MOUNTAINEER’S WASTE: PAST, PRESENT AND FUTURE

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Abstract
The growing number of mountaineers (climbers and trekkers) makes the problem of human waste amount to a considerable size (in tonnes of faeces and cubic metres of urine) of environmental degradation. Purity in the high mountains depends mainly on the mountaineers visiting them (the rule of ‘Leave No Trace’); however, if there is no assured suitable sanitation system, no mountaineer can be blamed for leaving human waste (faeces and urine), because the process of excretion cannot be stopped. The management can address the issue in three ways: complete (non-invasive), partial (superficial), and invasive. Those approaches have been elaborately explained in three case studies: Fuji-san (Japan), Yamunotri (India) and Kilimanjaro (Tanzania), respectively. Each of the places have been described based on the provided human waste disposal solutions, starting from the historical perspective and ending with the plans for future implementations, i.e. how it was, how it is, and how it will be. The results showed the improvement of understanding of the environmental pollution by human waste, at least from the management site. Decent changes have appeared in recent years – management bodies care more about human waste disposal. The authorities of mountain regions are gradually exchanging the old, leaking toilets for brand-new eco-friendly ones. Even if this process is slow – mostly because of economical limitations – management bodies appear to be noticing this threat. However, mountaineers do not always follow the implemented and recommended solution, as this study shows. The users should change their irresponsible behaviour, because even the best solutions in the case of human waste disposal in high-mountain conditions will fail if they do not follow the rules.

Keywords: high-mountain environment, climbing management, human excrement, disposal solutions, historical perspective

1. INTRODUCTION

Mountains, with their remote and majestic beauty, are among the most popular destination for tourism (Mieczkowski, 1995). Mountains are usually characterized as inaccessible, fragile, diversified and marginal areas (Messerli & Ives, 1997) and thus that for ages most mountain ecosystems remained in isolation from the outside world. Even though only 10% of the world’s population lives in mountain areas, the mountains are even more important for people who live in the lowlands (Messerli & Ives, 1997). It is worth noting that in some parts of the world, the mountains are the only source of fresh water (80–100% in some tropical areas), so keeping them clean is extremely important. This clearly shows that mountain areas and their resources are important for billions of people, not only those living within and in their immediate vicinity, but also downstream and further afield (Price & Messerli, 2002; Price, 2004).

Currently, that delicate ecosystem is being invaded by increasing level of tourism activity, which have been growing since the 1960s round the world (Boyle & Samson, 1985; Cordell & Super, 2000; Jin–Hyung et al., 2001; Apollo 2015; Pröbstl–Haider et al., 2016). This trend is expected to continue (Ryan, 2003), as each year, hiking, trekking and mountain climbing, broadly defined as mountaineering, are becoming more popular (Nepal, 2003; Apollo, 2014a; Marek & Wieczorek, 2016). People simply want to escape from the crowded urban environment to the
relative calm and cleanliness of the mountains (Godde et al., 1999) or make pilgrimages to mountain areas for religious purposes (e.g. Chota Char Dham in Kumaun Himalaya).

Mountain tourism can be a key factor in promoting an overall improvement in the locals’ quality of life through initiatives in economic development and environmental conservation (Nepal, 2003). However, the increasing volume of tourists presents a serious threat to both the quality of the natural environment and the unique cultural identity of local communities (Apollo, 2015).

The main goal of this paper is to take a closer look at only one aspect of these impacts, namely environmental pollution by human waste. Human faeces are very dangerous in that it contains numerous pathogens that, without a specialised recycling process, pose a threat to both animals and humans. Thus, proper disposal of human waste is an important concern for the appropriate management of high–mountain areas. Unfortunately, inadequate disposal of human waste is a common problem in many mountain areas. Author is aware that it is no possibility to make general recommendations that apply to all mountain areas which are different in many ways (e.g.: in terms of climate, land relief, altitude, and even culture or nationality of people living on them. However, there is an obvious need to determine the nature of the ecosystem and identify the residents' and visitors' behaviours for introducing the proper manner of waste disposal. So, the main intention of this work is to look closer on the devastating impact of human excrement on high–mountain environments based on the provided human waste disposal solutions, starting from the historical perspective and ending with the plans for future implementations, i.e. how it was, how it is, and how it will be.

This paper is the result of a study on literature and a long–term follow–up in dozens of mountain ranges around the world concerning the disposal of human excrement, but most of all, it concerns own studies.

2. BACKGROUND: HIGH–MOUNTAIN TOURISM AND MOUNTAINEERING

This section provides an introduction to the better understanding of the mountaineering in respect of boundaries of activities, meaning of the term and characteristics and number of users. I will also show the complex of interactions between mountaineering and high–mountain environment. This background is necessary to proper understanding of the study.

2.1. Boundaries of high–mountain activity

In the realm of high–altitude medicine, the term high altitude refers to terrestrial elevations over 1500 metres and is commonly divided into three categories: High altitude = 1500–3 500 metres, Very high altitude = 3 500–5 500 metres and Extreme altitude = above 5 500 metres (Hackett & Roach, 2001; Wilson et al., 2009). According to this, the term high–mountain tourism concerns any kind of mountain tourism activity above an altitude of 1 500 metres.

