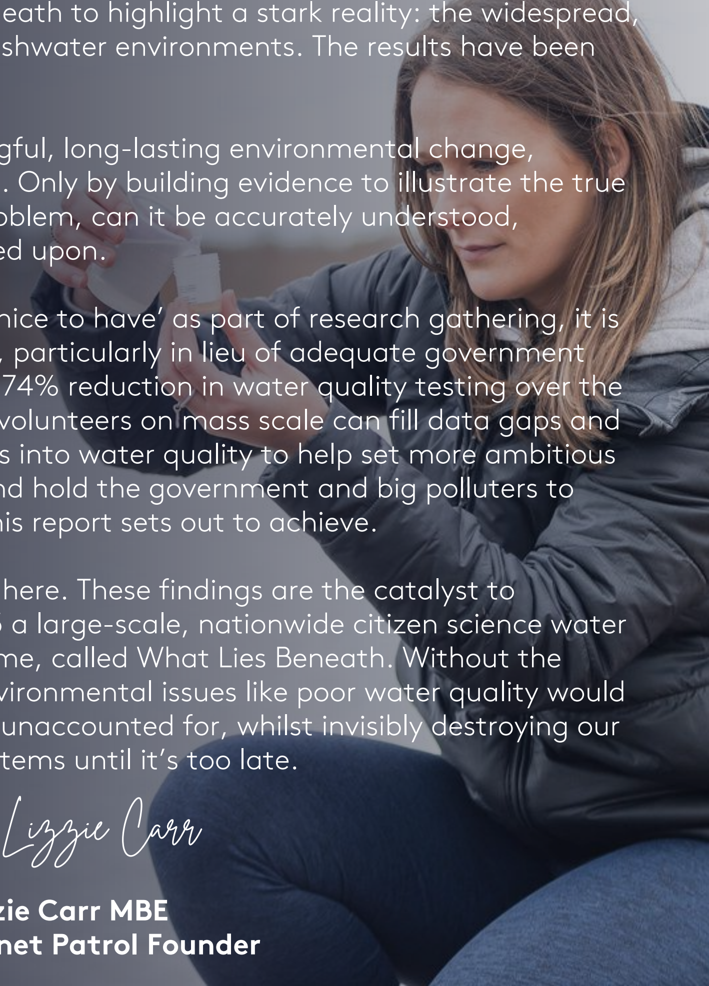
In order to drive meaningful, long-lasting environmental change, gathering data is crucial. Only by building evidence to illustrate the true scale and extent of a problem, can it be accurately understood, communicated and acted upon.

Citizen science is not a 'nice to have' as part of research gathering, it is an essential component, particularly in lieu of adequate government funding that has seen a 74% reduction in water quality testing over the last 10 years. Deploying volunteers on mass scale can fill data gaps and provide real time insights into water quality to help set more ambitious targets across the UK and hold the government and big polluters to account. That is what this report sets out to achieve.

We don't intend to stop here. These findings are the catalyst to launching in Spring 2023 a large-scale, nationwide citizen science water quality testing programme, called What Lies Beneath. Without the efforts of volunteers, environmental issues like poor water quality would persist, unobserved and unaccounted for, whilst invisibly destroying our environment and ecosystems until it's too late.

Lizzie Carr

Lizzie Carr MBE
Planet Patrol Founder



EXECUTIVE SUMMARY

Water quality is in crisis in the UK. According to the European Union Water Framework Directive (EU WFD), there is not a single river in the UK that is currently in an overall state of 'good' health. There is an urgent and growing need to clean up the UK's waterways.

Planet Patrol has produced this water quality report to investigate the current state of waterways in England and Scotland. Data was gathered by 57 volunteer citizen scientists at testing sites across the UK who measured six different parameters. Through analysis of these results, Planet Patrol presents a collection of key findings, summarised below, based on location and made a series of recommendations for action.

Critically, three sites failed to meet acceptable standards across five parameters tested.

Sites on the River Wey near Sutton Green, the Upper River Ivel near Radwell and the River Mole near Dorking all exhibited unacceptable levels of nitrates and nitrites, phosphate, total coliform presence, and unacceptable pH-levels.

A further twenty sites failed to meet acceptable standards for both phosphate and nitrate levels.

This encompasses 41.67% of all testing sites.

Only one testing site – the River Dart near Dittisham - met the acceptable criteria for five parameters tested.

This means that all other sites failed to meet an acceptable standard of water quality for at least one of the pollutants measured.

Considering the states of waterways in terms of the pollutants measured gives the following key findings:

POLLUTANT	KEY FINDING
NITRATE	**48.43%** of all test results failed to meet an acceptable concentration.
NITRITE	**9.44%** of all test results failed to meet an acceptable concentration.
PHOSPHATE	**69.17%** of all test results failed to meet an acceptable concentration.
PH	**25.91%** of all test results were outside the tolerable pH range.
TOTAL COLIFORM BACTERIA	**85.97%** of all test results were positive for total coliform bacteria.
METALS	The majority of the sites surface water was found to be within acceptable limits for the 31 metals tested. However, there were the following five instances of failure: 1 - One site was above the Environmental Quality Standard (EQS) for copper. 2 - One site was above the EQS for zinc. 3 - One site was above the WHO drinking water standard for manganese. 4 - Four sites were above the proposed short term predicted no-effect concentration (PNEC) for iron. 5 - Six sites were above the UK Drinking Water Standard for potassium.

Table 1 outlines the key findings for each pollutant measured.

RESULTS BY LOCATION

✓ PASS ✗ FAIL

Pass and fail thresholds outlined in section 3

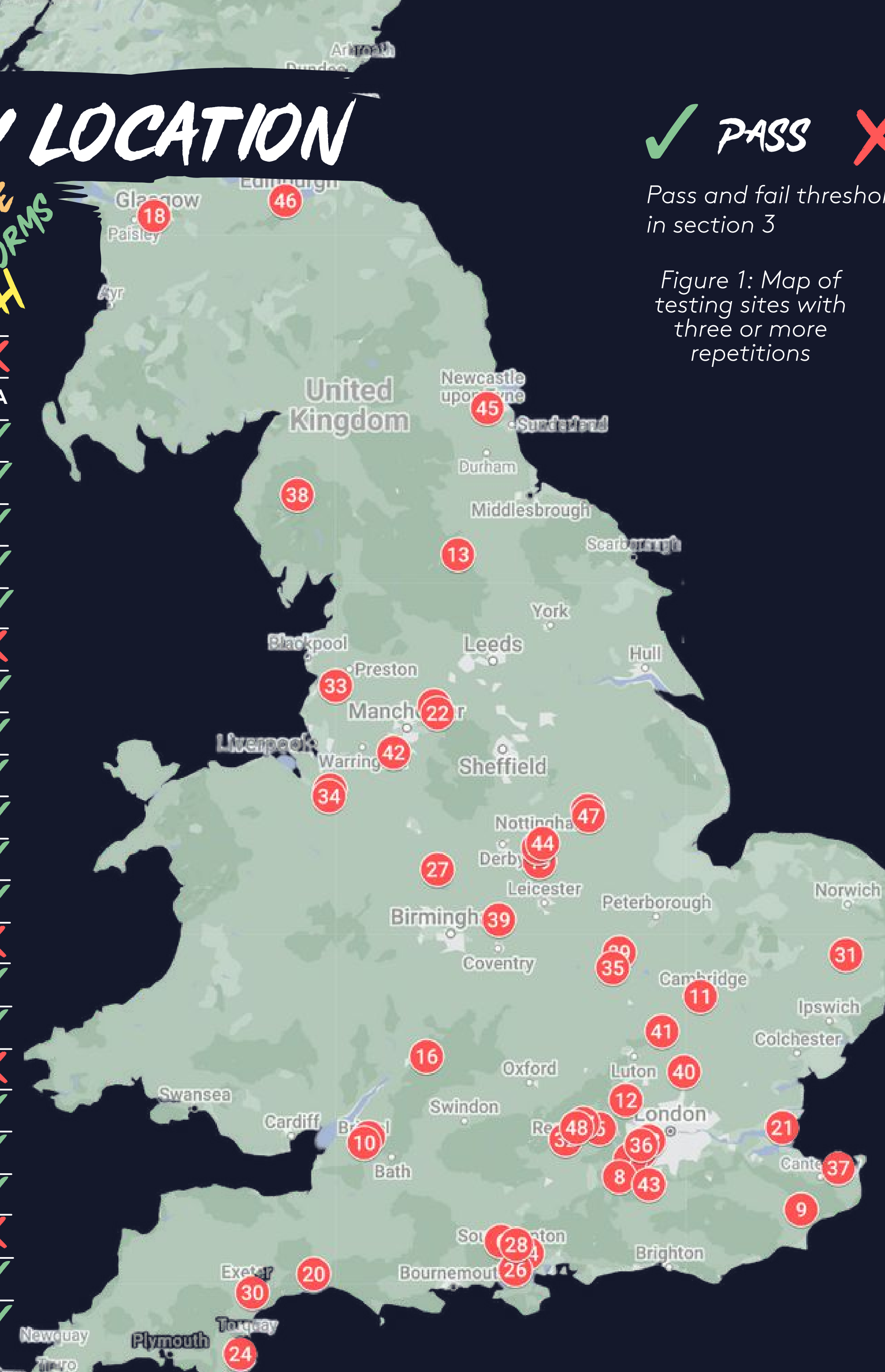


Figure 1: Map of testing sites with three or more repetitions

WATERWAY	NITRATE	NITRITE	PHOSPHATE	COLIFORMS	PH
1 RIVER DEE	✓	✓	✗	✗	✗
2 RIVER FROME	✓	✓	✗	NA	NA
3 RIVER THAMES	✗	✓	✗	✗	✓
4 RIVER TRENT	✓	✗	✓	✗	✓
5 RIVER THAMES	✗	✓	✓	✗	✓
6 RIVER TEST	✗	✓	✓	✗	✓
7 WEY NAVIGATION	✓	✗	✗	✗	✓
8 RIVER WEY	✗	✓	✗	✗	✗
9 EAST STOUR RIVER	✗	✓	✗	✗	✓
10 BRISTOL FEEDER CANAL	✗	✓	✗	✗	✓
11 RIVER CAM	✓	✗	✗	✗	✓
12 RIVER CHESS	✗	✓	✗	✗	✓
13 RIVER URE	✓	✓	✓	✗	✓
14 RIVER HAMBLE	✓	✓	✗	✗	✓
15 RIVER TAME	✓	✓	✓	✗	✗
16 HATHERLEY BROOK	✓	✓	✗	✗	✓
17 RIVER THAMES	✓	✗	✗	✗	✓
18 RIVER KELVIN	✓	✓	✓	✗	✗
19 KINGSTON BROOK	✓	✓	✗	✗	✓
20 RIVER AXE	✓	✓	✗	✗	✓
21 THAMES ESTUARY	✓	✗	✗	NA	✓
22 RIVER TAME	✓	✓	✓	✓	✗
23 RIVER THAMES	✗	✓	✗	✗	✓
24 RIVER DART	✓	✓	✓	✓	✓

WATERWAY	NITRATE	NITRITE	PHOSPHATE	COLIFORMS	PH
25 RIVER TRENT	✗	✓	✗	✗	✓
26 THE DARK WATER	✓	✓	✓	✗	✗
27 RIVER TRENT	✗	✓	✗	✗	✓
28 RIVER ITCHEN	✗	✓	✗	✗	✓
29 RIVER NENE	✗	✓	✗	✗	✓
30 RIVER EXE	✗	✓	✗	✗	✓
31 RIVER WAVENEY	✓	✓	✓	✗	✓
32 RIVER THAMES	✗	✓	✗	✗	✓
33 LEEDS LIVERPOOL CANAL	✓	✓	✓	✗	✓
34 RIVER DEE	✓	✓	✓	✗	✓
35 RIVER NENE	✗	✓	✗	✗	✓
36 RIVER CRANE	✗	✓	✗	✗	✓
37 RIVER STOUR	✗	✓	✗	✗	✓
38 DERWENTWATER	✓	✓	✗	✗	✗
39 COVERNTRY CANAL	✓	✓	✓	NA	✓
40 RIVER LEA	✗	✓	✗	✗	✓
41 RIVER IVEL	✗	✓	✗	✗	✗
42 RIVER BOLLIN	✗	✗	✗	NA	✓
43 RIVER MOLE	✗	✓	✗	✗	✗
44 RIVER TRENT	✗	✓	✗	✗	✓
45 THE OUSEBURN	✓	✓	✗	✗	✓
46 EDINBURGH CANAL	✓	✓	✓	✗	✓
47 BALDERTON LAKE	✗	✗	✗	NA	✓
48 RIVER THAMES	✗	✓	✓	NA	NA

RECOMMENDATIONS

1. The Secretary of State for DEFRA (currently Thérèse Coffey MP) to reject plans to amend the legislation that requires 75% of English rivers to achieve 'good' status by 2027.

2. DEFRA to bring forward the enforcement[EA1] date for the increase in Variable Monetary Penalties for polluting water companies to 1st February 2023.

3. DEFRA to strengthen the effectiveness of the Storm Overflows Discharge Reduction Plan (SODRP) by making the following amendments:

    Amendment A: Reduce the maximum achievement date on all SODRP targets to be 2035 rather than 2050.

    Amendment B: Prohibit water companies from increasing water bills to fund the critical infrastructure investment required.

4. The Environmental Agency to accelerate the speed at which citizen science is integrated into formal data collection activities for developing evidenced-based policies.

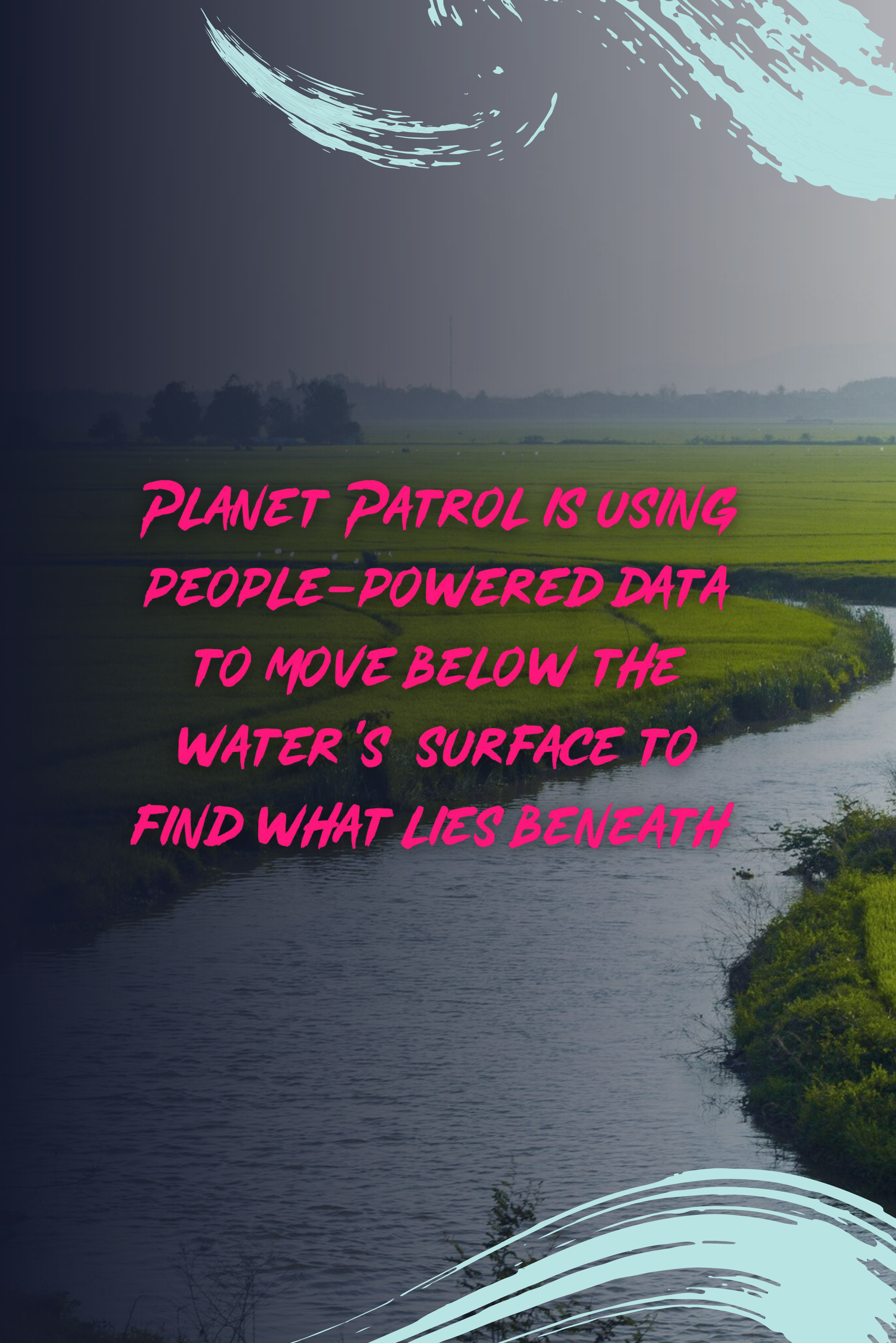
5. Use funds raised from the increase in Variable Monetary Penalties for polluting water companies, to increase the criminal prosecution rates of those who damage water quality.

