Riverine Macro-litter: Plastic Pollution in Different Tributaries of the Ishëm River (Albania)

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Abstract - According *the Ocean Cleanup* Ishëm River is the most polluted river in Europe with 733,000 kg of solid waste per year ending up in the Adriatic Sea. The Ishëm mouth is inside the MPAs Patok-Fushëkuqe-Ishëm with a surface of 5,001 ha under protection status: Managed Nature Reserve IUCN Category IV and Important Bird Area (AL006). Additionally Cape Rodon Nature Reserve is located within the Protected Landscape/Seascape Area of the Cape of Rodon-Lalzi Bay-Ishmi Forest with a surface area of 2,500 ha and classified under the IUCN Category V. In 2020, *River-Cleanup.org* has come to Albania to change the history of Ishëm River on plastic pollution together with Albanian people, especially the youth awareness, to protect the beauties of their natural resources. The riverine litter surveys were carried out on riverbanks at four study sites along Ishëm River, at Lana Stream, Tirana River, Limuth Stream and Gjola River. Study sites were randomly selected along the riverbank, parallel to the waterline, with a stretch of 100 m long. The mean macro-litter density of the Ishëm River became 0.992 items/m^2 and 1,269 items/100 m. The largest part of riverine litter items at the aggregated level were made of artificial polymer materials (82%). What we found mostly in the Ishem River about items there are G7 (drink bottles <=0.5l), G3 (shopping bags, incl. pieces), G30 (crisps packets/sweets wrappers) and G8 (drink bottles >0.5l).

Keywords: macro-litter, riverbank, Ishëm River, plastic

1. Introduction

Research shows that ocean plastic pollution is a land-based problem. According to European Environment Agency (EEA), plastic makes up 85% of all marine plastic waste and up to 80% comes from land. It is estimated that more than 11 billion kilograms of plastic enter the ocean each year – this equates to 1 garbage truck per minute. Plastic waste in the ocean comes in different forms – beverage bottles, shampoo sachets, takeout food containers, grocery bags, and straws [1, 2, 3].

The first objective of this research has to do with assessment of the abundance, composition, and sources of riverine macro-litter (>2.5 cm) on four sites across the Ishëm River, at Lana Stream, Tirana River, Limuth Stream and Gjola River that are discharged in the Albanian coastline – at Rodon Bay, a coastline of the Adriatic Sea on the southeast side. Another objective is to recognise the circumstances about the riverine macro-litter on rivers of Albania.

2. Methods and Materials
2.1. Survey along the Ishëm River

The riverine macro-litter surveys were carried out on riverbanks positioned at Ishëm River: Lana Stream Tirana River, Limuth Stream, Gjola River, that discharges in the Rodon Bay in Albania during the Autumn (Fig. 1). The delta of the Ishëm River is located in Cape Rodon. One of the most important rivers that flows into the Adriatic Sea is Ishmi. This river ends in the Adriatic Sea with a long tongue directed from the northeast and is formed by the confluence of the Tirana, Lana, Zeza, Tërkuza and Gjola rivers. This river accumulates the pollution of these bodies of water, which through its flow are discharged into the Adriatic Sea. The Ishëm River flows through Central Albania and is formed by the River of Tirana, Lana and the Tërkuza stream. Before joining the waters of Tërkuza, the river of Tirana, which is the main branch of the River Ishmi and at the same time its longest branch, receives the waters of Lana. The Gjola River, after receiving the waters coming from Tirana, joins the Zeza River in the village of Bilaj, forming the Ishëm River. These three branches of the Ishëm River preserve

