SOENECS
Innovative Sustainable Solutions

Insight Report: 2030

Invisible Ocean Pollutants from our Roads

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SUEZ 2030 Futures Insight Report no.1:
Invisible Ocean Pollutants from our Roads

Contents.

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Foreword.

John Scanlon
CEO SUEZ recycling and recovery UK

The problem of plastics leaking into our rivers and oceans, long recognised by environmentalists, was thrust into the spotlight when Blue Planet II hit our screens in 2017 and images of sea creatures swimming amongst plastic litter captured the public's imagination. Although less visible than a discarded plastic bottle or snack wrapper, microplastics have also grown in prominence, with fibres from synthetics clothing and microbeads used in cosmetics attracting headlines in mainstream media. The public's concerns around all forms of plastic pollution are rightly not relenting and this is a call to arms in the UK for much of the planned policy reform we expect to see in the near future.

However, over the last year, a less well-known source of microplastic pollution in our oceans has begun to attract attention, namely particles from tyre wear, and it is these particles that are the subject of this report and the target for its recommendations.

As a resource management company, our day job is to efficiently collect, sort and recycle plastic (and other forms of) packaging, which reduces pollution in our oceans, however our role as a leader in environmental services extends far beyond this. To help stay ahead of the debate and to ensure we are doing all we can to maximise our collaborative efforts with our customers and peers to decarbonise our operations, we need to consider less well understood sources of pollution and the potential impacts from our operations.

We commissioned this research by SOENECS to better understand pollution from tyre wear particles, because we are developing a new fleet of electric vehicles and were unsure of the overall environmental impacts of doing so, and to explore some of the potential interventions each of us could take to mitigate these impacts, from embracing new technology to improving our driving habits. More importantly we wanted to fully appreciate the role that our sector could play in overcoming the current problem and the many risks identified. It is clear that decreasing tyre wear plastic particles in our environment will require leadership, collaboration, science and creativity.

As with many of today's biggest environmental issues, the research highlights the complexities of pollution from tyre particles and the need to take a holistic, systems based approach when identifying interventions to avoid unintended consequences – who'd have thought that going electric will increase tyre dust pollution? With every car tyre weighing around a kilogram less at the end of its life than when it first hit the road, it also shows that whilst the full impact of pollution from tyre particles isn't yet fully understood, it is doubtless disproportionate to the low level awareness of tyre particles as a source of microplastic pollution in our oceans. And we hope that this report, along with other academic and industry sponsored research can go some of the way to addressing this imbalance. Awareness is the first step to improvement.

Beyond helping to increase awareness of microplastic pollution in our oceans from tyre usage, adding to the growing debate around the issue, we hope that this report ultimately encourages action from all of us, and greater collaboration across the value chain to find and deliver solutions, just as we have seen for other types of plastics.

Introduction.

During 2020, the SOENECS team, having been commissioned by SUEZ recycling and recovery UK, researched the causes and impact of tyre degradation on the marine and ocean environments, the new technologies and innovations that will arise between now and 2030 and what the industry and government are, or should be, implementing to mitigate the impact.

Tyre Wear Particles (TWP) are the abraded surface of vehicle tyres, between 1nm to 0.5mm[1], and deposited on the road surface or blown into surrounding environments. TWP comprise a cocktail of natural rubber, synthetic compounds, fillers, antioxidants, antiozonants and curing systems. Due to the mix of materials, they are classed as a microplastic.

SOENECS is a circular economy and resource managment research and innovation practice and this research was conducted to determine the scale of tyre wear in the UK and its impact on marine and ocean environments. A combination of desk research, interviews and a questionnaire were used to deliver this project. A summary of key findings are shown in Figure 1.

