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AMOUNT, COMPOSITION AND SOURCES OF MACROLITTER FROM A HIGHLY FREQUENTED ROADWAY

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CONTEXT AND OBJECTIVES

Some researches estimate that most debris entering the ocean come from urban areas and are mainly transported by rivers but field data are still insufficient. Detailed knowledge on litter composition, where debris are produced and introduced to waterways are therefore needed. To address this lack, the Plasti-nium project focuses on macrolitter fluxes in urban area and receiving hydrosystems. As part of this project, this study aims at (i) providing new insights on the amount, the composition and the fluxes of roadway macrolitter including plastic debris, (ii) assessing their input sources to define littering behavior and (iii) identifying the main driving/influencing factors in the rate of debris accumulation to estimate mean annual loads, through a one-year survey on a highly frequented French roadway.

Sampling site and procedure

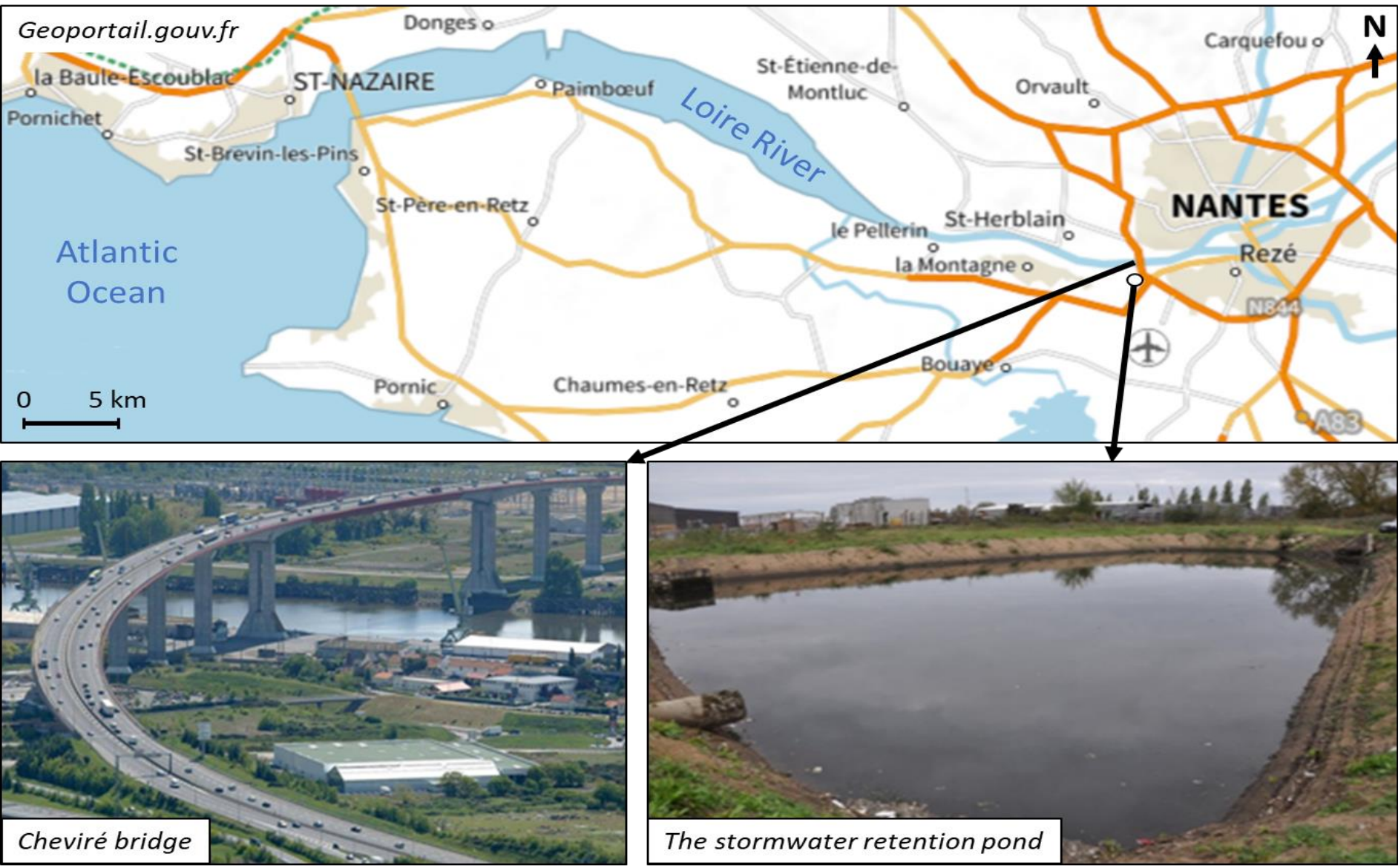


Figure 2: Location of the Cheviré bridge in Nantes and its stormwater retention pond.