the characteristics of mountain streams [4]. The discharges of the Tirana and Lana rivers into the Ishëm River, cause that these pollutions are also poured directly into the Adriatic Sea.
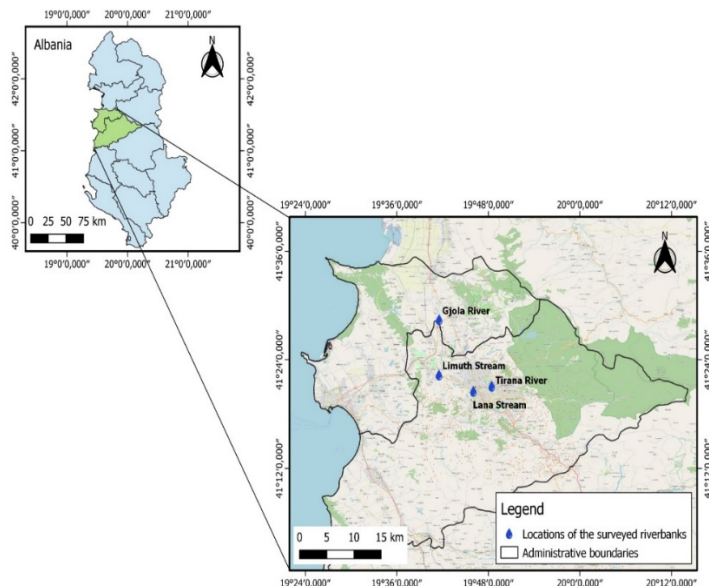

Fig. 1. Locations of the surveyed riverbank, for four surveyed riverbanks of the Ishëm River: Lana Stream, Tirana River, Limuth Stream, Gjola River.

2.2. Study Method of Macro litter on riverbanks and citizen science

All riverine litter items were collected on a distance 100 m long stretches of riverbank parallel to the watermark there are gathered all riverine litter items, whereas the width of sampling area goes at a maximum 25 m (see Fig. 2) [5, 6]. The riverine litter surveys were carry out according to operational guidelines produced by the EU MSFD Technical [7]. During October 2020 four stretches have been surveyed in a surface 7,700 m^2. All riverine macro-litter items on the riverbank founded larger than 2.5 cm were collected in the area, cleaning the riverbank at the end.

Citizens science is done from high school students, students, teachers, professors from Durres in collaboration with specialists from Agency of Protected Areas of Durres and Municipality of Kruja who participated in the cleaning ups actions.
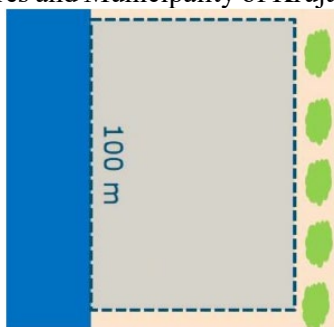

Fig. 2. The River-OSPAR method to sample macrolitter on a 100-m stretch of the riverbank [5].

2.3 Analysis of Data and Processing

The density of macro-litter of riverine litter items per m^2 -is calculated with formula: $C_M = n/(w \times l)$. C_M is the density of riverine litter items/m^2, n is the number of riverine litter items recorded, and w and l are the width and length of the sampling unit in meter [8]. The number of riverine items was calculated per 100 m stretch. The riverine litter items recorded - were categorized into eight major groups of material types: as artificial polymer materials, cloth/textile, paper/cardboard, rubber, processed/worked wood, glass/ceramics, metal and unidentified items and/or chemicals according to the Master List of Categories of Litter Items [7]. The collected riverine macro-litter items were also categorized into three major groups of riverine items: single-use plastics, non-single-use plastics, and non-plastic marine litter items. The sources of riverine macro-litter were categorized into eight classes: (1) shoreline, including poor waste management practices, tourism, and recreational

activities; (2) shipping; (3) fly-tipping; (4) fisheries and aquaculture; (5) sanitary and sewage-related; (6) agriculture; (7) medical-related; and (8) non-sourced according [9].

