PLASTICS ON THE PEAK

THE 2021 GLOBAL MOUNTAIN WASTE SURVEY



GRID ARENDAL

A UNEP Partner

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The results presented in this document are based on a global survey launched on the 22nd of March 2021 until 16th of May 2021.

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Waste on Mount Elbrouz. *Photo by Breffni Bolze.*

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Executive summary

Waste produced around the globe is expected to grow in the next decades, increasing the pressure on the environment and especially natural ecosystems. In recent years, it was proven that most waste reaching the ocean has been transported by rivers. Those rivers' headwaters are all located in the mountains, but very little is known on the contribution of those areas to the global waste issue. The population of those living in mountains was estimated in 2015 at around 1.05 billion, representing about 15 percent of the world's population. There is a need to collect information and data about waste in mountains regions around the world in order to better understand, estimate the extent of the issue and suggest solutions.

The 2021 Global Waste Survey was designed as a first step to collect the mountain community's opinion and first-hand experience on waste at a global level. Mountains and polar regions are experiencing the effects of climate change at a faster rate than other parts of the world. Mountain dwellers and visitors are witnesses of environmental change and their perception on waste present in the mountains and its evolution in time is valuable information that constitutes the basis of this report.

Survey results highlighted that waste is perceived as an issue for a large majority of respondents. Its presence is perceived across mountains in all continents. Plastic waste was the type of waste seen most frequently by the respondents. It is also one of the most persistent materials when released in the environment. One of the main results of the survey is the presence of waste across all continents, with different perceived quantities depending on the mountain regions.

Survey respondents have highlighted the directions in which efforts could be taken in order to improve the waste issue in the mountains. Respondents also emphasised the responsibility of individuals towards the presence of waste in the mountains. One of the main aspects pointed out by respondents is the need to increase education about waste and its consequences in the natural mountain environment. The second aspect needing improvement is the waste management infrastructure, which is related to income level, legislation and local authorities. A third aspect is improving the use and creation of more sustainable, longer lasting and reusable alternatives to the packaging available on the market at the moment. Reducing the total amount of waste should still be the overall objective, and a combination of these solutions could contribute to improving the situation in the mountains while respecting local conditions.



Waste dumping in Croatia. *Photo by Croatian participant.*

Introduction

Solid waste has been an increasing issue in many parts of the world over the last few decades. A recent publication by the World Bank sheds some light on the extent of the problem in urbanized areas and how it is expected to evolve by 2050. About 33% of municipal solid waste is mismanaged annually worldwide, representing about 660 million tons in 2016 (Kaza et al., 2018). The highest total amount of waste generated by region is in East Asia and the Pacific, with about 468 Million tons. However, waste generation per capita is highest in more developed countries and regions, such as North America where an average of 2.21 kg of waste is generated by per day per person (Kaza et al., 2018).

With increasing knowledge about marine litter, multiple studies have found freshwater streams and rivers to be major pathways for waste transport into the sea (Lebreton and Andrady, 2019; Lechthaler et al., 2020; Meijer et al., 2021; UNEP, 2021). Waste has been found in most of the rivers around the globe, and can contribute to marine pollution at the bottom of the sea, in the water column or simply drifting on the surface of seas and oceans (Lebreton et al., 2018).

Rivers take their source in upland areas and mountains, travelling sometimes thousands of kilometers across land that includes densely populated areas before pouring out into the sea. The waste present in these upper watersheds can potentially be transported by rainwater, wind, wildlife or human activity to streams, eventually reaching the larger rivers and ending up in the sea.

While there is an increasing amount of information about populated riverine regions, deltas, and coastal areas, the level of information relating to waste in upper watersheds and remote areas is relatively low.

The objective of this survey was to gather comprehensive information about the presence and type of waste in mountain ranges around the world. We gave a special focus to remote mountain areas, not including the highly populated municipalities located at higher elevation. We relied on people's perception of waste and their observations. The survey targeted communities of mountain enthusiasts who spend significant amount of time in the mountains and were willing to share their perspectives on the waste issue.



Plastic waste dumped near a river in Pakistan.
Photo by Canadian participant.

