FreshWater Watch
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EMISSIONS ANALYTICS

Tyre pollution in the Evenlode and Windrush river catchments

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River Evenlode (c) Sam Frith

Executive summary

A small scale study in the Evenlode and Windrush has revealed worrying evidence of tyre pollution in local freshwater systems.

This year, Earthwatch Europe has conducted two Great UK WaterBlitzes; facilitating citizen scientists across the UK to monitor the health of their local freshwater bodies, creating a robust dataset that provides an informative snapshot of the health of our nation's freshwater.

As well as generating data at **spatial scale**, citizen science can be used to take a **deeper dive** into water quality within specific catchments to evidence exactly what underpins their poor health. Through collaboration with Emissions Analytics, Earthwatch Europe has used citizen science to demonstrate that tyre particle matter may be contributing to water pollution in two tributaries of the Thames: the Evenlode and the Windrush.

Across our road networks, surface water runoff washes into the environment every time it rains. Roadway runoff is mostly connected to storm sewers or combined sewers through storm drains; they are not commonly connected to the sewage system and are, therefore, capable of entering our freshwater environments without treatment. In England alone, there are more than 18,000 outfalls associated with the motorways and main roads and likely **more than a million local highway drains discharging directly to watercourses**[1].

Citizen scientists collected samples of water from puddles on roads, water running from roads into rivers, and from rivers directly, for chemical analysis. Antioxidants, stabilizers and rubber compounds, indicative of tyre pollution, were found in 100% of samples collected.

We urge the Environment Agency and Highway Agency to take tyre particulate matter more seriously; for authorities to integrate citizen science into their freshwater monitoring frameworks; and for citizen scientists to continue monitoring and advocating for their rivers.

Earthwatch Europe want to see data-driven change to ensure that our future rivers are healthy from source to sea.

Key findings

- Antioxidants, stabilizers and rubber compounds were found in **100%** of samples collected along roads draining into the Evenlode and Windrush
- These chemicals are indicative of **tyre pollution**
- Although concentrations of chemicals were low, long-term exposure may have a **harmful effect** on the aquatic environment, particularly through bioaccumulation

Urban run-off and tyre-wear pollution

Urban run-off is the surface water that results from rainwater, irrigation, and car washing in urban areas.