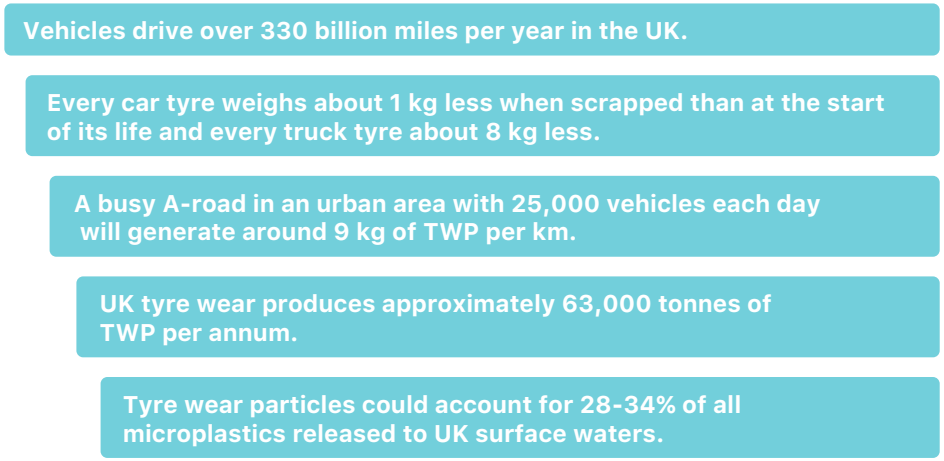


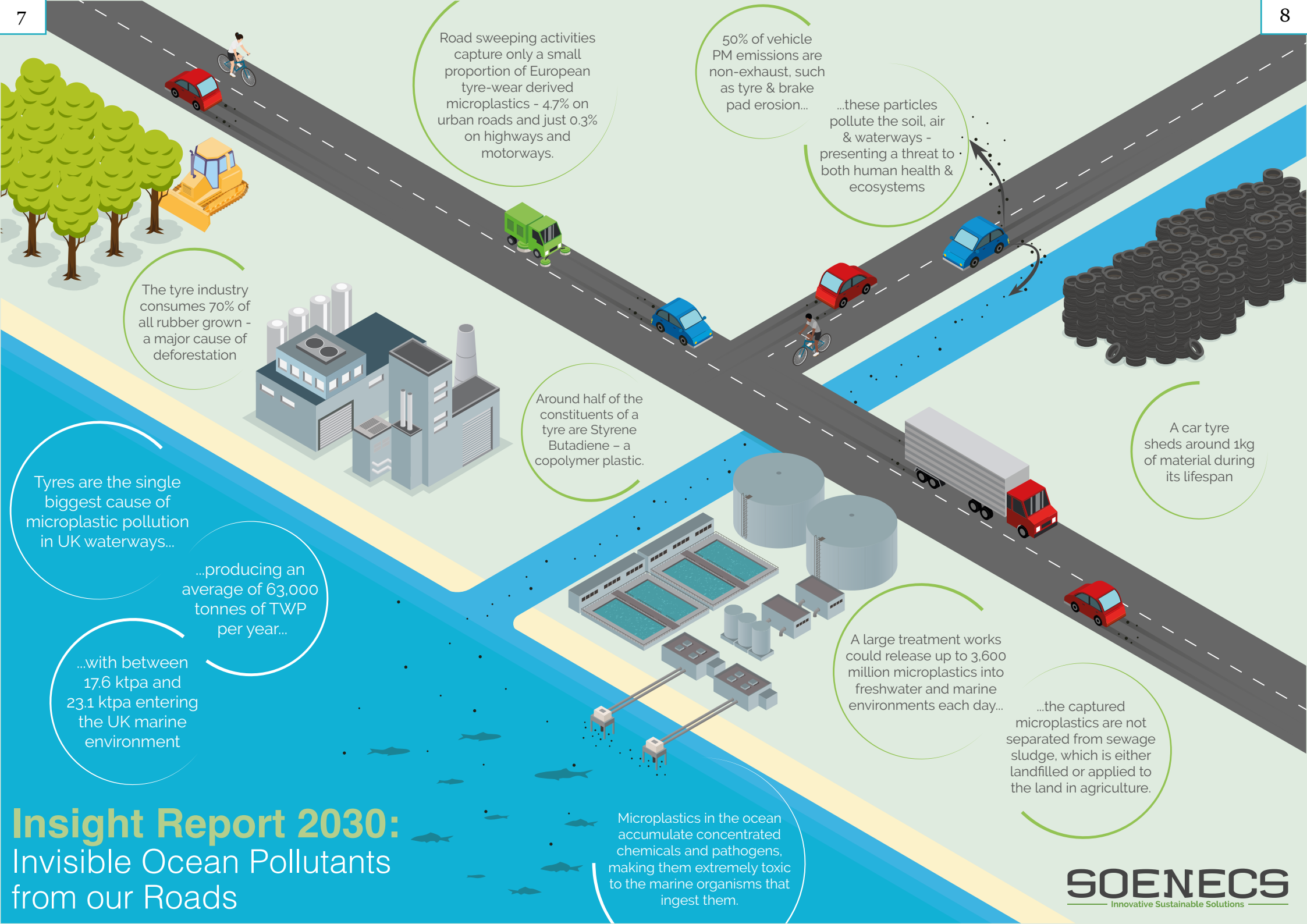
FIGURE 1 - The scale of tyre wear generation in the UK[6]

The research was conducted during the COVID-19 pandemic, which led to road traffic decreasing by 51.7 billion vehicle miles; a reduction of 14.6%[2]. Traffic levels rose back to near pre-COVID levels after the first lockdown ended, however, during the lockdown and since people have been asked to avoid public transport so some who would not have driven previously, may be driving now and some who would have driven previously, may not be driving now. Travel patterns have, therefore, altered and the impact is ongoing so it feels too early to say what impact COVID-19 has had on the findings of this research.

The term ***"Invisible Ocean Pollutant"*** has been coined because of the physical invisibility of TWP and that few people know TWP are a major source of pollution in the oceans. The conclusion from the research undertaken is that TWP are a major environmental pollutant and this is only starting to become recognised as an issue. Annually between 28%[4] (17,640 tonnes) and 34%[5] (23,120 tonnes) of TWP are entering the UK marine environment. Globally, this is a major environmental concern, where it is currently estimated that up to 1.03 million tonnes of microplastic will be in the oceans by 2030 (if using the UK assumption of 28-34%, 288,400 – 350,200 tonnes of TWP), and more than doubling to over 2.5 million tonnes (700,000 – 850,000 tonnes of TWP) by 2050[3].

The resource management sector (*Sector*), through street sweeping and wastewater treatment, is the only sector intercepting TWP at an industrial level. The *Sector* now has the opportunity to highlight TWP as a mainstream environmental issue, and by its own actions, continue to reduce TWP emitted into the environment, and support more research to understand the pathways to the oceans, the scale and impact and what mitigation could be undertaken.

A summary of the pathway to the ocean by TWP is shown in Figure 2 which highlights some of the significant facts drawn from the research. This Insight Report will summarise the detailed research and discussion contained within the adjoining Annexes and give recommendations to the resource management sector on some of the potential actions available to address and to mitigate the ***"Invisible Ocean Pollutants"*** that are Tyre Wear Particles.



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Pathway to the Oceans.

"After 12 years fighting ocean plastic, it's become clear that we need to tackle pollution we can see, but also what we can't!

Tyre dust is invisible to the naked eye, but is released in large quantities, all over the world, and ends up in our air, earth, waterways and ocean."

Emily Penn,
Co-Founder and Director of eXXpedition

"If we are to avoid plastics ending up in the oceans, the solutions lie on land. This involves a collective re-engineering of how we produce and consume"

Andre Abreu and Maria Luiza Pedrotti,
Tara Expeditions Foundation

The hypothesis for this report was to determine the process and impact of tyres on our marine and ocean environment. However, as the research was conducted, it also became clear that not many people were aware that tyre wear particles ended up in the ocean, and indeed, even if they did know, they did not understand the amount of TWP entering the oceans.

During the course of research a number of significant papers, that received national press coverage, were published and may change this perception. These papers included in May 2020, a major DEFRA report[4] and in July 2020, a Nature[5] publication. Both papers presented significantly more evidence of the impact of TWP on the oceans and may have increased the breadth of understanding of this issue. Two aspects were reiterated by the authors:

"The findings support the predictions of previous desk based studies that tyre wear particles are a major direct source of microplastics to the environment"

DEFRA and Parker-Jurd et al [4]

"About 34% of the emitted coarse TWP (100 kt yr-1) were deposited in the World Oceans"

Evangeliou et al [5]

These two studies combined with the limited research available (on a global scale, only around 1% of microplastics studies report finding any tyre particles at all[7]) and input from our workshop attendees, support the hypothesis that although tyre wear particles are a major contributor to microplastics in the ocean, they have received little media or research interest to date.

However, few experts can agree on the extent of the problem. Is it 20%, 34% or even as high as 65% of microplastic entering the oceans? What is the definition? Tyres, brake dust and road markings have all been classified as TWP by experts, including by B Bänsch-Baltruschat et al[8] and P J Kole et al[9]. How should we combat it? The design of tyres, interception at source and reduced driving are just some of the recurring opportunities mentioned (to name a few).

Whilst the researchers do not agree on the proportion, the common pathway to the ocean for TWP is much better understood and the flow diagram in Figure 3 highlights the main journey from our vehicle tyres to our oceans and waterways and potentially into our food chain. The figures indicate that the three primary receptors for tyre wear particles are [1] street sweeping, [2] the road drainage system, leading directly to water courses and surrounding land and [3] Wastewater Treatment Plants (WWTPs). The graphic shows that once entering a receptor, TWP will be captured at different proportions:

- Between 0.1 and 10% of TWP is blown onto surrounding environments.
- Street sweeping currently captures 0.3% to 4.7% of TWP.
- WWTPs have the potential to capture between 72% and 94% of TWP.

The proportion of runoff going to WWTPs is uncertain, but estimates show that between 20% and 40% of runoff enters a WWTP (more research is required on this area). Based on these statistics over half of all TWP goes directly to water courses.