2.2. High–mountain tourism and the term of mountaineering

Mountain tourism is comprised of mass tourism to popular sites, the ski industry, adventure tourism (trekking, climbing, rafting), cultural tourism, ecotourism and pilgrimage (Godde et al., 1999). In other words, high–mountain tourism covers any mountain activities conducted above 1 500 metres. This paper, however, is focusing only on mountaineering activity.

During the last decades, the meaning of the mountaineering term (German: Bergsteigen; Spanish: Montañismo) has evolved (see e.g., Collister, 1984; Whitlock et al., 1991; Beedie & Hudson, 2003; Pomfret, 2006; Rotillon, 2006; Ion, 2010). In this paper, the term mountaineering has been adopted from Beedie and Hudson (2003), who subdivided it into climbing (which now refers to adventure climbing or sports climbing) and trekking (hill walking in 'exotic' places).
2.3. Characteristics of mountaineers

According to reasons, why mountaineering activity is taken, mountaineers can be divided into two main groups of tourists: (1) people who visit them for adventure (trekking, climbing) and (2) pilgrims. Obviously, these two groups, guiding by completely different motivations (secular vs. sacred), are completely distinct, so they have to be considered separately.

**Adventure mountain tourism**

Adventure mountain tourism, such as hiking, trekking and mountain climbing, broadly defined as mountaineering is becoming more popular. With the development of extreme sports, people are heading to the mountains in search of new, often strong emotions and sensations. It is quite difficult (if not impossible) to specify the reasons why people merge their life with high mountains (Apollo, 2014a). However, generally, there are two kinds of mountaineers at the high mountain stage today. Both groups are guided by different motives, and according to A. Maslow's (1954) hierarchy of needs, there are; self–sufficient mountaineers (self–actualisation) and mountaineers using the services of paid guides (esteem) (Apollo, 2014a). Self–actualisation means 'What a man can be, he must be', according to A. Maslow (1954). This quotation forms the basis of the perceived need for self–actualisation and is an apt description of the people who connect their lives with mountains. Self–realisation expressed in the pursuit of continuous development and personal growth is an apt description of the people who are part of this philosophy of life. Below in the hierarchy is a place for humans who need to feel respected; this includes the need to have self–esteem and self–respect–these people often engage in mountaineering to gain recognition. Esteem presents the typical human desire to be accepted and valued by others. The reason (motivation) why people visit mountains matters, mostly because those who 'love' mountains care more about them.

Recently, the number of high–altitude adventure tourists increased dramatically. This is caused by two aspects: evolution of climbing techniques and increasing the physical capabilities of climbers and a commercial approach to this kind of activity (Apollo, 2014a). Before this period, mountaineering was treated as a kind of elite activity. Ethical principles, including the principles of conservation, were an important part of the ethos of climbing. Recently, as mountain adventure tourism has become a mass sport, and the characteristic of climbing activity and the climber’s profile have changed completely, much less mountain users care about the impacts on the natural environment, and this kills the real spirit of mountaineering.

**Pilgrims**

A pilgrimage has been defined as ‘A journey resulting from religious causes, externally to a holy site, and internally for spiritual purposes and internal understanding’ (Barber, 1993). Pilgrims and the making of pilgrimages are common in many religions. It is a journey to a holy place for religious reasons. There is no big difference between particular pilgrimages from various religions, as all of them have one goal, i.e. to be closer with to the broadly defined god or gods. For this reason, pilgrims visit sacred sites (e.g. summit, lake, river).

A pilgrimage to mountain regions is the oldest form of tourism that has been practiced from time immemorial. The mountains of the world are known for their serene landscape and sanctity, and they are major centres of recreation and spirituality (Sati, 2015). The Himalaya in India, Mt. Kailash in China (Tibet), Mt. Kii and Fuji–san in Japan, Mt. Sinai (Ṭūr Sinā‘) in Egypt, Mt. Coropuna, Mt. Ausungate and the Sinaqara glacier in Peru and Llullaillaco Volcano in Argentina are the best examples of this form of spirituality.

As was previously mentioned, the motivation of pilgrims does not change with faith (religion); however, the behavioural characteristics of pilgrims definitely change along with faith. As an example, please compare the Hindu approach to protection of the environment with Christians from Europe or Buddhists from Japan. The creator, through every religion's sacred book, and the prophets speak the same thing—the environment is sacred (Taylor, 2007; Watling, 2009).
It may be concluded unequivocally that every religious man should pay huge attention to environmental protection, mostly because god did not create the environment for a random reason, and man, as a god’s representative on this planet, if he is not charged with sustaining it, then at least he should not destroy it. However, not all pilgrims take their god's will seriously. Without any doubt, Hindu sacred places are the most polluted around the world (Alley, 1998; Timothy & Nyaupane, 2009). In highland pilgrimages to the Himalayas, dumping of waste and rubbish in open spaces and in bodies of water leads to air and water pollution (Satí, 2014; 2015).