3. Results and Discussions
3.1. Densities of Riverine Macro-Litter in the Surveyed Riverbank of the Ishëm River

The mean litter density of the four sites studied Lana Stream, Tirana River, Limuth Stream and Gjola River riverbank of the Ishëm River was 1,269 items/100 m, respectively 779 items/100 m, 1069 items/100 m, 992 items/100 m and 2,237 items/100 m; and 0.992 items/m^2, respectively 1.558 items/m^2, 0.356 items/m^2, 1.417 items/m^2 and 0.639 items/m^2 (Fig. 3). Comparing the mean riverine litter density of our study to riverine litter at riverbank macrolitter in the Dutch Rhine–Meuse delta, it is viewable that mean riverine litter density in our study is 5 times higher than on Dutch Rhine–Meuse delta [10]. Making a comparison of the mean riverine litter density of Ishëm River to the Nederrijn River, Meuse River, Waal River it is respectively 3 times higher, 5 times higher, 8 times than the Nederrijn River, Meuse River, Waal River [10]. Making a comparison of the mean riverine litter density of this study to riverine litter in German riversides, it is 2 times higher in our study than German riversides [11]. The mean riverine litter of our study is 2 times lower than Erzen River [12]. Riverine litter surveying protocols and riverine litter densities makes the comparison of results difficult when we study them in terms of units.
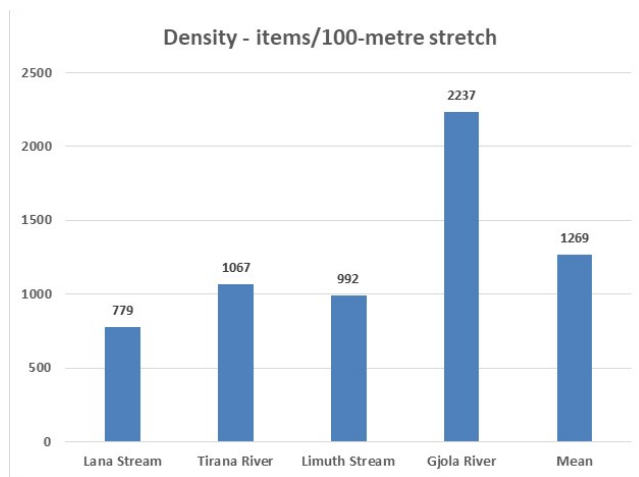

Fig. 3 Abundance of riverine macro-litter items for four surveyed riverbanks of the Ishëm River: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank and the mean of total surveyed riverbank (items per 100 m stretch)

Table 1 **Riverbank riverine litter densities worldwide and in the Mediterranean, including Albania**

Survey zone	Number of studied riverbanks	Mean density of riverine litter (items/m^2 or items/ 100 m)	References
Dutch Rhine–Meuse delta	291	243 items/100 m	[10]
Nederin	192	426 items/100 m	[10]
Meuse	93	283 items/100 m	[10]
Waal	6	166 items/100 m	[10]
German riversides	250	0.54 items/m2	[11]
Erzen River	2	2,487 items/100 m	[12]

3.2 Riverine Litter Composition of Surveyed Riverbanks

Artificial polymer materials (82%, or 4,174 items of 5075 total riverine items). belonged to most of the riverine macro-litter items at the aggregated level ("aggregate level" which indicates the sum or the aggregation of many individual level units/sum total). Macro-litter in Erzen that belongs to waters plastic items was 93% [12].

Macro-litter in Rhone River that belongs to waters plastic items was 77% [13]. Also according to [11] who surveyed German riversides the greater majority of riverine litter was made of plastics with 50.5%, including cigarette buts.

The second largest material type of riverine litter items at the aggregated level was paper/cardboard (11% or 559 items), whereas in Erzen River was glass/ceramics (3%, or 151 items) [12]. It was the same the second most abundant material type of litter items was paper/cardboard represented 14% in Rhone River waters [13], whereas the second most abundant material type of litter items glass/ceramics (16%) in German riversides [11].

The third largest group of items at the aggregated level of our Ishëm River was cloth/textile amounts to 3% (147 items), whereas in Erzen surveyed riverbank was processed/ worked wood amounts to 1.3% [12]. The third most abundant group of items was paper (13%) in German riversides [11]. The third most abundant group of items was metal items in Rhone River waters (5%) [13]. The group was followed by items made of glass/ceramics (2%) and metal and unidentified or chemicals (both 1%) on Ishëm surveyed riverbanks.