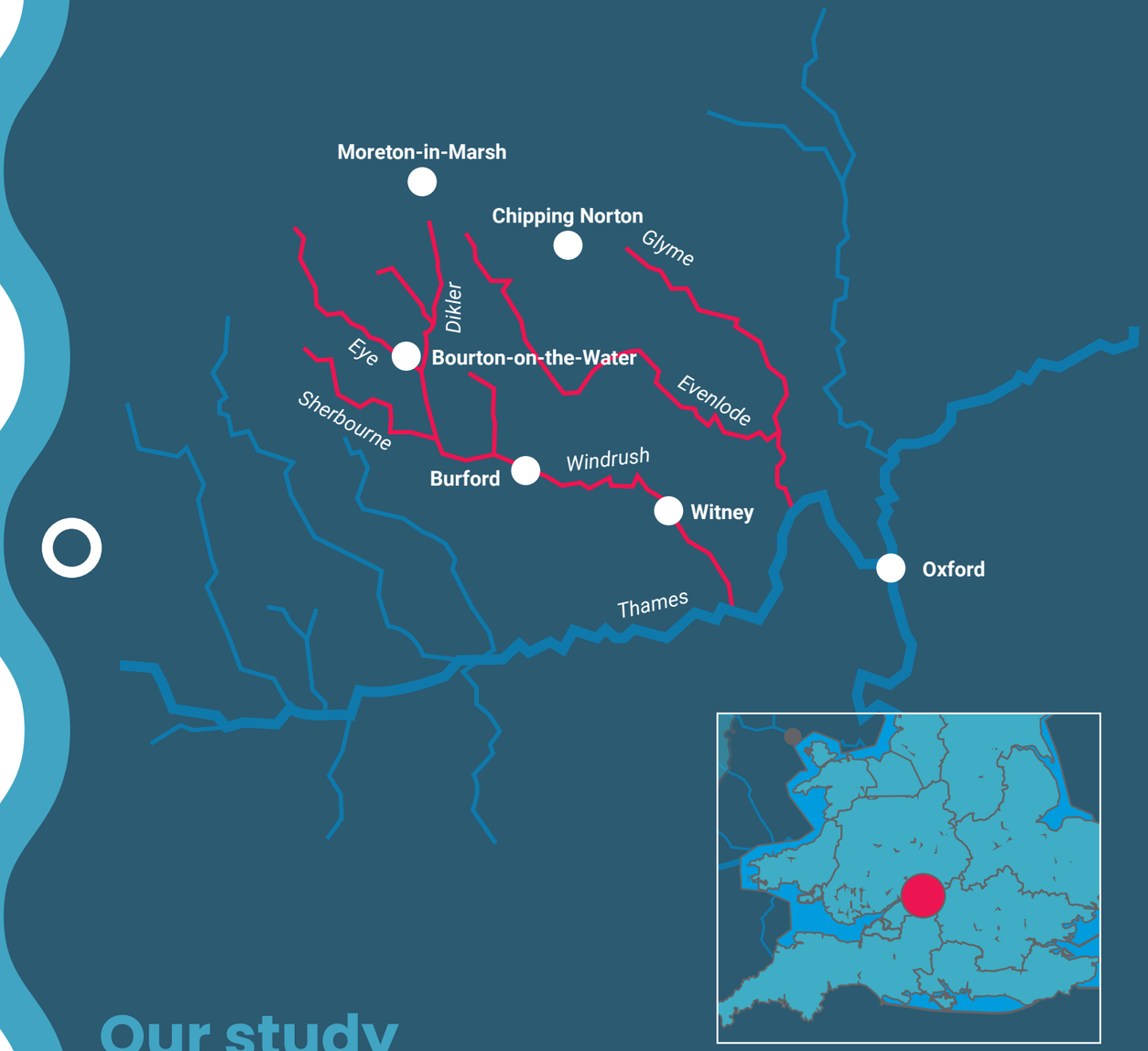
Urban runoff flows over land or impervious surfaces - such as paved streets, parking lots, and building rooftops - into sewer systems to be treated at wastewater facilities, or directly into waterways through drainage culverts. Urban runoff can pick up pollutants as it flows through towns and cities; including litter, animal excrement and particulate matter.

Tyre-wear pollution is a very serious and growing environmental problem, one that is being exacerbated by the growing popularity of large, heavy passenger vehicles and the increasing number of heavy goods vehicles on the roads. What's more, this pollution is completely unregulated, unlike exhaust emissions which are being addressed by car makers thanks to the pressure placed on them by European emissions standards. New cars now produce less particulate matter but there is growing concern around 'non-exhaust emissions'.

Non-exhaust emissions are particles released into the air from brake wear, tyre wear, road surface wear and resuspension of road dust during on-road vehicle usage. No legislation is in place to limit or reduce these emissions, but they cause a great deal of concern for both air and water quality.

What's in a tyre?

The British Tyre Manufacturing Association states that truck tyres typically contain 30% natural rubber, and car tyres contain about 15%. Tyres are made up of 42% elastomers (both natural and man-made rubber material), 28% carbon black and silica, 12% steel, 6% oils, 5% teaxtile, 1% zinc oxide, 1% sulphur and 5% other ingredients.



Our study

Citizen scientists collected sixteen samples for analysis by Emissions Analytics.

Samples were collected from puddles on roads, from water running from the road into ditches and/or rivers, and directly from rivers, from the 26 July to the 2 of August. This period was characterised by heavy rains and high river flows.