2.4. Number of mountaineers

More than 50 million people visit mountains each year (Smith & Warburton, 2012), and recently the number of high-altitude adventure tourists has increased drastically. However, this number may seem to be underestimated, especially when some mountain areas are visited by hundreds of thousand tourists each year, e.g. approx. 300 000 climbers each year try to climb Japan's holy mountain—Mt. Fuji (3 776 m) (Jones & Yamamoto, 2016), and there is a similar situation with Africa’s Mt. Kilimanjaro (5 895 m)—50 000 climbers (Apollo, 2014a) or Mt Aconcagua (Marek & Wieczorek, 2015). The size of tourist traffic in high–mountain areas can also be estimated by checking how many people belong to mountain clubs or similar societies, e.g. USA—approx. 2.3 million; France—approx. 1.5 million, including approx. 250 thousand affiliated clubs; German—speaking Alpine countries—approx. 1.5 million trekkers; Deutscher Alpenverein (DAV)—approx. 893 thousand; Oesterreichischer Alpenverein (OeAV)—approx. 400 thousand; Schweizer Alpen–Club (SAC)—approx. 135 thousand; Polish Mountaineering Association (PZA)—approx. 5 thousand (Jodłowski, 2011). However, as proven by Jodłowski (2011), the real number of mountaineers is much larger, e.g. in Poland, even 10–16 times higher (50–80 thousand people). This numbers comes from estimates (visits to climbing websites, climbing gear and specialised journal sales, etc.).

These 50 million mountain visitors also seem incorrect even when only the Himalayas are taken into consideration. The Himalaya are home to over 52.7 million people (Apollo, 2017a) and had 46.8 million visitors in 2011 (Apollo, 2016). A huge part of this number is domestic visitors (45.3 million) (Apollo, 2016), mostly pilgrims visiting sacred temples located in the High Himalayas (e.g. Amarnath, 3 888 m; Manimahesh Lake, 4 080 m; the complex of four temples at Chota Char Dham, 3 048–3 553 m). In total, approx. 4.7 million people visit the High Himalayas each year, and most of the crowded paths in the Himalayas lead to the temples and are visited by hundreds of thousands of pilgrims each year. For example, in 2011, the Amarnath Holy Cave (3 888 m) was visited by 634 788 pilgrims, while the Badrinath Temple (3 133 m) had 980 667 visitors, and the Jamunotri Temple (3 291 m) had 287 688 visitors (BKTC, 2016).

2.5. Mountaineering and high–mountain environment

This mentioned above, huge, and still growing, number of tourists is a serious threat to every aspect of the very fragile high–mountain environment. Mostly because once injured, such an environment will suffer for ages.

Outdoor leisure activities can be a key factor in promoting an overall improvement in the locals’ quality of life through initiatives in economic development and environmental conservation (Żemła, 2014; Apollo, 2015). However, the increasing volume of tourists presents a serious threat to both the quality of the natural environment and the unique cultural identity of local communities. As a consequence of that increase, the pressure on naturally fragile ecosystem is growing and may lead to the serious collision (Apollo, 2015). That clash—between the totally vulnerable and defenceless mountain environment and bringing changes to the tourism industries—can affect the natural environment (Apollo, 2015). Based on the systemic approach the geographical system is a very complex system, composed of the elements of a different nature (abiotic, biotic, anthropopic),
connected with each other in many different ways, and creating the hierarchical entity of the ‘reality’ (Andreychouk, 2008; 2015). In mountain ecosystems, interactions on the line: tourist and environment may be seen at all stages of the trip. The particular stage refers to the part of the trip, i.e. the first stage covers the part from a well–developed city to the last village—the last place accessible by road; the second stage concerns the area between the last village and the base camp; the third stage applies to the part from which the target from the base camp is reachable (Apollo, 2017b).

**Figure 1.** Basic system of environmental impacts caused by mountaineers (Apollo, 2014a)

Mountaineering makes changes at any stage, however, the most important are those in the second and third stages—those after the last village on the regular road. At the third stage the human impact zones in high–mountain areas can be divided into four main zones: (i) Base Camp or similar camps on the route, (ii) approach or descent zone, (iii) main attraction area (target), and (iv) camping zone above Base Camp (cf. Pyke, 2001). In each zone, high–mountain tourism can affect the natural environment (Fig. 1) by: anthropogenic landslides and trail impact (Nepal, 2003; Marion & Olive, 2006; Tomczyk & Ewertowski, 2013), anthropogenic microforms on rocks (Schuster et al., 2001; Jones & Hollenhorst, 2002; Carter et al., 2008), trampling and damage to vegetation (Nepal, 2003; Marion & Olive, 2006; Cole & Bayfield, 1993; Cole, 1995a; 1995b) introducing new spices of plants (Weaver et al., 2001; Barros & Pickering, 2014) and/or animals (Gajon et al., 2006), disturbance or attracting animals (MacArthur et al., 1982; Gander & Ingold, 1997), disruption of the natural landscape by tourist infrastructure and climbing equipment left behind (Pyke, 2001; Ganetti & Dawa, 2009; Jodłowski, 2011), pollution by noise (Shah et al., 1997; Hempton & Grossmann, 2009), rubbish (Price, 1981; 1985; Cullen, 1986; Roe et al., 1997) and excrement [see section 3 (tab. 1)], etc. And through this, it affects the main elements of the natural environment: geological substrate, land relief, water, vegetation cover, soil, fauna and the landscape. Figure 1 shows the basic system of environmental impacts caused by mountain visitors.