The highest percentage of plastics on each studied area was recorded at Gjola River riverbank (95%, 2121 items), followed by Tirana River riverbank (84%, 893 items) and then both Lana Stream and Limuth Stream (both 65%). At Limuth Stream riverbank, paper/cardboard included 30%, at Lana Stream 22%, whereas at Tirana River riverbank 7.5% and Gjola River riverbank 0.3%.
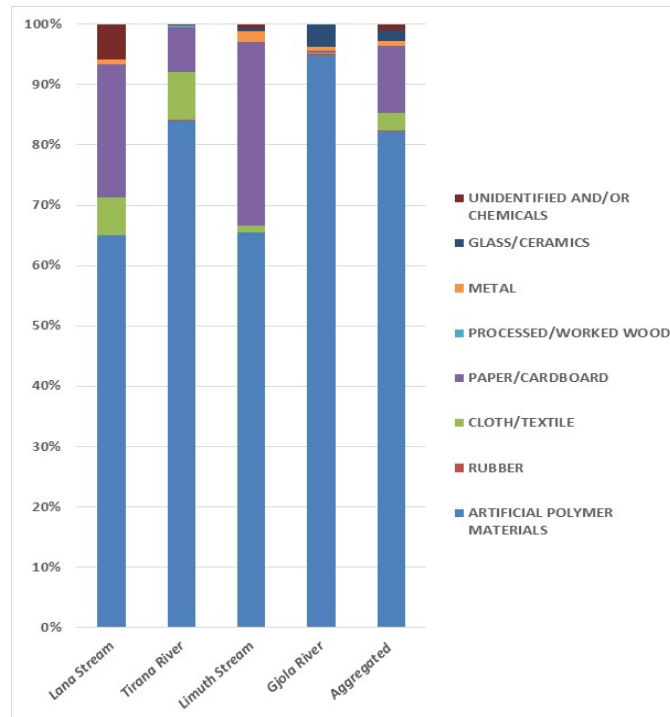

Fig. 4. Percentage (%) of total riverine litter items according eight major groups of material types: artificial polymer materials; cloth/textile; paper/cardboard; rubber processed/ worked wood; glass/ceramics, metal of the Ishëm River: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank and aggregated level.

The top 20 riverine items attributed for 96% of all 5075 riverine items registered (Table 2). Among 59 litter item categories recorded, drink bottles < =0.5 l (G7) were the most repeatedly found items with 19.7% (998 items). In the second place with more riverine items shopping bags, incl. pieces (G3) with 15.7%, followed by crisps packets/sweets wrappers (G30) with 14.7%, drink bottles >0.5l (G8) with 13.8%, and paper fragments (G156), with 5.4%. Cardboard (boxes & fragments) (G148), polystyrene pieces 2.5 cm > < 50cm, > 50 cm (G82 +G83), clothing / rags (clothing, hats, towels) (G137), cleaner bottles & containers (G9), plastic construction waste (G89), other cosmetics bottles & containers (G12), plastic caps/lids drinks (G21), flip-flops (G102), other medical items (swabs, bandaging, adhesive plaster, etc.) (G211), and jars, including pieces (G201) were between the top 15 items found.

Table 2 Top 20 items found on the two studied riverbanks of the Ishëm River: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank [7]. Annex 8.1 – Master List of Categories of Litter Items.

Ranking	Items name	Material type	Code	Total	% of Total Items
1	Drink bottles <=0.5l	ARTIFICIAL POLYMER MATERIALS	G7	998	19.7
2	Shopping Bags, incl. pieces	ARTIFICIAL POLYMER MATERIALS	G3	799	15.7
3	Crisps packets/sweets wrappers	ARTIFICIAL POLYMER MATERIALS	G30	747	14.7
4	Drink bottles >0.5l	ARTIFICIAL POLYMER MATERIALS	G8	701	13.8
5	Paper fragments	PAPER/CARDBOARD	G156	273	5.4
6	Cardboard (boxes & fragments)	PAPER/CARDBOARD	G148	241	4.7
7	Polystyrene pieces 2.5 cm > < 50cm, > 50 cm	ARTIFICIAL POLYMER MATERIALS	G82 +G83	208	4.1
8	Clothing / rags (clothing, hats, towels)	CLOTH/TEXTILE	G137	141	2.8
9	Cleaner bottles & containers	ARTIFICIAL POLYMER MATERIALS	G9	136	2.7
10	Plastic construction waste	ARTIFICIAL POLYMER MATERIALS	G89	124	2.4
11	Other cosmetics bottles & containers	ARTIFICIAL POLYMER MATERIALS	G12	83	1.6
12	Plastic caps/lids drinks	ARTIFICIAL POLYMER MATERIALS	G21	77	1.5
13	Flip-flops	ARTIFICIAL POLYMER MATERIALS	G102	64	1.3
14	Other medical items (swabs, bandaging, adhesive plaster, etc.)	UNIDENTIFIED AND/OR CHEMICALS	G211	55	1.1
15	Jars, including pieces	GLASS/CERAMICS	G201	44	0.9
16	Sheets, industrial packaging, plastic sheeting	ARTIFICIAL POLYMER MATERIALS	G67	39	0.8
17	Cartons/Tetrapack (others)	PAPER/CARDBOARD	G151	39	0.8
18	Bottles, including pieces	GLASS/CERAMICS	G200	35	0.7
19	Shoes/sandals	ARTIFICIAL POLYMER MATERIALS	G71	33	0.7
20	Toys and party poppers	ARTIFICIAL POLYMER MATERIALS	G32	26	0.5