During the studied period, $93,680 \pm 16,147$ vehicles crossed that bridge each day in both directions (personal communication from DIRO – Direction Interdépartementale des Routes Ouest). Rates of heavy vehicles were relatively constant ($9.9 \pm 1.2\%$). The sample C5 partially corresponds to the second national lockdown relative to the COVID-19 pandemic (from October 30th to December 15th, 2020, Fig. 2) but levels of road traffic exhibited no significant differences. The sample C6 integrates the Bella storm (occurred on December 27th and 28th, 2020, Fig. 2) during which 20 mm of rain fell and winds gusted up to 90 km/h (<https://www.infoclimat.fr/>).

Amount and composition

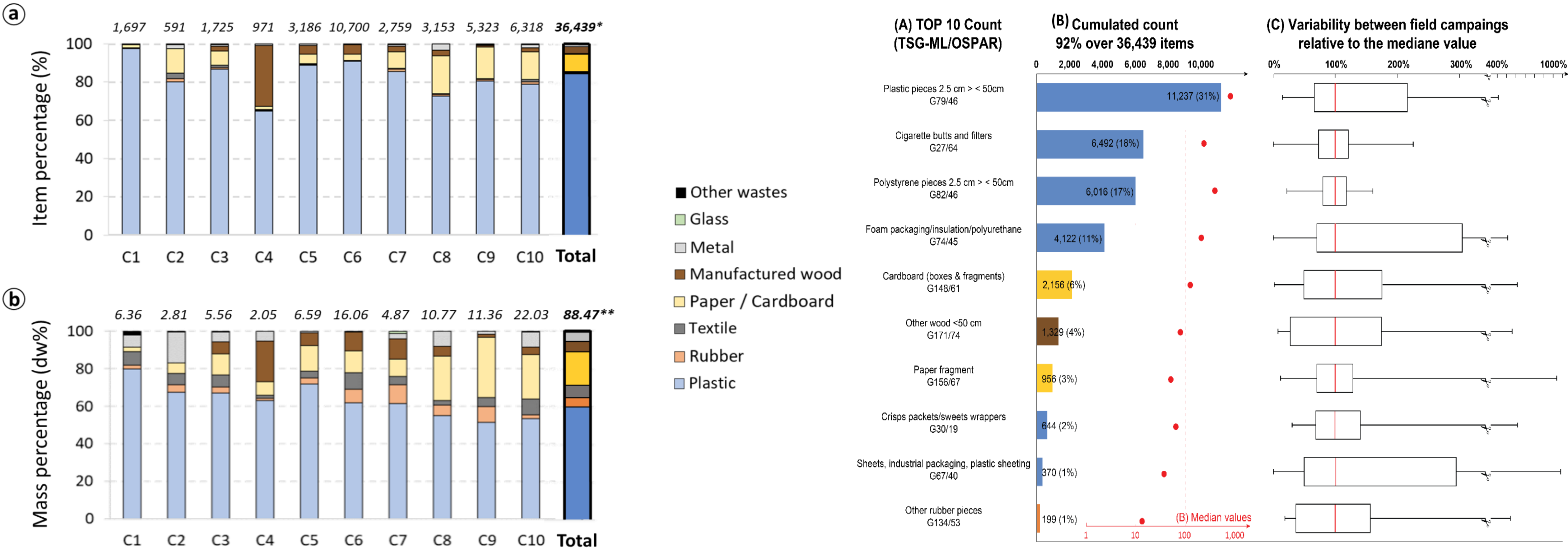


Figure 3: a) Percentages of items (*total number of items) and b) by dry weight (dw%); **total masses in kg) of the different categories of materials sampled during the ten campaigns (C1 to C10) and during the total period of sampling (Total).

Figure 4: (A) Cumulated Top 10 items by count. (B) Cumulated count and median values between the ten field campaigns. (C) Variability in % relative to the median values (red bars) between the ten field campaigns.

A total of 36,439 items representing 88.5 kg of macrolitter were collected (Fig. 3).

Plastic categories were predominant in each campaign (Fig. 3) and their levels are similar to those measured in French urban stormwater [1] and small urban river [2], as well as in large European rivers [3, 4, 5].

Single-use packages were recurring and Top 3 items are consistent with the predominance of plastic fragments reported in a French urban river [2] and with the high proportions of cigarette butts and polystyrene pieces noticed in South African urban stormwater [6]. A majority of plastic pieces and cigarette butts was also observed on American roadways [7]. With Top 10s constituting 92% of all collected items by count (Fig. 4), macrodebris present a low diversity of components.