INTRODUCTION

All around us, the world's waterways are threatened by a seemingly-endless wave of pollution but, since 2016, Planet Patrol has been on a path to reverse this. Six years later and the core values of our mission are stronger than ever. Planet Patrol is determined to inspire collective action; to educate through people-powered research and to hold both big polluters and theUK government responsible.

To stop this flow of pollution, data is crucial. Only then can the true scale of the problem be accurately understood and more informed decisions made to better protect the environment. To build a widespread, scientifically robust repository of evidence, Planet Patrol launched a participatory app through which the general public can engage in citizen science. To date, litter has been recorded in 83 countries globally. Together, app users have removed and recorded almost half a million pieces of litter from every continent, except Antarctica.

However, the environmental issues affecting waterways extend well beyond plastics and other litter. In 2020 Planet Patrol saw its first paddle boarding litter pick cancelled due to poor water quality after a sewage discharge in a river. In 2021, additional events in more locations were cancelled for the same reason. It was time to expand the scope of research and cast the 'data collection net' beyond just plastics and litter, using people-powered data to move below the water's surface to find what lies beneath.



1.1 Current State of Water

In 2017, the UK transposed the EU Water Framework Directive into the Water Environment Regulations of 2017 in England and Wales. This law included the EU Water Framework Directive's requirements for 'good ecological status' metric and 'good chemical status' and the requirement that 75% of English rivers are to achieve 'good' status by 2027 . Currently in the UK there is not a single body of water that achieves 'good' chemical status[1] and no river is in 'good' overall health. In fact, with only 16% of England's waters reported as having 'good' ecological status, England's surface water bodies rank as some of the worst in Europe.

Worse still, not only has the percentage of UK waters reporting 'good' ecological status flatlined at 16% since 2016, the UK government is now proposing amendments to the Water Framework Directive in the EU Law (Revocation and Reform) Bill which will extend the 2027 target date for improving water quality or abolish the Water Directive timelines entirely. This is why we present Recommendation 1, as this proposed change in law will likely result in a further deterioration of water quality.

DEFRA also outlines commitments to improving freshwater as part of its 25 Year Environment Plan. The Plan pledges to restore 75% of the UK's one million hectares of terrestrial and freshwater protected sites to favourable conditions by 2042. It also promises to return at least 75% of our waters to as close to their natural state as soon as is 'practicable'[2] and introduce a Storm Overflow Discharge Reduction Plan with a set of stringent new targets to protect people and the environment[3]. Whilst DEFRA have delivered a Storm Overflows Discharge Reduction Plan, as we outlined in Recommendation 3, this does not go far enough given the the worsening state of our waterways. Furthermore the UK Government has continued to cut environmental funding from £120 million in 2009 to just £40 million by 2020. As a result, the number of water quality samples taken by the Environment Agency fell from 160,000 in 2013 to just 41,519 in 2021 (most recent statistics available). That is a 74% reduction in testing[4].

Government Commitments

- All rivers in 'good ecological status' by **2027** ✗
- 75% of terrestrial and freshwater protected sites restored to favourable conditions by **2042** ✗
- At least three quarters of water returned to as close to natural state as soon as 'practical' ✗

27% of rivers met good ecological status in 2010

14% of rivers met good ecological status in 2019

*Note that different methodology was used to assess ecological status by the EA in 2010 and 2019

14% of English rivers have 'good' ecological status[1]

0 rivers in England have 'good' chemical status[1]

1.2 THE CAUSES OF POOR WATER HEALTH

Understanding the root causes that contribute to the poor health of waterways is crucial to tackling the problem. The January 2022 Water Quality Inquiry Report[5] published by the Environmental Audit Committee outlines the main factors preventing water bodies in England from achieving a good status.

Aside from the often unavoidable physical modification of rivers, particularly in urban environments, the main factors driving poor water health are:

Statistics relate to waterways in England[1]

The causes of poor water health vary by environment. For instance, urban rivers are expected to be most impacted by sewage and urban diffuse pollution, whereas rural rivers are more at risk from agricultural pollution.

Whether from agriculture or sewage sources, nutrient pollution – such as nitrates, nitrites and phosphates - negatively impacts upon water quality. The prevalence of these excess nutrients is a matter of grave concern. In England, 27 water catchments, which include 31 internationally important water bodies and protected sites, are now in an unfavourable condition due to an excess of nitrates, nitrites and phosphates.[6]

1.3 THE FUTURE OF WATERWAYS

The UK's waterways are intrinsic to people's livelihoods.They are extremely valuable for nature and biodiversity as well as personal wellbeing. As such, the poor water quality currently observed in the UK is likely to have severe economic and environmental implications.

Under the Water Framework Directive there is a legal obligation to improve water quality by 2027 and as the Retained EU Law Bill has not yet gone through Parliament,[7] the 2027 target remains intact.

However as we have previously outlined in this report and in the recommendations, despite there being a legal obligation to improve water quality by 2027, the timelines attached to announced government interventions either overshoot 2027 (as in the Storm Overflow Discharge Reduction Plan) or do not attach specific enforcement dates (as with increase in Variable Monetary Penalties for polluters).

Unless remedial steps are taken, the EA predicts that climate change will exacerbate the poor health of waterways, causing further harm.

The UK climate change projections (UKCP18)[8] predicts hotter drier summers; milder, wetter winters; rising sea levels and the more frequent occurrence of extreme weather events. Although the effects will vary based on geographical location, it is expected that a changing climate will alter the flow of many UK rivers.[9] In scenarios of lessening river flow, concentrations of pollutants will be higher resulting in greater impacts on biodiversity. In other locations rainfall is predicted to increase, potentially resulting in a higher frequency of combined sewer overflow usage, and consequently a higher frequency of heavily polluted wastewater being released into the environment.[10] It is likely run-off from agricultural land and urban areas would also increase.

In addition to being forecast to be severely impacted by climate change, waterways are also a key component in many climate adaptation responses. In a review of 1,800 climate adaptation strategies, over 80% were water-related.[11] It is therefore clear that not only is clean water essential for human health, but also for tackling climate change. As waterways are on the frontline of the climate crisis it is essential that we take urgent action to improve water quality.

1.4 Introducing Planet Patrol's 2022 Water Quality Study

In May 2022, Planet Patrol launched its first citizen science water quality testing pilot. Tests were run extensively across five key parameters across the breadth of England and Scotland resulting in the largest national study of its kind. Planet Patrol recruited 57 members of the general public (not necessarily from scientific backgrounds) to take part.

Spread across England and Scotland, these volunteers were inducted through an initial webinar and provided with a detailed handbook, a series of video demonstrations, and instructions delivered within the Planet Patrol app. Once training was complete, Planet Patrol's citizen scientists began gathering data from their allocated testing site every other week for 12 weeks.

Planet Patrol continued to support volunteers throughout the sampling period via a series of focus groups and direct communication. This personalised approach helped facilitate an in-depth and consistent evaluation of the process and offered a dedicated space for volunteers to voice any feedback.

1,229

water quality readings taken

Following Planet Patrol's site selection guidance, testing locations covered a variety of rivers, canals, brooks and lakes in England and Scotland. The methodology used is fully replicable across other locations too. Many of the recommendations based on these findings hold relevance for the relevant government agencies in Wales, Scotland and Northern Ireland too.

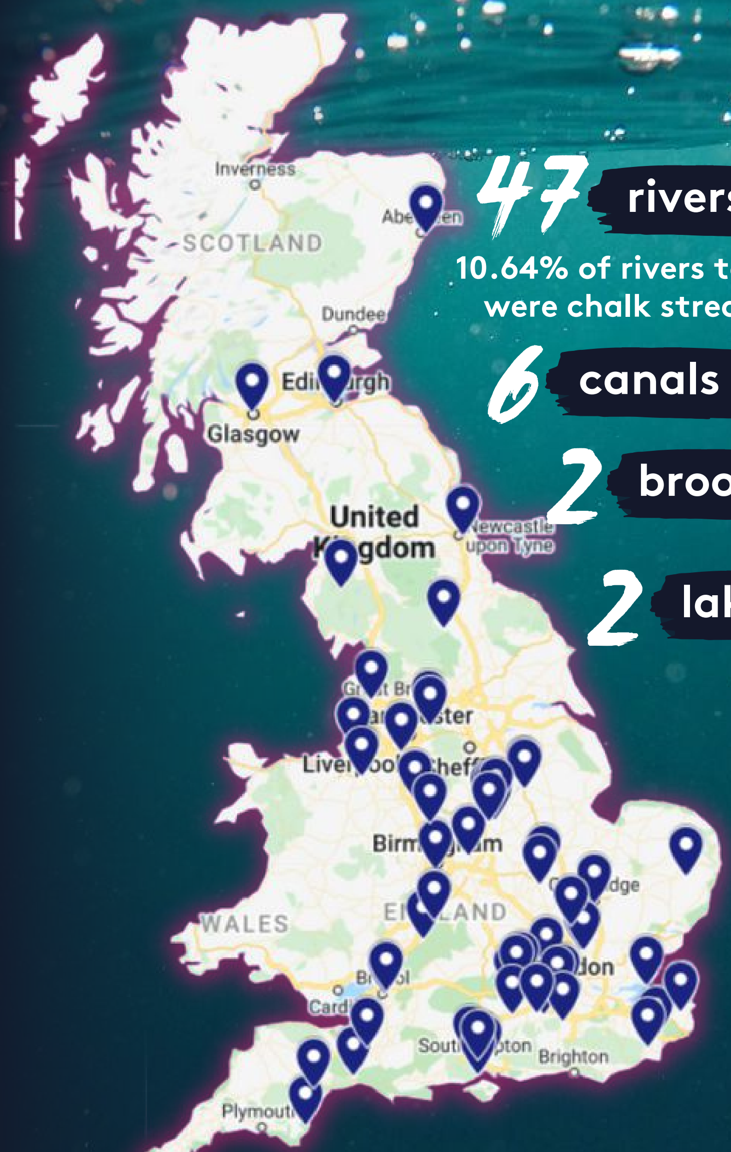
From May to July 2022, each citizen scientist tested their local waterway every two weeks. They measured concentrations of nitrates, nitrites and phosphates; they checked pH levels, and recorded the presence or absence of total coliform bacteria.

As well as these pollutants, citizen scientists also tested the presence of 31 different metals. Water samples from 38 locations were sent to laboratories at the University of Nottingham for analysis. In total, 1,178 metal concentration readings were taken from 38 water samples, revealing the differing concentrations of metals present at each geographical location.

Over the study period, 1,229 water quality readings were taken at 57 different testing sites. In 48 of these locations, three or more water quality readings were collected consistently across key dates for different parameters. For these locations, the median or mode values were calculated and the results could be used for inter-site comparison.

57 citizen scientists

48 sites with three or more repeat tests



47 rivers

10.64% of rivers tested were chalk streams

6 canals

2 brooks

2 lakes

Figure 2: Map of testing locations

1.5 Introduction to pollutants and metals tested

Nitrate

Compound of the element **nitrogen** and a form of **nutrient**

Sources: **agricultural run-off** and **sewage discharge**

Nitrite

Compound of the element **nitrogen** and a form of**nutrient**

Produced by the **nitrification** of **ammonia** by **bacteria**

Phosphate

Compound of the element phosphorus and a form of nutrient.

Sources: **agricultural run-off** and **sewage discharge**

pH

Measure of how **acidic** or **alkaline**a liquid is. Neutral water has a pH of 7. Below 7 it is acidic and above 7 it is alkaline.

Fluctuations in pH are usually related to pollution from **industry** such as **mining**, **smelting**or the **burning of coal**

Total Coliform Bacteria

Coliforms are a group of **faecal bacteria**

Sources: **agricultural run-off** and **sewage discharge**

Metals

Samples analysed for **31** different metals.

Sources: **abandoned mines**, **metal processing factories**, **road run-off** and **fertilisers**

METHODOLOGY

2.1 SAMPLING DESIGN

TThe sampling period ran from the 1st May until the 20th July 2022. Before sampling commenced, sites were selected based upon Planet Patrol's site-selection guidance and relevant training was delivered to volunteers. A variety of rivers, brooks, lakes and canals were chosen to represent the variety of waterbodies in the UK. As such, 57 different locations were selected for study.

The methodology was co-developed by Planet Patrol and Dr Thomas Stanton of Loughborough University.

Figure 3: Pages from the handbook

2.2 SITE-SELECTION GUIDANCE

Planet Patrol has specific guidance for site selection which has been used to inform location choice. Sampling sites should not require the volunteer to trespass, nor should they put the volunteer in danger. This means avoiding steep, slippery banks and potential hazards such as electric fences and barbed wire. It is also essential for volunteers to consider how they would get out, should they fall into the water. Volunteers were advised not to select a site directly downstream of an outfall to avoid bias. As Planet Patrol staff did not visit each site, it acknowledges that selected sites, in some cases, may not be representative of the waterbody as a whole.

2.3 TESTING SCHEDULE

The citizen scientists tested sites every second Sunday between the beginning of May and the end of July. In the event of sickness or absence, each volunteer was instructed to conduct tests as close as possible to the bi-monthly schedule. However, in some cases, volunteers were not able to test every two weeks for the reasons cited. Data gathered between the 1st of May and the 20th of July is included in this report.

2.4 Data collection

POLLUTANT	TESTING TECHNOLOGY
NITRATE & NITRITE	Concentration tested using Nitrate/Nitrite semi-quantitative test strips 
PHOSPHATE	Concentration tested using Insta-Test Phosphate (low range, 0-2500ppb) kit 
pH	Level tested using wide range pH water test kit 
TOTAL COLIFORM BACTERIA	Presence or absence (5 cfu/ml, which is 500 cfu/100ml) determined using bacteria water test kit 
METALS	The average concentration of 31 metals and the bioavailability and predicted no-effect concentrations of 5 metals were calculated by the University of Nottingham based on analysis of two filtered 30 ml water samples from each testing site. 

Table 2.4 outlines the testing methodology for each pollutant measured.

TThe testing approach outlined in Table 2 is not a methodology used by the EA and does not compare to a fully accredited laboratory-based analysis methodology, except for the metal analysis.

However, all selected test kits are from reputable, accredited supplies and provide a robust, cost-effective approach that can deliver immediate results.The relative simplicity of chosen test kits to collect data facilitates analysis at a volunteer-led spatial and temporal resolution.

Citizen scientists input every water quality reading taken into Planet Patrol's mobile app. Users are required to upload a photograph of their test kit - at the test site - each time they take a water quality reading.

There are also automatic geolocation and time stamp features in the app to reference exact location and timings for each upload, time-referenced and geotagged. Once the photograph is submitted, the user must complete information about the readings taken.

2.5 Data analysis and validation

To establish the relative water quality and health of each testing site, the following processes were used to analyse and validate test results.

