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IMPROVEMENT OF THE VENTILATION SYSTEM IN MOBILE TOILETS

The purpose of the study is to improve the ventilation system of dry composting eco-toilets according to the analysis of the problems of waste generated within tourist destinations, including the human waste. To achieve the goal and to solve the identified tasks a range of research methods has been used in the study: *praximetric method* (analysis of research experience); summarizing of the information of printed sources on the problems of waste management within tourist destinations; comparative analysis has been used for identification of quantitative indicators and dynamics of tourist flows and generated waste.

The problem of waste in tourist destinations was analyzed due to the increased tourist flows. The problem of the tourists' access to the effective toilets system was updated. The problem of human waste within tourist destinations was studied; the methods of this type of waste management were offered. The necessity of solving the problem of effective ventilation in dry toilets was proved. The device for intensification of ventilation in dry eco-toilets was developed. The problem of human waste within tourist destinations was identified as one of the significant environmental aspects of tourist activity. The device for intensification of ventilation in dry eco-toilets was developed for the first time. The exhaust ventilation system for dry composting eco-toilets which is based on the use of the developed device of fresh air boost allows intensifying of ventilation with the help of wind, improves hygiene and aesthetic parameters of dry eco-toilets.

Key words: tourist destinations, municipal waste, human waste, eco-toilet, ventilation.

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УДОСКОНАЛЕННЯ СИСТЕМИ ВЕНТИЛЯЦІЇ В МОБІЛЬНИХ САНВУЗЛАХ

Метою дослідження було удосконалити систему вентиляції в сухих компостуючих екотуалетах на основі аналізу проблем відходів, що утворюються в межах територій туристичних destinations, в тому числі і відходів людської життєдіяльності. Для досягнення мети і вирішення поставлених у дослідженні завдань застосовано такий комплекс методів дослідження: праксиметричний (аналіз наукового досвіду) та узагальнення матеріалів друкованих джерел з проблеми поводження з відходами в межах туристичних destinations; порівняльний аналіз – для виявлення кількісних показників та динаміки кількості туристів та утворення відходів.

Проаналізовано проблему відходів туристичних destinations в зв'язку зі зростанням туристичних потоків. Актуалізовано проблему доступу туристів до ефективної системи санвузлів в їх межах. Досліджено проблему відходів людської життєдіяльності у межах туристичних destinations, запропоновано методи поводження з таким видом відходів. Обґрунтовано необхідність вирішення проблеми ефективної вентиляції в сухих туалетах. Розроблено пристрій для інтенсифікації вентиляції у сухих екотуалетах. Ідентифіковано проблему відходів людської життєдіяльності туристичних destinations як один із суттєвих екологічних аспектів туристичної діяльності. Розроблено вперше пристрій для інтенсифікації вентиляції у сухих екотуалетах. Витяжна система вентиляції для сухого компостуючого екотуалету, яка базується на використанні розробленого пристрою для наддуву свіжого повітря, дозволяє інтенсифікувати витяжку за допомогою вітру, покращує санітарно-гігієнічні та естетичні показники сухих екотуалетів.

Ключові слова: туристична destination, побутові відходи, відходи людської життєдіяльності, екотуалет, вентиляція.

Problem statement. The rise of mountainous tourist destinations visited by tourists and excursionists made the problem of waste management relevant. Organized bathrooms usually destroy the tourist site attractiveness and create threats to the environment. It is known that communities which have no access to water supply and sewerage networks have a major problem of human waste management, because it is estimated that one person produces in average 500 liters of urine and 50 kg of feces in a year [1].

In such cases people often use pit latrines, but they are the source of infection, not very aesthetic and unpleasant for use, have an unpleasant smell, and attract flies. In addition, environmentalists prohibit draining of untreated waste water into the soil, as it pollutes the environment, particularly soil water with pathogens (bacteria, viruses, pathogens of protozoal and parasitic infections), various forms of nitrogen, phosphorus, detergents (persistent components of cleaning products) and other chemicals which are harmful to human health and the environment [2].

