

Article

Tread Wear of C3 Bus Tyres Around a City in Italy

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Abstract

Tyre wear is a major contributor to microplastic pollution. Heavy-duty vehicles, due to their higher weight and longer distances driven compared to passenger cars and vans, have the highest share of tyre wear from road transport. Heavy-duty vehicles cover a wide range of applications—from urban stop-and-go buses to long-distance lorries—and their maximum mass can vary from around 3.5 tonnes to more than 40 tonnes. However, experimental wear data on heavy-duty vehicles, and particularly on buses, for both original and retreaded tyres are scarce. Additionally, there is no standardised methodology for measuring their tyre wear. In this study, we measured the tread wear of regional buses operating around the city of Varese (Northern Italy) between 2019 and 2025. The tread depth reduction was 1.7–1.9 mm per 10,000 km for 22.5-inch tyres and 2.6–2.9 mm per 10,000 km for 19.5-inch tyres. Based on the annual distance driven (40,000 km for 22.5-inch tyres and 25,000 km for 19.5-inch tyres) and the tread characteristics, we estimated a mass loss of 550–800 mg/km per vehicle. These are some of the first wear emissions in the literature for new and retreaded tyres at both drive and steering axles.

Keywords: tyre wear; abrasion; tread depth; bus; mileage

1. Introduction

Tyres are a significant source of microplastic pollution. In the European Union (EU), tyre wear accounts for 0.5–1 kilotonnes (kt) of microplastic emissions per year [1]. One study estimated that, within the EU, the average contribution from heavy-duty vehicles (HDVs) was 50% of tyre wear from road transport [2]. In general, HDVs in Nordic countries account for one-third of regional tyre wear, whereas higher contributions have been reported for the United States, India, and South Korea [3]. Despite the heavy-duty vehicle fleet being much smaller than that of passenger cars, its higher contribution stems from greater emission factors and higher annual mileage [2]. However, publicly available experimental data on wear rates for heavy-duty vehicles are almost non-existent. At the 65th session of the Working Party on Pollution and Energy (GRPE) of the United Nations Economic Commission for Europe (UNECE) in 2013, the Russian Federation reported wear rates of 950–1200 mg/km per vehicle (assuming six tyres) [4]. A 2020 study in South Korea calculated rates of 799 mg/km (six tyres) and 949 mg/km (eight tyres) for buses and lorries, respectively, based on the typical empirical tread mass loss [5]. To the best of our knowledge, no publicly available data exist on the wear of retreaded tyres, even though heavy-duty vehicle tyres (i.e., class C3) are typically retreaded at least once [6].

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In addition to the measurement of tread mass loss, which has the practical difficulty of removing the tyre and weighing it, another method for estimating tyre wear involves measuring the tread depth reduction and estimating wear based on physical tyre characteristics [7]. In this approach, the tread depth reduction combined with the tyre width and the void volume is used to calculate the lost tread volume. Then, by assuming a tread density, the mass loss can be estimated. This approach has many assumptions (e.g., the tyre–road contact width, the void volume, and the tread density). While this approach is less accurate, it can still yield good agreement—within approximately 25% of actual mass loss measurements. The interested reader can find more details in Ref. [8]. On the other hand, tread data are easier to obtain, as tyres must be replaced once they reach the minimum legal tread depth for safety reasons [9], and companies need to predict the wear rates for fleet management. This minimum tread depth before replacement is 1.6 mm for normal (summer) tyres but can be 3–4 mm for snow (winter) tyres in some countries. Furthermore, future advancements may enable real-time wear prediction during vehicle operation [10,11]. Such information, whether collected in real time or manually on an annual basis, is valuable for tyre manufacturers seeking to optimise performance across different use cases.

One challenge in defining wear rates for heavy-duty vehicles is the diverse range of applications. For example, a study involving refuse lorries found that their daily routes included trips from the depot to the city, urban driving, and returns to the landfill sites and depot totalling 40 km, with 56% of the distance driven in urban areas [12]. In contrast, long-distance trucks primarily operate on highways, with secondary use on rural roads. Depending on the vehicle category, average annual distances can range between 58,000 km and 116,000 km (Regulation (EU) 2029/1242) [13]. However, the annual distance driven typically decreases as vehicles age, and studies report even lower values, e.g., 55,000 km for trucks [14].

The aim of this study is to derive tyre wear rates for urban and regional buses operating around a town in Northern Italy, based on long-term tread depth measurements under real-world conditions. These rates provide emission factors for both original and retreaded C3 tyres and can help to reduce the current uncertainties in tyre wear emission estimates for bus fleets, while highlighting the variability that must be considered in such assessments.

2. Materials and Methods

The database consisted of tread depth measurements from C3 tyres fitted to buses operating in the area around the town of Varese (Lombardy region) in Northern Italy. The measurements were taken between 2019 and 2025.