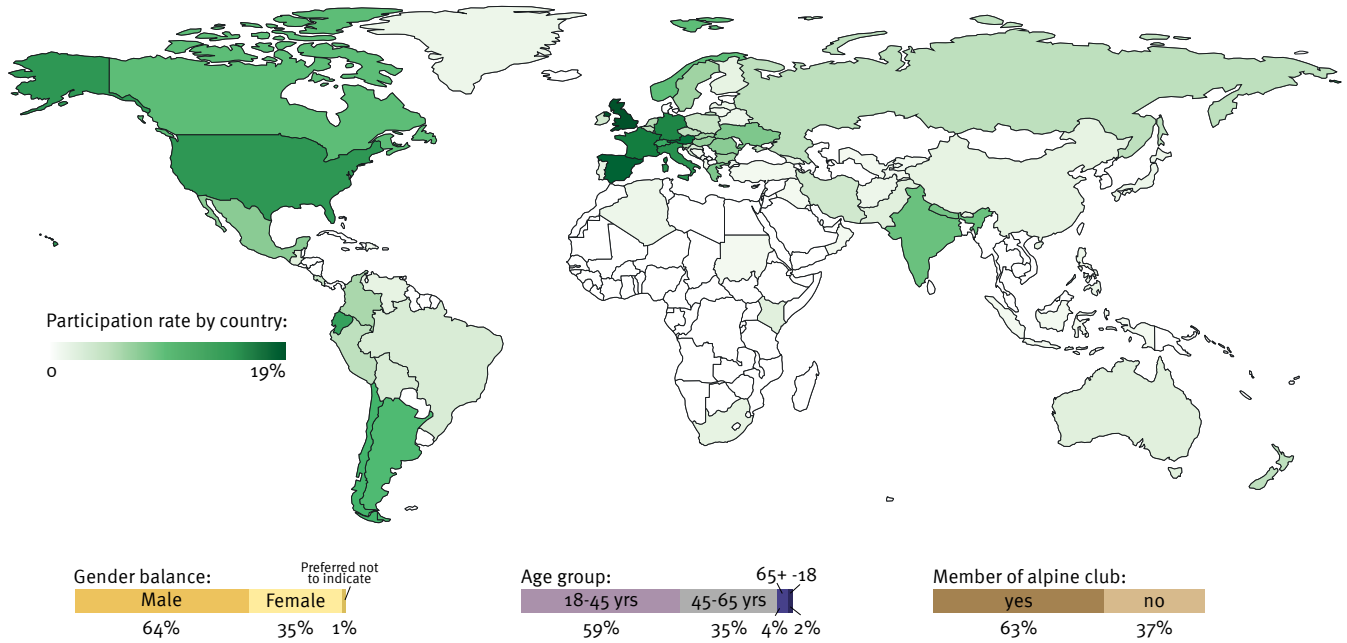
We teamed up with a number of strategic partners in order to make sure we reached our intended target audiences. These included the guiding and mountaineering federations: the International Federation of Mountain Guides Associations (IFMGA), the International Climbing and Mountaineering Federation (UIAA), the Union of International Mountain Leader Associations (UIMLA), and the Kilian Jornet Foundation. We also partnered with the United Nations Environment Programme (UNEP) and the Secretariat of the Basel, Rotterdam and Stockholm Conventions (BRS Secretariat), both of whom have ongoing work related to waste in mountain regions and important links to governments and other stakeholders in mountain regions. Last but not least, we partnered with the Mountain Research Initiative (MRI) in order to reach out to the research community.

The survey was shared on social media and on websites of all the partners to ensure our call reached the widest possible audience. This included directly targeting IFMGA-certified guides to gather feedback specifically from the guiding community.

1. Survey respondents profile

The survey was designed to collect answers from around the globe with the objective to compare information from a maximum number of mountain ranges. To favor a high response rate, the survey was translated into five languages: English, French, German, Russian and Spanish. The format of the online survey was adapted to multiple platforms including computers, smart phones and tablets.

The 2021 Mountain Waste Survey
1753 respondents from 74 nationalities



Sources: The 2021 Mountain Waste Survey; Countries boundaries from Natural Earth 4.1.0.
Partners: UNEP, MRI, IFMGA, UIAA; Kilian Jornet Foundation, UIMLA, Secretariat of BRS Conventions

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a. Nationalities

We received responses from 74 different nationalities around the world. The distribution of the respondents is largely dominated by European nationalities (78%), then South American (9%) and North American (7.5%) and finally Asian (4.2%). Only a little more than 1% of respondents originated from either Africa and Oceania. The sub-set of responses from the IFMGA guiding community included 366 responses, representing 20.8% of the total, and originating mostly from Europe with 86.9% of responses.

b. Age distribution

A little less than two thirds of the total respondents were aged between 18-45 years old, one third being between 45-65 years old, 4% were above 65 and about 2% below 18 years old. The survey reached a category of people old enough to have hands on experience of the mountain environment and probably spent sufficient time in the mountain to have an insight on waste.