The use of flush toilet is also not advisable and economically inefficient, because flush of human waste needs about 12 000 liters of water per year [1]. Thus, a large volume of water gets significantly contaminated with pathogens contained in a relatively small amount of human waste. In addition, the nutrients are lost in the process of the discharge. Furthermore, expensive drainage and wastewater systems are required for the collection and purification of polluted wastewater. Therefore, the development of simple, modern, convenient and economically efficient methods of this type of waste management such as dry composting eco-toilets, are relevant, especially within the rural tourist destinations where the number of tourists in season peaks may greatly exceed the number of locals during the peak tourist seasons.

Analysis of recent research and publications. The problem of waste within tourist destinations and the environmental aspects of the tourism industry as a whole are not studied much and almost not solved. Ukrainian scientific publications deal with the justification of sustainable tourism development strategy, outlining the main environmental impacts of tourism [3-7]. Developed mechanisms for environmental sustainable tourism implementing showed that the problem of waste is a priority [8, 9, 10]. The growth of tourism activity directly influences the amount of waste and thus the waste management problem gets more relevant. Such Ukrainian scientists as Hetman V.I., Verkhovtsev F. and others have studied the problem of human waste. The organization YAMEHO "MAMA-86-Yaremche" has many developments in this area. However, many practical aspects of environmentally friendly life management faced by the tourism organizers are not studied by the scientists and experts in tourism and the environment.

Unsolved aspects of the problem. Traditionally, tourism industry is considered environmentally friendly economic sector that may be an ecological alternative to industrial development. Recent statistical data shows that unlike other industries the tourism one despite general economic crisis continues to grow and therefore has great prospects. However, the growth of tourist flows, development and building of tourist infrastructure objects pose threats to the environment. These problems in Ukrainian scientific literature are partly studied in the context of the sustainable tourism management system development. In general, tourist infrastructure facilities are not considered as ones causing environmental impact. However, the current structure of life support systems, sanitary cleaning of tourist destinations settlements is imperfect and requires scientific bases including environmental aspects of their development. Thus, the problem of ineffective ventilation in dry eco-toilets set at tourist sites and distant from water supply and wastewater systems remains unsolved.

Objectives of the article. The purpose of the study is to analyze the waste generated within the territory of tourist destinations and to improve the ventilation system in dry composting eco-toilets on the basis of the human waste problems analysis.

Presentation of the main research and explanation of scientific results. One of the environmental problems is the lack of waste calculation within tourist destinations. In fact, only municipal solid wastes which are specific to such areas are calculated. Considering the fact, that according to the WTO every tourist in Europe generates at least 1 kg of solid waste per day, the dynamics of tourist flows in Ivano-Frankivsk region in the Ukrainian Carpathians shows that the amount of municipal waste is growing within tourist destinations too (Fig. 1) [11].

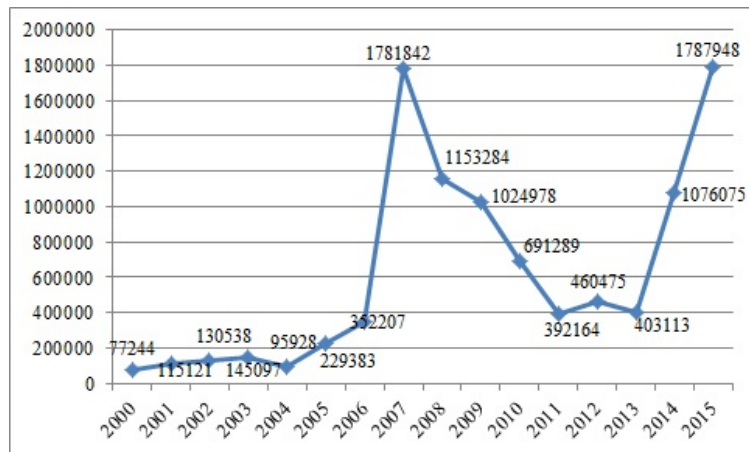


Fig. 1. Tourist flows in Ivano-Frankivsk region

Life support systems of tourist complexes require substantial amounts of energy and water resources. For example, 890 thousand people attended Yaremche city council in 2013, and in 2014, 934 thousand people. Provision of the territory by natural recreational resources at 1 km² per resident is respectively, 1,4 and 1,8 times higher than the average one in Ukraine [12]. This region is a multi-area for summer and winter tourism, mass cognitive and health recreation, and spa treatment.