In Ishmi River the top 10 riverine items contributed 86.1% of total items with 7 plastic (artificial polymer materials) material category, 2 paper/cardboard and 1 cloth/textile, almost similar in the Mediterranean Sea region riverine data, the top 10 riverine items composed 82.8% of total riverine items of subsequent material type 7 plastic, 2 paper/cardboard and 1 metal [14]. Whereas in Erzen River the top 10 riverine items contributed up to 86.8 % of total items with all plastic (artificial polymer materials) material category [12].

In Ishmi River the top 20 riverine items accounted for 95.8%, including the following material categories: 13 plastic, 2 paper/cardboard, 2 glass/ ceramics, 1 cloth/textile and 1 unidentified and/or chemicals, whereas in Erzen River, the top 20 items accounted for 94.5%, including the following material categories: 15 plastic (artificial polymer materials), 3 glass/ ceramics, 1 processed/worked wood and 1 paper/cardboard [12].

At Lana Stream riverbank (Fig. 5), the top 15 items contributed up to 98.5% of the total riverine items. The largest items took place crisps packets/sweets wrappers (G30) with 30.6%, followed by paper fragments (G156) with 22%, shopping bags, incl. pieces(G3) with 10.3%, and plastic caps/lids drinks (G21) with 9.8%.

At Tirana River riverbank (Fig.5), the top 15 items contributed up to 99.6% of the total riverine items. The most considerable riverine items were shopping bags, incl. pieces(G3) with 57.4%, followed by crisps packets/sweets wrappers (G30) with 23.4%, clothing / rags (clothing, hats, towels) (G137) with 7.8%, and followed by paper fragments (G156) with 5.1%.

At Limuth Stream riverbank (Fig. 5), the top 15 items contributed up to 97.7% of the total riverine items. The largest items took place cardboard (boxes & fragments) (G148) with 24.3%, followed by crisps packets/sweets wrappers (G30) with 21.1%, followed by drink bottles <=0.5l (G7) with 14%, and plastic construction waste (G89) with 12.1%.

At Gjola River riverbank (Fig.5), the top 15 items contributed up to 97.3% of the total riverine items. The most considerable riverine items were drink bottles <=0.5l (G7) with 36.7%, followed by drink bottles >0.5l (G8) with 30.4%, polystyrene pieces 2.5 cm > < 50cm, > 50 cm (G82+G83) with 8.9%, and followed by cleaner bottles & containers (G9) with 6.1%.

Fig. 5 Top 15 riverine macro-litter items in % placed at each of the two surveyed riverbanks: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank.

Single-use plastics, non-single-use plastics and non-plastic riverine litter items were also another categorization of riverine litter items for the two studied riverbanks and at the aggregated level (Fig. 6). According [15] the successive riverine items were calculated as single-use plastics: shopping bags, including pieces (G3), drink bottles >0.5 l (G8), drink bottles <= 0.5 l (G7), plastic caps/lids from drinks (G21), food containers including fast food containers (G10), cigarette butts and filters (G27), cups and cup lids (G33) and sanitary towels/panty liners/backing strips (G96), crisps packets/sweets wrappers (G30), cotton bud sticks (G95), lolly sticks (G31), cutlery and trays (G34), toilet fresheners(G97) and straws and stirrers (G35).