The *Sector* is currently preventing a small amount of TWP from entering the ocean through street sweeping and WWTPs, however, the impact is small, and more focus needs to be given to designing out the problem for the future and intercepting at source in the meantime. The information contained within Annex 1 explores in detail the statistics and some of the current practice in relation to TWP.

"Tyres are the single biggest cause of microplastic pollution in 'surface waters' (rivers, lakes, wetlands and oceans) in the UK - totalling between 7,000 and 19,000 tonnes."

Friends of the Earth [10]

"A busy road with 25,000 vehicles travelling on it each day will generate around nine kilograms of tyre dust per kilometre."

Kruszelnicki [11]

COMPOSITION OF TYRES

- Tyres contain 24-35% natural rubber.
- The remainder is synthetic fibres and metal.

DEGRADATION OF TYRES

- 120 million car tyres in UK.
- TWP will be deposited on road surfaces as micro particles (under 0.5mm).
- 46,000 tonnes per annum of tyre materials lost through wear.

PRIMARY RECEPTOR

- TWP captured during street sweeping.
- TWP washed into drainage.
- Micro TWP blown into surrounding environment.

SECONDARY RECEPTOR

- Street cleansing waste enters landfill.
- Drainage runoff goes directly into marine environment or to a Waste Water Treatment Plant.
- Airborne TWP will be mixed into soils, ingested by animals or blown into water course.

ENTERING THE MARINE ENVIRONMENT

- TWP will be suspended in water course and may eventually end up in the oceans.

ENTERING THE FOOD CHAIN

- Suspended particles are mistaken by marine life as food and ingested.

ENTERING THE HUMAN FOOD CHAIN

- Commercial fishing captures marine life with ingested TWP (and other microplastics).

FIGURE 3 - The SOENECS TWP pathway from "Road to Food Chain"

Impact on the Aquatic Environment & Food-Chain from Microplastics.

It has already been shown that there is a paucity of research data on TWP, meaning exploring the impact of TWP on the aquatic environment is challenging. Tyre companies are generally not convinced that microplastic waste from tyres has the potential to be harmful to ecosystems or human health, stating that more research is required in the area to evidence such claims[12].

Professor Richard Thompson, from Plymouth University, suggests a reason for the lack of information is that *"Tyre particles are challenging to identify from environmental samples, and this might explain the discrepancies between modelling estimates and actual field sampling."* Given that approximately 30% of microplastics in the ocean is TWP, it is appropriate to look at the impact of all microplastics on the aquatic environment.

Research does show that if ingested by invertebrates and fish, microplastics, due to the volume which the particles occupy, see Figure 4, will lead to a reduction of food intake and thus a loss of energy and vitality. Furthermore, polymer additives can be leached out in the digestive tract leading to toxic impacts[13]. The research that has been carried out in the scientific community indicates microplastic in food and drinking water:

- Fish exposed to microplastics reproduce less but their offspring, who were not directly exposed to plastic particles, also had fewer young, suggesting the effects can linger into subsequent generations.[14]
- Continuous exposure of crustaceans over generations to microplastic may cause population extinction.[15]
- Tests conducted for Orb at the State University of New York revealed that in some bottled water over 10,000 microplastic particles are found.[16]

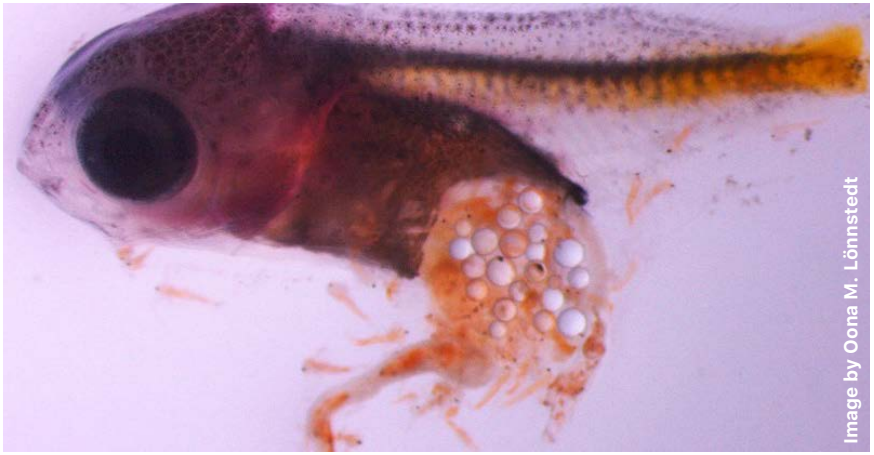


FIGURE 4 - Microplastics are shown as small globules in fish under a microscope[17]

Scientists do agree tyre particles contain two main classes of chemicals – organic and inorganic. As they are the building blocks of life, the majority of organic chemicals are completely safe, with some exceptions, in particular 'persistent organic pollutants.'

Inorganic chemicals, which include synthetic compounds from tyres, are especially toxic to aquatic creatures, and in laboratory experiments damage human DNA. This means that whilst the data may not be fully verifiable, the fact that the tyre, which has been designed to degrade, deposits TWP onto our roads, is contributing to polluting our marine environment.

Dr Charles Rolsky from Arizona State University suggests that, *"There's evidence that plastic is making its way into our bodies, but very few studies have looked for it there. And at this point, we don't know whether this plastic is just a nuisance or whether it represents a human health hazard."* [18]

In December 2020, a new study was published that showed evidence of 12 microplastic fragments in six human placentas. This led to the authors concluding that "*due to the crucial role of placenta in supporting the foetus development … the presence of exogenous and potentially harmful (plastic) particles is a matter of great concern.*" [19]

Lack of food system research, compounded by the limited research into tyre particles as a microplastic, means determining the source of these microplastics is difficult.

Are the microplastics in our bodies TWP? To address this, Professor Thompson and his team are starting a new research programme in 2021 that will "*measure tyre particle concentrations at their points of entry to the marine environment and then describe their subsequent transport in the water column.*"

Research has shown evidence of microplastics in marine food chains.

What do the Experts & Questionnaire Respondees think?

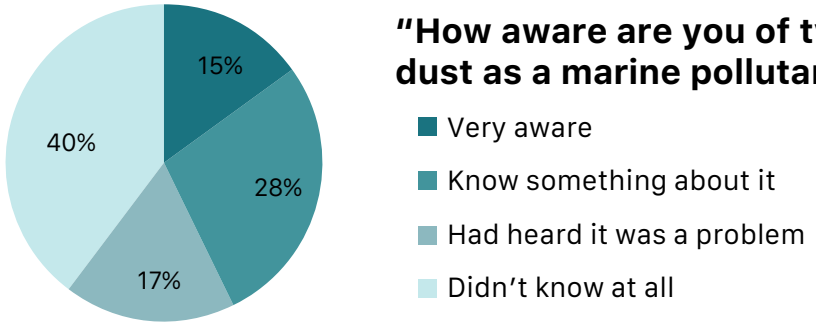
There were two engagement routes taken between March and April 2020; an online questionnaire was distributed amongst peers and on 22 May 2020, a virtual workshop with a hand-picked mix of leading academics, policymakers, industry representatives and a global ocean pollution explorer was hosted. The outputs from these activities are summarised below and more detail can be found in Annex 3.