Although vehicle speed and positioning data were not available, the roads and routes were typical of suburban areas in Northern Italy and are usually classified in emissions regulations as regional or rural roads. The reported nominal average speed of the buses was 25.7 km/h. Based on calculations from the route timetables, the mean speed ranged from 22 and 38 km/h, depending on the route. On the same route, the mean speed varied within ± 3 km/h depending on the time of the day and the traffic conditions. The routes did not involve major altitude changes, except for one hilly route with an altitude difference of around 450 m. The primary surface material of the urban and suburban roads of the region is asphalt concrete.

Figure 1 summarises the average monthly temperatures for the years 2019–2025. The data are based on available climate records from ARPA Lombardia (Regional Environmental Protection Agency of Lombardy). The annual average temperature in the region was around 14 °C. July 2022 was the hottest month and January 2021 the coldest month in the examined period. Winters were generally mild, with almost no snow in

lowland areas. Of the years examined, 2022 was the driest and 2024 the wettest in the examined period.

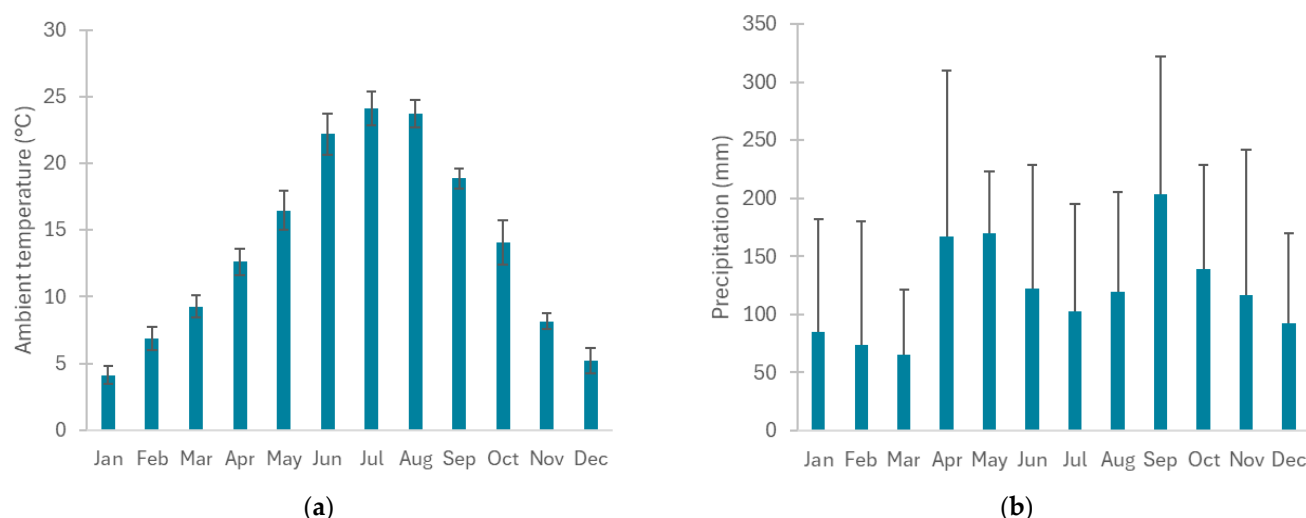


Figure 1. Weather statistics in the area of Varese for the years 2019–2025: (a) average ambient temperature; (b) precipitation per month of the year. Error bars show one standard deviation.

The vehicles were low-floor, single-deck, two-axle rigid buses, fitted with two wheels on the front axle and four wheels on the rear axle. Typical bus models and tyres types are summarised in Table 1. In total, 203 buses were tested, identified on the basis of their number plates. The (seated) passenger capacity ranged from 30–35 in the smaller buses to 45–50 passengers in the larger ones. The buses included in study had an unladen weight of around 10–11 tonnes and a technically permissible maximum laden mass (TPMLM) of 18–19 tonnes. The buses were typically full during weekday mornings and evenings, when people were commuting to school and work, but less crowded at other times of the day.

The tyres were “regional” tyres, optimised for medium-haul operating conditions generally on highway and secondary routes. They perform particularly well on winding roads and under variable road conditions.

Table 1. Tyre sizes and tyre and bus brands with the most data available in the database.

Tyre Size	Tyre Brands	Bus Brands
265/70 R19.5	Goodyear (Akron, Ohio, USA): Kmax, Treadmax, UltraGrip Coach, Regional, Marathon	Otocar (Arifiye, Turkey): Vectio U
	Michelin (Clermont-Ferrand, France): X Multi Z, X Coach Z, Inciti	BMC (İzmir, Turkey): ProBus 850
	Recamic (retreaded brand of the Michelin Group): XD	Iveco (Turin, Italy): Crossway
	Coach, XZU3	Mercedes-Benz (Stuttgart, Germany): Citaro U, 0.530, 0.550, Tourismo, Tourino, O.350 RHD E3, Intouro, Tour
275/70 R22.5	Continental (Hanover, Germany): HS3, HA3	MAN (Munich, Germany): Lion’s City
295/80 R22.5	Bridgestone (Kyōbashi, Tokyo, Japan) (Ecopia)	VOLVO (Gothenburg, Sweden): 8700 B12BLE, 9700
	Marix, Marangoni (Rovereto Italy): Ecotour	SETRA (Daimler Truck, Leinfelden-Echterdingen, Germany): 415