Cigarette butts and filters(G27), lolly sticks (G31), cutlery and trays (G34), cotton bud sticks (G95), sanitary towels/panty liners/backing strips (G96) and toilet fresheners (G97) are not noticed in Ishem riverbanks.

At the aggregated level, single-use plastics contributed up to 66% of the riverine items in Ishëm River, whereas in Erzen River single-use plastics contributed up to 26% of the riverine items or 2.5 times higher were single-use plastic items in Ishem River than Erzen River (Gjyli at al., 2022). The amount of single-use plastics at riverbanks ranged from 47% at Limuth Stream riverbank, 59% at Lana Stream, 70% at Gjola River to 81% to Tirana River riverbank.

Almost 4 times higher was the percentage of single-use plastics compared with non-single-use plastics (16%) at the aggregated level.

On July 2, 2021, there are banned plastic ear sticks, plastic cutlery, straws, mixing sticks for drinks, and balloon holders according the Directive on Single-Use Plastics in the European Union (EU).

On June 1, 2022, there are banned plastic carrier bags and oxo-degradable and oxo-bio degradable bags with a finer thickness than 70 microns according the decision of the Council of Ministers no. 367/2022.
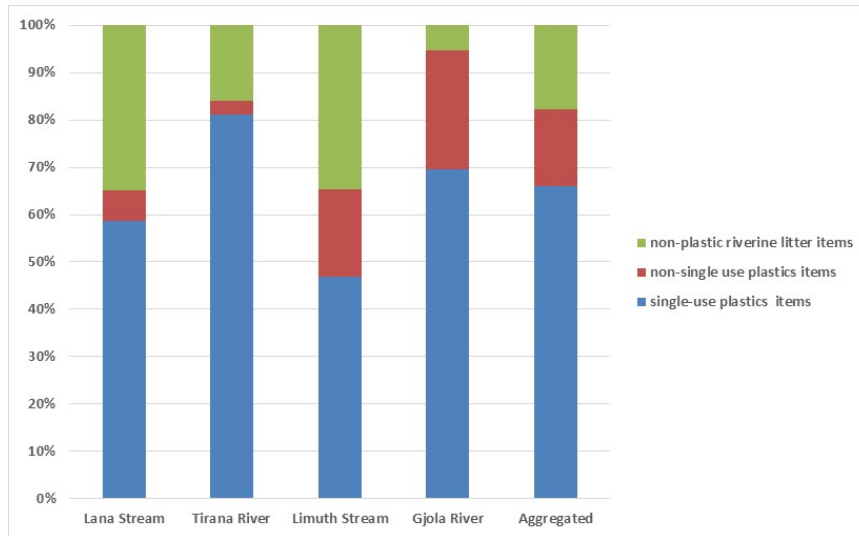

Fig. 6 Single-use plastic items in % noted in four studied riverbanks: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank, and the aggregated level.
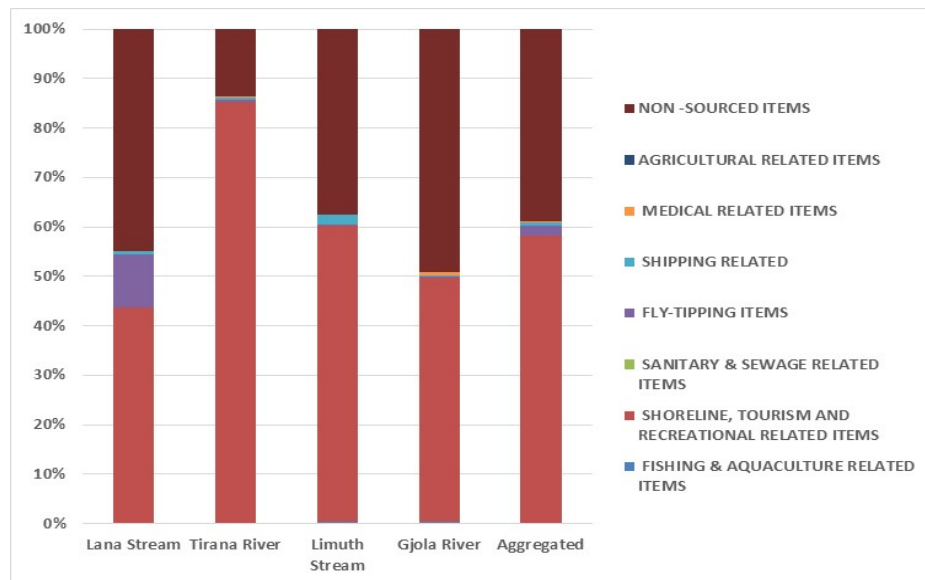