2.5.1 Analysing test results

Each appointed citizen scientist was responsible for taking water quality readings at each sampling point every two weeks for 12 weeks - the duration of the study period. Therefore, at the majority of sampling points, six test results were collected in total. For all sites in which three or more readings for a pollutant were recorded, the median and mode values were calculated. In the event that the median or mode could be one of two values, the higher value was consistently chosen. By selecting the more conservative value, the likelihood of incorrectly categorising a site as in good health was reduced.

2.5.2 Identifying Nitrate Vulnerable Zones

All sites were screened to determine whether they qualified as a Nitrate Vulnerable Zone (NVZ). These are areas at risk of agricultural nitrate pollution and, according to the UK government, currently compromise 55% of land in England.[12] To identify NVZs, maps from DEFRA[13] and SEPA[14] were used. These sources revealed that 45.61% of testing sites (26 out of 57) were within NVZs.

2.5.3 Identifying proximity to polluting infrastructure

To establish the relative water quality and health of each testing site, the following processes were used to analyse and validate test results.

For each test site, the proximity to wastewater treatment plants, agricultural land and boat moorings was investigated. These three features have all been variously linked to elevated pollution levels.

Identifying wastewater treatment plants:
To link a test site to nearby wastewater treatments plants, the following process was used:

1. The test site was located on Google Earth.[15]
2. A 10km radius was set upstream from the test site.
3. Using the UWWTD treatment plants map,[16] wastewater plants within this 10km radius were identified.
4. The distance between the plant and the testing site was measured.
5. The proximity was recorded and used to analyse results.

Identifying agricultural land:
As well as calculating test site proximity to NVZs (outlined above), their closeness to agricultural land was also considered. However, as a diffuse pollution source, the specific source of agricultural pollution is hard to accurately identify. As such, a simple process was implemented:

1. Within a radius of 1km from each test site, both pastoral and arable agricultural land was identified on the bank of the waterways using Google Maps satellite view.[17]
2. The presence or absence of this land was recorded.

Identifying boat moorings:
A similar process was used to establish the presence of boat moorings:

1. Using Google Maps satellite view, boat mooring points were identified within 1km upstream of a test site.
2. The presence or absence of mooring points was recorded.

2.6 LIMITATIONS OF METHODOLOGY

2.6.1 Citizen science

As with all data sourced by citizen scientists, there is the potential for bias. Planet Patrol recognises that there may be preconceptions of the prevalence of certain pollutants in the waterways tested. However, the use of approved and verified testing kits reduces the risk of individual biases impacting the dataset.

2.6.2 Representativeness

As the testing period ran from the 1st May until the 20th July for pollutants, the results gathered do not reflect the entire calendar year. For example, these months typically correspond to a time of reduced rainfall. As a result, the water levels at test sites could have been at their lowest annual points. Following this pilot study, testing could have been conducted throughout a whole year in order to allow seasonal comparisons.

Water samples for metal analysis were collected on one day at each site. As such, they are not representative of the whole year. Nevertheless, these results offer a snapshot insight on metal pollution in water bodies UK-wide and act as a valuable starting point for further investigation into metal pollution.

Finally, tests were completed at different times of day between test sites and it is not possible to account for the impact that these variations may have had upon test results.

2.6.3 Human error

There was potential for human error in the interpretation of test kit colour charts. To reduce the likelihood of error, the training material recommended that all test results were checked by a second person. While supporting people would likely have been inducted by the volunteer citizen scientist, the level of knowledge they had is unknown. Nevertheless, 42.08% of tests were checked by another person.

The accuracy of test timings was another opportunity for human error. It was necessary to leave tests for set amounts of time prior to reading results for accuracy. Adhering to these timings was essential, as test colours naturally darken after the required time has elapsed. If timings were miscalculated, there was a possibility for incorrect readings.

42.08% **of tests were checked by another person**

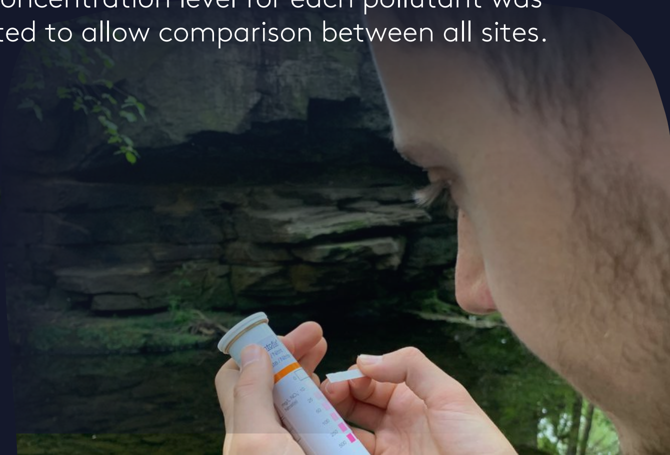
2.6.4 Storage temperatures

The coliform presence and absence test required an incubation period in participants' homes. The storage temperature would affect the outcomes of this process. As such, it was advised that all coliform tests were stored within an ideal temperature range of 20-32 degrees Celsius.

2.6.5 Testing kit ranges and standards

There was some discrepancy between the concentrations of pollutants measured using the testing kits and the acceptable level of concentration defined by the World Health Organisation (WHO) and the EA. For example, nitrites are defined as safe for drinking at a concentration of 3 mg/l or below. However, the nitrite testing kits established whether nitrites were present at a concentration of 5 mg/l. As such, if nitrite concentration exceeded 5 mg/l it was classed as a 'fail'. However, any testing sites with a concentration of nitrite between 3 mg/l and 5 mg/l would be categorised as a 'pass'. As a result, there is a risk that some testing sites, with a concentration of nitrite above the WHO drinking water guideline have been counted as safe.

Different water body types can have different safety threshold levels for pollutant concentrations. Due to the scope of this study, one concentration level for each pollutant was selected to allow comparison between all sites.



DISCUSSION

3.1 NITRATES AND NITRITES

While nitrates and nitrites are both naturally occurring nitrogen-based compounds, they are chemically and structurally different. A nitrate is formed of one nitrogen atom, bonded to three atoms of oxygen. A nitrite, on the other hand, is made of one nitrogen and only two oxygen atoms.These compounds are both harmful if they are out of balance in waterways.

3.1.1 SOURCES OF NITRATES AND NITRITES

Nitrates and nitrites originate from different sources. In England, agriculture is responsible for 70%[18] of all nitrates flowing into water courses. One reason for this prevalence is that nitrates are used extensively in fertilisers, pesticides and throughout the intensive farming of livestock and poultry. Rainfall regularly washes these pesticides and fertilisers from fields.

As this water runs-off of farmland, it flows into nearby water bodies. This running water also erodes agricultural topsoil, a process which carries additional nitrate pollution to surrounding waterways. A further 25-30%[19] of nitrate pollution is from sewage discharge and a [17] remaining small percentage is attributed to surface run-off and water contamination from animal waste.

Nitrites, on the other hand, are primarily produced via the nitrification of ammonia by bacteria. As nitrites were not found to be such a problem as nitrates (see section 3.1.2), their specific sources and impacts will not be as comprehensively addressed as those of nitrates in this report.

AGRICULTURAL RUN-OFF

Agriculture is responsible for 70% of nitrates flowing into water systems. Rainfall washes fertilisers, pesticides and topsoil off farmland into nearby water bodies.[16]

25-30%

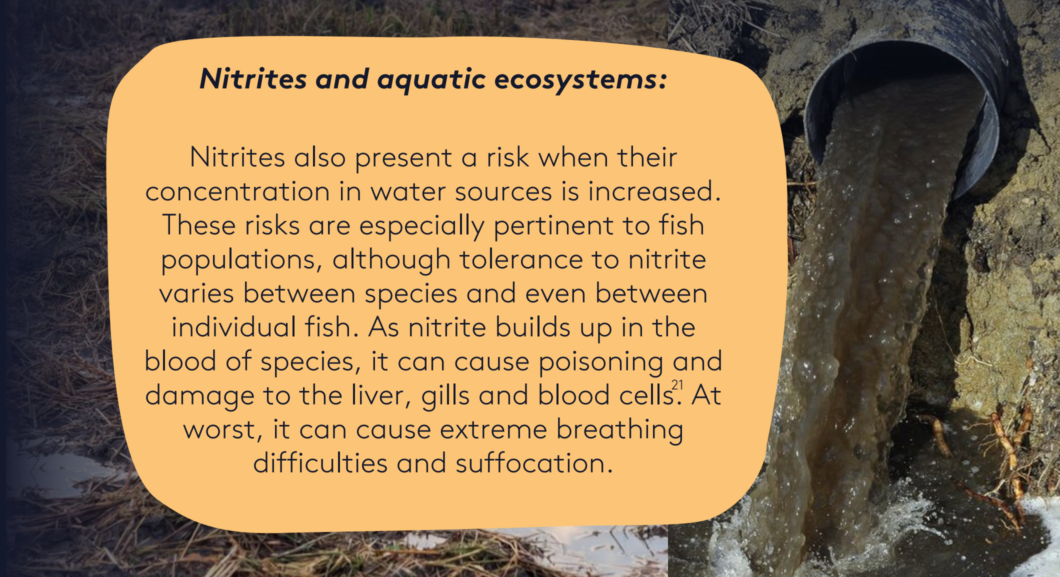
of nitrate pollution comes from sewage discharge[17]

3.1.2 IMPACTS OF NITRATES AND NITRITES

An excess of nitrates in water bodies creates a variety of environmental, social and economic impacts. To help combat the issues outlined below, 55% of land in England has been designated as a Nitrate Vulnerable Zone (NVZ). NVZ status is applied to areas of land that are at particular risk from agricultural nitrate pollution.

Treating drinking water for nitrates:
Consuming water containing an elevated concentration of nitrate would pose multiple risks to human health, especially for infants. As such nitrates must be removed from water before it is safe to drink at a cost of more than £8 million a year.[20] Thus cost is passed onto the consumer via water bills.

Although this processing is essential for human health, this type of nitrate removal offers no environmental benefits as the newly cleaned water is immediately extracted. As such, high levels of nitrates may exist, untreated, in non-drinking water sources throughout the UK.



Nitrites and aquatic ecosystems:

Nitrites also present a risk when their concentration in water sources is increased. These risks are especially pertinent to fish populations, although tolerance to nitrite varies between species and even between individual fish. As nitrite builds up in the blood of species, it can cause poisoning and damage to the liver, gills and blood cells.[21] At worst, it can cause extreme breathing difficulties and suffocation.

3.1.3 'ACCEPTABLE' LEVELS OF NITRATES AND NITRITES IN WATER SOURCES

NITRATE

PASS	FAIL
Nitrate concentration below 50 mg/l. This indicates no or low level of pollution.	Nitrate concentration greater than or equal to 50 mg/l. This indicates a high level of pollution.

Table 3 outlining the pass / fail criteria for nitrates

Thresholds from the European Commission Nitrates Directive and Drinking Water Directive have been transposed into UK law. It is accepted that a nitrate concentration of 50 mg/l or more is indicative of a 'high' concentration. There are no set standards for nitrate in the Water Framework Directive for inland waterways, which focuses on ammonia and dissolved inorganic nitrogen. In this report, a testing site exhibiting a concentration of nitrate greater than or equal to 50 mg/l is categorised as a 'fail'. Any testing site with a concentration of nitrate less than 50 mg/l is classed as a 'pass'. This categorisation allows comparison between the different testing sites.

NITRITE

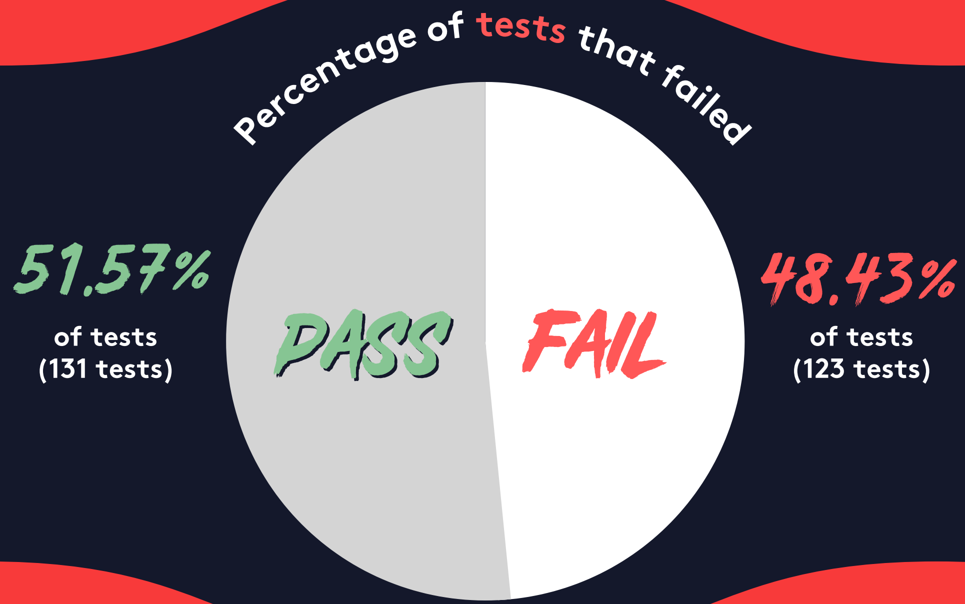
PASS	FAIL
Nitrite concentration below 5 mg/l. This indicates no or low level of pollution.	Nitrite concentration above or equal to 5 mg/l. This indicates a high level of pollution.

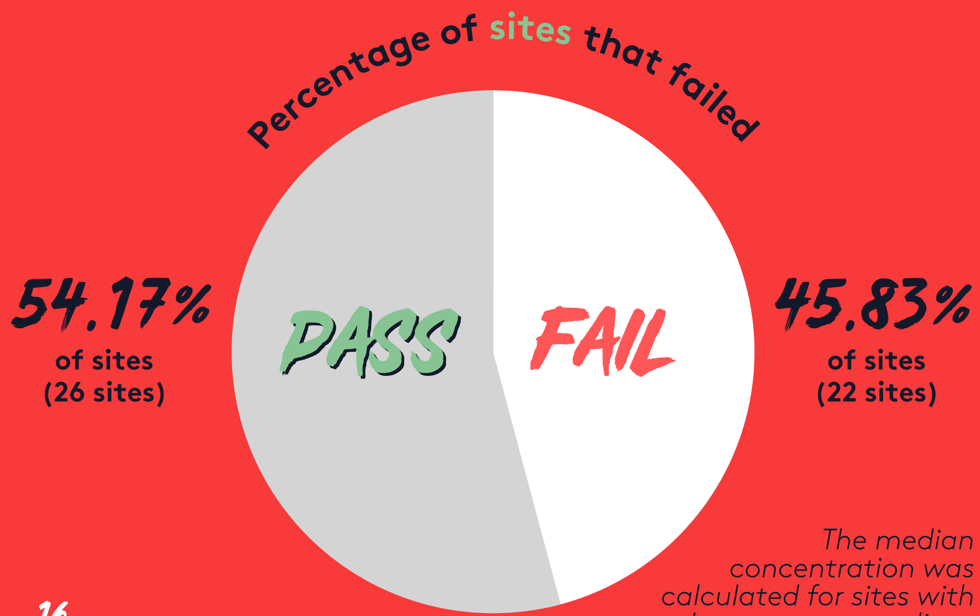
Table 4 outlining the pass / fail criteria for nitrites

There is not a clearly defined limit for nitrite pollution in waterways in the Water Framework Directive or other legislation. The most suitable guidelines available from Planet Patrol's research is the World Health Organisation (WHO) threshold for nitrite concentration in drinking water which is equal to or above 3 mg/l. However, it is unlikely (and not recommended) that a person in the UK will consume water directly from a freshwater source. Therefore, the most probable time in which a nitrite concentration above 3 mg/l could be a risk to human health, is if it is accidentally consumed during water sports or bathing.

Many aquarium maintenance websites recommend that the nitrite level should be as close to zero as possible, due to the compound's impact on fish. However, the testing kits used measure to 5 mg/l. As such, 5 mg/l was implemented as the boundary between pass and fail.