Table 2 gives an overview of the number of tyre manufacturers (brands), tyre models, and total number of measured tyres per tyre size. The majority of the measurements (63%) were for 295/80 R22.5 tyres, while the least measurements (9%) were available for 265/70 R19.5 tyres. Measurements for 275/70 R22.5 tyres represented about one quarter (28%). The percentage of 22.5” tyres (91%) in our study aligns well with the market share of 22.5”

tyres (>82%). The 295/80 R22.5 size is one of the best-selling sizes (others are 315/80 R22.5, 315/70 R22.5, 385/65 R22.5, 385/55 R22.5).

Table 2. Overview of tested brands and number of measurements.

Size	Brands/Models	Tyres Measured
265/70 R19.5	2/5	31 (9%)
275/70 R22.5	4/6	101 (28%)
295/80 R22.5	6/12	228 (63%)

The front tyres were always original, while the rear tyres were either new original tyres or retreaded tyres. Retreaded tyres (also called remoulded tyres) are used tyres that have undergone a process in which the worn tread is replaced with a new rubber layer, extending their lifespan. UNECE Regulation 109 governs retreaded tyre safety and performance in Europe for heavy-duty vehicles, commercial vehicles, and trailers (specifically tyres designed for M2, M3, N, O3, and O4 vehicles). The tyres in the specific fleet were retreaded only once either at the original tyre manufacturer or at companies dedicated to retreading.

Tread depth measurements were taken typically once per year during vehicle maintenance and during periodic technical inspection. The measurements were taken with the tyres mounted on the vehicle and with the inflation pressure at the nominal pressure (around 8 bar). Tread depth measurements were taken with an analogue tread gauge in the three main grooves, and the minimum value was reported. Measurements were taken only at one easily accessible point and not at multiple points around the tyre. The date and the vehicle mileage were also recorded in most cases. For some tyres, multiple measurements were available over the years before replacement (typically when the tread depth was reaching 2 mm). For these tyres, only the maximum tread depth reduction was considered for the calculations. For example, for an initial tread depth of 17 mm for a tyre that was replaced when the tread reached 2 mm, only the 15 mm tread depth reduction value was considered and not the intermediate measurements. Data with tread depth reductions of <5 mm were not considered in our analysis. The reason is that we assume that the measurement uncertainty is around 0.5 mm, and, for tread depth reductions <5 mm, the measurement uncertainty would be >10% ($=0.5 \text{ mm}/5 \text{ mm}$). In most cases, the tread depth reduction was >15 mm (close to the end of the tread's service life) and thus the measurement uncertainty per tyre was expected to be lower than 3%. With such large tread depth reductions, the impacts of any asymmetries around the tyre were also minimised. In our calculations, we averaged the left and right tyres (two tyres on the front axle and four tyres on the rear axle), further increasing the robustness of our estimates.

The mass loss was estimated from the equations in Appendix A of our previous paper [7]. The equations calculate the tread volume lost based on the physical characteristics of the tyres. For our calculations, we used a density of 1.15 g/cm^3 , a contact width of 75%, and a void ratio of 25% as the actual values were not available and could not be determined because no photos of all tyres were available. The density and contact width are based on data for C1 and C2 tyres. The C3 tread compounds should be slightly denser because they often contain higher amounts of reinforcing filler materials. Nevertheless, we decided to use the same density, as any other assumption would have introduced higher uncertainty. The void ratio was estimated based on a few photos of C3 drive-axle (rear) tyres from our study. The 25% value is at the low end of the range for C1 summer tyres. This is expected as C1 tyres typically focus on grip and aquaplaning performance. The tyres for the steer (front) axle had a void ratio of around 15%. As our data were

limited, and, in some cases, the same tyres were used at both axles, we used a fixed value of 25% for all tyres.

For the comparison of two cases, the two-tailed *t*-test assuming unequal variances was applied. For the comparison of more than two cases, single-factor analysis of variance (ANOVA) was applied, with Tukey's honestly significant difference (HSD) post hoc test to identify which specific groups differed. For both cases, the significance level for *p* was set to 0.05.

3. Results

3.1. Tread Wear over Distance

For most tyres, there were no intermediate data available before their replacement. Figure 2 plots, as an example, the tread wear reduction evolution as a function of the distance driven for three tyres of the same model for which intermediate data were available. The wear is almost linear and is similar for the three tyres, which were from the same model and fitted to buses of the same brand and model, following the same route.