c. Gender balance

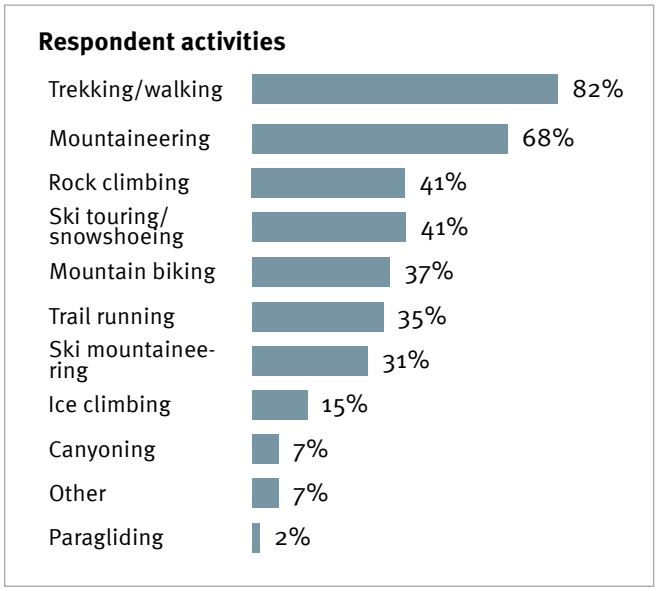
The gender balance of the respondents was approximately 2/3rds male and 1/3rd female. The fact that mountaineering continues to be predominantly practiced by men (Apollo, 2021) as well as a majority of male role models in the sport may be some explaining factors for the relatively low proportion of female mountain enthusiasts. When viewed at a continental scale, all continents featured approximately the same proportion of female respondents as the global average. The highest rate of female respondents was reached in South America with 42%. The sub-set of responses from the IFMGA guiding community included 16.9% of women, 81.2% of men and 1.9% preferred not to indicate.

d. Activities of respondents

63% of respondents declared being part of a mountaineering or alpine club or association. A majority can then be expected to have good knowledge of the mountain environment and would have visited multiple altitudinal zones and more or less



Hikers near Stoos, Switzerland. *Photo by Ante-Hamersmit on Unsplash.*



remote mountain locations. Respondents were given a set of activities to choose from with multiple choices possible. Based on the results, the most widespread activity is by far trekking or walking in the mountains, making up 82% of the respondents. The second most popular activity is mountaineering at 68%, and in third place there's a tie between rock climbing and ski touring/snowshoeing, both chosen by 41% of respondents.

e. Where have respondents noticed a waste issue?

The vast majority (94%) of the participants agreed that waste is an issue needing immediate attention in mountain areas around the world. The top three continents where the respondents believed the waste issue was most urgent were: #1: Europe,#2 Asia and #3 South America.

It's important to note that these results should be viewed in the context that the majority of respondents come from Europe and most respondents practice their favorite activities in the same continent they are living in. Only a small portion (less than 10% of each continent) of respondents actually travel to another continent for their activities, which requires more personal funds because of the longer travel distances and the longer stays expected within these mountain regions. In the case of mountain guides, the respondent group is more likely to travel abroad to guide clients in other mountain ranges and have a better basis for comparison. Meanwhile, they still perceive predominantly Europe, then Asia and South America, to have a waste issue, which is in accordance with the general public.

Responses from the survey originate from a large number of countries around the world. Sharing the survey through social media and the international partners' networks allowed us to reach people who frequently undertake activities in the mountains either for their profession or for leisure. With an average time of 12 minutes to complete the survey, participants showed that they have a high interest in the waste issue in the mountains, and with frequent travels to the mountains they are privileged observers of the mountain environment.

2. How is waste perceived in the world?

a. Global perspective

Globally, 69% of respondents declared seeing waste every time or most of the time they go to the mountains, and only 0.2% declared never seeing any waste at all. The most commonly seen types of waste are by far hard plastics (88%), such as bottles, and soft plastics (87%) such as packaging. According to respondents, organic waste (72%) is the second most seen type of waste in the mountains. In the same category, human waste such as faeces and urine (61%) are the third most seen. Other sorts of waste are less likely observed in mountains, but still 56% of respondents declared having seen glass, 40% have seen metal waste, while 39% have seen synthetic fabrics such as the ones used in mountain equipment. The less seen waste groups are hazardous waste, such as oil or fuel batteries (6,2%) and electronic waste (10.7%).