The Questionnaire

SOENECS distributed the questionnaire through their environmental sector networks and social media; 90 responses to 18 questions came from mostly UK-based respondents, as well as those in the USA, Brazil, India and across Europe.

"I was not fully aware of the extent of the negative impact of tyres on our environment. This survey has made me reflect much more. More awareness should be widely spread on this issue"

Eva from Closca Apparel & Fashion



Survey responses to the question -
"How aware are you of tyre dust as a marine pollutant?"

The questionnaire responses provide insight into where TWP ranks as an issue and how to address solutions. Respondees thought that:

- The top three environmental concerns were: Climate Change, Deforestation and Air Pollution
- 30% thought rubber made up more than 51% of the tyre
- 38% correctly answered that there were 120 million car tyres on UK roads
- 89% drove less than 20,000 miles per annum, with 73% less than 10,000 miles
- 26% thought that Electric Vehicles (EVs) would lead to greater TWP
- 55% thought that under 30% of microplastic in the ocean was from TWP
- The biggest concerns about TWP entering the ocean were:
  1. Food chain contamination
  2. Biodiversity loss and
  3. Water quality reduction
- Reduced transport, tyre composition changes and eco driving were the top three solutions to combating TWP
- Tyre manufacturers, followed by national government and car manufacturers should take responsibility for TWP
- To solve the problems of TWP, walking more, working from home more often and cycling more were the personal solutions to TWP that were widely supported.

Analysis of the survey responses suggested that for many people the issue of TWP as an ocean plastic pollutant was not at the front of their minds, however, when prompted, it made sense and that microplastics, regardless of their source, are a concern that we should be addressing.

The responses from the questionnaire indicate that there are still huge gaps in knowledge of environmentally informed people about TWP and impact on the ocean, however, the consensus of doing something about highlighting the issue and acting to reduce TWP is an imperative.

The *Sector* in partnership with the tyre manufacturing sector and Highways England should put concerted effort into raising TWP as an issue.

The Workshop

The purpose of the workshop held on 22nd May 2020 was to engage experts in TWP and strategic leaders in fields impacted or potentially responsible for the invisible pollutant. The aim was to determine if tyre and car manufacturers, as well as the public, understand the extent and impact of TWP, test the accuracy of research undertaken by SOENECS and explore causes of the TWP, its potential impact in 2030 and some of the possible solutions and mitigation measures that can be undertaken.

TECHNICAL & POLICY SOLUTIONS

The participants explored the various economic and social aspects that need to be taken into account; for example, cycle lanes etc are not accessible to all the population and asking someone to not drive in a rural area is impractical. It was suggested that a systemic approach needs to respond to a wide range of sources in the urban environment. Sometimes there is a conflicting objective. The workshop attendees suggested the following interventions:

EXTENDED PRODUCER RESPONSIBILITY (EPR)

EPR was suggested as an important incentive to industry to invest in redesigning the manufacturing phase and capturing TWP at source, as it will put pressure on manufacturers to consider the end of life of their products. It was suggested that EPR be applied not just to used tyres as currently planned, but on tyre wear as well.

TOWN AND COUNTRY PLANNING

Town and country planning have the opportunity to focus citizens more on walking, cycling etc, although using nudge behaviour policies might be more appropriate. More needs to be done to slow traffic and prioritise less TWP polluting modes of transport.

CORPORATE LEADERSHIP

The major corporates want empirical evidence, however, at present this is not available and there are additional questions that will stymie the decision makers, such as do electric vehicles have a bigger or smaller impact and what if we do make a change for the right reason and the unintended impact is worse? SUEZ for example has a large fleet and want to be a leader in switching hundreds of vehicles to electric to reduce tailpipe emissions, but this may lead to greater TWP.

BETTER DRIVING

Much is known about how a vehicle's tyres wear (braking, cornering etc) and there are many solutions, including, softer driving styles (less speed, less braking), driver training and a move towards autonomous vehicles, which will all reduce erratic driving and the generation of TWP. A detailed analysis of TWP prevention from better driving is also given in the next section.

DRAINAGE SOLUTIONS

Wheels on a surface will always cause friction leading to deposition, the chemistry of the compound may change, but the problem will persist unless we address runoff from the streets. The workshop attendees concluded that the technical solutions should be prioritised by understanding the current impact of the receptor, for example, single chamber drains are the logical interception point, but not if on a "B" road with low traffic flow. Roads with high volumes of traffic should be prioritised in the short term to capture TWP, in parallel with a cost effective "fit and forget" solution for lower volume roads.

The *Sector* should continue to pursue a switch to electric, whilst working with tyre and car manufacturers to reduce TWP.

The *Sector* as a major fleet and water treatment manager, should explore what direct impact they could have on "reducing ocean plastic pollution by intercepting TWP and preventing TWP by promoting better driving".

WORKSHOP SUMMARY

All participants agreed that policy and technical solutions, supported by existing empirical evidence, are now leading to the acknowledgement of TWP as an ocean plastic issue and there is good enough data (although more data is still required) and now a champion is required to lead.

What Innovations & Changes might we have by 2030?

Now less than a decade away, in many ways the world of 2030 and the impact of TWP on marine environments will be shaped by our actions and aspirations of today, in parallel with scientific, technological and engineering leaps designed to provide positive impacts on society and business. Projections and commitments have been made and modelled and indicate, among other things, that by 2030:

- two billion motor vehicles will be on the world roads[20]
- a ban on new petrol and diesel cars and vans in the UK will be in force[21], and
- smart roads supporting autonomous vehicles and low carbon construction will have been built.