Tourist sector creates additional stress on water resources in the region. Natural features of Yaremche and its surroundings are such that tourism industry can function almost year-round. There are 47 hotels (2,292 seats), 48 recreational facilities (2,472 seats), and 552 rural estates in Yaremche City Council. However, there is no information on the availability of permits for special water use, the amount of waste water discharges and treatment methods, as well as information on the reporting form 2TP-Vodohosp in local governments.

Table 1 shows the availability level of water supply and sewage services within tourist destinations of Ivano-Frankivsk and Chernivtsi regions according to the national report on the quality of drinking water [13].

Table 1

Availability of water supply and sewage services within tourist destinations of Ivano-Frankivsk and Chernivtsi regions

	Ivano-Frankivsk region			Chernivtsi region		
	Coverage level, %	Average water supply, l/day	Average sewage, l/day	Coverage level, %	Average water supply, l/day	Average sewage, l/day
In the region	4	38.7	101.8	6.2	150	120
Cities	100	89.8	101.2	81,8	180	170
Settlements	45.8	89.8	-	87,5	135	130
Villages	0.8	0.7	-	2.5	16.9	60

In the future we should expect an increase in water consumption in municipal needs because of the construction of local water pipes connected to the water supply and sewage systems of the cities for nearby villages [14].

The analysis of existing loads [15] and impacts allowed to select one of the key environmental issues (risks) for tourist destinations in the Carpathian region, which is the water pollution (especially in low-flow periods) from the point (discharges of untreated or insufficiently treated industrial and municipal waste) and diffuse sources (unsettled landfills, agricultural lands, animal waste, individual septic tanks and pit latrines, overbuilt coastal protection strips, etc.), which leads to the deterioration in the quality of drinking water.

Since tourist sites that are far from life support systems also need infrastructure improvement, including toilets, it is appropriate in such cases to use dry toilets within the rural tourist destinations. Dry toilet is the common name for various types of toilets with minimal or no use of water. They enhance the standard of living and do not pollute the environment (soil, groundwater). Thus, the owners of camping sites, rural estates, farms or rural tourist restaurants with no centralized sewage systems can get a significant benefit from the use of such toilets.

Dry toilets with separate urine collection (SUC) do not pollute and waste water; potentially dangerous human waste is separated, disinfected and reused. Human waste is considered as a resource here. After processing of the urine and feces these rich in nutrients products can be reused in agriculture. Well-built and equipped dry composting toilets with SUC almost do not attract flies.

Central water supply and sewage systems are not necessary for the proper functioning of these types of toilets. The design of the toilet makes it easily adaptable to different types of communities and they can be made of cheap local materials.

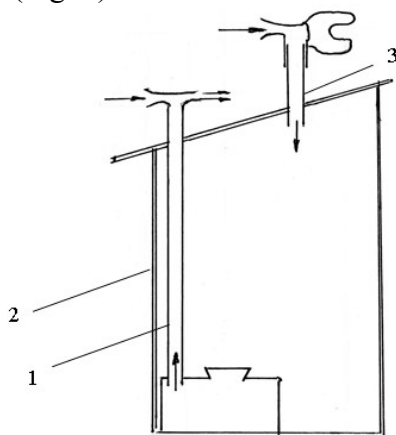
Depending on the means, wishes and habits of the user, there are many different types of dry toilets with separate urine collection:

- Toilets “squatting” made of fiberglass;
- Toilets “squatting” made of bricks, which can be made manually;
- Seat toilets equipped with separating part consisting of two different parts, each made manually;
- Seat toilets made of concrete, which can be made in place if there is a special form;
- Seat toilets made of fiberglass;
- Seat toilets made of porcelain. [1]

The condition of toilets, especially in public places, shows the social, economic, and cultural level of the community; that is why this aspect is important in planning of recreational areas organization. This is especially important for toilets within tourist destinations, as each element of tourist infrastructure forms the customer impression of the area and quality of tourist services. Effective ventilation is especially important for dry toilets. The air should always leave the toilet room and go out to the street.