b. Caveats

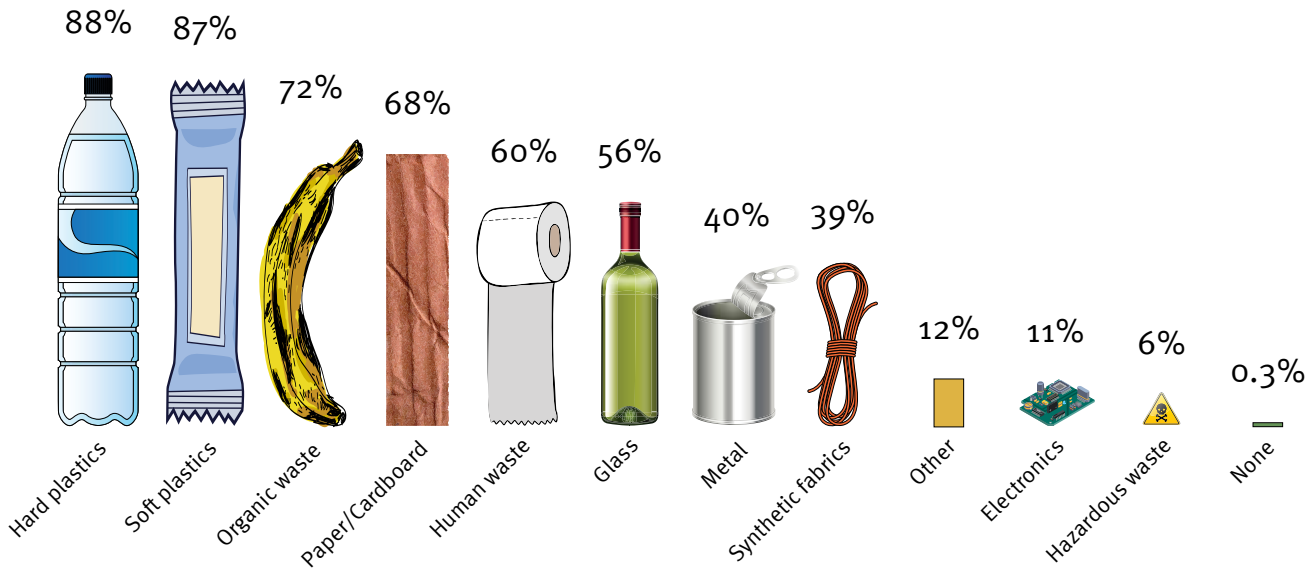
Organic waste is the second most seen type of waste worldwide, and it is probably the most widely accepted because of its natural biodegradation in the environment. However, most of this organic waste isn't natural to mountain areas or even from the same continent e.g. banana peels. Non-native organic waste takes much longer to degrade due to lower temperatures and can cause digestion issues for wildlife if ingested. Another type of organic waste is human waste, which overall is seen much more by mountain guides (79.5%, while the global average is 60%). Guides lead groups in the mountains, and often stay in predetermined areas such as refuges, huts, and base camps that have a tendency to host many people over the season which lasts from a few weeks to several months. If human waste is not managed adequately, this can become an issue especially if there is contamination of nearby streams and soil potentially affecting wildlife and cause human health hazard. Apart form being unsightly, it is almost always accompanied by toilet paper and other such waste.

Compared to the worldwide average of 10.7%, electronic waste appears to be seen more in Africa (20%), in Asia (12.7%), in South America (14%) and in North and South America (12.3% and 7.7%). Electronics are hazardous waste because of their chemical composition and require specific waste treatment. If found in the mountains, it can give an indication of poor local waste management systems. In some countries in the Himalayan range, such as Nepal, waste management often consists of the collection of waste in urban areas and then depositing it in landfills. For smaller communities in the mountains, waste management is less developed and often people discard their waste in open dumps, or worse along rivers banks, which is easily flushed down and out of their sight but creates accumulation downstream.

> ***Yes, waste is a matter of concern in the Lesser Himalayan region as it is contributing to environmental degradation and accumulation of waste in the base camps.***
>
> – Respondent from Darjeeling, India.

Types of waste seen in the mountains

Percentage of the total number of respondent having seen such waste



Sources: The 2021 Mountain Waste Survey; icons from Vecteezy.com
Partners: UNEP, MRI, IFMGA, UIAA; Kilian Jornet Foundation, UIMLA, Secretariat of BRS Conventions

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Waste found in Austrian mountains. *Photo by Austrian participant.*

3. Where is waste seen in the world´s mountains?

a. Global perspective

Participants of the survey were asked where they see waste during a typical mountain trip. Results found that the most common location for waste to be seen in mountains is on or beside trails (81.5%). Completing the podium, car parks (77.4%) and resting areas (72.6%) seem to be the other most critical places for finding waste. They are also the most common places where people come by or use during a typical mountain trip. Similarly, huts, refuges or established camps are associated with the presence of waste by 62.3% of respondents. People often spend multiple hours to several days in those places. On the other hand, global respondents founds that places further away from designated paths such as near rivers or lakes (58.8%), in the forest (52.8%) or in crevasses or caves (34.1%) and mountain pastures (30.2%) are perceived as less polluted by waste.