3.1.4 Nitrate Findings





The median concentration was calculated for sites with three or more readings

Throughout the sampling period, a total of 254 nitrate tests were completed. Collected at 48 different sites, the results show a concerning level of nitrate pollution across many of the country's' waterways. Nearly half of all nitrate tests (48.43%) exceeded a concentration of 50 mg/l and failed to meet acceptable levels of nitrate. Of the sites at which more than three readings were taken 45.83% had a median nitrate concentration of greater than or equal to 50mg/l.

However, the pass / fail split is dependent upon the acceptable concentration threshold adopted by the study. For instance, the FreshWater Habitats Trust uses more stringent guidelines than the ones provided by the European Commission Nitrates Directive and Drinking Water Directive used in this report. They suggest that any nitrate concentration above 2 mg/l[22] is of an unacceptable level. Using this threshold, the percentage of test results that fail would increase to 81.10% and the percentage of sites that would fail would increase to 81.25%. This percentage is likely to be higher, as the testing equipment allows volunteers to measure concentration to 10 mg/l.

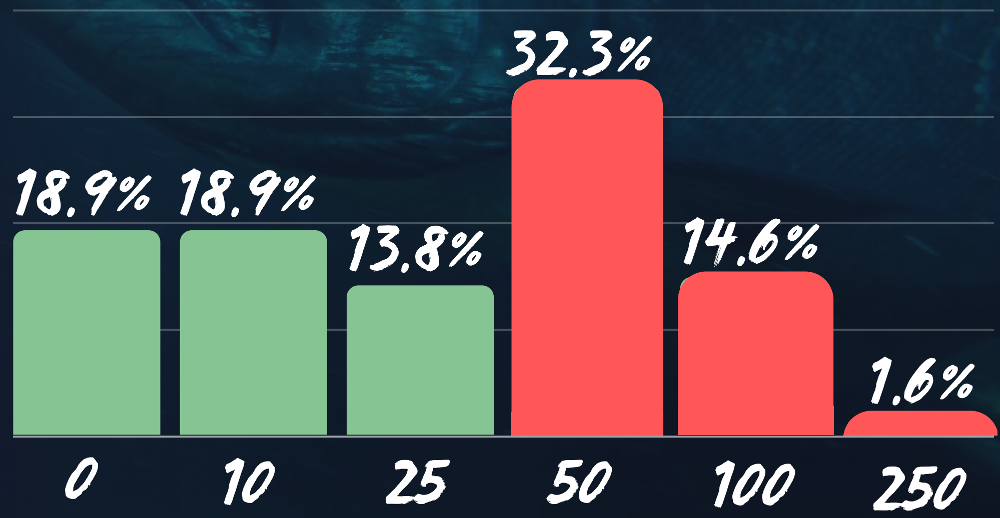


Figure 4 shows the percentage of each nitrate concentrations in milligrams per litre (mg/l) recorded across all sites

NITRATE FINDINGS BY LOCATION

First, Planet Patrol determined whether a testing site was within a NVZ. Of the test sites that had a median concentration of nitrate greater than or equal to 50mg/l and, as a consequence, failed their tests, 54.55% (12) are in the EA and Scottish Environmental Protection Agency (SEPA) designated NVZs. Of those sites that passed, 38.46% (10) were in an NVZ.

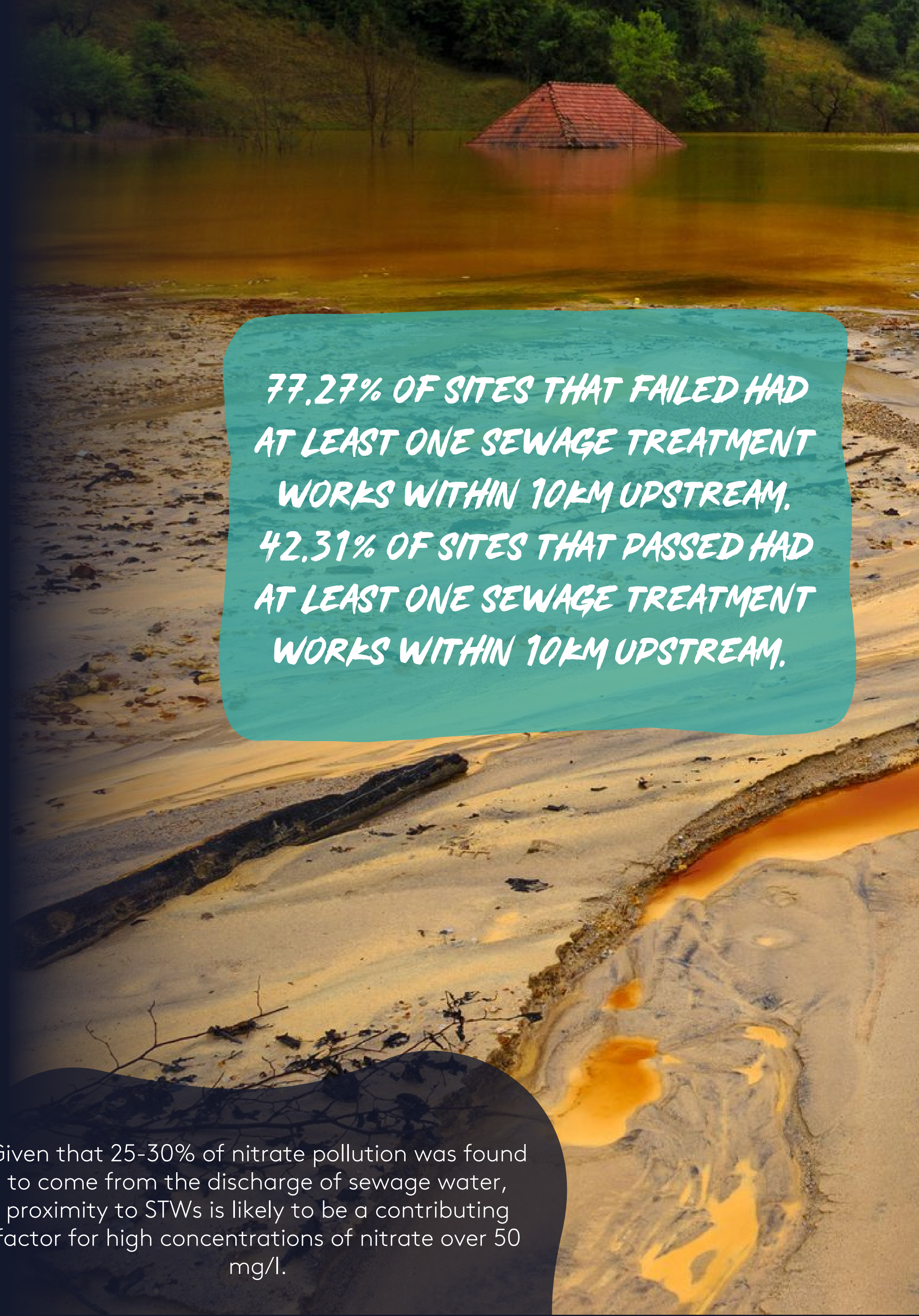
54.55%
of sites that failed were in a Nitrate Vulnerable Zone (NVZ)

It is worth noting that, according to Planet Patrol's initial data, being a designated NVZ is not a good predictor of nitrate pollution levels in waterways.

Next, the upstream land use of test sites was investigated. Sites with elevated nitrate concentrations (median greater than or equal to 50mg/l) were compared with the findings from testing sites reporting a 'safe' nitrate concentration (median less than 50 mg/l).

Proximity to sewage treatment works (STW), agricultural areas and boat moorings were all hypothesised as potential indicators of unacceptable nitrate levels. To test this hypothesis, a 10km radius was created around each site using Google Earth. This enabled the upstream land use to be defined.

NUMBER OF STW UPSTREAM	NUMBER OF SITES THAT FAIL	NUMBER OF SITES THAT PASS
1	10	6
2	4	6
3	1	6
4	1	1
5	1	0



77.27% OF SITES THAT FAILED HAD AT LEAST ONE SEWAGE TREATMENT WORKS WITHIN 10KM UPSTREAM. 42.31% OF SITES THAT PASSED HAD AT LEAST ONE SEWAGE TREATMENT WORKS WITHIN 10KM UPSTREAM.

Given that 25-30% of nitrate pollution was found to come from the discharge of sewage water, proximity to STWs is likely to be a contributing factor for high concentrations of nitrate over 50 mg/l.

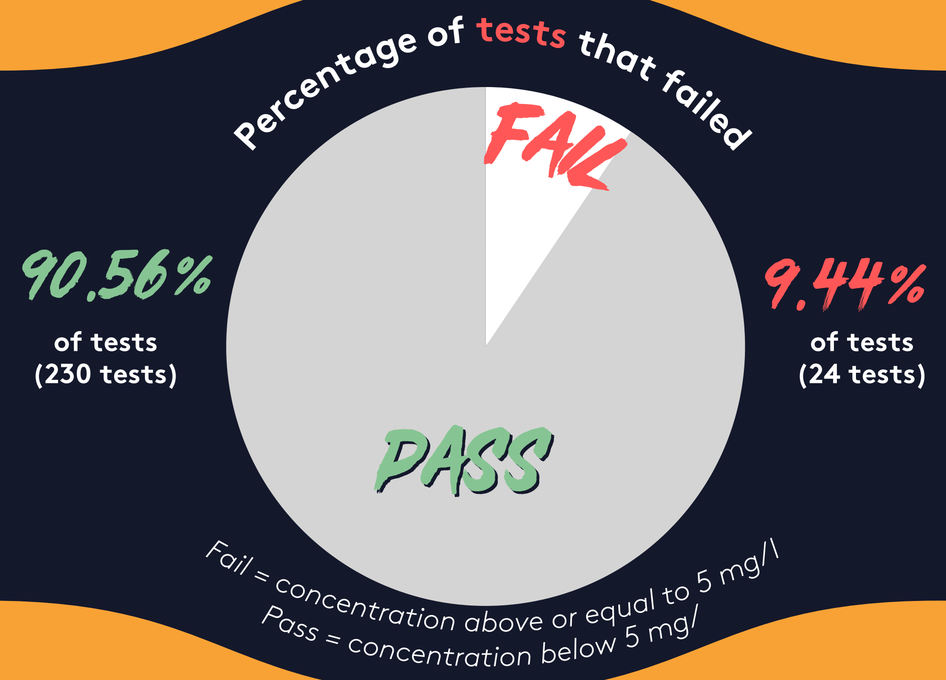
Next, proximity to agricultural land was considered. It has been established that agricultural processes account for 70% of nitrate pollution of waterways (section 3.1.1). Based on this assertion, testing sites in proximity to agricultural land are at particularly high risk of exceeding acceptable nitrate levels. For 72.73% (16 of 22) of sites that failed, agricultural land was identified within 1km upstream on the waterway bank. However, the figure was almost identical for sites that passed. A total 73.08% (19 of 26) of these sites had agricultural land within 1km upstream on the waterway bank.

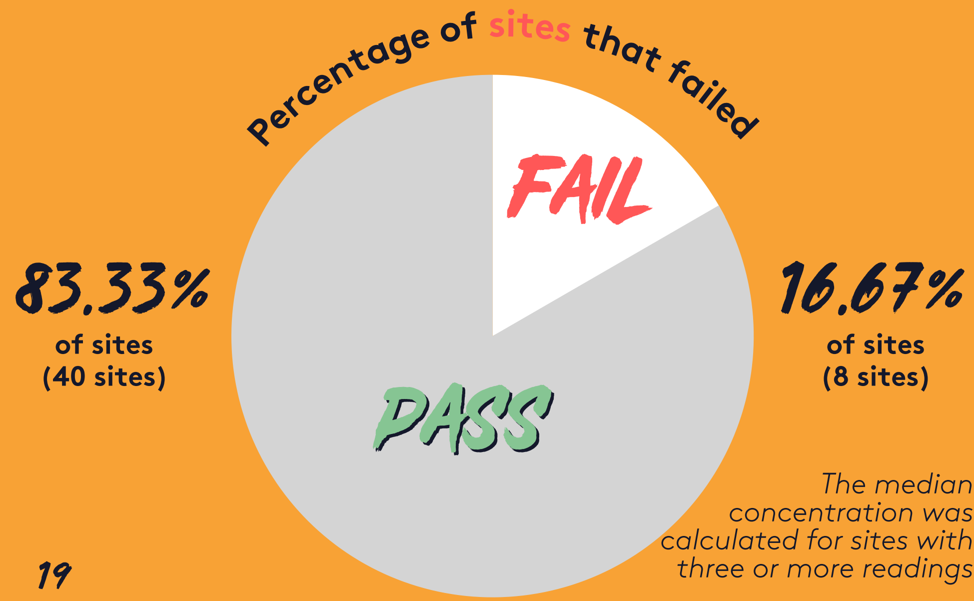
Minimal data on the impact of boat moorings on nitrate concentration was available. Nevertheless, the proximity was still investigated. A total of 40.91% (9 of 22) of sites that failed were within 1km of an upstream marina or mooring point. This figure was considerably lower for sites that passed. Of these sites, 23.08% (6) had a marina or mooring point within 1km upstream on the waterway bank.

Overall, a lower percentage of sites that pass are within 10km upstream of a STW, but there is no difference in proximity to agriculture between sites that pass and sites that fail. As such, further investigation into types and intensity of farming within 1km upstream on waterway banks should be investigated, which was not within the scope of this study.

Considering these findings, it is apparent that nearly 50% of tested waterways are failing to meet acceptable levels of nitrate pollution. If more stringent thresholds were used, over 80% of tested waterways would fail. In light of these findings, it is clear that nitrate pollution is an issue for waterways and must be urgently addressed.

3.1.5 Nitrite Findings





The median concentration was calculated for sites with three or more readings

Compared to that of nitrates, the nitrite findings show a more positive pass rate. Using the WHO drinking water standard of 3 mg/l, an optimistic 90.56% of readings were within the acceptable range. Measured across the sampling period, 40 (83.33%) of sites reported a median nitrite concentration below 5 mg/l. Based on these calculations, 8 sites (16.67%) had a median nitrite concentration greater than or equal to 5 mg/l and therefore failed to meet an acceptable level.

However, using the aquarium maintenance recommendation of 0 mg/l nitrite concentration a different picture is painted. Based on this threshold, only 63.39% of readings were within the acceptable range and 58.33% of sites had a median value within the acceptable range.

This means that 41.67% sites failed and were found to have more than 0 mg/l nitrite concentration.

Considering the negative impacts that nitrite pollution can have upon fish populations, this threshold is important to recognise and work towards.

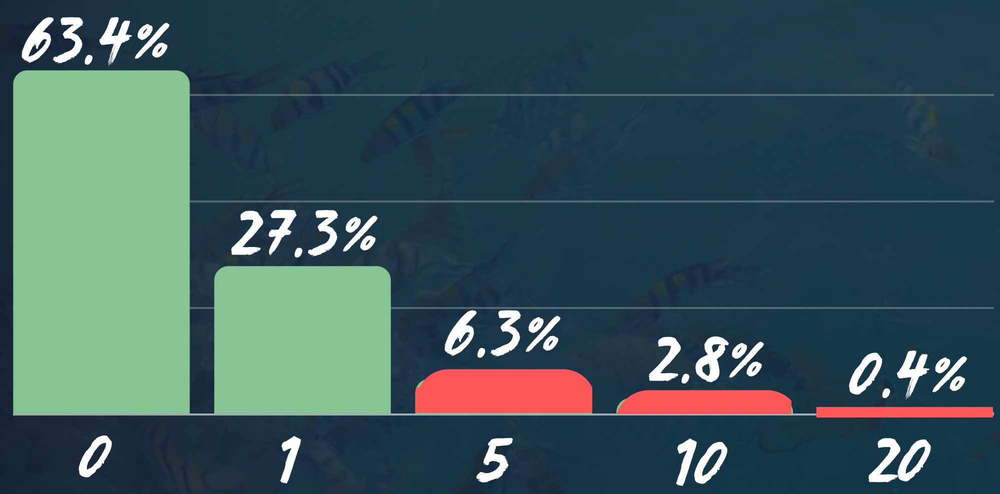


Figure 5 shows the percentage of each nitrite concentrations in milligrams per litre (mg/l) recorded across all sites

Discussion of Nitrite Results

With more test sites passing the acceptable threshold, these findings reveal that nitrite pollution is not as prevalent at testing sites as nitrates. This suggests that nitrite pollution is not currently as serious an issue as nitrate pollution. However, given the difference in threshold between the WHO guidelines and those of aquarium maintenance experts, clearer guidelines are needed on acceptable levels of nitrite concentration in waterways.