Seven pollutants of emerging concern, characteristic of tyre-wear are highlighted here. These volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) consist of **antioxidants**, **stabilizers and rubber compounds: (1)** Styrene, **(2)** Dimethyl trisulfide, **(3)** Benzene, 1,3-bis(1,1-dimethylethyl), **(4)** 2,4-Di-tert-butylphenol, **(5)** 2,5-Di-tert-butyl-1,4-benzoquinone, **(6)** Benzene, 1-methyl-4-(1-methylethenyl) and **(7)** 1,4-Benzenediol, 2,6-bis(1,1-dimethylethyl).

Combinations of these chemicals, indicative of tyre-wear, were found in every single sample collected. The presence of these chemicals on roads adjacent to rivers, and in river water itself, suggests that pollution from non-exhaust emissions is impacting these important tributaries to the river Thames.

Chemicals in road run-off

Styrene occurs naturally in a variety of foods such as fruits, vegetables, nuts, beverages, and meats; but it is primarily a synthetic chemical used to make products such as rubber, plastic, insulation, fiberglass, pipes, automobile parts, food containers, and carpet backing. Styrene can be toxic to aquatic organisms at relatively low concentrations. It is strongly advised not to let the chemical enter into the environment[2].

Dimethyl trisulfide (DMTS) is a typical volatile organic sulphide, which leads to rotten eggs or rotting stench in water, mainly from the death and decomposition of high-density blue algae and microbial decomposition of sulphur-containing organic matter in water[3].

Benzene, 1,3-bis(1,1- dimethylethyl) is an alkylbenzene. These chemicals are liquids with relatively low boiling points that are used primarily as solvents or as starting materials in the synthesis of other chemicals and drugs. In general, the toxicity of alkylbenzenes has been found to be relatively low. However, in high concentrations they might pose significant and potential health risks to man and the environment[4].

2,4-Di-tert-butylphenol (2,4-DTBP) is a member of the class of phenols carrying two tert-butyl substituents at positions 2 and 4. It has a role as a bacterial metabolite, an antioxidant and a marine metabolite. 2,4-DTBP is often a major component of violate or essential oils and it exhibits potent toxicity against almost all testing organisms[5].

2,5-Di-tert-butyl-1,4-benzoquinone (DTBBQ) is a member of p-quinones and a member of benzoquinones. Quinones can be toxic to aquatic life, including fish, mussels, and crustaceans[6].

Benzene, 1-methyl-4-(1-methylethenyl) or p-cymene is a monocyclic hydrocarbon and a monoterpene. It can be toxic to aquatic life if it enters waterways[7].

1,4-Benzenediol, 2,6-bis(1,1-dimethylethyl) is another alkylbenzene: in high concentrations they might pose significant and potential health risks to man and the environment[4].

The concentration of these chemicals in micrograms per millilitre (ug/ml) are shown in Table 1.

Most of these chemicals could not be found in the NORMAN Ecotoxicology Database. However, 2,4-DTBP has a predicted no-effect concentration (PNEC) of 0.32 micrograms per litre (ug/L). Concentrations of 2,4-DTBP were higher than its PNEC across all samples in which it was detected. 1,4-Benzenediol, 2,6-bis(1,1-dimethylethyl) has a PNEC of 1.21ug/L. Concentrations of this chemical were also higher than its PNEC across all samples in which it was detected. This means that these chemicals were found at concentrations that could present risk to aquatic life.