> ***Waste spoils surrounding nature (landscapes, vegetation and fauna) that can affect the overall ecosystem of the mountains.***
> – Respondent from Nairobi, Kenya.

b. Caveats

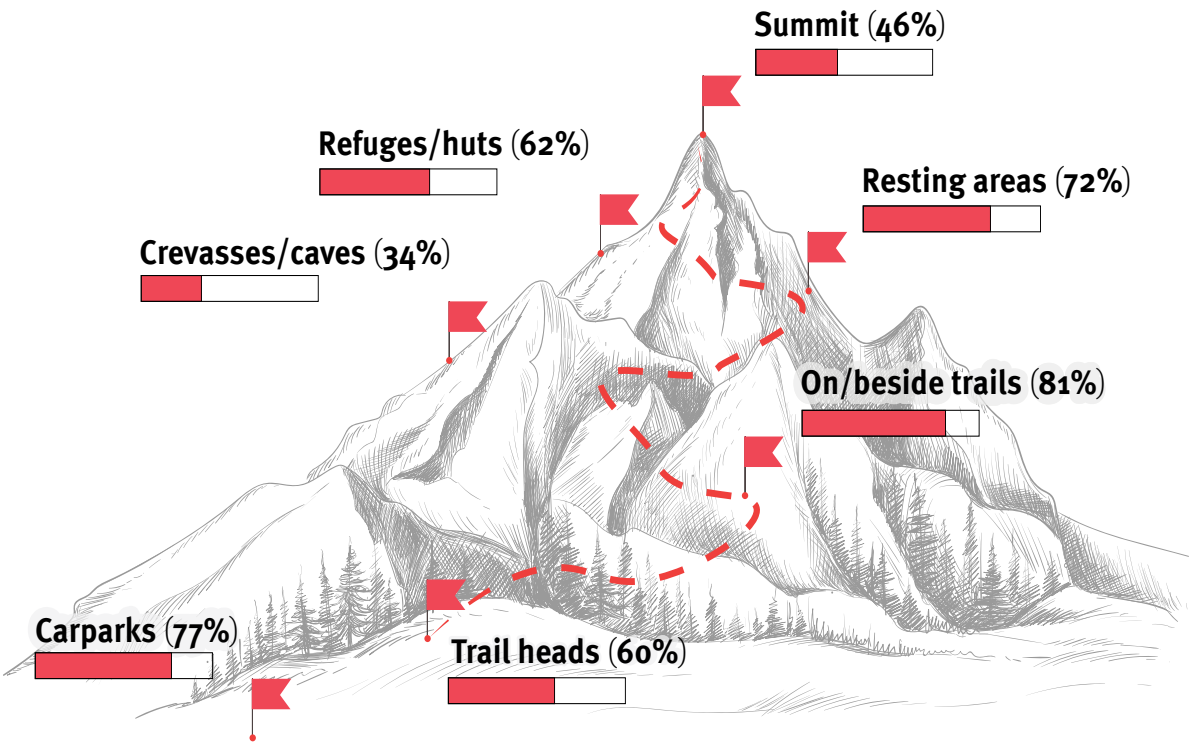
Those global numbers however hide quite important differences at the continental level. In Asia, respondents identified rivers and lakes as the main location to find waste (82.3%). Places further away from trails also are perceived as being more polluted that the global average, such as forests (61.6%) and mountain pastures (38.4%).

In North America, South America and Europe, respondents have a similar tendency to identify more easily places of higher passage frequency as being polluted by waste. A more frequent passage could mean a higher probability of seeing waste because it is likely to be transported and deposited by mountain users. However, this perception could be altered by the facts that people often stay on trails and are less likely to go in more difficult terrain.

> ***Tajikistan is a mountainous country and many tourists come here and they leave plastic waste in mountainous areas.***
> – Respondent from Dushanbe, Tajikistan.

Where is waste seen on mountains?

Percentage of survey respondents having seen waste in such places



Sources: The 2021 Mountain Waste Survey; Mountain drawing Harryarts/Freepik
Partners: UNEP, MRI, IFMGA, UIAA; Kilian Jornet Foundation, UIMLA, Secretariat of BRS Conventions

GRID-Arendal (2021)

4. How much waste is seen in the mountains?

a. Global perspective

Quantifying the waste on mountains is something difficult to estimate, especially with the naked eye and from a distance. This is why respondents were asked to estimate the quantity based on a familiar and common indicator – a typical mountain rucksack of 60L. Globally, most respondents (46%) estimated that during a typical mountain trip, they would see enough waste to fill only the top pocket of the rucksack. 26% would see enough to fill half of the rucksack and 15% would see enough to fill one or multiple rucksacks.

> ***As time goes by, there's more waste found on the mountains that I visit, I think it's a big issue because it stays there and creates a bad environment and affects the flora and fauna of the region.***
> – Respondent from Quito, Ecuador.

> ***I increasingly see waste at almost all mountain locations but especially in more accessible/ popular areas.***
> – Respondent from Uttoxeter, UK.