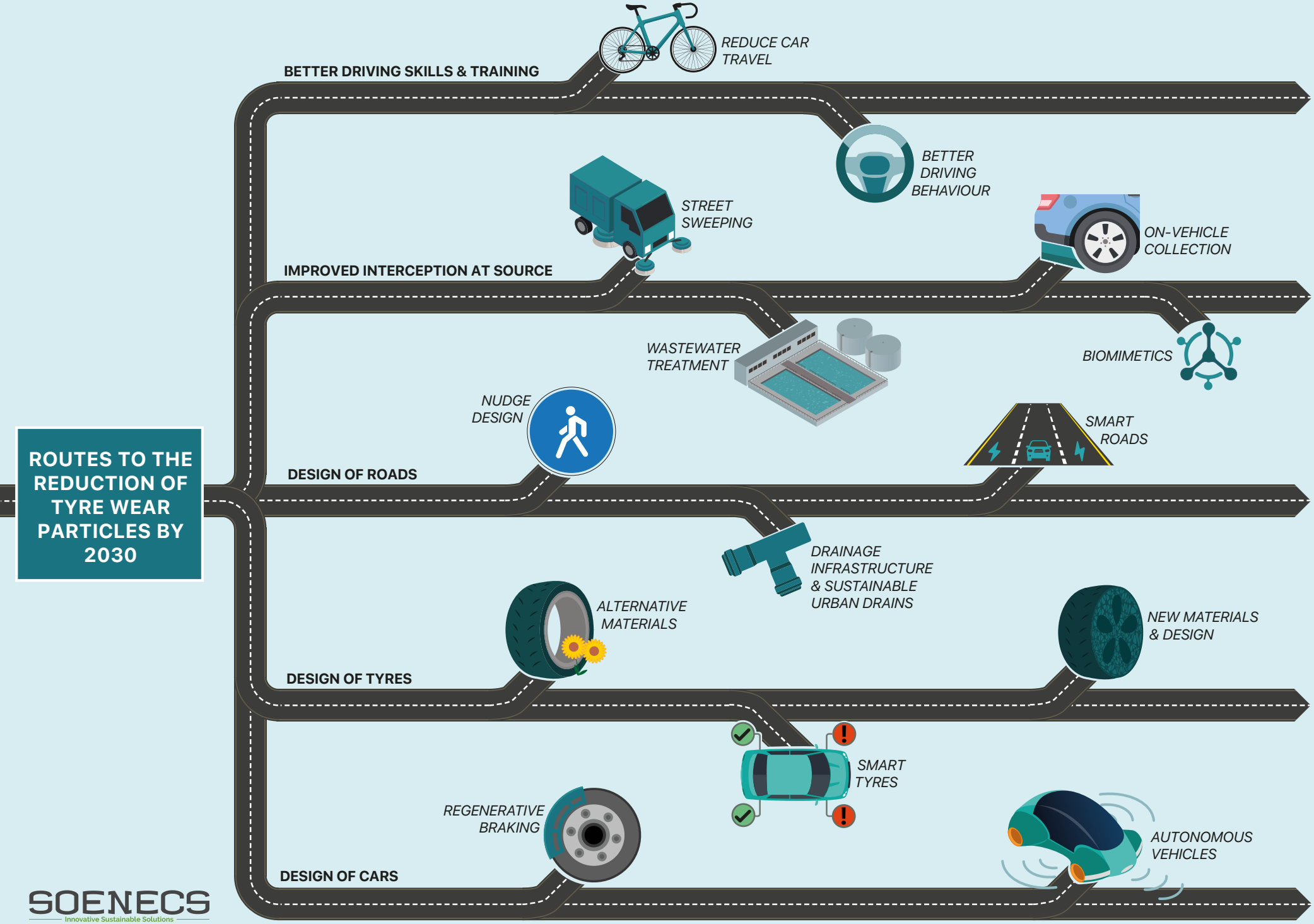
Over the last century, the car as a mode of transport has become normalised, so the extent to which UK citizens will shift their use of vehicles is impacted by both their geography, their lifestyle, and their wealth. Britain boasts a less efficient, less economic, and less distributed train network than many other European countries. Likewise, many rural areas are poorly serviced by buses, and other public transport options.

Many factors involved in the design, fabrication, production and maintenance of tyres, vehicles, roads and other transport networks, in combination with shifts in citizen behaviour, will influence the extent to which we are able to mitigate our invisible pollution problems of the present. The five factors are:

1. Design of tyres
2. Design of cars
3. Design of roads and their water management
4. Driving skills and training
5. Improved interception at source

Design of tyres, cars, roads, water management, interception methods and driver training will all influence the extent of TWP by 2030

ROUTES TO THE REDUCTION OF TYRE WEAR PARTICLES BY 2030



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1. Design of Tyres

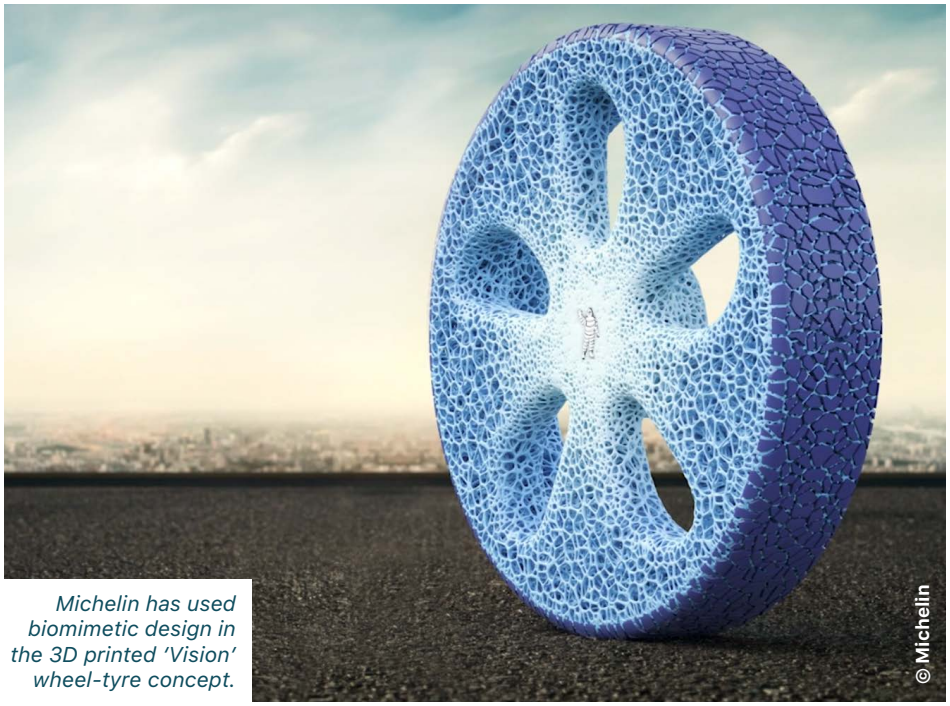
The redesign of the tyre to prevent TWP from being emitted into the environment would be the obvious answer to the problem, indeed, from the research undertaken, concepts including regenerative design, biodegradability, biomimetics, biotechnology and self-organizing grown and not made materials, are being explored by the research and development teams of several leading tyre manufacturers. Some of these may lead to TWP being a thing of 2020 and not 2030. The main innovations anticipated are explored below:

NEW MATERIALS

There is evidence that climate change will lead to the rubber tree's (Hevea brasiliensis) natural environment disappearing over the coming decades. As a result, manufacturers have started to research alternatives; rice husks (Pirelli), straw, beets, and wood waste (Michelin), dandelions and other plants (Continental and Yulex) and soyabean oil (Goodyear), are among the ingredients manufacturers are mixing in the search for new bio-butadiene and other bio-sourced tyre formulations.

Biotransformation, which involves chemical and biological agents breaking down plastic such that it poses no harm to the environment, will also factor in how and why the future tyre materials market develops. Evidence shows that modern cultivation methods in combination with genetic modifications mark the potential dawn of industrial-scale production for some of these new compounds.