This paper, however is focused at only one aspect of these impacts, namely environmental pollution by human waste. Please note that, purity in the high mountains depends mainly on the mountaineers visiting them (the rule of ‘Leave No Trace’); however, if there is no assured suitable sanitation system, no mountaineer can be blamed for leaving human waste (faeces and urine), because the process of excretion cannot be stopped.
3. MOUNTAINEERS EXCREMENT: A LITERATURE REVIEW

Numerous papers have shown impact of mountaineer’s excrement on high–mountain environments. Table 1 shows the literature review, where it was mentioned the main issue of the paper and the mountain range, where those research has been conducted. Below some important threats, in terms of: pathogens and their disposal time, effects of health risks, and size of the waste.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Mountain Range (Citation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faeces and urine volume</td>
<td>Andes (Barros et al., 2007; Barros &amp; Pickering, 2015), Australian Alps (Leary, 2000), Himalaya (Apollo, 2014a; 2014b; 2014c)</td>
</tr>
<tr>
<td>Mountaineers’ concerns</td>
<td>Alaska Range (Ewert, 1991; Kedrowski, 2009)</td>
</tr>
<tr>
<td>Permeation of the pathogens into environment</td>
<td>Cascade Range (Els, 1997), Mt. Kilimanjaro (Wakibara et al., 2009), Sierra Nevada (Suk et al., 1987), Tatra Mountains (Gąsiorowski &amp; Sienkiewicz, 2013)</td>
</tr>
<tr>
<td>Health hazards</td>
<td>Alaska Range (McLaughlin, 2002), Alpine environments in Tasmania (Bridle &amp; Kirkpatrick, 2003), Andes (Car et al., 2002)</td>
</tr>
<tr>
<td>Waste disposal time</td>
<td>Alaska Range (Goodwin et al., 2012), Alpine environments in Tasmania (Bridle &amp; Kirkpatrick, 2005), Antarctica (Meyer et al., 1963; Hughes, 2003), Rocky Mountains (Temple et al., 1982), Sierra Nevada (Reeves, 1979)</td>
</tr>
<tr>
<td>Residents’ concerns</td>
<td>Arthur Range (Lachapelle, 1995), Himalaya (Glaeser, 2001; Waseem et al., 2005; Salerno, 2010; Manfredi et al., 2010)</td>
</tr>
<tr>
<td>Disposal techniques</td>
<td>Alaska Range (Robinson, 2010; Ells &amp; Monz, 2011; Goodwin et al., 2012), Alps (Weissenbacher et al., 2008), Arthur Range (Lachapelle, 1995), Australian Alps (Human Waste Management Strategy: Main Range Unit, Kosciuszko National Park, 2005), Columbia Mountains (Hill &amp; Henry, 2013), Rocky Mountains (Temple et al., 1982)</td>
</tr>
<tr>
<td>Flora impacts</td>
<td>Alpine environments in Tasmania (Bridle &amp; Kirkpatrick, 2003), Rocky Mountain (Bowman &amp; Steltzer, 1998; Bilbrough et al., 2000), Philip Smith Mountains (Bilbrough et al., 2000)</td>
</tr>
<tr>
<td>A review article</td>
<td>Disposal techniques (Cole et al., 1987; Human Waste Management Workshop, 2000; Human Waste Management Strategy, 2005; Franceys et al., 1992), Human waste (Cilimburg et al., 2000), Water pollution (Brassington, 1999; Hammitt et al., 2015)</td>
</tr>
<tr>
<td>Scholars’ concerns</td>
<td>Arthur Range (Dixon &amp; Hawes, 2015), Australian Alps (Buckley et al., 2000), Himalaya (Lama &amp; Sherpa, 1994; Miles–Watson &amp; Miles–Watson, 2013), Hindu Kush (Baloch, 2007), Hombori Mountains (Walther et al., 2008), Mt. Kenya (Lama &amp; Sattar, 2004)</td>
</tr>
</tbody>
</table>

Pathogens and their disposal time

Human faeces in very dangerous, in that it contains over 100 bacteria, protozoans and viruses that, without a specialised recycling process, pose a threat to both animals and humans (Cowgill, 1971; Carr et al., 2002). For example, the salmonella bacterium that infects many species of animals may survive in the wild for a long time (Liddle, 1997). Studies show that even buried 20 cm below ground level, it can survive up to 51 weeks (Temple et al., 1982). Common parasites include *Giardia lamblia*, *Cryptosporidium parvum* and *Entamoeba histolytica* (well described by Cilimburt et al., 2000).
**Effects of health risks**

McLaughlin (2005), in his research in 2002, showed that nearly 30% of climbers during their descent from the highest peak in North America—Denali (also known as Mt. McKinley, its former official name), had symptoms associated with acute gastroenteritis. Similar conclusions come from studies at Aconcagua (6 962 m), the highest mountain in South America. Studies by E. Carr et al. (2002) show the occurrence of many diseases in climbers directly associated with the faecal contamination of water, both at camps and along the route.