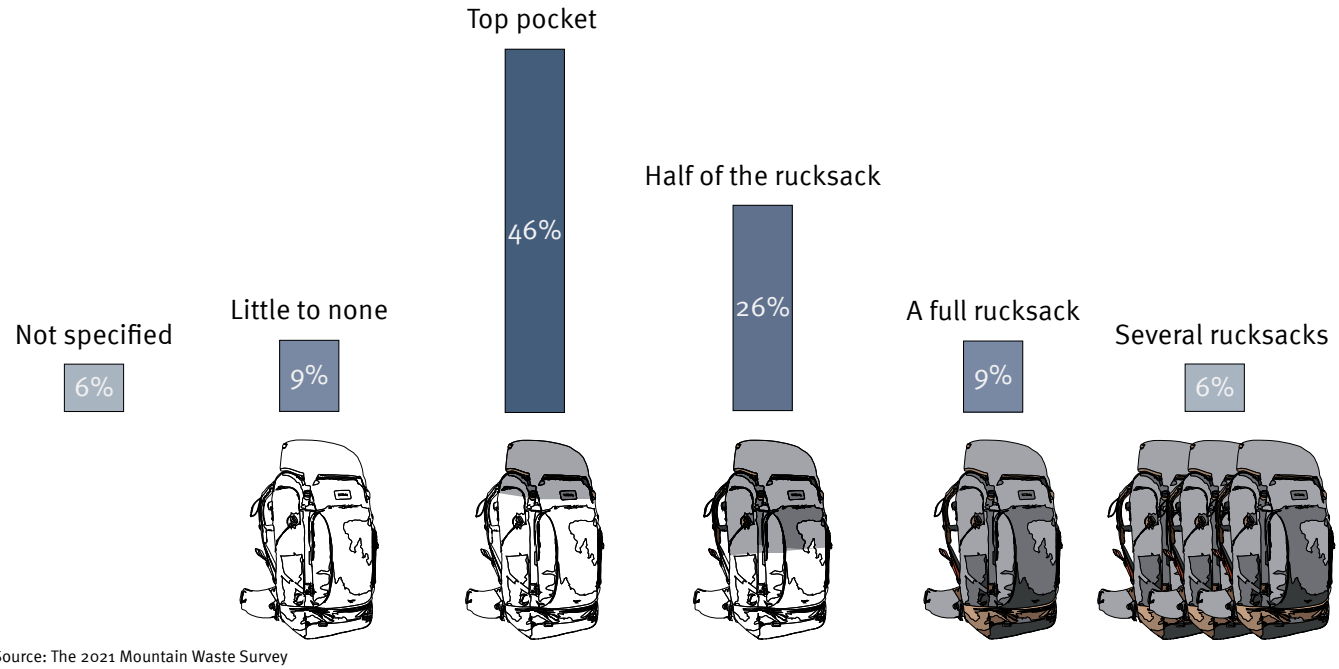
b. Caveats

These results are however largely influenced by European answers covering 78% of the total, as well as South American (9%) and North American (7.5%) answers. When looking at specific regions such as Asia, result differ quite significantly. 56.1% of Asian respondent declared seeing enough waste to fill one or several rucksacks during a typical trip in the mountains. Only 19.1% see enough waste to fill the top pocket of the rucksack. In Africa, 60% of the respondents declared seeing enough waste to fill one or multiple rucksacks during a typical mountain trip.

Those results might be related to different societal issues such as waste management practices. Such high quantities of waste are less likely to be brought to the mountain solely by mountain dwellers and visitors. Waste management at higher altitude is more challenging, and infrastructures are less developed in Asia and Africa than Europe, South or North America. Respondents could well be seeing waste originating from households as well, and those tend to be deposited in landfills and open dumps in mountains areas, which are prone to remobilisation by natural hazards or wildlife (Alfthan et al. 2016)

How much waste is seen during a typical mountain trip?

Percentage of respondents seeing enough waste to fill parts of a 60L rucksack:



Source: The 2021 Mountain Waste Survey
Partners: UNEP, MRI, IFMGA, UIAA; Kilian Jornet Foundation, UIMLA, Secretariat of BRS Conventions

GRID-Arendal (2021)

5. Evolution of waste over time

a. Global perspective

94.6% of respondents globally answered positively to the question whether waste was an issue needing immediate attention in the mountains. Answers were similar for all continents and groups considered. As respondents were experienced mountain users, with multiple years of knowledge of going recurrently at the same places throughout different seasons, their perception of waste evolution over time can serve as a valuable indicator. A total of 62.1% of respondents perceived waste to have increased in the last 5 years, and only 14.8% thought it decreased over the same period. Recently, the COVID-19 pandemic has struck the world, but also brought a new kind of waste into our everyday lives. Respondents were asked if they had seen any COVID-19 related waste during their typical mountain trip, and globally 77.3% declared having done so. Similar results were found for all continents, except Asia where only 63% of the respondents have seen such waste in the mountains.