Modern cultivation methods could make dandelions a practical alternative to hevea.



Michelin has used biomimetic design in the 3D printed 'Vision' wheel-tyre concept.

SMART AND TUBELESS TYRES

Michelin developed the 'VISION concept' whereby tyres are no longer inflated but comprise a web-like structure that spans their entire composition. The weight borne by the tyre would be many times more distributed, leading to a possible reduction in external wear. Goodyear, in partnership with Dupont, is utilising synthetic biology in its development of biosynthetic monomer BioIsoprene to create biodegradable tyre. However, many of these new materials may only replace rubber, meaning that synthetics are still emitted. If the new materials replace the majority of tyre components, then this may change TWP leading to the damage of the ocean environment. Manufacturers, including Goodyear and Pirelli are also looking to integrate sensors into the tyres to give feedback to drivers about wear.

It is possible that tomorrow's tyres may embed the equivalent of a nervous system which reports on both their material and structural status, and environments through which a vehicle travels.

2. Design of Cars

The move to electric cars, which are currently heavier and typically fitted with tyres with low rolling resistance, means that EVs usually have longer braking distances than their petrol and diesel equivalents, leading to TWP of around 20% higher. However, regenerative braking technology combined with the move to autonomous driving can enable smoother braking leading to less TWP. By 2030, an EV's battery technology will result in lighter vehicles driven autonomously and therefore TWP should be significantly reduced, albeit there will still be millions of vehicles on the road that will still have a 2020 TWP impact.

Therefore, weighing up the extent to which EVs do and may add to an already significant problem is complex and is starting to be addressed.

The *Sector* should undertake a cost/pollution/benefit analysis of moving to EVs with TWP one of the comparators.

The design of EVs will be a significant factor in the impact of TWPs.

TWP capture should be considered by planners and road builders.

3. Design of Roads & their Water Management

From a behaviour change perspective, town and country planning has the opportunity to focus citizens more on walking, cycling and reducing vehicle usage by using nudge behaviour policies. It also has a role to play through infrastructure design, including drainage. Planners will be able to make use of emerging research. There are three main options for new roads, Sustainable Urban Drainage Systems (SUDS), new smart drains as proposed by Matter and research presented by Thames21, showing that a combined sewer is better for the prevention of microplastic pollution as it routes the pollutants to a WWTP where some of the microplastic can be captured.

Of the number of new roads that could be "smarter" in 2030, if implemented now, these will only make up a fraction of the 262,300 miles of paved roads in the UK[22], but many of these roads will be high traffic flow and the world of 2030 may see smart roads with integral TWP capture technology.

The *Sector* should ensure that the planners and highway engineers are considering TWP capture methods for new roads and options for retro-fit of capture devices in high traffic, high runoff areas.

4. Driving Skills & Training

The simplest and most effective way of reducing TWP production is to reduce travel using road vehicles and then change to slower and less aggressive driving to reduce degradation of tyres. Better driving will, in many cases, extend the time that a single tyre's TWP will be emitted, rather than stop it, however, over time, a 10% extension in tyre life will lead to fewer tyres and therefore less TWP.

There are varying methods for calculating TWP emissions per vehicle, multiple approaches have been taken and local circumstances will normally dictate[15]. Using one of the most referenced studies from the Netherlands[23], SOENECS has created an impact of journey sharing on emission of TWP.

Mode of transport	Passengers per vehicle mg of TWP travelling 5km		
	1	5	25
Moped (1 person max)	65	350	1,625
Motorcycle (2 people max)	300	1,054	4,569
Passenger car (5 people max)	660	684	3,418
Bus (50 people max)	2,075	2,085	2,139

Table 1 - Impact of sharing journeys on emission of TWP

The table indicates that regardless of how many people are travelling 5km, the moped is least polluting. A bus is least polluting for 25 people with the passenger car only coming second when fully loaded. There are permutations to this, for example, if there are 4 people travelling, a motorcycle would be second best.

Mode of transport	mg of TWP Payload of 1 tonne for 1km	mg of TWP Payload of 5 tonnes for 1km	mg of TWP Payload of 10 tonnes for 1km
Van (max load 1t)	159	795	1,590
Truck (max load 5t)	658	658	1,316
Lorry (max load 15t)	850	850	850

Table 2 - TWP emissions based on load capacity

As the *Sector* carries heavy bulky items, a goods analysis has also been created in Table 2. There is a similar profile, in that if we treat goods the same as people (in that we see both people and goods as proxy of the capacity of that vehicle), then we can anticipate TWP based on number of journeys to complete a task.

The *Sector* should investigate its current TWP footprint and create an action plan to reduce it.

Combined with the many ways to 'drive softly', a hierarchy of how to reduce TWP pollution has been created and is shown in Figure 5.

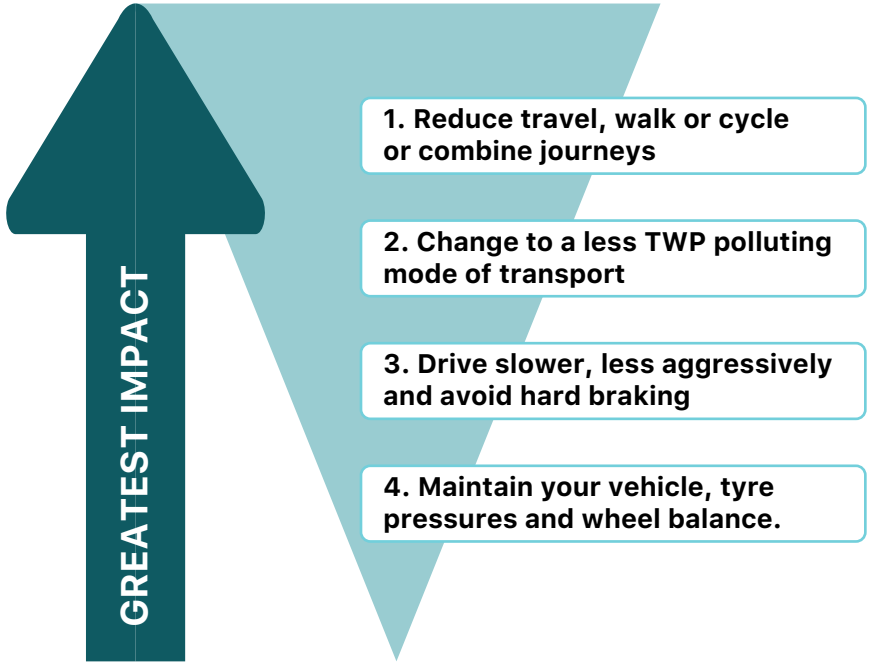


FIGURE 5 - The SOENECS Ocean pollution prevention hierarchy for Tyre Wear Particles

5. Improved Interception at Source

Given that over the next decade the number of tyres that are on the road will increase and the abrasion is not going to change overnight, we need to investigate interception prior to entering the aquatic environments.