**Size of the waste**

Also, the size of human waste may be a huge problem, especially without special disposal treatment. Only one study concerning the size of the problem of faeces and urine has been done in high-altitude conditions (Apollo, 2014a; 2014b; 2014c). Based on the measured average daily amount of human excreta left by climbers in high mountains (for explanation see Apollo, 2014b; 2014c), a simple formula was developed (Eq. 1, 2) (Apollo, 2014b; 2014c):

\[
F \ [\text{kg}] = t \times P \times f \quad (1) \\
U \ [\text{L}] = t \times P \times u \quad (2)
\]

Where:
- \( F \) = faeces;
- \( U \) = urine;
- \( t \) = time of residence at the camp [days];
- \( P \) = total number of people visiting the region during the climbing season (usually a calendar year);
- \( f \) = constant (averaged) amount of faeces [kg] per day (\( f = 0.032 \) kg);
- \( u \) = constant (averaged) amount of urine [L] per day (\( u = 1.8 \) L).

Based on this data, an example calculation of quantitative values of human faeces and urine left by climbers in 2013 on Denali was conducted. The results show that the 1 151 people that climbed Denali within 18 days (the mean residence time in the massif) left behind over 660 kg of faeces and more than 37 thousand litres of urine in the massif in 2013 alone (Tab. 2). These numbers cannot be trivialized, especially when we will take into consideration all human excrement that remained after mountaineers in the last 100 years (Apollo, 2014b). Table 3 shows calculated data from the first ascent till 2013.

**Table 2** Human faeces (dry mass) and urine remaining on Denali after 1,151 climbers in 2013 (Apollo, 2014b).

<table>
<thead>
<tr>
<th>Camp</th>
<th>Toilet</th>
<th>Residence time in the camp</th>
<th>Faeces [kg]</th>
<th>Urine [L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Yes*</td>
<td>3</td>
<td>110.496</td>
<td>6,215.4</td>
</tr>
<tr>
<td>II</td>
<td>No</td>
<td>1</td>
<td>36.832</td>
<td>2,071.8</td>
</tr>
<tr>
<td>III</td>
<td>No</td>
<td>2</td>
<td>73.664</td>
<td>4,143.6</td>
</tr>
<tr>
<td>IV</td>
<td>Yes*</td>
<td>8</td>
<td>294.656</td>
<td>16,574.4</td>
</tr>
<tr>
<td>V</td>
<td>No</td>
<td>4</td>
<td>147.328</td>
<td>8,287.2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>662.976</td>
<td>37,292.4</td>
</tr>
</tbody>
</table>

* Existing toilets of the camps I and IV are included in the total, because they are drilled on ice (so-called pit toilet) and excrements are not removed from mountains environment.
Table 3 Human faeces (dry mass) and urine remaining on Denali after 39,650 climbers in a period of time 1913 – 2013 (Apollo, 2014b)

<table>
<thead>
<tr>
<th>Camp</th>
<th>Toilet</th>
<th>Residence time in the camp</th>
<th>Faeces [kg]</th>
<th>Urine [L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Yes*</td>
<td>3</td>
<td>3,806.4</td>
<td>214,110</td>
</tr>
<tr>
<td>II</td>
<td>No</td>
<td>1</td>
<td>1,268.8</td>
<td>71,370</td>
</tr>
<tr>
<td>III</td>
<td>No</td>
<td>2</td>
<td>2,537.6</td>
<td>142,740</td>
</tr>
<tr>
<td>IV</td>
<td>Yes*</td>
<td>8</td>
<td>10,150.4</td>
<td>570,960</td>
</tr>
<tr>
<td>V</td>
<td>No</td>
<td>4</td>
<td>5,075.2</td>
<td>285,480</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>22,838.4</td>
<td>1,284,660</td>
</tr>
</tbody>
</table>

* Existing toilets of the camps I and IV are included in the total, because they are drilled on ice (so-called pit toilet) and excrements are not removed from mountains environment.

The above example come from the popular Seven Summits peak–Denali–however, the number of visitors cannot by compared to the numbers of pilgrims. Please try to imagine the problem of pollution after the 980 667 pilgrims who visited the Badrinath Temple (3 133 m) in 2011 only (DoT, 2011).

4. METHODOLOGY
4.1. Study area

For this study three location has been chosen: Mt. Fuji (Japan), Yamunotri Temple (India) and Kilimanjaro (Tanzania). Below I will describe them briefly, in terms of geographical location, the main reasons of visits, and number of mountaineers.

Mt. Fuji (3 776 m)

Mt. Fuji or Mt. Fuji–san, Japan's highest peak, is considered one of the preeminent tourism destinations in the country (Fig. 2a). Mt. Fuji draws approximately 250–300 thousand people every year to its summit during the mountaineering season (Tab. 2), which runs from 1 July to 31 August (Jones & Yamamoto, 2016). A total of four mountaineering trails have been built from the Shizuoka and Yamanashi sides of the mountain. Mt. Fuji has inspired artists and poets and has been the object of pilgrimage for centuries (Jones & Yamamoto, 2016). Fuji–san is one of the three sacred mountains of Japan (the others being Mt. Tate and Mt. Haku) for followers of Shinto, which, until 1868, was forbidden for women to access. In the culture of the country of the "rising sun", this volcano is often the inspiration for many artists who put it in their works, among them, the world–famous woodcuts by Katsushika Hokusai (Thirty–six Views of Mount Fuji), by which the mountain has become a symbol of Japan.