To increase the intensity of ventilation in such eco-toilets we have developed a device [16] which consists of the entrance pipe, which goes into the top of the toilet, and the turning system on the top, which automatically turns according to the direction of the wind. This device of fresh air boost allows to boost pressure in the eco-toilet and to intensify ventilation with the help of wind.

The device of exhaust ventilation for dry composting eco-toilets works in the following way: ejector extract system lowers pressure in the toilet and because of the difference between the pressure in the toilet bowl and the pressure in the cabin partial extract happens. To strengthen the intensity of the exhaust system we have added the device that is installed on the top of eco-toilet in the form of a pipe, outside part of which over the eco-toilet has a rotating device that automatically turns an input nozzle against the wind, which will provide the additional pressure in the eco-toilet and therefore the boost of fresh air (Fig. 2)



1 – ejector extract system; 2 – eco-toilet cabin; 3 – fresh air boost system

Fig. 2. The work principle of exhaust ventilation system of dry composting eco-toilet [16]

This device can be used for improvement of dry composting toilets in the villages Mykulychyn and Vorokhta in Yaremche City Council in Ivano-Frankivsk region. Currently there are 15 of them. These dry toilets were ordered and built by YAMEHO “МАМА-86-Yaremche”, which was implementing a number of environmental projects, including “Safe Sanitation, Health and Dignity” realized in partnership with WECF with the support of FE (France).

Research conclusions and recommendations for further research in this area. Problems of accumulation and management of solid waste within tourist destinations are among the major unstudied and unsolved environmental problems in tourism and recreation in Ukraine, especially in mountainous Ivano-Frankivsk region, which is particularly vulnerable to human impacts. Tourist objects that are distant from the central life support systems require efficient and environmentally friendly sanitation infrastructure elements. The use of dry toilets is appropriate within tourist destinations, but ineffective ventilation creates problems for their use. Designed exhaust ventilation system for dry composting eco-toilet which is based on the use of the developed device of fresh air boost allows intensifying of ventilation using wind energy.

Список літератури:

1. Сухий екотуалет для роздільного збору сечі [Електронний ресурс]. – Режим доступу: www.mama-86.org.ua/archive/files/Urine_Diverting_Toilet_Ukr_Web.pdf
2. Як вирішити проблему стічних вод для окремого домогосподарства у неканалізованій місцевості [Електронний ресурс] – Режим доступу: <http://www.ecotoilet.com.ua/UserFiles/Images/Content/content/instructions.pdf>
3. Воробйова О.А. Екологічна безпека як складова сталого розвитку рекреаційно-туристичних територій / О.А. Воробйова // Сталій розвиток та екологічна безпека суспільства в економічних трансформаціях: матеріали Третьої Всеукр. наук.-практ. конф. (Бахчисарай, 15-16 вер. 2011 р.). – Сімферополь: Фенікс, 2011. – с. 46-48.
4. Голод А.П. Екологічна безпека туризму в регіоні: суть та шляхи забезпечення / А.П. Голод, З.П. Новосад // Науковий вісник НЛТУ України: [зб. наук.-техн. праць]. – Львів: РВВ НЛТУ України, 2012. – Вип. 22.3. – с. 84-88.
5. Караван Ю.В. Екологічні аспекти сталого розвитку туризму / Ю.В. Караван // Збірник матеріалів міжнародної науково-практичної конференції «Стратегія розвитку туризму у 21 ст. у контексті вирішення глобальних проблем сучасності (Львів 28.05.2014 р.). – Львів: ЛІЕТ, 2014. – с. 265-271.
6. Кучинська І.В. Туризм в умовах глобальної екологічної кризи: сучасні виклики і перспективи розвитку: / І.В. Кучинська // Збірник матеріалів міжнародної науково-практичної конференції «Стратегія розвитку туризму у 21 ст. у контексті вирішення глобальних проблем сучасності (Львів 28.5.2014 р.). – Львів: ЛІЕТ, 2014. – с. 291-301.
7. Коробейникова Я.С. Екологічні проблеми територій туристичних дестинацій [Текст] / Я.С. Коробейникова // Екологічна безпека та збалансоване ресурсокористування. Науково-технічний журнал. – Івано-Франківськ, 2013 – Вип. №1(7). – с. 91-94.
8. Коробейникова Я.С. Проблеми водопостачання та водовідведення в гірських туристичних дестинаціях / Я.С. Коробейникова // Матеріали I Міжнародної науково-практичної конференції «Водопостачання та водовідведення: проектування, будова, експлуатація, моніторинг». – Львів : ЗУКЦ, 2015. – 156 с.
9. Korobeinykova, Ia. and Murava, Iu. (2015), “Regulatory mechanisms for ensuring ecological safety of tourist destination territories”, *Naukovyi visnyk KRNU*, no. 19, pp. 17-21.
10. Murava, Iu. and Korobeinykova, Ia. (2016), “The analysis of the waste problem in tourist destinations on the example of Carpathian region in Ukraine”, *Journal of Ecological Engineering*, no. 17 (2), pp. 43-51.
11. Туристичні потоки у Івано-Франківську область [Електронний ресурс]. – Режим доступу: www.ifstat.gov.ua