STREET SWEEPING

The process of street sweeping already captures a proportion of the TWP although this is not the primary function of this service. The facilities currently run by SUEZ to separate fractions of sand, aggregate, organics and metals are already in place, however, by 2030, might these be used to capture TWPs for recycling, indeed, might there be more frequent street sweeping in high traffic areas, as that has been reclassified as an "Ocean Plastic prevention service"?

The *Sector* should explore in partnership with highways and local government, increasing street sweeping to capture more TWP and prevent ocean plastic pollution.

WASTEWATER TREATMENT PLANTS

It is clear that WWTPs are already an important interceptor of TWP, however, the role of a WWTP as a TWP (and other microplastics) interceptor is contrary to its functional purpose and by 2030, with advances and widespread adoption in micro plastic capture technology, the WWPTs could be a significant interceptor of TWPs, for runoff that reaches them.

An example is the SUEZ AQUADVANCED® Urban Drainage solution which monitors, plans and optimises the sewerage system by processing meteorological data and measurements from the network or from the river or marine ecosystem in real time. This technology could lead to significantly higher TWP capture from two perspectives, maintaining the network to avoid storm overflow and enabling greater interception of TWP preventing it becoming sludge for treatment on land.

The *Sector* should prioritise WWTP as a TWP intervention solution.

"For too long we have taken the ocean for granted. Our actions have pushed species to the brink and had an impact on every ocean habitat, no matter how remote or how deep."

Sir David Attenborough, The Ocean and Us, BBC Earth, United Nations Ocean Conference[24]

BIOMIMETICS

As in materials science more generally, biomimetics sits at the forefront of nanomaterials innovation, with examples including the first commercially available biomimetic membrane, which was brought to market by Danish company Aquaporin. Mimicking the pore-forming aquaporin proteins found in living cells, this nanotechnological innovation is currently being applied to desalination. Together with applications in nanosensing, UnifAI is currently working on a project which integrates these processes to create 'self-cleaning' water infrastructure that protects itself from biofilm build-up, which in turn reduces the risk of pathogen and coliform build-up.

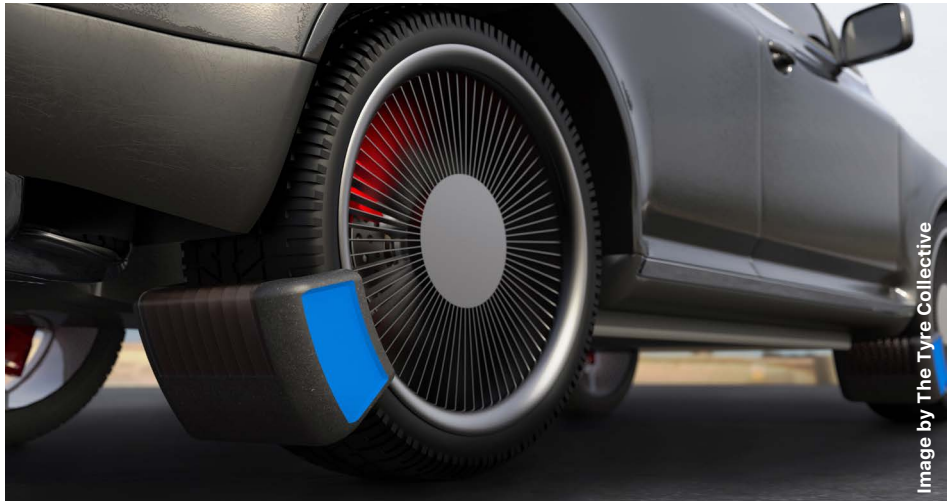
By 2030, we might reasonably expect that this and similar biologically-inspired water treatment concepts have come to market, of which at least one will likely be designed to tackle micro/nano tyre pollution.

ON VEHICLE SOLUTIONS

Until recently, a tyre guard amounted to no more than a means of preventing dirt from splattering the underside of a car or, as in the instance of cyclists, their legs. However, a group of Royal College of Art postgraduate students have developed an idea to capture TWP. The Tyre Collective views dirt, more particularly tyre dust, as a valuable commodity that, with a little ingenuity, can be captured to reincarnate time and time again.

Announced earlier in 2020, their prototype, developed in consultation with Imperial College London's Department of Aeronautics, is a simple, yet compelling, concept in capturing tyre wear at source. With the current version collecting 60% of the airborne particles emitted from their test rig, the team hopes their concept will go some way to closing the invisible pollution loop. Since it appears that the device could be retrofitted to vehicles, if the concept makes it to market entry, its market could be large. In any event, the innovation points to future vehicles with integrated tyre dust capture systems, which whether tyre guards, or something else, could be emptied at collection points at service stations or waste recycling facilities.

The *Sector* should use their fleets to support more research into novel on vehicle collection solutions for TWP.



On vehicle solutions such as this concept from The Tyre Collective can capture TWP

NEW DRAINAGE CAPTURE METHODS

The rise of the "Smart Drain" by companies such as Matter will revolutionise the way that runoff enters the aquatic environment. A combination of sensors and innovative micro filtration may lead to the interception of suspended TWP (as well as other micro road pollutants such as paint and platinum) at source and present them for recycling and recovery.

The *Sector* should work with innovators to explore "smart drains" as a way to reducing its TWP impact

"There are many misconceptions about plastic pollution and people not wanting to believe the truth and so we need to explore how we can change our behaviours and be more sustainable."

Oriana Romano

"People don't understand what they can do that will have a greater environmental benefit. For politicians this is then expanded into what policy areas would have the bigger influence?"

Samantha Tharme

"From a policy perspective, tyres and the oceans are about 'unsexy' topics, but the case is not made so much as for e.g. around food systems and macroplastics such as bottles."

Duncan Baker-Brown

Conclusion.

This Insight Report has highlighted that the invisible pollutant; tyre wear particles from the road network is just that, physically and intellectually invisible. A large proportion of the experts and peers who took part in this research did not realize that micropollutants from road tyres were a significant contributing factor to ocean plastic pollution.

At present, it appears that plastic pollution is not the primary driver of material sourcing and wider innovations in the tyre industry, with the need to address issues including climate change, vehicle efficiency and performance, driver safety and market competitiveness taking clear precedence. However, innovations with an initial intent to address one problem often address others, and several of the latest tyre sourcing, design, production and maintenance concepts recently presented by leaders in the tyre sector have the capacity to help mitigate the problem of invisible plastic pollution.

It is clear from our look towards 2030 that many things are set to change; a future that includes EVs and self-driving cars, and with that, many more cars generally. This shift makes it evident that without a shift in tyre composition, engineering and design, and the introduction of pollution capture technologies on vehicles, road surfaces, storm and other drainage, and sewer systems, in under a decade from now we will have far more TWP in our oceans and freshwater bodies than today.

There needs to be far more awareness among local authorities, real estate developers, industry and governments more generally, of the potential role of drainage and other urban and peri-urban infrastructure in mitigating the invisible pollution problem.