3.1.6 Current Government Targets, Penalties and Incentives

The UK government released a target in March 2022, aiming to reduce the agricultural nitrogen contribution to water environments by at least 40% by 2037[23] (against a 2018 baseline) and in July 2022 announced a 'Nutrient Mitigation Scheme'.[24] As such, there are currently several measures in place to encourage a reduction of nitrate and nitrite water pollution. These are generally directed at farmers to incentivise improvement. First of all, fixed penalties of £100 or £300 can be issued from the EA as well as 'variable money penalties' of up to £250,000.[25] However, this does not currently serve as a substantial pollution deterrent - at the current inspection rate, farms in England can expect a visit from the EA once every 263[26] years.

Aware of the issue, the EA is working to increase inspections. With new funding, they will be able to increase from 400 to 4000 inspections per year by 2023.[27] While all progress should be celebrated, there are approximately 192,000 farms in the UK. This suggests that far more funding is required if the EA is to effectively monitor and improve agricultural nitrate and nitrite pollution.

As well as these penalties, some incentives also exist. For instance, the New Farming Investment Fund offers grants for equipment and infrastructure to help farmers increase their productivity whilst reducing pollution.[28] The Future Farming Programme will reward farmers for sustainably managing their nutrients and reducing runoff and the UK government is developing a nutrient management standard for the Sustainable Farming Incentive, which - building on existing pilots - will help spread best practice amongst farmers.

3.2 PHOSPHORUS AND PHOSPHATES

Phosphates are chemical compounds containing the element phosphorus. Due to its high reactivity, atoms of phosphorus do not exist naturally in a pure state. Instead, they easily react with other atoms and molecules to form compounds such as phosphate or phosphoric acid.

In the latest assessment by the EA:

55% OF RIVERS AND 73% OF LAKES

FAILED TO MEET A 'GOOD ECOLOGICAL STATUS FOR PHOSPHORUS'[29]

3.2.1 SOURCES OF PHOSPHATE POLLUTION

Similarly to nitrates, a significant proportion of phosphate pollution flows from agricultural practices. As the global population expands, so too does the demand for food and other goods. To meet these growing needs, fertilisers containing phosphorus have been increasingly used to boost yields over the last 70 years. Over this period, a surplus of phosphates has been applied to agricultural land through the use of fertilisers, slurry and anaerobic digestate.

When it rains, runoff from farmland carries phosphates into water bodies. Field drainage can also provide a rapid and direct pathway for these nutrients to enter watercourses.[30] Indeed, the latest figures available from DEFRA show that there was an annual average of 3.2 kg phosphorus gained per hectare of farmland in England during 2019.[31] However, phosphate pollution does not exclusively stem from the agricultural industry. Pollution also comes from sewage discharge, food waste and food and drink additives.

3.2.2 Impacts of phosphate pollution

An unsustainable use of phosphates compromises food and water security, freshwater biodiversity, and human health. Its continued use in fertilisers leads to biodiversity losses in both fresh and saltwater ecosystems. The cost of responding to water-based phosphorus pollution in the UK alone is estimated at £170 million per year.[32]

One specific impact is eutrophication.

Eutrophication

occurs when excessive levels of nitrates, phosphates and other nutrients enter a body of water. High concentrations of these nutrients can accelerate the growth of algae and cause algal blooms.

These blooms prevent sunlight from penetrating the water surface. Without sunlight, other aquatic plants cannot photosynthesise, leading to a depletion of oxygen. Aquatic animals will then have less oxygen available to them. Without sufficient oxygen, fish populations often migrate away from an area or, in extreme cases, die out.

As well as causing biodiversity decline, these blooms also have an economic cost. Cleaning the blooms from water bodies is expensive - but essential. There are a range of serious health implications that are linked to eutrophied drinking water. Without treatment, eutrophied water is unsuitable for drinking as well as for angling and other profitable water sports.[33]

3.2.3 'ACCEPTABLE' LEVELS OF PHOSPHATE IN WATER SOURCES

PASS	FAIL
Phosphate concentration below 100ppb. This indicates no or low level of pollution.	Phosphate concentration above or equal to 100ppb. This indicates a high level of pollution.

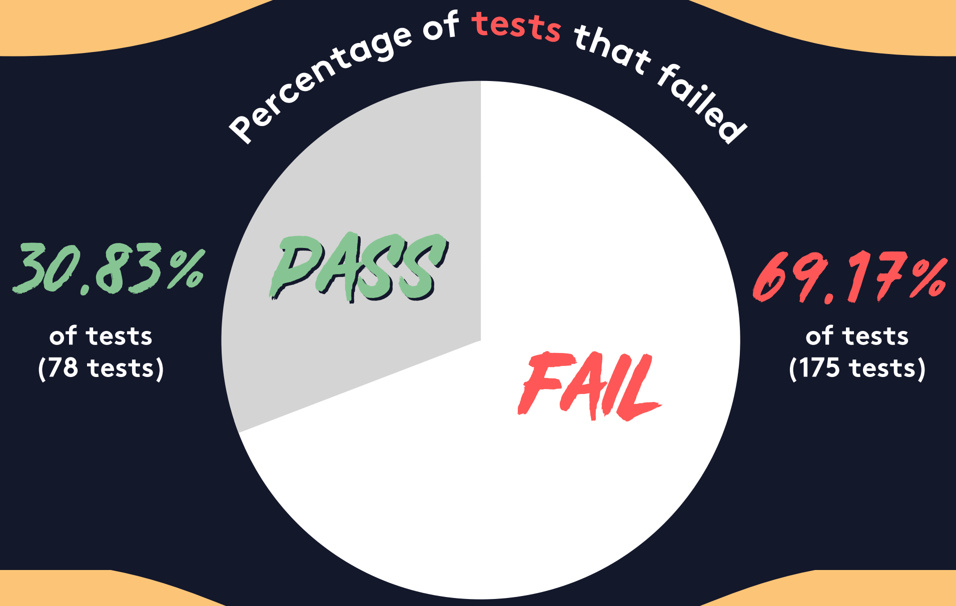
Table 5 outlining the pass / fail criteria for phosphate

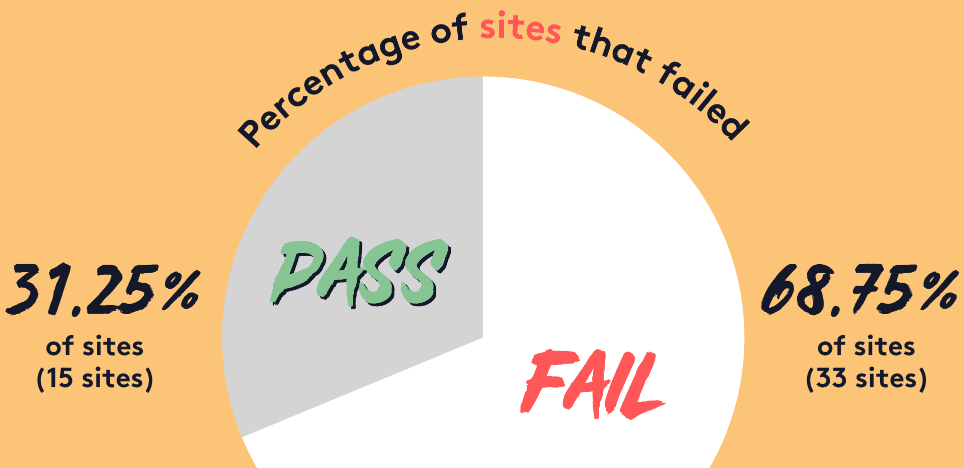
To be deemed 'acceptable' both ecologically and for human health, guidance recommends that rivers should not exceed annual mean phosphate concentrations of 0.1 mg/l[34] (equivalent to 100 parts per billion[35] or ppb).

In line with government guidance, Freshwater Habitats Trust also classifies water samples as 'poor quality' if phosphate concentrations exceed 0.1 mg/l. This is a biologically relevant threshold[36] as concentrations of phosphate above 0.1mg/l have been shown to significantly affect egg survival, hatching and abundance of certain species, such as the mayfly. It should be noted that the methods to calculate high, good, moderate and poor standards for phosphorus outlined in the Water Framework Directive have not been used in this report, as calculations require a value for alkalinity, which was not measured by citizen scientists.

The categories of 'pass' and 'fail' are used to denote whether a test result or site meets the 100 ppb (equivalent to 0.1 mg/l) threshold.

3.2.4 PHOSPHATE FINDINGS





The median concentration was calculated for sites with three or more readings

OVERALL PHOSPHATE FINDINGS

Of all 253 samples taken, 175 showed elevated phosphate concentrations above 100ppb. This means that 69.17% failed and were categorised as exhibiting a high level of pollution.

Of the 48 sites with three or more readings, 33 displayed elevated concentrations of phosphate and recorded as a fail. A total of 68.75% of sites had a median phosphate concentration of greater than or equal to 100ppb. Of particular concern are eight sites where the median phosphate concentration was very high and exceeded 500ppb. These sites were on the River Thames, River Cam, River Exe, River Stour, River Bollin, River Mole and River Trent.

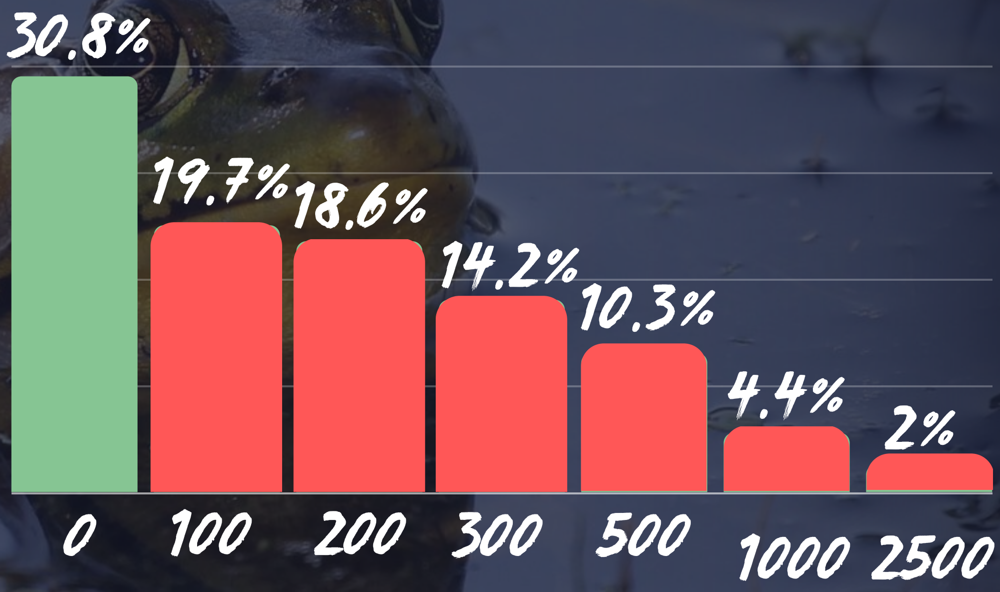


Figure 6 shows the percentage of each nitrate concentrations in milligrams per litre (mg/l) recorded across all sites

Figure X highlights that less than one third of testing sites reported an acceptable level of phosphate in their samples. This is a concerning finding, especially when it is considered that 10.28% of results were five times greater than the 'acceptable' 100ppb level. Further still, 4.35% showed a concentration ten times higher than this recommendation.

68.6% of sites failed to meet an acceptable phosphate standard

10.3% of results were five times higher than the 'acceptable' level

4.4% of results were ten times higher than the 'acceptable' level.

SITES ON THE RIVER THAMES, RIVER CAM, RIVER EXE, RIVER STOUR, RIVER BOLLIN, RIVER MOLE AND RIVER TRENT HAD WORRYINGLY HIGH PHOSPHATE CONCENTRATIONS

PHOSPHATE FINDINGS BY LOCATION

Planet Patrol investigated the proximity of sites with elevated phosphate concentrations of a median value greater than or equal to 100ppb to typically highly polluting infrastructure. As with nitrates, these were STWs, agricultural areas and boat moorings. Again, these were compared to sites with 'safe' phosphate concentrations of a median less than 100ppb.

NUMBER OF STW UPSTREAM	NUMBER OF SITES THAT FAIL	NUMBER OF SITES THAT PASS
1	12	4
2	6	1
3	1	1
4	2	0
5	1	0

Two thirds (66.67%) of the 33 individual testing sites that failed were within a 10km proximity to upstream STWs. This percentage was lower for testing sites that passed. It was found that 40% of these sites had STWs upstream. As with nitrates, the presence of STWs upstream is likely to elevate phosphate concentrations downstream.

A further 75.76% (25) of sites that failed had agricultural land within 1km upstream on the waterway bank. As with nitrates, there was no significant difference in findings for sites that passed. Indeed, 66.67% (10) of sites that passed had agricultural land within 1km upstream on the waterway bank. However, of the sites which failed with particularly high concentrations of phosphate (500ppb), 75% had agricultural land on 1km of waterway upstream.

Interestingly, a slightly greater percentage of sites which passed were found to have a marina or mooring point within 1km upstream on the waterway bank. This was the case for 33.33% of sites which passed, compared to 30.3% of sites which failed.

Overall, a lower percentage of sites that pass are within 10km upstream of a STW, but the percentage of sites with agricultural land 1km upstream along the bank was similar (75.76% for sites that failed, 66.67% for sites that passed). Further investigation into types and intensity of farming within 1km upstream on the waterway bank should be investigated in future studies of this nature.

CRITICALLY, 68.75% OF SITES WITH THREE OR MORE READINGS FAILED TO MEET AN ACCEPTABLE PHOSPHATE STANDARD.

Such negative findings suggest that urgent action is required to protect biodiversity, water quality and ultimately, meet targets for climate change. The 'Our Phosphorus Future' project is currently working to limit pollution and set ambitious targets. A team of 100 scientists and industry experts developed a phosphorus report calling for '50:50:50'. This refers to a 50% reduction in global phosphorus pollution and a 50% increase in the recycling of phosphorus lost in residues and wastes, by 2050.[37]

3.2.5 Current government phosphate target

Set against a 2018 baseline, the UK government aims to reduce agricultural phosphorus transmission to the water environment by at least 40% by 2037. Additionally, it plans to limit phosphorus loadings from treated wastewater by 80% by 2037 compared to a 2020 baseline.[38] However, using such near-term baselines raises a question over the possible benefits of these targets. In 2018 and 2020, waterway phosphate pollution may have already been at a concerning level and, as such, reductions may still not return pollution to a safe level. It would be necessary to look further back in time to avoid shifting baseline syndrome.

Government targets:

40% **Reduce agricultural phosphorus transmission to the water environment by at least 40% by 2037 compared to a 2018 baseline.**

80% **Limit phosphorus loadings from treated wastewater by 80% by 2037 compared to a 2020 baseline.**[38]

The problem

2018 and 2020 baselines have elevated, non-natural, phosphorus levels. Target reductions may still not reduce pollution to a safe level.

Shifting baseline syndrome

A gradual change in the accepted norms for the condition of the natural environment due to a lack of experience, memory and/or knowledge of its past condition.

3.3 TOTAL COLIFORMS

Coliforms are a group of faecal bacteria which, when found, indicate the presence of sewage. Examples of coliform bacteria include the well-known *E.coli*, as well as *hafnia*, *enterobacter*, *citrobacter* and *klebsiella*. All these bacteria can be tested to measure the general sanitary quality of a water source.