It confirms both the predominance of plastics in urban macrolitter and the significant contribution of road runoff to the presence of (single-use) plastics in urban stormwater and receiving hydrosystems.

Sources

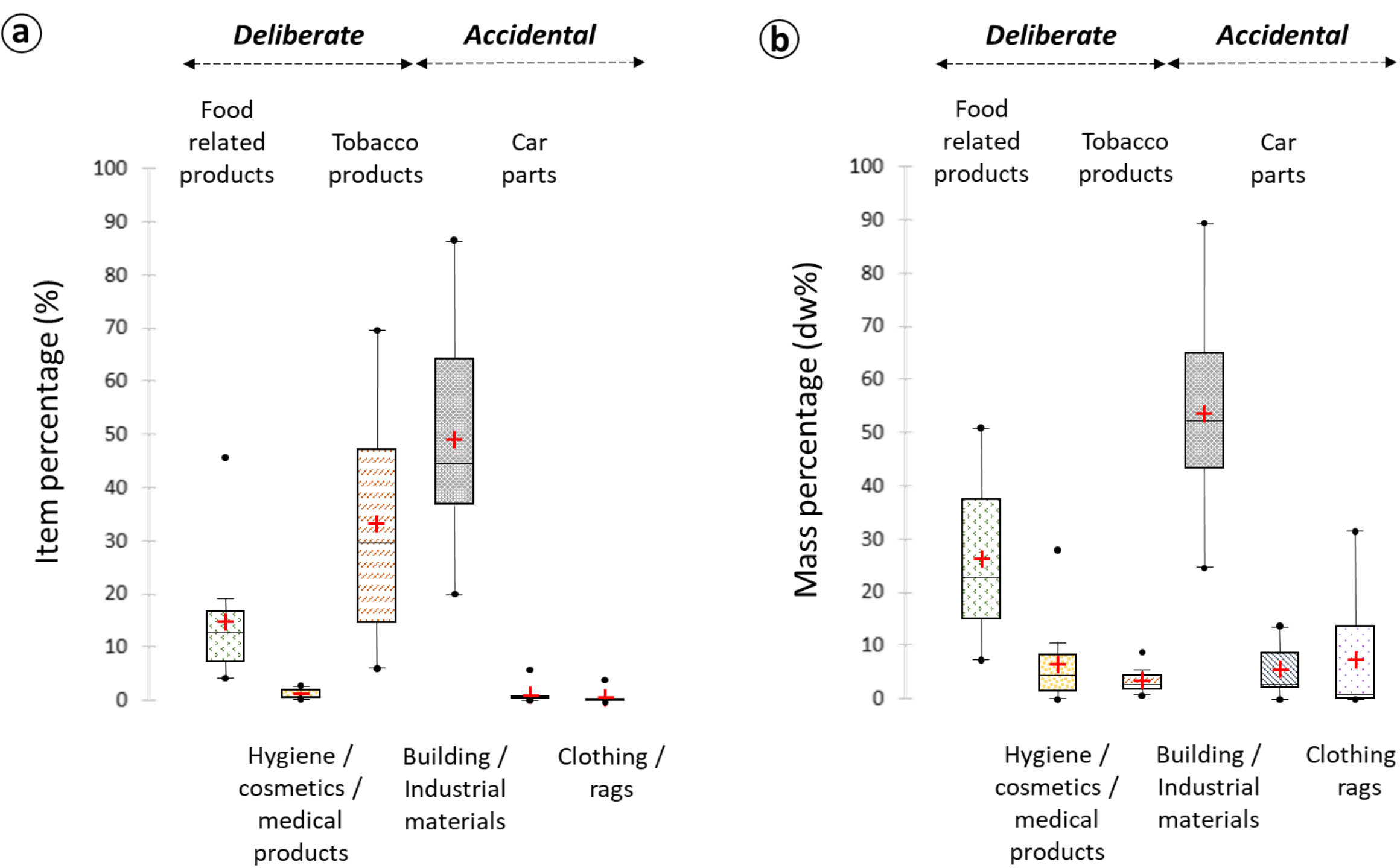


Figure 5: Boxplots representing the variability and the mean percentages (red crosses) of items a) by count and b) dry weight (dw%) during the ten campaigns according to their uses and economic sectors (food related products (n = 25), cosmetics/medical products (n = 11), tobacco products (n = 4), building/industrial materials (n = 15), vehicle debris (n = 1), clothes/textile (n = 1); 43% of items).

Contrary to popular belief, accidental leaks (median percentage of 62.8% by dry weight) were more important than deliberate ones. Building/industrial materials exhibited the highest mean percentages (Fig. 5a and b) meaning that main leaks result from unsecured loads during the transport of goods for building and industrial activities. These trends are highly variable according to roadway types [8, 9] but littering prevention strategies should take it into consideration.