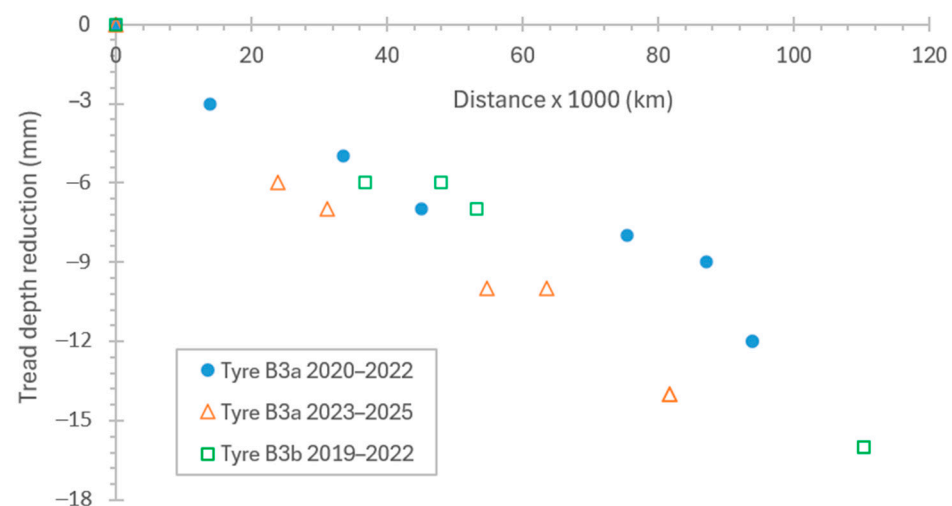


Figure 2. Tread depth reduction as a function of the distance driven for three tyre sets of the same model (B3), fitted on two buses (“a” and “b”) and following the same route.

3.2. Overall Tread Wear Results

Figure 3 plots the tread wear of five sets of tyres from two tyre manufacturers (sizes 265/70 R19.5). The average annual distance was 24,000 km (range 16,000–34,000 km). The average tread depth reduction per 10,000 km was 2.9 mm (range 1.8–4.5 mm). However, for brand A, only one measurement was available. Focusing on brand B, the average annual distance was 29,400 km (range 23,000–34,000 km). The tread depth reduction per 10,000 km was 2.6 mm (one standard deviation 30%, range 1.8–3.4 mm). A similar average value (2.6 mm/10,000 km) was also calculated when removing the data for tyres fitted on one specific bus model that had high wear rates. The specific buses were following a route that had an altitude difference of 450 m. In contrast, no other route had significant altitude changes. The variability of the wear of each tyre set was 15–25%, except for the tyre that included the hilly route, which had higher variability.

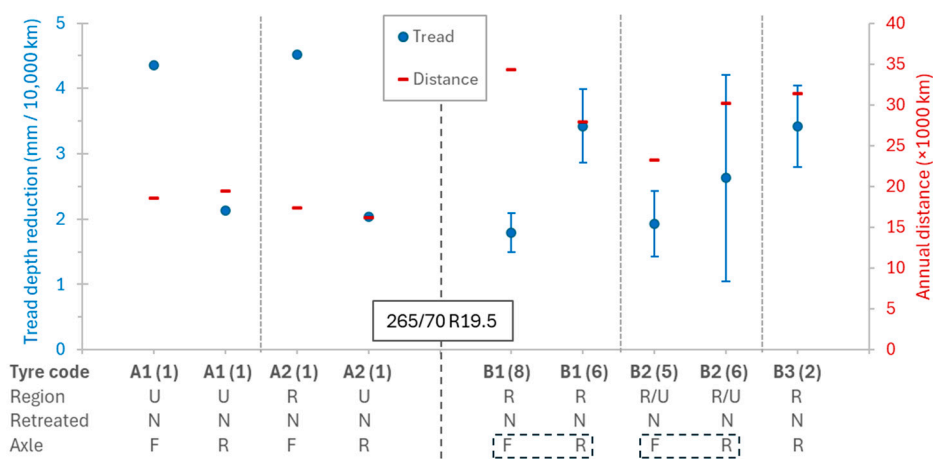


Figure 3. Tread depth reduction and annual distance of 265/70 R19.5 tyres. In brackets, next to the tyre code, the number of measurements that were used for the calculations is given. Region (route) is unknown (not documented) (U) or rural (R); retreaded is new (N) or retreaded one time (R1). Axle is front (F) or rear (R). Dotted squares indicate that a comparison of the front and rear axle wear is possible (see Section 3.3).

Figure 4 plots the tread wear of ten tyre sets from four tyre manufacturers (size 275/70 R22.5). The average annual distance was 42,300 km (range 28,000–51,000 km). The average tread depth reduction per 10,000 km was 1.7 mm (one standard deviation 19%, range 1.3–2.2 mm). The variability of the wear of each tyre set was 17–53%, typically around 30%.