Table 2. Number of mountaineers in the years 1980–2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Mountain region</th>
<th>Number of visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mt. Fuji¹</td>
<td>Yamunotri²</td>
</tr>
<tr>
<td>1980</td>
<td>100 000</td>
<td>62 000</td>
</tr>
<tr>
<td>1990</td>
<td>n/a</td>
<td>101 000</td>
</tr>
<tr>
<td>2000</td>
<td>n/a</td>
<td>88 672</td>
</tr>
<tr>
<td>2010</td>
<td>320 975</td>
<td>287 688</td>
</tr>
</tbody>
</table>

Source: ¹ Quinn & Woodward, 2015; ² DoT, 2011; ³ TANAPA, 2015; ⁴ data for 2012
Yamunotri Temple (3 235 m)

Yamunotri Temple is situated in the western region of the Garhwal Himalayas at an altitude of 3 235 metres near the source of the Jamuna River (Fig. 2c). Yamunotri (with Badrinath, Kedarnath and Gangotri) is a part of the important Hindu pilgrimage circuit in the Indian Himalayas (Uttarakhand), which is called the Chota Char Dham. These four sacral temples are word–famous pilgrimages, have their own religious importance and are well known for their natural and scenic beauties as well (Sati, 2014). The above comment is proven by the increasing number of pilgrims and tourists who visit Yamunotri (Tab. 2). Please note that in 2010, this was 287 688 visitors (DoT, 2011).

Figure 2. Places described in this paper as examples of human waste disposal techniques:
complete (non–invasive)–(a) Mt. Fuji; (b) bio–friendly toilet on Yoshida trail;
partial (superficial)–(c) Yamunotri Temple; (d) leaky toilet tanks on the path to the temple;
invasive–(e) Kilimanjaro; (f) wooden toilet over a drilled hole in the ground
Source: photograph by the author
**Kilimanjaro (5 895 m)**

Located in Northeast Tanzania, Mt. Kilimanjaro is the highest mountain on the African continent (Fig. 2e), which is called by geologists the 'heart of Gondwana'. Kilimanjaro is a large stratovolcano and is composed of three distinct volcanic cones: Shira (3 943 m), Mawenzi (5 150 m) and, the highest, Kibo (5 895 m). Uhuru Peak (Freedom Peak in Kiswahili) is the highest summit on Kibo's crater rim. Kilimanjaro is world’s highest freestanding mountain. It is so popular that it has become known as 'Everyman's Everest'.

Mt. Kilimanjaro is visited by approx. 50 000 hikers per year (Tab. 2). However, this number can be even several times higher, because hikers can employ between 100 000–200 000 guides and porters to support their climb. Hiring the guide and porters is obligatory for everybody—not only for unqualified hikers, but also for experienced mountaineers. From 1991, the park authorities from Kilimanjaro National Park (KINAPA) made it compulsory for all climbers to sign up with an agency.

### 4.2. The framework: three methods of human waste disposal

The solution to the problem of human excrement in popular and crowded mountain areas depends on two aspects (Apollo, 2014b): (1) a suitable waste management policy, depending on the number of tourists, existing vegetation, altitude, climate, etc.; (2) the respecting and observance of this policy by the tourists themselves. The second aspect completely depends on the first one—a tourist can only follow the rules or not.

Apollo (2014b) showed that proper management techniques can address the issue in three ways:

- **complete (non–invasive)**—the use of sealed toilet containers, 100% waste disposal and recycling, no interference with the natural environment and the quality of the visual landscape;
- **partial (superficial)**—hiding the problem, leaky toilet tanks and a lack of recycling, maintaining only the apparent cleanliness of the landscape;
- **invasive**—leaving the tourist on his own, without any environmental solutions, ignoring the problem or lack of financial resources.

### 4.3. Methods

According to the above, the management can address the issue in three ways: complete (non–invasive), partial (superficial), and invasive. Those three approaches have been elaborately explained in three case studies: Fuji–san (Japan), Yamunotri (India) and Kilimanjaro (Tanzania), respectively. Each of the places have been described based on the provided human waste disposal solutions, starting from the historical perspective and ending with the plans for future implementations, i.e. how it was, how it is, and how it will be. The author's intention was also to show evolution in the approaches, and point out the errors of the current policy.

This paper is the result of a study on literature and a long–term follow–up in dozens of mountain ranges around the world concerning the disposal of human excrement, but most of all, it concerns own studies.

### 5. CASE STUDIES: PAST, PRESENT AND FUTURE IN THE MOUNTAINEERS EXCRETA' DISPOSAL TECHNIQUES

#### 5.1. Complete (non–invasive) treatment—Mt. Fuji example

Even in rich Japan, until 2006, most of the toilets in common use in National Parks (included Mt. Fuji NP) were still pit toilets with no bottoms in their tanks. What is more, some of these toilets have caused the surrounding water to become contaminated with bacteria. This
management was insufficient for maintaining a desirable level of sanitation, especially with the increase in visitors. Before the government intervened with a Mt. Fuji clean–up campaign, raw sewage from the mountain's few toilets ran downslope into open channels.