3.3.1 SOURCES OF COLIFORM BACTERIA

15,000
Combined sewer overflows in England, through which untreated sewage can be discharge during heavy rainfall

'WORST'
In 2021, water and sewerage companies 'achieved' their worst performance rating since 2011

2.7 MILLION HOURS
The duration raw sewage was released into waterways in 2021

372,533
The number of times raw sewage was released into waterways in 2021

IN FACT, A STUDY CONDUCTED BY IMPERIAL COLLEGE LONDON FOUND THAT OF THE PIPES WHICH SPILLED IN 2021, 79% WERE LACKING IN CAPACITY.

SEWAGE OVERFLOWS

TThere are around 15,000[39] combined sewer overflows (CSOs) in England, designed to prevent sewage overflowing into infrastructure and homes during times of heavy rainfall by discharging untreated sewage into rivers and streams. Discharge pipes must have a permit under UK law. However, there are 184 unregulated pipes across the UK[40] meaning that, not only is the discharge from these pipes unmonitored, but also illegal.

Through a process of data monitoring, it has been revealed that overflows are also regular at times of low or no rainfall, when there is no obvious threat to wastewater or domestic infrastructure.[41] CSOs are therefore intended to be used infrequently and under exceptional conditions only; reflected in the permit conditions stipulated by the EA. Their use nonetheless appears to be increasingly routine, as pressures on the sewerage network grows. In addition, climate-change induced rainfall shifts could significantly increase the times of year and frequency of overflows in the future.

POPULATION PRESSURES

The issue of sewage discharge is exacerbated by population growth. Our use of the water and sewerage network has increased in line with a rising population and rapid urban development. Together, these factors all place additional pressure upon an ageing sewage network that is not designed to meet such high capacity.[42]

Intentional sewage discharge from water firms

In 2021 water companies ‘achieved’ their worst environmental performance rating since 2011. This is determined using the EA’s Environmental Performance Assessment.[39] The problem of coliform bacteria pollution is closely tied with water companies. In England, these companies release raw sewage directly into rivers and coastal waters. Discharging sewage in this manner is not an occasional occurrence - it is closer to standard practice. In 2021, water firms in England expelled raw sewage into rivers 372,533 times for a total period of 2.7 million hours.[45]

It should be noted that official data may not be a true reflection of the total number of events. Since 2009, the government has relied on water companies to monitor their own sewage outflows. One reported event could, in reality, last for several weeks.[46]

In August 2022, the UK government released the Storm Overflows Discharge Reduction Plan.[47] This new policy requires water companies to improve all storm overflows discharging into bathing areas and improve 75% of overflows discharging to high priority sites for nature by 2035. By 2050 no storm overflows will be permitted to operate outside of heavy rainfall. However, the timescales outlined in this Plan are not ambitious enough. The Plan would leave 48% of storm overflows completely unimproved by 2040, allowing another 18 years of unacceptable levels of discharge into our waterways. Only 38% of storm overflows that cause the most ecological harm would be due to be improved by 2030, and 75% by 2035, meaning by 2035, sewage could still be discharged into over 1000 priority wildlife sites.[48]

Going forward, water companies must publish discharge information in near real-time and continually renovate their infrastructure to keep pace with growing population and environmental pressures. In recognition of the current 'cost of living crisis', this Plan will not add to the water bills of UK households until 2025.[49] However, it is yet unclear what the additional cost will be after this date.

Other Sources

Diffuse pollution from agriculture and urban spaces can also add to total coliform bacteria pollution. Faecal contamination from domestic dogs and wild birds are also known to contribute to the problem.

3.3.2 Impacts of Coliform Bacteria in Water Sources

The impacts of coliform bacteria are not always visible. Water contaminated with coliform bacteria may not smell or taste bad, or necessarily appear dirty.

However, the presence of even small amounts of some kinds of coliform bacteria can indicate that other disease-causing pathogens are present. Some of these, such as hepatitis A and septicaemia, can be potentially deadly if consumed in drinking water.

Presence of coliform bacteria can also indicate potential presence of organic pollutants, microplastics, pharmaceuticals, nutrients and heavy metals that are discharged from water companies along with raw sewage. Such discharge can lead to ecological harm due to their impact on water chemistry.[50]

3.3.3 Acceptable Levels of Total Coliform Bacteria

Planet Patrol found only one standard specifying acceptable levels of coliform bacteria. Published in the Bathing Water Regulations (a public health directive), the guidance referred to two types of coliform bacteria: intestinal enterococci and E.coli. Levels of these two bacteria are used to classify designated bathing sites as excellent, good, sufficient or poor. This use of bacteria levels as an indicator of river water quality for bathing suggests that the standard reflects public health concerns, rather than a wider, environmental awareness. This guidance is also limited to two types of bacteria.

In this study, volunteer citizen scientists tested for the presence of coliform bacteria at a level greater than or equal to 500 colony forming units (cfu)/100ml. The coliform bacteria tested for could originate in human sources such as the sewerage network or septic tanks. It is also possible that they have animal origins such as the spreading of slurry spreading or from poultry farm runoff. Below 500 cfu/100ml of E.coli corresponds to excellent bathing status for inland waterways. However, in this sampling period volunteers tested for total coliform bacteria - including E.coli - and used 500 cfu/100ml as the proxy for an excellent status for bathing, a level acceptable for human health.

What is a designated bathing site?

For a water way to be given a designated bathing water status, four important actions must be completed:

1. Its water quality must be tested weekly between the 15th of May and the 30th of September by the EA to determine if it is safe to paddle, play and swim in.[51]
2. There must be signage to indicate if the water is clean enough for paddling, playing or swimming.
3. A management plan must be implemented for the river. This is to ensure that there are facilities in place for the people who already visit to paddle, swim and play.
4. A full investigation must be completed into the pollution sources of the river. Any unacceptable levels of pollution found, trigger the necessity of a clean-up plan to be implemented.

3.3.4 Current bathing statuses

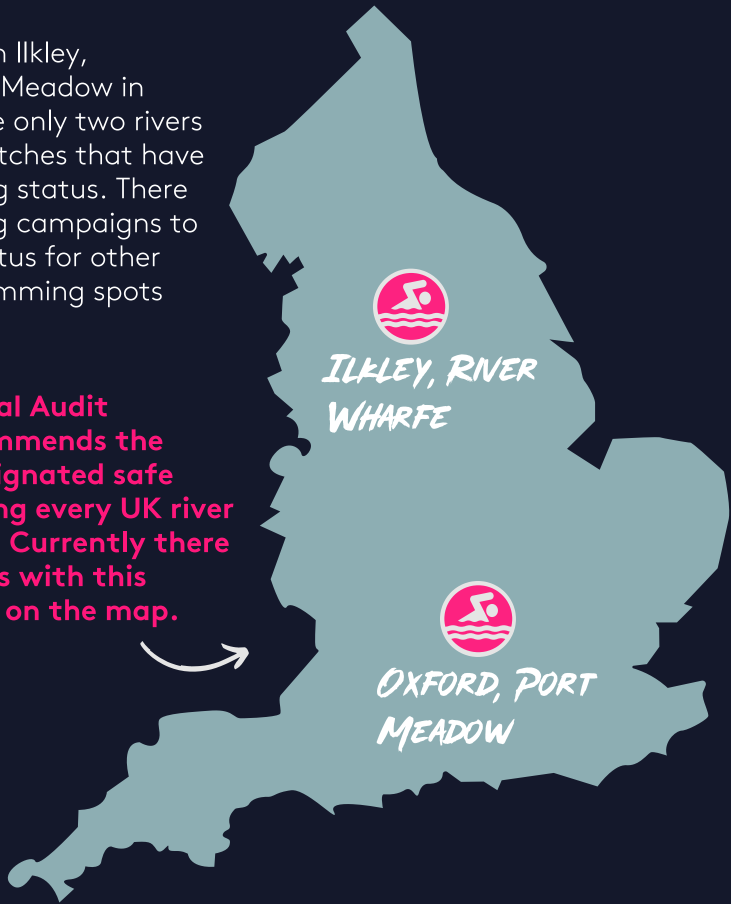
Number of bathing sites on rivers

2	32	76	420
England	Germany	Poland	France

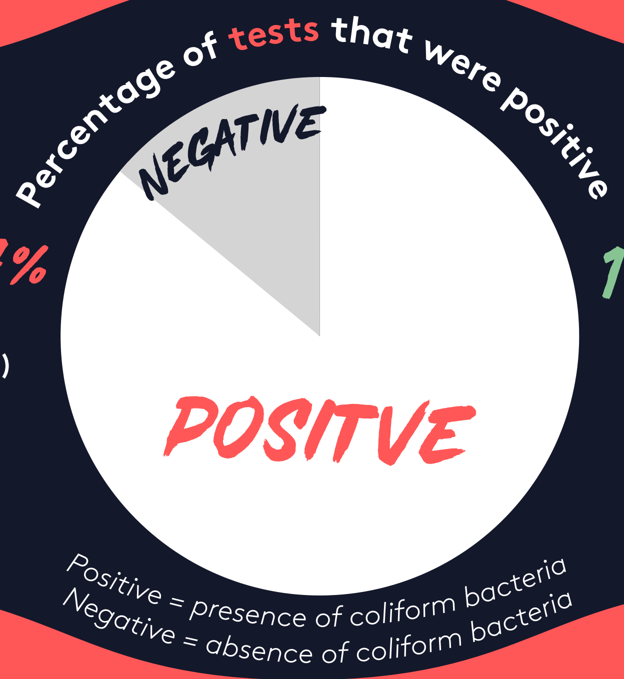
In the UK, two rivers and 16 lakes have been given designated bathing status. Compared to some European countries, this figure is low. For example, Germany has 32 bathing water stretches in rivers, Poland has 76 and France boasts 420.[52]

The River Wharfe in Ilkley, Yorkshire and Port Meadow in Oxfordshire are the only two rivers in the UK with stretches that have designated bathing status. There are several ongoing campaigns to secure bathing status for other popular inland swimming spots around England.

The Environmental Audit Committee recommends the creation of a designated safe bathing area along every UK river by the year 2025. Currently there are two river sites with this status, as shown on the map.

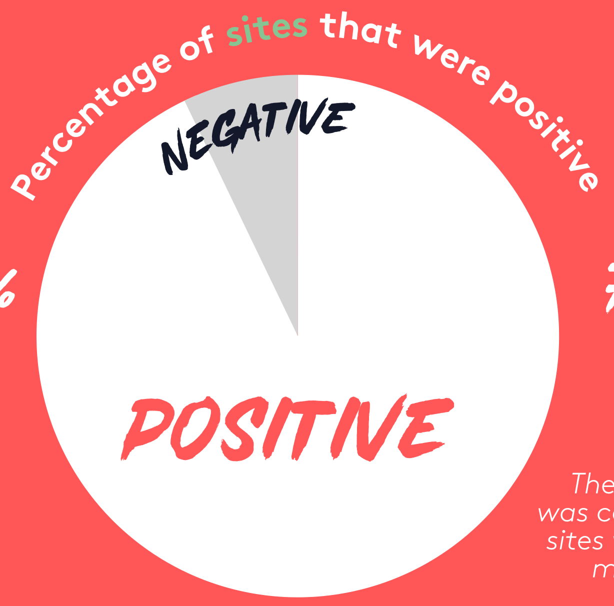


3.3.5 Total coliform findings



85.97%
of tests
(190 tests)

14.03%
of tests
(31 tests)



92.86%
of sites
(39 sites)

7.14%
of sites
(3 sites)

The mode result was calculated for sites with three or more readings

Overall total coliform findings

Throughout the sampling period, a total of 221 individual tests were carried out to determine the presence or absence of total coliform bacteria. Planet Patrol's analysis revealed that 85.97% (190) of water samples contained coliform bacteria at a concentration greater than or equal to 500 cfu/100ml.

For the sites where three or more coliform tests were conducted, the results are even more serious. A total 92.86% of sites (39) had a mode of presence of coliforms. As such, 92.86% of test sites would not be classed as 'excellent' for bathing using the rationale explained above.

TOTAL COLIFORM FINDINGS BY LOCATION

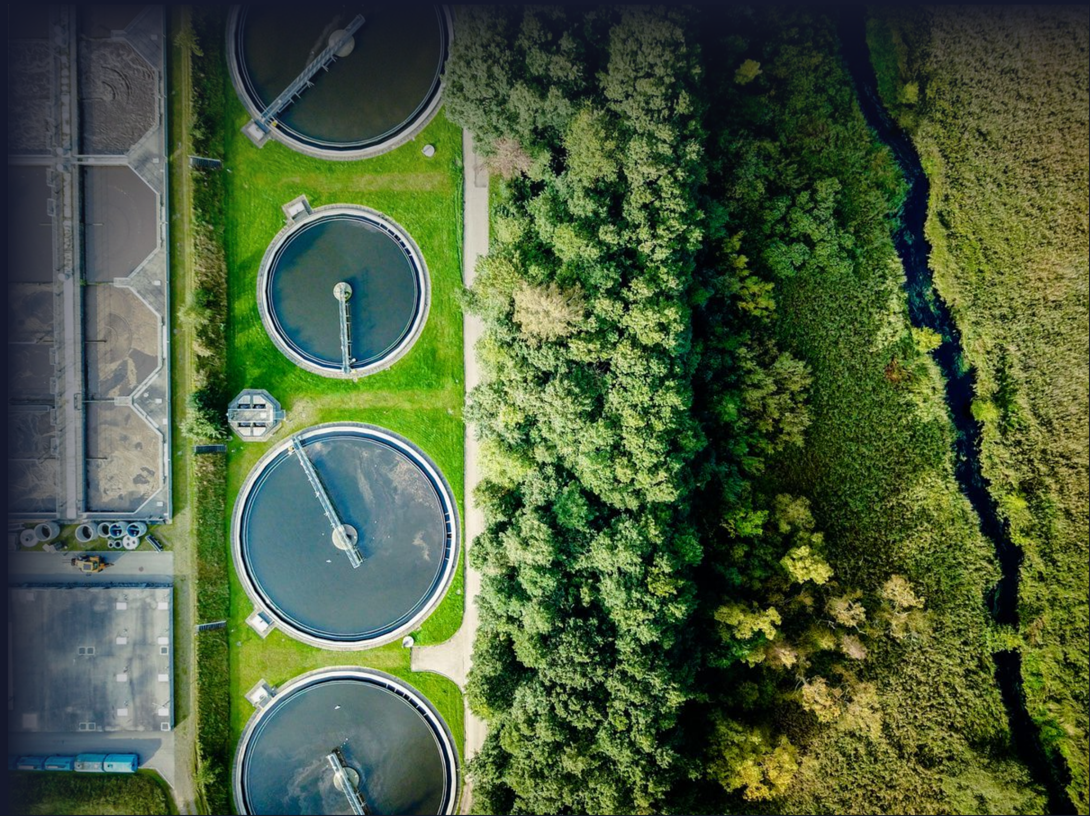
Planet Patrol investigated the proximity of sites with an identified presence of coliform bacteria to sewage treatment works (STW), agricultural areas and boat moorings. These sites were compared to those in which no total coliform bacteria were identified.

NUMBER OF STW UPSTREAM	NUMBER OF SITES THAT FAIL	NUMBER OF SITES THAT PASS
1	13	1
2	7	0
3	2	0
4	2	0
5	1	0

Highly pertinent to these findings, is the proximity of test sites with identified presence of bacteria to STWs. Planet Patrol's analysis revealed that 64.1% of these test sites were downstream from one or more STWs. In comparison, only 33.33% (1 of 3) of sites with an absence of total coliforms had STWs upstream. The remaining 66.67% (2 of 3) sites with an absence of total coliforms, had no STWs upstream. Although in some cases, there is a direct link between upstream STWs and the presence of total coliform bacteria, there can be other contributing factors such as agriculture or leaks from private septic tanks.

Other infrastructure was also found in close proximity to coliform testing sites. A total 74.36% of sites (29) with a presence of total coliforms had agricultural land within 1km upstream on the waterway bank. Interestingly, agricultural land was also within 1km for all testing sites where no total coliform was identified.

A total of 30.77% (12) of sites with a presence of total coliform bacteria had a marina or mooring point 1km upstream on the waterway bank. Similar percentages were found for testing sites with an absence of total coliform. For two of these sites (66,67%), no mooring points were found whereas for one (33.33%), there was a nearby mooring point.