CONCLUSIONS

To the best of our knowledge, this one-year survey is the first on European roadway macrolitter. Roadway macrolitter has a low diversity of components and a large predominance of (single-use) plastics, supporting the reduction of their production. The main contribution to roadway macrolitter seems to have an accidental nature and prevention efforts need to be based mainly on a more efficient protection of loads during building and/or industrial activities. Loads of macrolitter and plastic items are fully dependent on traffic levels but the accumulation rates of debris can obviously be enhanced by extreme climatic events. With an annual density around 24 kg/y/ha at the Cheviré bridge, it appears that roadway macrolitter represents significant contributions to the fluxes of plastic items in stormwater from urban areas.

Influencing factors

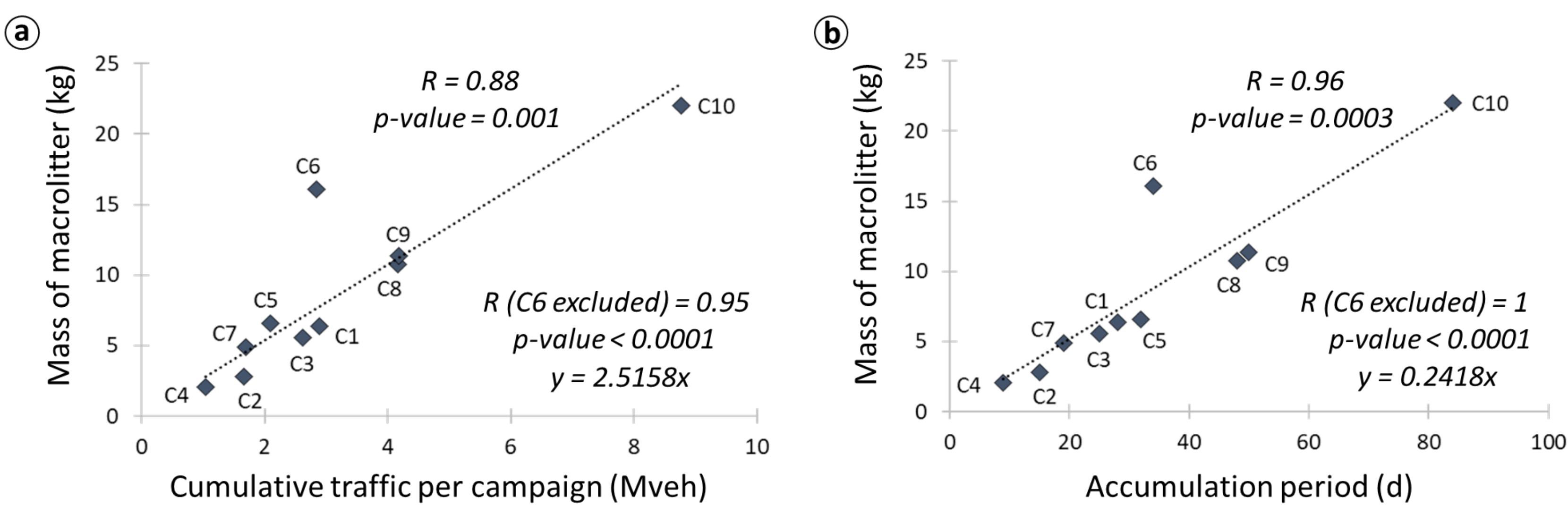


Figure 6: The correlations of total masses weighted with both b) the cumulative traffic per campaign (in millions of vehicles) and c) the macrolitter accumulation period (in days). The Spearman correlation coefficients (R), the p-values including and excluding C6 and the correlation equations are indicated.

Masses of macrolitter exhibited a significant positive correlation with the cumulative traffic (Fig. 6a). Without considering the campaign integrating the Bella storm, this correlation was even more significant (C6, Fig. 6a) underscoring the important role of this kind of extreme climatic event in macrolitter inputs. Efforts should be done to perform a better quantification and consideration of these events.

The road traffic is therefore the main driving factor determining the masses of macrolitter. As this parameter is relatively constant at the Cheviré bridge, a similar correlation was observed with the duration of each campaign (Fig. 6b), suggesting a constant litter accumulation in the pond over time.

By extrapolating, annual loads and densities at the Cheviré bridge are around 88 kg/yr of macrolitter and 50 kg/yr of plastics representing a density of 24 kg/yr/ha. Similar inputs of plastics to those of the Cheviré bridge could be expected on 5% of the French highway sections having similar traffic conditions (<https://www.data.gouv.fr/>), which would represent 115 t/yr. Highly frequented highways therefore represent a significant source of plastic debris.

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