Today, there is a privatised hut system, modern bio–toilets, government regulation and an extensive education campaign that leveraged Japan's 'shame culture' (Rassler, 2014). The issue of human waste management has been dealt with mainly through technical approaches, such as constructing bio–toilets, or biological processing toilets (Fig. 2b), and by using helicopters to carry down storage tanks (Norihisa & Suzuki, 2006). However, helicopter removal of waste is an effective but expensive and hazardous operation, especially in difficult mountain landscape.

Japan, as a world leader of modern technology, introduces more new technologies in all aspects of life, as well as in the case waste disposal. As an example, it is worth mentioning the Seiwa Denko bio–toilet. Over a period of forty–five days, this Bio–Lux device successfully processed sewage from 8 000 people, without using a single drop of water. Bio–Lux does not require specialised sawdust or bacteria, either: the unit uses conventional sawdust. The enteric bacteria found in excrement–along with the natural microbes found in sawdust–do the work of breaking down sewage and toilet paper. Excrement and kitchen waste are largely made up of water, and sawdust can absorb that moisture, which is then heated and agitated to evaporate it. The heat applied kills the bacteria found in human waste. After treating the liquid or solid waste, nitrogen, phosphoric acid and other inorganic substances remain in the sawdust, which creates an ideal fertiliser. The sawdust must be replaced a few times a year but does not need to be periodically scooped out. The result is hygienic and odourless, as well (Ushijima, 2015).

Bio–toilets are the future–especially when the 'human waste' disposal process has to be done at the difficulty of accessing the spot, e.g. mountain slopes covered with forests. The staff at Mount Rainier National Park learned about the effectiveness of using composting toilets from Mount Fuji, and they have begun installing them at Mount Rainier, using the Japanese technology to reduce waste (Taylor, 2010).

It is worth mentioning that other kinds of technology have also been used for human waste disposal, like solar dehydrating toilets in Longs Peak (Rocky Mountain National Park, USA), which have been in successful operation since 1983. Liquids are diverted to a tray evaporator, and the dried solids are packed out weekly by llamas (Arnold, 2010).

Using eco–friendly toilets on Mt. Fuji is possible after payment, typically US$1–2 per use, and thanks to the adequate distance between them, proper disposal of human waste depends solely on the mountaineers. However, even if Mt. Fuji has toilets almost everywhere, yet signs of urination outdoors can be easily found. Some of these urinations may be attributed to a lack of coins to open automatic toilet doors. Thus, better education is needed or some upgrading at the existing procedures is necessary.

5.2. Partial (superficial) treatment–Yamunotri example

Currently, on the main 6–kilometre path from Janki Chatti to Yamunotri Temple, there are a lot of so–called bio–toilets. However, most of these only appear to be eco–friendly, as upon closer inspection, most of them are leaking. Overfill bottom tanks have a special hole, which allows the outflow of human waste (Fig. 2d). In this way, pilgrims pollute the sacred river of Yamuna through their own excrement. At the same time, though, they pray to the river, which is worshipped as a Hindu goddess called Yamuna (Kapoor, 2002). In the Vedas, Yamuna is known as Yami, while in other literature, she is called Kalindi.

Fortunately, in recent years, the Uttarakhand government has come up with an idea of deploying bio–digester toilets on the way to the four Dhams. The toilets have been developed by the Defence Research & Development Organisation (DRDO), and around 100 of these would be placed on the high–altitude paths leading to Kedarnath, Badrinath, Gangotri and Yamunotri (Kumar, 2015). This is good news, especially as this type of toilet has already been successfully tested in the
western part of the Himalayas. The first bio–toilet was set up in Ladakh in 1994. Since then, 159 more have been constructed in high–altitude regions like Ladakh and Siachen.

The bio–friendly toilet developed by DRDO is ‘quite’ simple: human excrement goes into the special tank below the toilet, and then bacteria feed on the faeces. However, no bacteria function in cold, high–mountain conditions. This is why the DRDO company decided to send scientists to Antarctica under India’s 13th Antarctic Mission in 1994 to look for microorganisms that can break down excreta. The bacteria (i.e. Clostridium and Methanosarcina) that they found can live in the cold, as well as in a hot climate, and they feed on waste to survive. When human excreta comes into contact with the bacteria, it gets converted into methane and water through a series of steps of anaerobic digestion–hydrolysis, acidogenesis, acetogenesis and methanogenesis (Paliwal, 2012).

This is a huge step for human waste disposal, not only for the mountain areas, but also for the lowlands. This could help countries like India, for example. India is home to 60 per cent of the world’s population that defecates in the open (for more information, see WHO and UNICEF, 2014). Indeed, according to the Census of India (Census of India, 2011) with 67% of rural households and 13% of urban households defecating in the open. This has serious health implications and is consequently a huge economic burden (John et al., 2011). Open defecation causes numerous water–borne diseases, like diarrhoea. In India alone, about 0.4 million children die annually precisely because of diarrhea (Kumar & Vollmer, 2013).