> ***Our area has always seen waste in our beautiful mountains. This year with Covid and everyone out it was a bit horrifying. The trash was awful, the human and dog waste was disgusting and people disturbing fragile areas was also at a record high.***
>
> – Respondent from San Juan, Colorado USA.

> ***It's just inexcusable not to take with you all you bring to the mountains.***
>
> – Respondent from Cuenca, Spain.

Plastics, which are the most common types of waste found, tend to be very resistant to UV radiation and seasonal weather extremes and only after extensive exposure, eventually breaks down and create microplastics. For this reason, it is difficult to estimate for how long waste seen in mountains has been present. Facemasks, gloves and hand sanitiser bottles appeared only after the start of the pandemic in spring 2020 and thus would be have been deposited rather recently.



Face mask on a trail in Austria. Photo by Hangya Roland.

6. Where does the waste come from?

a. Items brought by mountain dwellers and visitors

It seems that waste can be found mostly around places where people pass by or spend time in the mountains. Respondents were asked to what extent they would bring some plastics during a typical mountain trip. Globally, the most carried items containing plastics are first aid products (74%), food packaging (70.3%), and mountaineering equipment (68.8%). These seem to be essential items that are needed for a mountain trip, for which the majority of people prioritize having in their rucksack. The second group of items most carried are plastic bottles (46.3%) and plastic bags (45.3%), which can be useful and lightweight options in many situations when being in the mountains. Some plastics are brought into the mountains as single-use items such as ponchos (16.9%) or "constitute" farming/forestry equipment (4.2%). The low number for farming/forestry equipment probably reflects the lower percentage of "non-guiding" mountain professionals that were targeted through the survey.

> ***I take wet wipes but I also take small plastic dog poo bags to bring home any used wet wipes.***
> – UK respondent.

> ***The easiest is not to litter, but it's not enough – one should research on more sustainable packaging materials, and materials from which our mountain gear, clothes, shoes etc. are made – those materials should be less harmful to the environment.***
> – Respondent from Bavaria, Germany.

Guides have a responsibility towards the groups they lead, and their role is to prioritise safety above all. 88% of guides bring plastics through first aid products and 85.8% through mountaineering equipment such as ropes, tents, harnesses, etc., which is higher than the global average. Practicality and usefulness can be seen differently from one continent to another. 35.6% of Asian respondents, double the global average, have declared bringing plastic ponchos during their mountain trips. By doing so, they probably favour both good protection from heavy rainfall that can occur during warm seasons and local availability of the solution over environmental considerations.



Energy gel packaging. *Photo by Italian participant.*

b. Global perspective

Waste present in the mountains can't be solely considered as originating from mountain users. Overall, respondents gave the highest score to "littering or negligence by mountain users" with 4.36 out of 5 as the primary cause for litter in the mountains. This is followed by a score of 3.29 out of 5 for "Poor waste management in resting areas (e.g., huts, camp sites, picnic sites, remote villages)". However, in third position, "waste transported by natural processes such as wind or water" with 2.91 out of 5 indicates that waste is transported from outside through natural means. To a lesser extent, illegal waste dumps, unintentional loss of general waste and loss of equipment were also identified as part of the reasons why waste is present in the mountains.

c. Caveats

Asian respondents, while identifying "littering or negligence by mountain users" as the number one cause, and "poor waste management in resting areas" in second place, believe that "illegal waste dumps" are the third most important cause of waste. With Asia being the only continent with such answer, it stands to reason that local factors must drive this perception.

7. What actions can contribute to solve the waste issue in the mountains of the world?

a. Global perspective

Answers from all over the world were in strong agreement on the actions that can contribute most to solving or improving the waste issue in mountains areas. 90.3% of respondents believe in this statement: "Having every mountain user take all their rubbish out and implement principles of 'leave no trace' or 'Take in, take out'". In second place, with 78.8% of respondents agreeing: "increase education on impacts of litter". In third place with 65.5% is: "Create more sustainable, long lasting and reusable alternatives". These results were similar throughout continents and also among the mountain guides group, indicating a strong support and alignment of values behind these types of actions.

Clean-up events are organized in many parts of the world, and the will to clean comes with the irritating presence of waste. The knowledge of any clean-up event in the area on the mountain visited by respondent gives an indication of how waste is perceived by the population. Globally, 57.1% of respondents are aware of clean-up events. Those are usually organized by individuals or local associations, using social media or local communities outreach to gather enough helping hands. Such events allow to efficiently collect waste from across the mountain and dispose of it in dedicated places. Respondents were asked for their opinion on which entities should be responsible for clean-up events in the mountains, and the large majority (86.4%) said it was the responsibility of individuals. In second place they indicated tourism and trekking associations (54.3%) and thirdly municipalities or other governmental entities (53.7%). This is in line with the finding that mountain dwellers and visitors should take all rubbish out themselves.