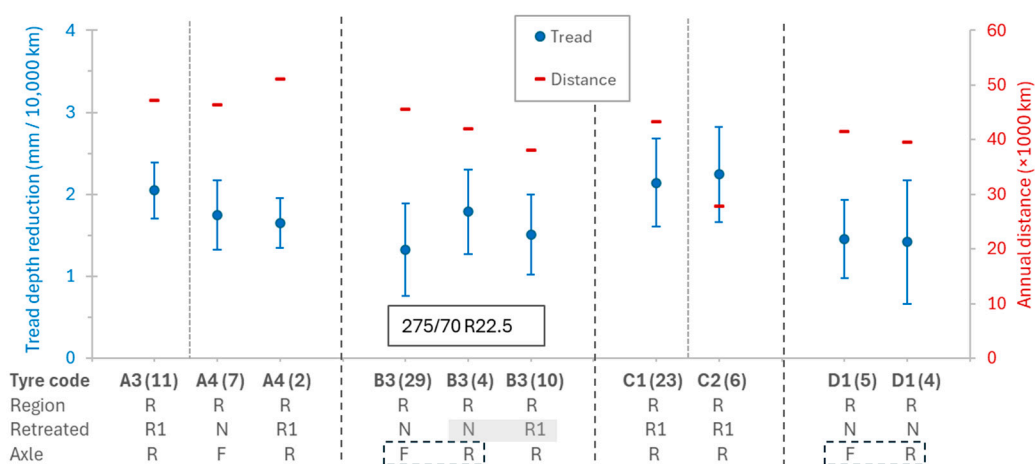


Figure 4. Tread depth reduction and annual distance of 275/70 R22.5 tyres. In brackets, next to the tyre code, the number of measurements that were used for the calculations is given. Region (route) is unknown (U) or rural (R); retreaded is new (N) or retreaded one time (R1). Axle is front (F) or rear (R). Dotted squares indicate that a comparison of the front and rear axle wear is possible. Shaded squares indicate that a comparison of the original and retreaded tyre wear is possible (see Section 3.3).

Figure 5 plots the tread wear of twenty-six tyre sets from six manufacturers (size 295/80 R22.5). The average annual distance was 36,300 km (range 19,000–49,000 km). The average tread depth reduction per 10,000 km was 1.9 mm (one standard deviation 31%, range 1.1–3.7 mm). The variability was 11–89%, with an average value of 39%. The high variability in some cases could be attributed to the limited number of available measured tyres.

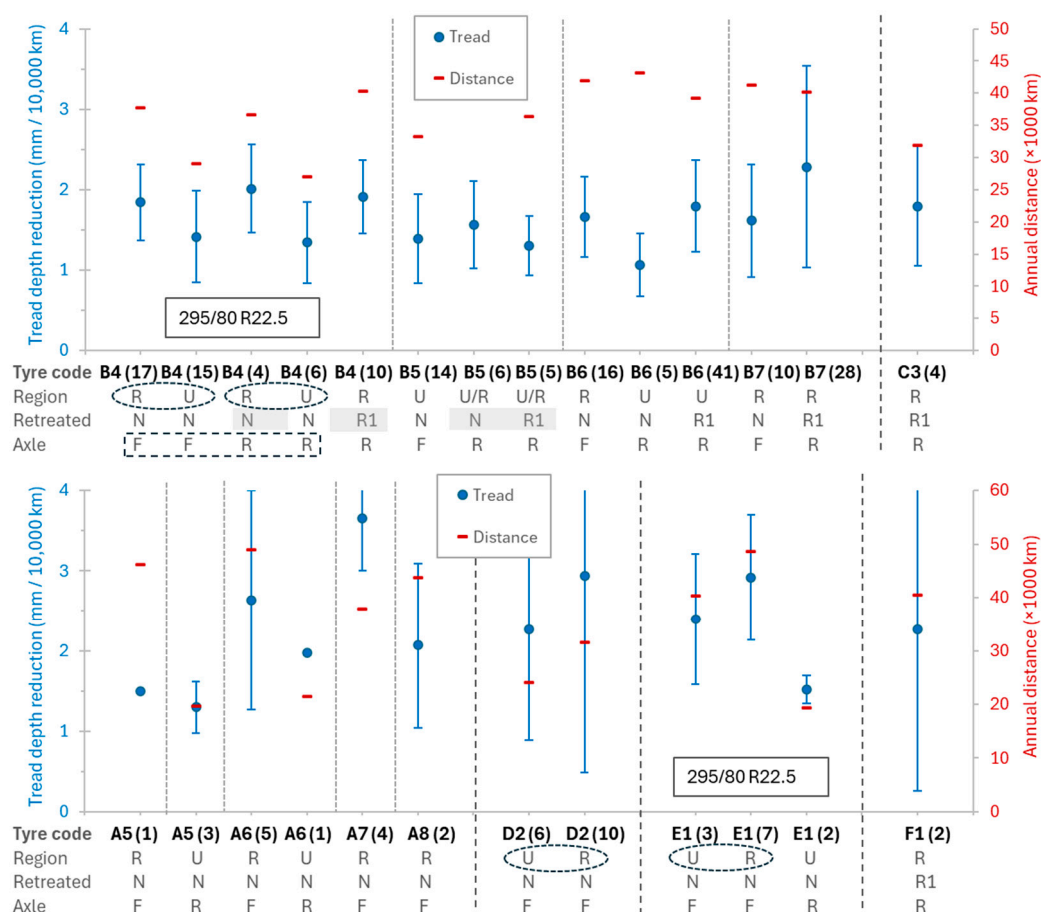


Figure 5. Tread depth reduction and annual distance of 295/80 R22.5 tyres. Upper panel: brands B and C; lower panel: brands A, D, E, F. In brackets, next to the tyre code, the number of measurements that were used for the calculations is given. Region (route) is unknown (U) or rural (R); retreaded is new (N) or retreaded one time (R1). Axle is front (F) or rear (R). Dotted squares indicate that a comparison of the front and rear axle wear is possible. Shaded squares indicate that a comparison of the original and retreaded tyre wear is possible. Dotted ovals indicate that a comparison of the regional and unknown route wear is possible (see Section 3.3).