5.3. Invasive treatment–Kilimanjaro example

Kilimanjaro, like the other Seven Summit peaks, has a serious ecological problem with human waste, although many toilets can be found on the most popular routes (located mostly close to the campgrounds). Unfortunately, most of them are usually overfilled, with not only faeces. The porters throw leftover food into them, and tourists, among other items, throw newspapers, personal hygiene products, plastic bottles and even used clothing (Kaseva, 2009). What is even more dangerous is the lack of tightness of the tank. Most of the toilets on the way to Kilimanjaro are wooden constructions lying over previously drilled or dug holes (Fig. 2f). Unfortunately, they are not equipped with a sealed container, so everything what has been deposited in them penetrates the connecting groundwater. When full, a pit toilet is covered, and the shelter is moved to a different location. Between the camps, guides and park authorities are recommending people to bury faeces in the ground. However, what if each of the more than 50 thousand climbers of Kilimanjaro do the same? According to M. Apollo’s (2014a) calculation in 2007, more than 9 tonnes of faeces and more than 0.5 million litres of urine remain on Kilimanjaro after the hikers. These values are hard to imagine. But the summary from 1990 to 2007 is even more unimaginable: 107.5 tonnes of faeces and 6 million litres of urine. This value cannot be without environmental damage when absorbed by nature (Apollo 2014c).

The park’s management has been taking very serious measures to ensure that toilet facilities are improved all over the mountain. In doing this, the park is currently on the path to demolishing all temporary toilets and replacing them with large, modern ones. A total of 59 modern toilets have been built in different mountain stations at present (KINAPA). KINAPA will also issue a policy that requires Kilimanjaro tour operators to enforce the use a portable toilet or a WAG bag by their clients and porters. Lack of enforcement means the loss of their permit to have clients on Kilimanjaro.

6. CONCLUSION

This study focuses only on a small fragment of the environmental impact that mountaineering has, namely on the often overlooked problems caused by products of defecation and micturition. Blaming only tourists or climbers for such invasiveness would be erroneous, because they simply cannot fully control their excretion processes and are not provided with proper local
solutions (Apollo, 2014b). However, it should be noted that there are researchers who believe that the problem of human faeces should be reflected in the rules of sustainable tourism. Thus, there should be a similar rule for excrement as there is for common rubbish: Pack It In–Pack It Out. All collected waste during a trip would then be transported to a disposal point by the tourists themselves (Meyer, 1994). However, these views are secluded, mainly due to technical problems with transportation and which is practically impossible in areas below an isotherm of 0°C (Apollo, 2014b). However, decent changes have appeared in recent years—management bodies care more about human waste disposal, as this study shows. The authorities of mountain regions are gradually exchanging the old, leaking toilets for brand–new eco–friendly ones. Even if this process is slow—mostly because of economical limitations—management bodies appear to be noticing this threat.

7. RECOMMENDATIONS

It is extremely difficult, if not fully impossible, to make general recommendations that apply to all mountain ecosystems; one and only one solution to deal with human waste. Managers and authorities are always trying to find the best solution that will match perfectly to the individual environmental characteristics.

However, simple recommendation for each ‘player’ can be made:

- Managers should calculate how much excrement remains after tourists in unbelievably fragile high–mountain environments. Thus, they can realise the scale of this problem, which cannot be underestimated. When dealing with human waste, the following strategies are recommended Cole et al. (1987): (I) Reducing use (prohibiting or limiting the numbers of visitors); (II) Modifying the location of use (locate facilities on durable sites); (III) Modify the type of use and visitor behaviour (education); (IV) Increase the resistance of the resource (provide sanitation infrastructure); (V) Maintain or rehabilitate the resource (remove waste from toilets); and (added by Apollo, 2014b) (VI) Punish for breaching of the rules (introduce high fines).

- Tourists should change their irresponsible behaviour, because even the best solutions in the case of human waste disposal in high–mountain conditions will fail if they do not follow the rules. We as tourists also have to assume some inconvenience related to the protection of high–mountain environments against human waste pollution. In summary, in areas where toilets are not available, we have to use special cans for self–removing our own human waste from high–mountain environments. We have to get used to the perception of our own excrement as rubbish, and we do not throw garbage away at every turn. Pilgrims should care about the environment in accordance with the will of the creator (Taylor, 2007; Watling, 2009). Spiritual leaders should remind to the faithful that protecting the environment is their obligation, and not a free will.

AREAS OF FUTURE RESEARCH

The present paper is based on author’s findings about different practices of tourist waste disposal/management in high–mountain environment and shows them in the historical perspective. However, it is cover 3 case studies only. Thus more detailed studies are necessary. For example, evaluation should cover more areas. Because, without proper perspective it is impossible to determine whether the problem is global or not. This paper is focusing at disposal of human waste in high–mountain environment, however it would be interesting to see how disposal looks like separately in case of faeces and urine.

ACKNOWLEDGEMENT

This research was financially supported by the Pedagogical University of Cracow. I would like to thank to Professor Viacheslav Andreychouk and to anonymous Referees for their valuable suggestions and comments. I am also thankful to Editor Dr Petre Bretcan, however, if any mistake is left is my own.
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