> ***Strict call for action to revert the degradation caused by solid waste is needed urgently.***
> – Respondent from Kathmandu, Nepal.

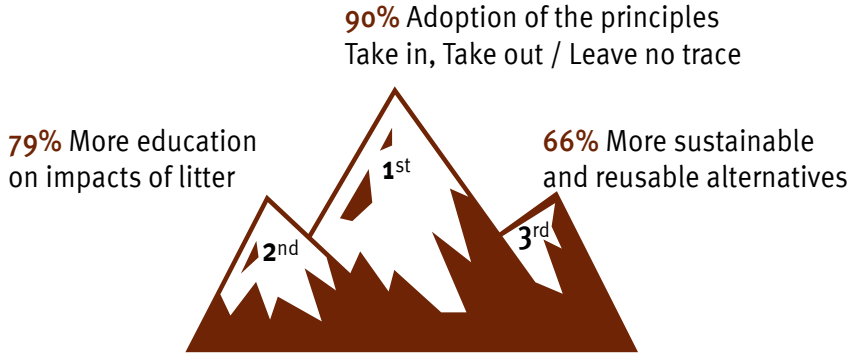
b. Caveats

Asian respondents believed tourism and trekking associations (83.6%) and municipalities and other government entities (79.5%) bear a larger responsibility for clean-ups. Reasons may include a higher dependence of mountain dwellers and visitors on these trekking associations or municipalities, leading respondents to believe they should be more

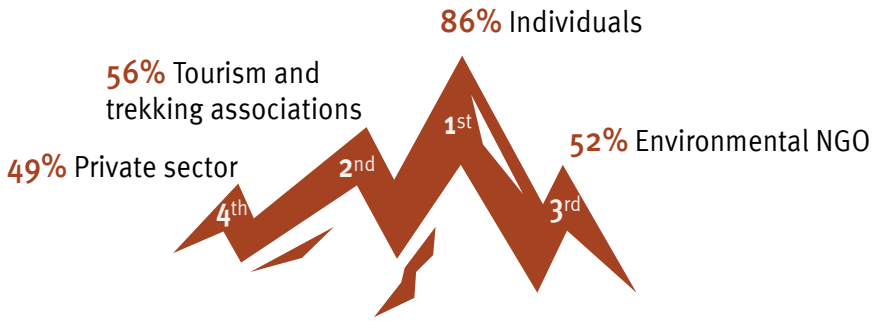
Solutions to the waste issue in mountains

Percentage of the total number of respondents

How can we reduce or eliminate waste in the mountains ?



Who should be responsible for mountain clean-up activities ?



Sources: The 2021 Mountain Waste Survey; icons from Vecteezy.com
Partners: UNEP, MRI, IFMGA, UIAA; Kilian Jornet Foundation, UIMLA, Secretariat of BRS Conventions

GRID-Arendal (2021)



Mountain Riders clean up. *Photo by Mountain Riders.*

involved in cleaning up activities. Perception of such entities getting a large amount of revenue from tourism activity might also work against them. A way to better distribute the income generated by these activities could be to create incentives for the local population to bring down waste from the mountains. At a broader scale, improving waste management schemes based on this source of revenue could also counter balance the relatively bad perception of foreign tourists in the Asian mountains.

> ***There are a lot of so called trekkers that loves nature but don't apply the leave no trace policy. Nowadays, people are loving the outdoor activities, hence, trash is the main issue that needs to be resolved or addressed.***
>
> – Respondent from Philippines.

Reference List

Alfthan, B., Semernya, L., Ramola, A., Adler, C., Peñaranda, L.F., Andresen, M., Rucevska, I., Jurek, M., Schoolmeester, T., Baker, E., Hauer, W. & Memon, M., 2016. Waste Management Outlook for Mountain Regions – Sources and Solutions. UNEP, GRID-Arendal and ISWA. Nairobi, Arendal and Vienna. www.unep.org, www.grida.no, www.iswa.org

Apollo, M., 2021. There is greater gender equality in mountaineering research. Current Issues in Tourism 1–6.

Kaza, S., Yao, L., Bhada-Tata, P., Van Woerden, F., 2018. What a waste 2.0: a global snapshot of solid waste management to 2050. World Bank Publications.

Lebreton, L., Andrady, A., 2019. Future scenarios of global plastic waste generation and disposal. Palgrave Communications 5, 1–11.

Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A., 2018. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Scientific reports 8, 1–15.

Lechthaler, S., Waldschläger, K., Stauch, G., Schüttrumpf, H., 2020. The way of macroplastic through the environment. Environments 7, 73.

Meijer, L.J., van Emmerik, T., van der Ent, R., Schmidt, C., Lebreton, L., 2021. More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances 7, eaaz5803.

UNEP, 2021. From Pollution to Solution: A global assessment of marine litter and plastic pollution. United Nations Environment Programme, Nairobi..