3.3. Tread Wear Comparisons

In this study, it is not appropriate to compare tyre wear at the two axles because the averages have been calculated for different tyre models, buses, and routes. Usually, tyres are designed only for a specific axle (e.g., steering, drive, or trailer). Nevertheless, for some tyre models, there were data from the same tyre manufacturer, following comparable routes and fitted at both axles (see Figures 3–5, dotted squares, and Table 3). The tyres at the steering axle seem to have lower or comparable wear regarding the tyres at the rear drive axle. Only two from the five sets had statistically significant differences, with front tyres having lower wear. Although logical, as higher forces are applied at the drive axle, it should be highlighted that the majority of the data come from one tyre manufacturer, and dedicated studies are needed to properly evaluate this.

Table 3. Comparison of tread wear for original tyre models fitted on the front and rear axles under similar driving conditions. Asterisk (*) indicates statistically significant differences with significance level $p = 0.05$.

Tyre Size	Model	Front vs. Rear Axle
265/70 R19.5	B1	−48% *

	B2	−27%
275/70 R22.5	B3	−26% *
	D1	2%
295/80 R22.5	B4	−8% to 5%

Some original tyre models were retreaded by the tyre manufacturer, and it was possible to compare the differences in wear (see Figures 3–5, shaded squares, and Table 4). Note that retreaded tyres are only allowed at the rear axle. Although the data are from one tyre manufacturer, there is no indication of higher wear with retreaded tyres. The opposite trend is observed, indicating that the material formulation was not significantly different. The differences were not statistically significant at the 0.05 level for any case examined.

Table 4. Comparison of tread wear for original and retreaded tyre models fitted on the rear axles under similar driving conditions.

Tyre Size	Model	Retreaded vs. Original
275/70 R22.5	B3	−14%
295/80 R22.5	B4	−5%
	B5	−16%

For some tyres, it was possible to compare the regional routes to unknown routes (Table 5). Data from three tyre manufacturers showed consistently lower wear with unknown routes for both axles. However, the difference was statistically significant only for two of the four sets. The unknown routes were mainly trips between towns and had less start-and-stop driving conditions. However, the details required to calculate average speeds were not known.

Table 5. Comparison of tread wear for tyre models fitted on the same axle but on buses following different driving conditions. Asterisk (*) indicates statistically significant differences with significance level $p = 0.05$.

Tyre Size	Model	Unknown vs. Regional
295/80 R22.5	D2 (front axle)	−23%
	E1 (front axle)	−18%
	B4 (front and rear axle)	−23% to −33% *

Figure 6 compares tyre models that were used under similar conditions: (i) regional roads, new at the front axle, or (ii) regional roads, retreaded at the rear axle. Only cases for which at least three measurements were available were considered. For the 275/70 R22.5 size, the differences from the average were 13–16%. Only for one tyre model (B3) was the difference statistically significant. For the 295/80 R22.5 size, the differences from the average were 48% and 14%. In general, tyres of brand B showed low wear in all cases. For the case with large differences between tyre models (295/80 R22.5, new tyres at front axle), the values for brand B tyres were lower than the rest. The differences were statistically significant between the first three tyres (B4, B6, B7) and the last three (A7, D2, E1).