Fig. 7 Sources of riverine litter in % where are included shoreline sources such as tourism and recreational activities items, fisheries and aquaculture items, fly-tipping items, sanity and sewage-related items, shipping related items, agricultural-related items, medical-related items, and non-sourced items noted in riverbanks: Lana Stream riverbank, Tirana River riverbank, Limuth Stream riverbank, Gjola River riverbank, and the aggregated level.

Riverine litter items recorded at aggregated level at the Ishëm River ascribed to the successive sources such as tourism and recreational activities items tourism and recreational-related items including poor waste management, fisheries and aquaculture items, shipping-related, sanitary sewage-related, fly-tipping items and medical-related in quantity 61.2% or 3,106 riverine items(Fig. 7), whereas in Erzen River 38.8% riverine items or 2 times more in Ishëm River than Erzen River [12]. Agricultural-related items are not noticed. At the aggregated level, litter items from riverine bank sources such as

tourism and recreational activities, (including poor waste management practices), contributed up to 58.1% or 2947 items of all riverine litter items. The second most often noticed items were sources fly-tipping items contributed up to 1.8% or 93 items, while the third most noticed items were sources shipping-related items for 0.7% or 38 items.

At the individual riverbank level (Fig. 7), the notes of riverine litter sources such as tourism and recreational activities contributed up to 85.1% at Tirana River riverbank, 60% at Limuth River riverbank, 49.4% at Gjola River riverbank, whereas 43.5% at Lana Stream riverbank.

4. Conclusion

The largest part of riverine litter items at the aggregated level were made of artificial polymer materials (82%). The second largest material type of riverine litter items at the aggregated level was paper/cardboard. What we found mostly in the Ishem River among 59 items there were drink bottles <=0.5l (G7) with 19.7%, shopping bags, incl. pieces (G3) with 15.7%, crisps packets/sweets wrappers (G30) with14.7%, drink bottles >0.5l (G8) with 13.8% and paper fragments (G156) with 5.4%. At the aggregated level, single-use plastics contributed up to 66% of the riverine items. The mean litter density of the four sites studied Lana Stream, Tirana River, Limuth Stream and Gjola River riverbank of the Ishëm River was 1,269 items/100 m and 0.992 items/m^2. In Ishmi River the top 10 riverine items contributed 86.1% of total items with 7 plastic (artificial polymer materials) material category, 2 paper/cardboard and 1 cloth/textile, almost similar in the Mediterranean Sea region riverine data, the top 10 riverine items composed 82.8% of total riverine items of subsequent material type 7 plastic, 2 paper/cardboard and 1 metal. At Lana Stream riverbank the most considerable riverine crisps were packets/sweets wrappers (G30) with 30.6%; at Tirana River riverbank there were shopping bags, incl. pieces(G3) with 57.4%; at Limuth Stream riverbank there were cardboard (boxes & fragments) (G148) with 24.3%; at Gjola River riverbank there were drink bottles <=0.5l (G7) with 36.7%. At the aggregated level, single-use plastics contributed up to 66% of the riverine items, showing that single-use plastics contribute more to the pollution of the river. On July 2, 2021, there are banned plastic ear sticks, plastic cutlery, straws, mixing sticks for drinks, and balloon holders according the Directive on Single-Use Plastics in the European Union (EU). On June 1, 2022, there are banned plastic carrier bags and oxo-degradable and oxo-bio degradable bags with a finer thickness than 70 microns according the decision of the Council of Ministers no. 367/2022.

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