3.3.6 Discussion of total coliform findings

90%

Coliform bacteria were present at over 90% of testing sites

The presence of total coliform bacteria at over 90% of testing sites clearly demonstrates the reach and severity of pollution from sewage discharge. Given the negative impacts upon human health and the environment, it is imperative that urgent action is taken to reduce polluting behaviour - only then will it be possible for water quality to improve.

Fines

Action is being taken to tackle intentional sewage dispersal. Since 2015, EA prosecutions against water companies have secured fines of over £138 million.[53] While this may sound substantial, these fines - currently handed out by courts - represent a mere inconvenience to water companies. Very often they amount to less than the annual salary of a water company Chief Executive.

Furthermore, financial penalties do not reflect the true environmental damage caused by the regular discharge of untreated sewage. To effectively dissuade water firms from the practice - and to accurately value the ecosystems destroyed - these penalties must be dramatically increased and enforced. Whilst the government has now announced an increase in penalties for polluting water companies the date of enforcement has yet to be announced. This is why Planet Patrol's Recommendation 2 is for an enforcement date to be announced as soon as possible and our Recommendation 5 is for the money raised from these penalties be used to finance the prosecution of polluters.

Spotlight on fines

£138 MILLION **total fines secured by Environment Agency against water companies since 2015.**

Fines often amount to less than a water company CEO's annual salary

Current financial penalties do not reflect the true environmental damage

On bathing water standards

Bathing water regulations have been designed to reflect public health concerns, hence the use of bacteria as the main indicator of water quality for bathing. Other pollutants - such as toxic metals - are also of concern, and should be considered for inclusion in bathing water standards. The focus on bathing water standards in the media - which only considers bacterial levels - risks skewing protective measures towards public health, at the cost of environmental health.

Encouragingly, there is an emerging public will to address coliform bacteria pollution. A petition in 2021 titled, 'ban water companies discharging raw sewage into water courses' gained 111,431 signatures, and was debated in Parliament.[54] The government responded to reassure signatories that this was a matter of utmost importance and that a Storm Overflow Taskforce has been set up.[55] Whilst a similar petition is currently live (running until March 2023) focused on banning water companies from discharging raw sewage into the sea.[56]

3.4 pH

The pH level is a measure of how acidic or alkaline a liquid is. If a liquid is neutral, it will have a pH of 7. Any pH below 7 indicates that the liquid is acidic, whereas any value above 7 suggests it is alkaline.

Freshwater rivers, lakes, ponds and streams generally range between an acidic pH of 5 and an alkaline pH of 9. On average, the optimum pH level for a freshwater body is 7.4,[57] however this varies depending on the ecosystem and habitat type.

3.4.1 Drivers of pH changes

Different pollutants can increase or decrease the pH of a waterbody outside of the typical ranges outlined above. Fluctuations can often be human-induced and are linked to pollution from mining, smelting and the burning of coal.

3.4.2 Impacts of pH changes

Lower pHs increase the toxicity of some pollutants. For example, certain heavy metals - such as copper, zinc and cadmium[58] - are more toxic in water that has an acidic pH. If the pH of a water body is reduced, it can increase the toxicity risk if these heavy metals enter the system.

Just as aquatic species have different temperature tolerances, they also have different tolerances to pH. Some need a neutral pH while others may need a more alkaline pH to thrive. As pH levels move up and down outside of this tolerable range, it can compromise the health of aquatic plants and animals. The further outside of the optimum pH range a value is, the higher the mortality rates of these species. The more sensitive a species, the more affected it is by changes in pH.

3.4.3 What pH range is 'acceptable' ecologically and for human health?

Figure 7

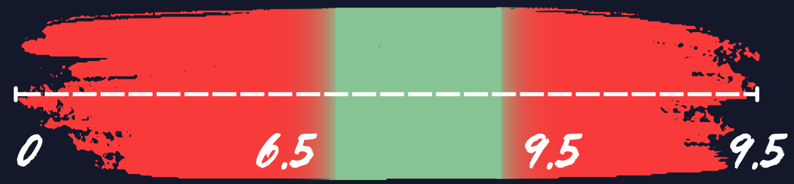
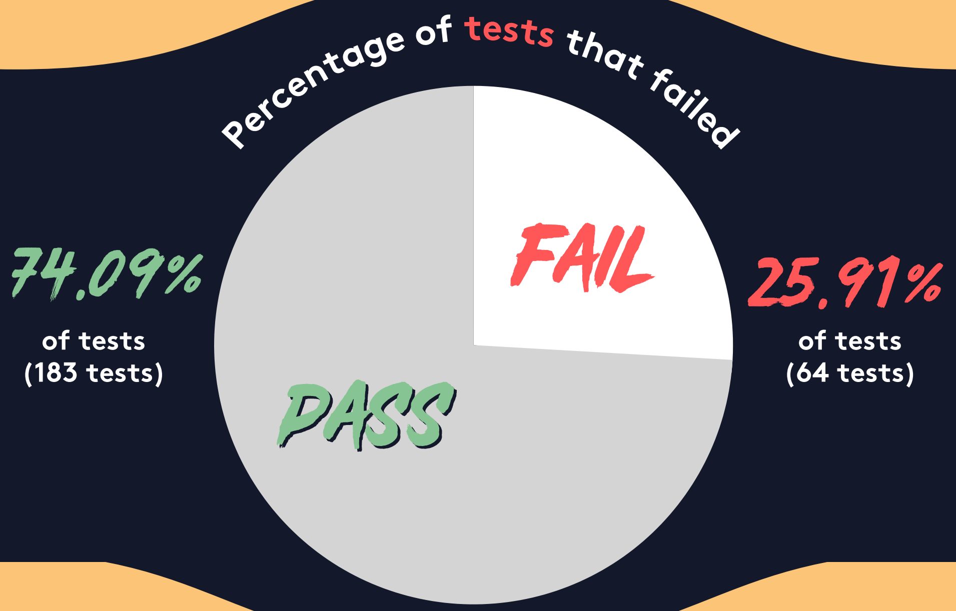


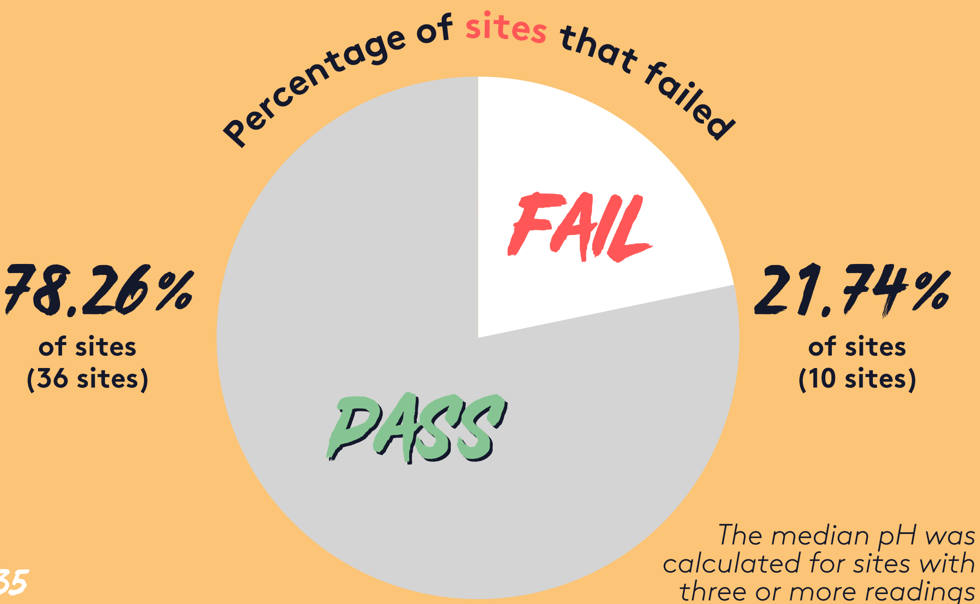
Figure 7: DEFRA recommended pH range is between 6.5 to 9.5 for drinking water. The tolerable pH range for organisms varies, but here Planet Patrol uses this pH range to allow comparison between locations.

In terms of human health, DEFRA recommends a pH range between 6.5 to 9.5 for drinking water.[59] Ecologically speaking, the tolerable pH range for organisms varies depending on the water body type, species and organism life stage as outlined above. Anything outside of the tolerance range can cause sub-lethal or lethal effects on organisms.

In order to compare between locations, Planet Patrol classifies a tolerable pH range as between 6.5 to 9.5. The criteria of 'pass' or 'fail' is used to denote whether a test result or site falls within the specified, tolerable pH range.

3.4.5 PH FINDINGS





The median pH was calculated for sites with three or more readings

74.09%

Nearly three quarters of all tests were within the recommended pH range

ACIDIC

All 25.91% of tests that failed were because the water was too acidic

PH 4-5

Of particular concern are 19 pH readings of 4 and 5 on the River Tame and Derwentwater

Citizen scientists took a total of 247 pH readings throughout the sampling period. Of these, 183 were found to be inside the recommended pH range. This means that 74.09%, close to three quarters of all tests, were recorded as a pass and do not pose an immediate threat to either human health or to water-based ecology. The remaining quarter of tests, 25.91%, were outside of the recommended pH range. It is interesting to consider that every sample that failed was too acidic rather than too alkaline.

Looking at the 46 testing sites where more than three readings had been taken, the median pH value fell outside of the recommended range for 21.74% of sites (10 sites). All failed for being too acidic.

The 19 readings revealing pH values of 4 or 5 are of particular concern. These were taken at two sites on the River Tame and one site on Derwentwater which had median pH readings of 5.

With nearly 75% of readings falling within the recommended acceptable level, pH is not as much of an issue when compared to nitrate pollution and phosphate pollution. However, a total of 17% of tests failed with a pH reading of 6 and a further 8.1% failed with reading of 5.

With approximately 25% of sites outside of the recommended tolerable pH range, it still remains essential to make improvements to the pH levels of waterways.

3.5 METALS

Metals occur naturally in the aquatic environment due to weathering of surface geology. Due to human activity, the levels of these metals entering water systems has been artificially elevated.

3.5.1 SOURCES OF METALS

Thousands of kilometres of water bodies across the UK are polluted with metals. These metals come primarily from sources such as active and abandoned mines, metal-processing industries and, even though it is now banned, leaded petrol. Indeed, the EA estimated[60] that over 1,500km of rivers in England are polluted by metals from mines.

3.5.2 IMPACTS OF METALS

Metals are often overlooked in environmental pollution studies despite often being extremely toxic and long-lasting in the environment. Unlike other forms of pollution, metals do not degrade over time.

As a result, pollution from over a hundred years ago will still negatively affect the environment and biodiversity today. When the long-term impacts of metal pollution are considered, it highlights the urgent need to halt substances from entering our waterways.

It is possible to clean metal pollution from waterways. However, there are heavy economic implications involved in this process. For example, Natural Resources Wales has recently estimated it will cost £282 million to end water pollution from existing mines.[61]

3.5.3 ADDITIONAL METAL TESTING METHODOLOGY

The methodology for collecting data on metals varied to that of the other pollutants. As such, more detail on this process is provided.

Citizen scientists were trained to collect and filter water samples using comprehensive instructions co-developed by Planet Patrol and Andrea Sartorius and Dr Lisa Yon of the University of Nottingham.

Two filtered, 30 ml water samples were sourced from each of the 38 different metal testing sites chosen for study. These samples were sent to the University of Nottingham for laboratory analysis. This process calculated the average concentration of 31 different metals in each water sample.

Using the methodology developed by the UK Technical Advisory Group for the Water Framework Directive, the bioavailable concentrations and site-specific Predicted No-Effect Concentrations (PNECs) of lead, copper, zinc, manganese and nickel were calculated in each water sample.

Comparison between the bioavailable concentration with the PNEC and the generic Environmental Quality Standard (EQS) allowed us to calculate whether the concentration of lead, copper, zinc, manganese and nickel were above or below recommended threshold levels. This indicated the potential health risks for aquatic animals from copper, lead, manganese, nickel, and zinc pollution.

Apart from lead, copper, zinc, manganese, nickel and iron, there was an absence of recommendations for concentrations of metals in waterways, from Planet Patrol's research. Therefore, we compared concentrations of other metals to WHO drinking water standards and health-based values.[65] The WHO did not publish health-based values for 15 of the metals tested for reasons such as 'the contribution from drinking-water to daily intake is small', 'not of health concern at levels found in drinking water' or were not mentioned in their guidelines for drinking water quality.

KEY TERMS

PREDICTED NO EFFECT CONCENTRATION (PNEC)

The concentration below which a specified percentage of species in an ecosystem are expected to be protected.[62]

BIOAVAILABILITY

The amount of an element or compound, such as a metal, that is accessible to an organism for uptake or adsorption.[63]

ENVIRONMENTAL QUALITY STANDARD (EQS)

Standards which are set to protect water bodies from the harmful effects of the contaminants that could flow through them.[64]

3.5.4 METAL FINDINGS

The Water Framework Directive (WFD) required all European Union Member States to ensure that inland and coastal waters achieved 'good' water quality status by 2015. One of the measures used to deliver these requirements are the Environmental Quality Standards (EQS). An EQS refers to the concentration of a chemical in the environment below which there is not expected to be an adverse effect on the specific endpoint being considered. For instance, an endpoint could be to protect aquatic life. A water body cannot achieve a 'good' status if the EQS for any WFD Priority/Priority Hazardous Substance or Specific Pollutant is exceeded.[68]

BIOAVAILABILITY

It is very difficult to measure the bioavailable concentration of a metal directly. Therefore models have been used to predict the bioavailable concentration from dissolved concentrations of metals. Of the metals tested, models exist for lead, copper, zinc, manganese and nickel.

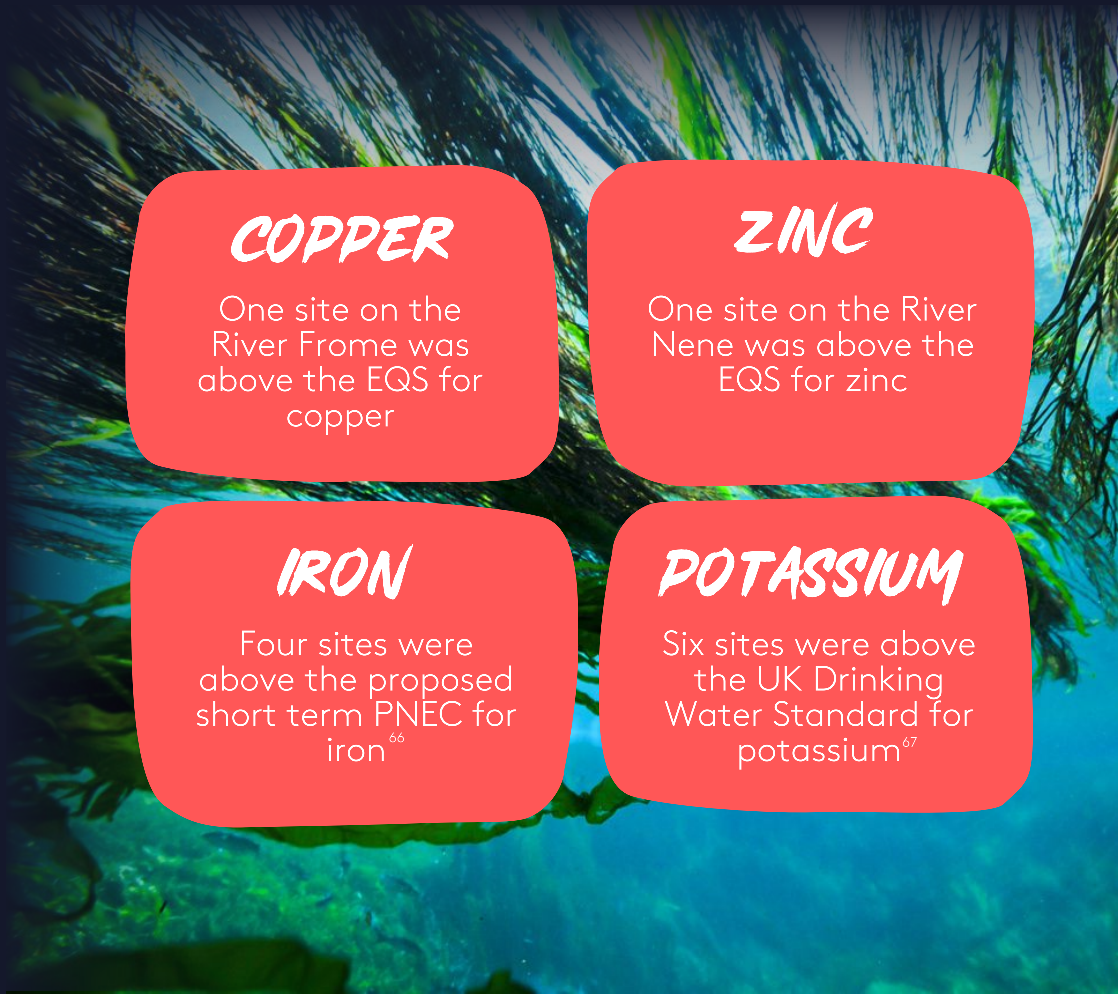
The bioavailability of lead, copper, zinc, manganese and nickel were calculated across 36 different sites with the following results:

METAL	PNEC / EQS OUTCOME
LEAD	No sites were above the PNEC, EQS was not calculated
COPPER	No sites were above the PNEC, but one site on the River Frome was above the EQS
ZINC	No sites were above the PNEC, but one site on the River Nene was above the EQS
MANGANESE	No sites were above the PNEC or EQS
NICKEL	No sites were above the PNEC or EQS

AVERAGE METAL CONCENTRATIONS

The average metal concentrations in the surface water of 38 sites were compared to WHO drinking water standards. Although one site on the Edinburgh Canal was above the WHO drinking standard for manganese, no sites were above the WHO drinking water standard for the following metals:

Boron, beryllium, aluminium, chromium, nickel, copper, arsenic, selenium, molybdenum, barium, lead, uranium and sliver



COPPER

One site on the River Frome was above the EQS for copper

ZINC

One site on the River Nene was above the EQS for zinc

IRON

Four sites were above the proposed short term PNEC for iron[66]

POTASSIUM

Six sites were above the UK Drinking Water Standard for potassium[67]

Other standards were identified for a further five of the metals tested for:

Metal	Outcome
Iron	Four sites were found to be above the proposed short term PNEC (0.041 mg/l)[66]
Cadmium	All sites were below the annual average EQS (0.2 µg/l annual average for inland surface water)[69]
Potassium	Six sites were above the UK Drinking Water Standard (12 mg/l)[67]
Silver	All sites were below the EQS[70]
Vanadium	All sites were below the EQS[71]

However, WHO standards and other similar and easily accessible standards are unavailable - from Planet Patrol's research - for the following other metals tested for:

Sodium, magnesium, sulphur, calcium, titanium, lithium, cobalt, rubidium, strontium, caesium, thallium.

Because of the lack of established thresholds for these metals, from Planet Patrol's research, Planet Patrol have been unable to calculate whether the concentrations of these metals fall above or below an acceptable level.

3.5.5 Discussion of metal findings

While the findings regarding metal concentrations are largely positive, one site on the River Frome was above the EQS for copper and one site on the River Nene was above the EQS for zinc. When high metal concentrations were found in a waterway this can be very problematic, and is likely the dominant pressure in the system.

None of the waterbody sites sampled were identified by the EA in the latest available data (2019) as 'impacted' by pollution from abandoned metal mines. Given[72] that elevated levels of certain metals were identified, it illustrates that current monitoring efforts may not be capturing the true extent of metal pollution.

Two caveats must also be addressed. Firstly, both filtered water samples were collected on the same day at each site. Without repetitions across additional days, we cannot say whether calculated concentrations of metals remain the same over time, or if they are the same across the waterway measured.

Secondly, the water samples were collected from surface water for analysis. Some of the metals analysed are heavy which, due to their weight, quickly sink to the low level sediment at the bottom of a water body. Therefore, a lack of contamination in a site's surface water, does not necessarily guarantee that the sediment is equally clean. In the future, studies should compare surface water samples to sediment samples so we can better understand metal pollution in waterways.

Impact of climate change

With predictions of heavier rainfall and increased frequency of storms due to climate change, sediment is expected to be disturbed more often. If contaminated, this would cause heavy metals in the sediment to rise to the surface before resettling as well as spreading the pollution over a wider area. Therefore, it is highly important that sediment pollution is investigated and understood. As such, future studies should compare surface water samples to sediment samples. are surface water samples to sediment samples to better understand metal pollution in waterways.

3.6 CASE STUDIES

In this section, two rivers are investigated to demonstrate the complexities and variety of the water quality analysis. First, data from the four testing sites along the River Trent are examined. Following that, the data collected from the River Thames' six testing sites is presented.

RIVER THAMES BACKGROUND

The famous River Thames is the longest in England and the second longest throughout the whole of the UK. Starting in Gloucestershire, it flows across the country before arriving at the North Sea. Before reaching the Thames Estuary, the final 89 km of the river are tidal. These conditions make the river inhabitable to aquatic mammals such as the grey seals and even, on occasion, dolphins.

One reason for the Thames' consistently poor environmental performance is its exposure to the sewage system of Greater London. To reduce sewage release of this into the river, the Thames Tideway Scheme[73] is currently under construction at a cost of £4.2 billion. This project will collect sewage from the Greater London area before it overflows and channel it into a 25 km long tunnel running underneath the tidal Thames.

This infrastructure will transport sewage water to be treated at Beckton Sewage Treatment Works.[74] Once completed, the project is expected to reduce sewage discharge into the Thames in the Greater London area by 50% by 2030[75] and will dramatically improve the river's water quality.

RIVER THAMES

Figure 8

READING: 3/4

✗ Phosphate: 300 ppb
✗ Nitrate: 50 mg/l
✗ Coliforms: Present
✓ pH: 6.5

MEDMENHAM: 2/4

✗ Phosphate: 200 ppb
✓ Nitrate: 10 mg/l
✗ Coliforms: Present
✓ pH: 7

MAIDENHEAD: 2/4

✓ Phosphate: 0 ppb
✗ Nitrate: 50 mg/l
✗ Coliforms: Present
✓ pH: 7

HENLEY-ON-THAMES: 1/2

✗ Phosphate: 100 ppb
✓ Nitrate: 25 mg/l
Coliforms: NA
pH: NA

WEST MOSELEY: 3/4

✗ Phosphate: 500 ppb
✗ Nitrate: 50 mg/l
✗ Coliforms: Present
✓ pH: 6.5

RICHMOND: 3/4

✗ Phosphate: 500 ppb
✗ Nitrate: 50 mg/l
✗ Coliforms: Present
✓ pH: 7

Figure 8 presents results from each site on the River Thames. The median reading for phosphate, nitrate and pH and mode reading for total coliform bacteria presence is displayed. Next to the site name, the number of parameters a site fails for, e.g. 3/4, is shown.

RIVER THAMES FINDINGS

Figure 8 depicts the test results for water quality along the River Thames. The water quality observed in Reading, West Molesey and Richmond did not meet an acceptable median phosphate concentration or an acceptable median nitrate concentration. All three sites also tested positive for total coliforms. While these three sites all failed on the same parameters, Reading is situated far upstream from West Molesey and Richmond. This suggests that a failed test is more closely linked to the surrounding pollution sources than a test site's overall position up or down stream.

RIVER TRENT BACKGROUND

From its source in Staffordshire to its end in the North Midlands, the River Trent runs as the third longest river in the UK. Trent - meaning 'strongly flooding' - is an accurate name for this waterbody as it is regularly prone to bursting its bank. Water from the Trent feeds the nearby Site of Special Scientific Interest (SSSI), the Attenborough Nature Reserve. This valuable habitat is located close to the Clifton and Wilford test sites highlighted below. As such, the Trent is a crucial water source for many of the flora and fauna found in the reserve.

FINDINGS

Figure 9 shows how three testing sites failed water quality tests on three parameters and one, Newark-on-Trent, failed on two. Wildford exhibits an especially high median phosphate concentration which, considering its proximity to an SSSI, is a matter of concern. Such high concentrations of phosphate pollution could negatively impact freshwater ecosystems and make the water hazardous for human health.

With an acceptable nitrate concentration and the lowest median pH value, Newark-on-Trent displays the most positive results. As the neighbouring testing site to Wildford, these results show how water quality can quickly change throughout a river's course.

CLIFTON: 3/4

- ✗ Phosphate: 300 ppb
- ✗ Nitrate: 50 mg/l
- ✗ Coliforms: Present
- ✓ pH: 7

GREAT HAYWOOD: 3/4

- ✗ Phosphate: 200 ppb
- ✗ Nitrate: 50 mg/l
- ✗ Coliforms: Present
- ✓ pH: 7

NEWARK-ON-TRENT: 3/4

- ✗ Phosphate: 500 ppb
- ✗ Nitrate: 100 mg/l
- ✗ Coliforms: Present
- ✓ pH: 7

WILFORD: 3/4

- ✗ Phosphate: 500 ppb
- ✗ Nitrate: 100 mg/l
- ✗ Coliforms: Present
- ✓ pH: 7

RIVER TRENT

Figure 9

Figure 9 presents results from each site on the River Trent. The median reading for phosphate, nitrate and pH and mode reading for total coliform bacteria presence is displayed. Next to the site name, the number of parameters a site fails for, e.g. 3/4, is shown.

RIVER THAMES AND RIVER TRENT

When considered together, both the River Trent and River Thames are failing. Not one site on either river passes water quality tests on all parameters.

This suggests that pollutants are variable and prevalent along the courses of both these rivers. Of particular concern are the levels of phosphate and nitrate pollution as no testing site shows an acceptable level for both of these pollutants. One positive takeaway is that pH is not an issue for either river as all test readings fall within the acceptable range. This is in line with the trends observed at other testing sites: pH levels tend to be at a more acceptable level than the median concentrations of other pollutants.

RECOMMENDATIONS

1. The Secretary of State for DEFRA (currently Thérèse Coffey MP) to reject plans to amend the legislation that requires 75% of English rivers to achieve 'good' status by 2027

This legal requirement was transferred into UK law from the Water Framework Directive after the UK left the EU. It is a piece of legislation currently set to be amended by December 2023, under the Government's EU Law (Revocation and Reform) Bill.

This amendment proposes changing 2027 to 'as soon as practicable' which is both vague and loose, weakening protections to waterways currently in place.

The 2027 target is both a major driver of public and private investment into cleaning up our waterways and a vital tool to hold to account industries with permits to pollute (these are more numerous than just water companies).

2. DEFRA to bring forward the enforcement[EA1] date for the increase in Variable Monetary Penalties for polluting water companies to 1st February 2023

On 3rd October 2022 DEFRA's Environment Secretary announced they will raise proposals to increase the Variable Monetary Penalties for polluting water companies from £250,000 to £250 million.

We recommend DEFRA makes this new penalty value enforceable as soon as possible. With the UK's heaviest rainfall months, and therefore likely most active overflow period, falling between January and April, we recommend this increase is in place from the 1st February 2023.

3: DEFRA to strengthen the effectiveness of the Storm Overflows Discharge Reduction Plan (SODRP) by making the following amendments:

Amendment A: Reduce the maximum achievement date on all SODRP targets to be 2035 rather than 2050.

The 'Plan' outlines a number of targets for water companies to reduce their use of storm overflows, however the achievement dates for many of these targets range from 2035 – 2050. The UK committed to improving river quality by 2027 when it signed up to the Environment Act. Reducing storm overflow use by 2050 equates to a 23 year overshoot of the 2027 target.

Amendment B: Prohibit water companies from increasing water bills to fund the critical infrastructure investment required.

The 'Plan' outlines that water bills may rise in 2025 to fund the investment needed for the critical infrastructure upgrade. However given the current proposed timelines, bill payers will not experience the water quality improvements for 10 - 25 years after this. As such, our perspective is that any shortfall in capital should be paid for by the water companies, not bill payers or taxpayers.

4: The Environmental Agency to accelerate the speed at which citizen science is integrated into formal data collection activities for developing evidenced-based policies

Currently the role of citizen science in data collection is insufficiently recognised by the UK government. Efforts to embed the approach in catchment-level monitoring activities (such as the United Utilities and River Trust lead CastCo project), must be expanded beyond remit of Ofwat, those it regulates, and interested charities and academics.

The government's Environment Audit Committee recently called for a closer relationship between government, regulators and citizen science organisations to realise the true value of mass data collected at scale, yet such initiatives are still not being led by governmental organisations.

We therefore recommend the Environment Agency accelerates the speed at which citizen science is formally embedded into all UK water quality monitoring activities. To implement this, we advise including citizen science organisations in water monitoring frameworks and regulation.

Recommendation 5: Use funds raised from the increase in Variable Monetary Penalties] for polluting water companies, to increase the criminal prosecution rates of those who damage water quality

Currently due to a chronic underfunding of environmental regulators there is a lack of criminal prosecutions for water quality damage.

There are simply not enough resources available to prosecute offenders and there is also very little data available about the evidence necessary for successful prosecution.

We propose using the funds raised from the proposed increase in penalty charges for polluting water companies, to finance the resourcing and research needed to increase prosecution rates.

GLOSSARY

CITIZEN SCIENCE	Involves the general public in scientific research.[76] In this report, all findings are based upon people-powered data collection and referred to as such. This process can bring society, science and policy making closer together.
GOOD ECOLOGICAL STATUS	A metric for assessing the health of the water environment. It is assigned using various water flow, habitat and biological quality tests. Failure to meet any one individual test means that the whole water body fails to achieve good ecological status.
POINT SOURCE POLLUTION	A stationary location or fixed facility from which pollutants are discharged.[77]
DIFFUSE POLLUTION	Pollution from widespread activities with no one discrete source such as acid rain or agricultural runoff.[78] Diffuse pollution is more difficult to identify than point-source pollution.
EUTROPHICATION	The gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients in a water ecosystem.[79]
WATER FRAMEWORK DIRECTIVE	Released in 2000, this an overview of the development, present state and future of European Water Policy.[80] Following Brexit, the requirements of the EU WFD, have been transposed into UK law and implemented domestically in the Water Environment Regulations of 2017 in England and Wales
NITRATES DIRECTIVE	Aimed at improving water quality by protecting against nitrate pollution from agricultural sources. This includes improving the management of animal manures and chemical nitrogen fertilisers.[81]
ANAEROBIC DIGESTATE	A nutrient[81]-rich substance that can be used as a fertiliser.
BATHING STATUS	For water to be given bathing status, they must be regularly tested for bacteria levels. They will be awarded a categorisation based on the level of bacteria present which will then inform the possibility of swimming in the area.[82]
COMBINED SEWER OVERFLOW (CSO)	This infrastructure was developed to reduce the risk of sewage backup during periods of prolonged rainfall.[83]
NITRATE VULNERABLE ZONE (NVZ)	Areas designated as being at risk from agricultural nitrate pollution. They include about 55% of land in England.[84]
ENVIRONMENT AGENCY (EA)	A UK-based, executive non-departmental public body, sponsored by the government Department for Environment, Food & Rural Affairs.[85]
SCOTTISH ENVIRONMENTAL PROTECTION AGENCY (SEPA)	Scotland's principal environmental regulator, protecting and improving Scotland's environment.[79]
PREDICTED NO EFFECT CONCENTRATION (PNEC)	The concentration below which a specified percentage of species in an ecosystem are expected to be protected.
BIOAVAILABILITY	The amount of an element or compound, such as a metal, that is accessible to an organism for uptake or adsorption.
ENVIRONMENTAL QUALITY STANDARD (EQS)	Standards which are set to protect water bodies from the harmful effects of the contaminants that could flow through them.
WORLD HEALTH ORGANISATION (WHO)	WHO's primary role is to direct international health within the United Nations' system and to lead partners in global health responses.[80]

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Test kit providers: Quantofix Nitrate/Nitrite semi-quantitative test strips, La Motte Insta-Test Phosphate kit, SimplexHealth wide range pH water test kit, Simplex Health bacteria water test.

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