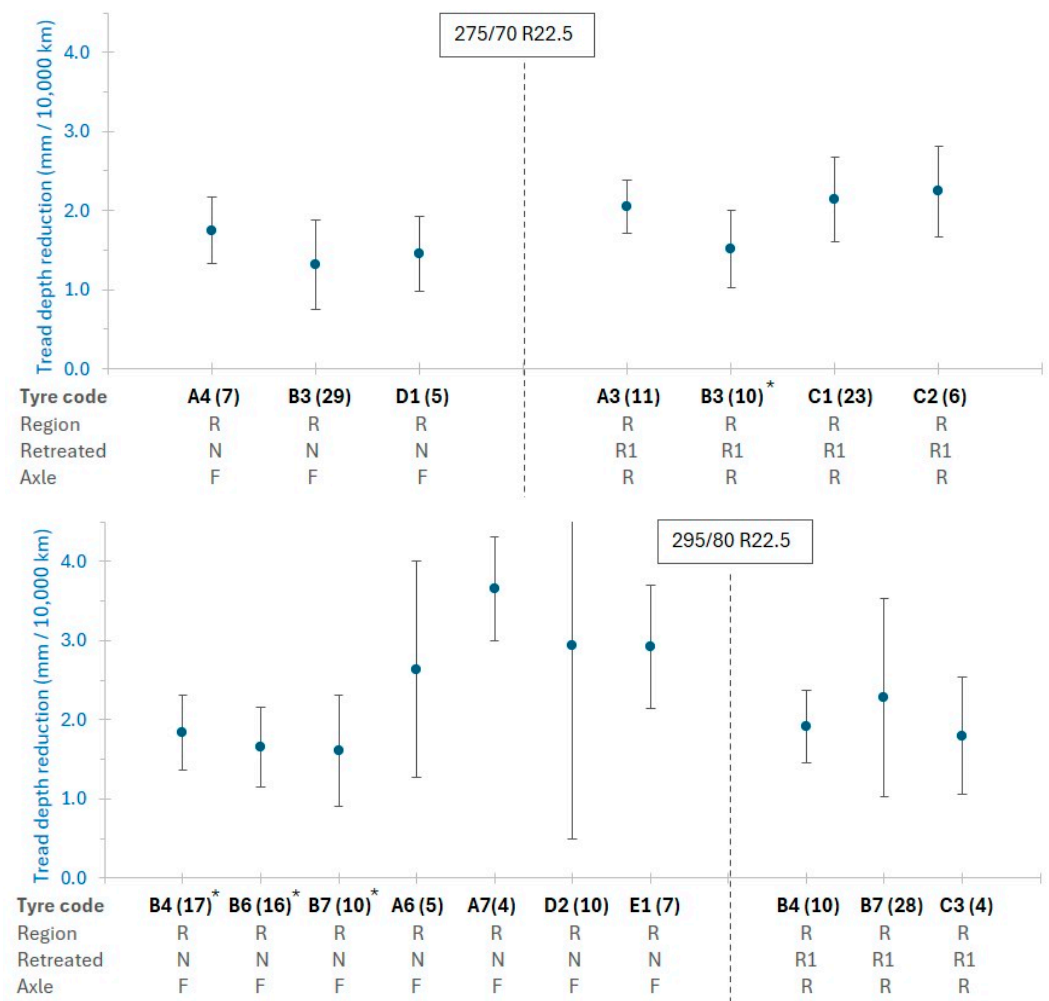


Figure 6. Tread depth reductions of 275/70 R22.5 (upper panel) and 295/80 R22.5 (lower panel) tyres. In brackets, next to the tyre code, the number of measurements that were used for the calculations is given. Region (route) is unknown (U) or rural (R); retreaded is new (N) or retreaded one time (R1). Axle is front (F) or rear (R). Asterisk (*) indicates a statistically significant difference from the rest (see text for details).

Table 6 summarises the tread wear reductions for the three different tyre sizes and all available tyres and buses. It gives separate values for retreaded and non-retreaded tyres and for the front and rear axles. However, the results are not comparable as the same buses, tyres, and routes were not present in each sub-case. The impacts of the axle, retreaded condition, and route were discussed previously for the sub-cases in which this was possible.

Table 6. Summary of tread wear reductions and estimated tyre wear. Retreaded is new (N) or retreaded one time (R1). Axle is front (F) or rear (R).

Tyre Size	Retreaded	Axle	km/Year ×1000	Tread Wear mm/10,000 km	Emissions mg/km
265/70 R19.5	N	all	24.3–29.4	2.6–2.9	734–811
	N	F	23.4–25.4	2.7–3.1	
	N	R	25.0	2.7	787–840
275/70 R22.5	all	all	42.3	1.7	553
	N	F	44.5	1.5	
	N	R	40.8	1.6	516

	R1	R	41.5	1.9	587
295/80 R22.5	all	all	36.3	1.9	725
	N	F	38.8	2.2	
	N	R	30.0	1.5	663
	R1	R	38.1	1.9	773

3.4. Mass Loss Estimation

Table 6 gives also the estimated tyre wear calculated by assuming an average tread depth reduction or combining the reduction from the front and rear tyres. The buses that were fitted with 265/70 R19.5 tyres had an annual distance of around 25,000 km and tread depth reduction of 2.7 mm/10,000 km, with an estimated wear rate of around 750–800 mg/km. The buses that were fitted with 275/70 R22.5 tyres had a doubled annual distance and a tread depth reduction of 1.7 mm/10,000 km, with an estimated wear rate of around 550 mg/km. The buses that were fitted with 295/80 R22.5 tyres had annual distances of around 35,000 km and an average tread depth reduction of 1.9 mm/10,000 km, with an estimated wear rate of around 700 mg/km.

4. Discussion

The strength of this study lies in the large number of tread wear data points (>5 years, 360 tyre measurements of 6 tyre brands and 15 models, and more than 200 buses from 16 models of 7 brands) for vehicles driving on regional roads around a city in Northern Italy, which renders the calculated values robust and representative of the area and, most likely, other rural areas of Central Europe.