Borrowing the term from the award-winning sustainable architect, Duncan Baker-Brown, the *Sector* is already, in many cases, unknowingly 'mining the Anthropocene[1]' for some of the invisible pollutant. The challenge for the *Sector* is to do more and faster.

[1] The proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change

Solutions will need to be approached both from a financial or regulatory incentive perspective and design and life-cycle perspective, as well as involving leaders from governments, the waste, chemical, civil engineering and automotive industries, water treatment, urban infrastructure planning, technology, marine and freshwater biology, and wider environmental science sectors.

The ability to capture existing plastic in the oceans is an emerging science, and Emily Penn suggests that "we will probably never be able to capture the plastics in our eco-system", rather now is the time to prevent and reduce the pollution of oceans by TWP through actions led by the Resource Management Sector

The recommendations to the Resource Management Sector are many and varied and are interspersed through this Insight Paper. The authors of this report call on the Resource Management Sector to understand the critical role it has in emitting and capturing Tyre Wear Particles over the coming decade. The following is a compilation of all the recommendations in this report.

SOENECS is well positioned and willing to support the Sector and stakeholders listed in this Insight Paper to address and overcome the challenges, misconceptions and unknowns to make the topic of 'microplastic from the road network entering our marine environment' a tangible and visible topic for future mitigation. One of our expert contributors sums up the view of the authors and we ask the *Sector* to use this as a rally call:

"If we are to avoid plastics ending up in the oceans, the solutions lie on land. This involves a collective re-engineering of how we produce and consume"

Andre Abreu and Maria Luiza Pedrotti, Tara Expeditions Foundation

Recommendations.

The Resource Management Sector is already diverting TWP from the Oceans, however society needs to do more, and quickly. The authors recommend that the *Sector* as a strategic leader should:

1 **Work in partnership with the tyre manufacturing sector, University of Plymouth and Highways England to put concerted effort into raising TWP as an issue within and externally to the *Sector*.**

2 Research and collate an impact assessment on the current *Sector* vehicle and fleet TWP footprint and create an action plan to reduce it.

3 **Adopt the "ocean pollution prevention hierarchy for Tyre Wear Particles" to quickly reduce the TWP environmental impact from fleets.**

4 Model and investigate the impact of increased street sweeping, more processing and separation as a way to intercept more TWP.

5 **Prioritise, model and investigate the impact of increasing micro material capture at WWTPs as a TWP intervention solution.**

6 Prioritise, model and investigate the role planners and road builders have in considering TWP capture methods for new roads and options for retro-fit of capture devices in high traffic, high runoff areas.

7 **Create a guide for the *Sector* to assist with understanding how the purchase of Electric Vehicles over the next decade may impact TWP pollution.**

8 Prepare and research a business case for including tyre wear particles as material that needs to be included in Extended Producer Responsibility (EPR).

9 **Work with start-ups, manufacturers, organisations and researchers to explore novel and future thinking opportunities for TWP prevention.**

10 Expand the research to other road generated pollutants and dive deeper into solutions.

Partnerships are required to protect the environment from TWP.

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Emily Penn	*Co-founder and Leader - eXXpedition*
Helen Bird	*Plastics Specialist - WRAP*
James Close	*Head of Circular Economy - LWARB*
Olivier de Matos	*President - European Centre for Ecotoxicology and Toxicology of Chemicals*
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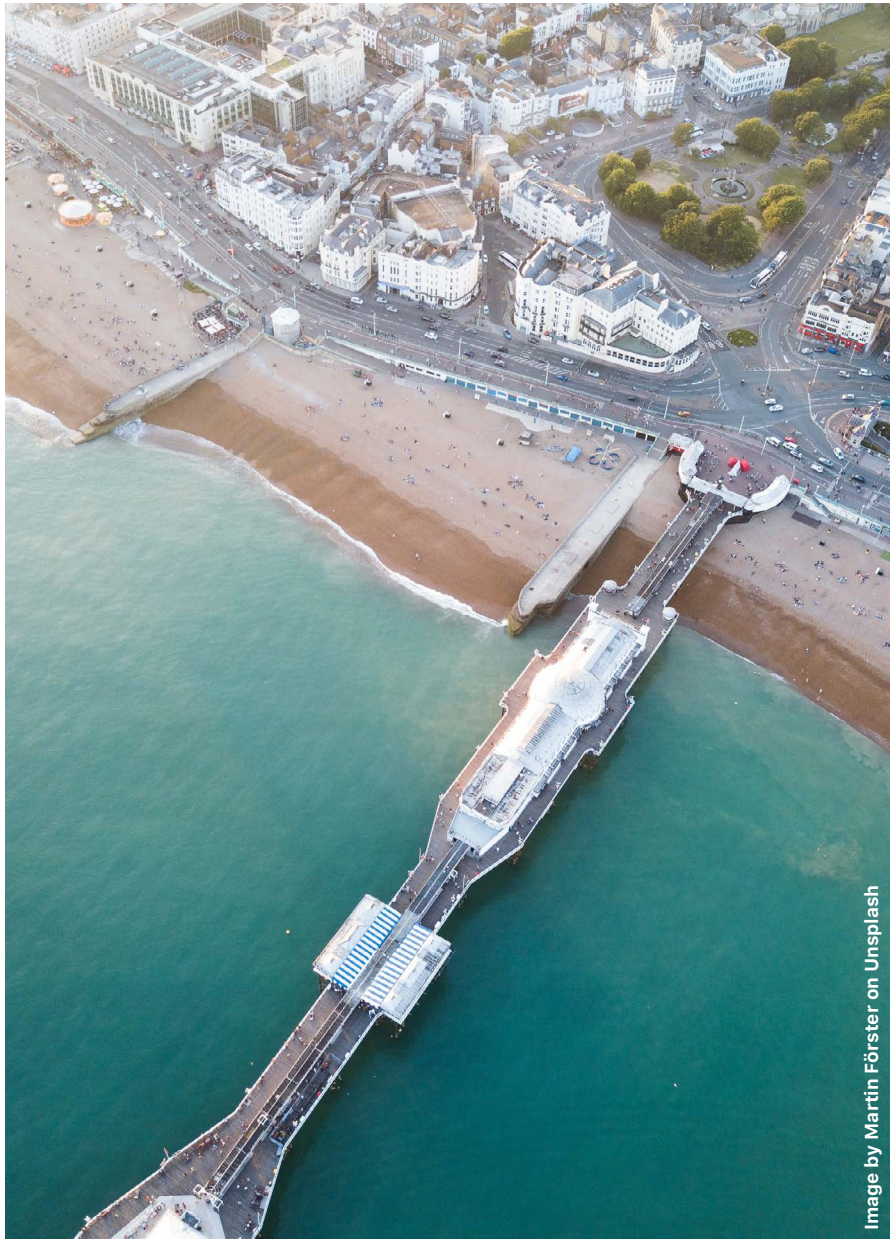

Image by Martin Förster on Unsplash

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