Site name	Road	Water type	Styrene	DMTS	Benzene, 1,3-bis(1,1-dimethylethyl)	2,4-DTBP	DTBBQ	p-cymene	1,4-Benzenediol, 2,6-bis(1,1-dimethylethyl)
			Rubber	Rubber	Stabilizer	Antioxidant / Stabilizer	Antioxidant / Stabilizer	Rubber	Antioxidant
Enstone Speed Camera	A44	Running on the road	0	0.028	2.336	0.224	0	0	0.014
Enstone PO	A44	Running on the road	0.177	0.084	3.775	0.283	0	0	0.049
Lidstone	Unnamed	Running on the road	0	0.405	2.793	0.279	0	0	0.025
London Road	London Road	Puddle	0	0	6.184	0.141	0	0	0.008
Cornwell Brook	Unnamed	Running on the road	0	0	5.987	0.168	0	0	0.012
Stow Road	A436	Puddle	0	0.023	0.956	0.032	0.013	0	0
Bourton	A429	Running on the road	0	0	4.02	0.16	0	0	0.009
Top Road	Unnamed	Puddle	0	0	4.837	0.198	0	0	0.011
Windrush	Unnamed	Puddle next to river	0	0	3.031	0.131	0	0	0.039
Barton	Unnamed	Puddle next to river	0	0	0.432	0	0	0	0
Critchford Lane	Critchford Lane	Stream	0	0	4.671	0.216	0	0	0
River @ Critchford	Critchford Lane	River	0	0	5.951	0.284	0	0	0.007
Ford	B4077	Puddle next to river	0	0.012	1.979	0.109	0.12	0	0.013
Enstone A44	A44	Road pipe into river	0	0	1.907	0.198	0	0	0
A44 Chipping Norton	A44	Running on the road	0	0	6.367	0.174	0	0	0.046
Moreton in Marsh	Car park	Road pipe into river	0	0	2.06	0.167	0.033	0.046	0.008

Earthwatch Europe wants to see accountability from all types of polluters: from agriculture, sewage overflows and urban run-off.

Where do we go from here?

In this pilot study, we have evidenced the concerning presence of tyre particle matter in water entering our rivers; with every single sample collected subjected to a cocktail of chemicals indicative of tyre pollution.

The potential impact of these chemicals cannot be underestimated. In the United States, 6PPD-quinone - a chemical that prevents tyres from degrading – was shown to be the cause of **acute mortality events in salmon**, with toxicity induced at threshold concentrations of ~1 microgram per litre[6].

As individuals, we can reduce tyre wear through optimised driving; reducing harsh braking, rapid acceleration, and fast cornering, which tend to lead to increased emission levels due to high forces between the tyre and the road. At the vehicle and road surface level, technological devices to capture tyre-wear at the vehicle, road pavement as a trap for particulate matter, as well as street cleaning and dust binding to remove pollution are all possible mitigation measures that could be implemented[9]. For wider treatment of road runoff, we want to see the use of **nature-based solutions;** retention basins (constructed ponds with vegetation around the perimeter of a pool of water), detention basins (a structure into which stormwater runoff is directed, held for a period, and slowly drained to a surface water body) and constructed wetlands (a man-made basin that contains slowly-moving surface water, organic materials as well as water-tolerant plants, and organisms similar to those found in natural wetlands) can all trap suspended particles and improve water quality[9].

We urge the Highway Agency to take particle matter more seriously and to start taking action to reduce these emissions; enforcing speed limits and maintaining road surfaces[9], ensuring vehicle weights are lowered and high-quality tyres are fitted across the UK. We urge the Environment Agency to invest proper resources into monitoring tyre particle matter across the nation's freshwater, for authorities to integrate citizen science into their freshwater monitoring frameworks, and for citizen scientists to continue monitoring and advocating for their rivers.

How bad could it be?

The average car emits 67mg of tyre particles per kilometre. The average driver covers 11,000 kilometres per year. This means every car produces approximately 737,000mg (or 737g) of tyre particle matter annually.

Now multiply that by the 41 million vehicles in the UK, and you have around 30 thousand tonnes of potentially toxic tyre particles produced each year. It is estimated that over 21 thousand tonnes run-off from roads, and almost 11 thousand tonnes enter our surface waters every single year[8].


River Windrush (c) Sam Frith

Methods

Citizen scientists collected sixteen water samples along the river Windrush over the dates of the 26 July to the 2 of August 2024. Emissions Analytics analysed the presence of VOCs and SVOCs using solid-phase microextraction with two-dimensional Gas Chromatography-Mass Spectrometry.

Samples were extracted using the DVB/PDMS/Carbon WR Smart SPME fibre and desorbed on a GC injection. An Agilent 8890 Gas Chromatographer equipped with a Markes International Bench Time-of-Flight Mass Spectrometer (GCxGC-TOF-MS), using a flow modulator from SepSolve Analytical was used to analyse chemical concentration.

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