In our study, for buses operating on rural roads, we found tread depth reductions of 1.7–2.9 mm/10,000 km. The average annual distance driven for each route was 25,000 to 45,000 km. This is in agreement with the mileage reported by Polish emission inventories [15]. We could not find any other values for buses in the literature. Our results cannot be extrapolated to “long-haul” tyres, which are optimised for longer distances and highway-speed operating conditions. Similarly, the results are not representative of trailer tyres. An older study found <1 mm/10,000 km for a truck operating on a highway [16]. A study of a tractor–semitrailer operating in Central London over a period of ten months (37,000 km) found rates of 1–2 mm/10,000 km [17]. Another study of three C1 (passenger car) summer tyre models tested in four different commercial fleets in Europe found wear rates of 0.5 to 2.5 mm/10,000 km. Our study with C2 tyres fitted on vans found 2.5 mm/10,000 km for the front tyres and half of this value for the rear tyres [8]. For C1 tyres fitted on passenger cars, we found rates of 1.47 mm/10,000 km and 0.64 mm/10,000 km for the front and rear tyres, respectively [7,18]. As there is a lack of data for C3 tyres, tread depth data for more tyres, other regions, other heavy-duty vehicles, and/or other usage patterns would be valuable to help address this gap.

From the tread loss observed in our study, we estimated wear factors ranging from 550 mg/km to 800 mg/km. In the literature, a few reviews have reported ranges of 350–700 mg/km [5,19] or 200–1000 mg/km [20] for buses. It should be highlighted that the calculated wear could differ across areas due to different ambient conditions and road topography [1,21]. Nevertheless, based on the values of this study and the fleet shares of the main vehicle categories, we estimate that buses contribute around 2% of road transport microplastics (18.5 kt/year) in the EU (details in the Appendix A). On the other hand, trucks contribute 40%, which means that more studies are needed for this category.

Our study also has many limitations, as it was mainly observational rather than explanatory. Although our measurement uncertainty was estimated to be <3%, the variability in the average value of each tyre, expressed as a coefficient of variance, was around 30% and included the impacts of the routes, drivers, buses, weather differences

over the years, and load differences. The detailed quantification of each parameter was not possible as this study was not designed to investigate the influence of these parameters. Studies that have investigated the impacts of various parameters have been summarised in previous reviews [1,22]. Another study of three C1 tyres tested in commercial fleets found high variability [23]. The absolute wear rates at each location were also very different for the same tyre. Interestingly, the differences in the average wear (i.e., the ranking of the tyres) were comparable at the four locations, but the variability in the wear rates of each tyre was too high to draw any conclusions.

By analysing subsets of the data (same tyres operating on different routes), we estimated the impact of routes to be around 20–30%, the differences between the front and rear wheels to be <25%, and the impact of retreaded tyres to be <15% (with retreaded tyres exhibiting lower wear). Comparisons of tyre models on the same axle following the same route showed, in general, differences within 15% of the average, except in one case where 48% was measured. As mentioned, our study was not designed to quantify differences between tyres. If the comparison of tyres is the aim of a study, then, during the same time period and on the same routes, the buses should be fitted with different tyre models. In this way, the impacts of the route and ambient conditions would be minimal, and the wear of the tyres would be comparable.

Our analysis confirms the need for dedicated tests when tyres need to be ranked or when the exact wear rate needs to be determined. Such a procedure was recently adopted by WP.29 of UNECE for C1 tyres (passenger cars). The candidate tyres are compared to reference tyres, following a route that has specific boundary conditions (shares of urban, rural, and highway driving; accelerations; permitted wear range of the reference tyres, etc.). A similar approach could be followed for C2 and C3 tyres in future regulations. However, due to the longer distances and the larger vehicles involved, the cost is expected to be much higher.

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Appendix A

Table A1 summarises the main road categories, their market fleet shares, the annual mileages, and the abrasion rates. The fleet composition and the mileage were taken from Ref.[2] and refer to the year 2025. The only exception concerns buses, for which the mileage and abrasion rates were based on Table 6. A weighted average was used to

calculate the specific values. In addition, compared to Ref. [2], a lower value for trucks (60,000 km instead of 1000,000) was applied, based on Ref. [24]. The abrasion rates for passenger cars were taken from the C1 tyre market assessment [25]. For vans, we used our C2 study [8]. For buses, we used the data from Table 6. For trucks, we kept the 800 mg/km assumption from Ref. [2]. The contribution of buses is only 2.3%, owing to their low fleet share in the market. By contrast, trucks contribute 40%, underlining the need for more studies of this vehicle category.

Table A1. Contributions to microplastics of the main vehicle categories. Data with asterisks (*) are based on weighted averages from Table 6. For the remaining values, see the text.

Category	Tyres	Fleet (Million)	Mileage (km/Year)	Abrasion Rate (mg/km)	Microplastics (kt/Year)	Contribution
Passenger cars	C1	257.5	11,500	105	311.9	38.9%
Vans	C2	30.8	20,000	250	154.1	19.2%
Buses	C3	0.73	37,130 *	681 *	18.5	2.3%
Trucks	C3	6.62	60,000	800	317.8	39.6%

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