12. Mandryk, O.M., Arkhypova, L.M., Pobigun, O.V. and Maniuk, O.R. (2016), "Renewable energy sources for sustainable tourism in the Carpathian region", *International Conference on Innovative Ideas in Science (IIS2015)*, 12-13 November 2015, Baia Mare, Romania. Volume 144.

13. Національна доповідь про стан навколишнього природного середовища в Україні у 2012 році [Електронний ресурс]. – Режим доступу: <http://www.menr.gov.ua/dopovidi>

14. Архипова Л.М., Пернеровська С.В. Прогноз гідрологічних параметрів методом сингулярного спектрального аналізу// Науковий вісник Національного гірничого університету: науково-технічний журнал. №2 (146) – Дніпропетровськ: ДВНЗ «Національний гірничий університет», 2015. – С. 45-50.

15. План управління пілотним річковим басейном Прута (проект) [Електронний ресурс] // ВЕГО «МАМА-86» – Режим доступу: <http://blacksea-riverbasins.net/sites/default/files/>

16. Пат. 108256 Україна, МПК F24F 7/00. Пристрій примусової витяжної вентиляції для сухого компостуючого екотуалету / Ю.І. Мурава, М.В. Корчемлюк, Л.М. Архипова, Я.С. Коробейникова; власник ІФНТУНГ. - №2016 00354; заявл. 16.01.2016; опублік. 11.07.2016, Бюл. №13. – 4 с.

References:

1. Dry eco-toilet for separate collection of urine, available at: www.mama-86.org.ua/archive/files/Urine_Diverting_Toilet_Ukr_Web.pdf (accessed September 12, 2016) (in Ukr.)

2. How to solve the waste water problem for individual household within the territory which is not connected to the sewage system, available at: <http://www.ecotoilet.com.ua/UserFiles/Images/Content/content/instructions.pdf> (accessed September 12, 2016) (in Ukr.)

3. Vorobiova, O.A. (2011), "Ecological safety as a part of sustainable development of tourist and recreation areas", *Stalyi rozvytok ta ekologichna bezpeka suspilstva v ekonomichnykh transformaciakh: materialy tretioii Vseukrainskoi naukovo-praktychnoi konferencii*, Bakhchysarai, September 15-16, 2011, pp. 46-48 (in Ukr.)

4. Holod, A.P. and Novosad, Z.P. (2012), "Ecological safety of tourism in the region: nature and ways of implementation", *Naukovyi Visnyk NLTU Ukrainy*, no. 22, pp. 84-88 (in Ukr.)

5. Karavan, Iu.V. (2014), "Ecological aspects of sustainable tourism development", *Zbirnyk materialiv prats mizhnarodnoi naukovo-praktychnoi konferentsii "Strategiia rozvytku turyzmu u 21 st. u konteksti vyrishennia globalnykh problem suchasnosti"*, May 28, 2014, Lviv, LIET, pp. 265-271 (in Ukr.)

6. Kuchynska, I.V. (2014), "Tourism in the global ecological crisis: challenges and perspectives of development", *Zbirnyk materialiv prats mizhnarodnoi naukovo-praktychnoi konferentsii "Strategiia rozvytku turyzmu u 21 st. u konteksti vyrishennia globalnykh problem suchasnosti"*, May 28, 2014, Lviv, LIET, pp. 291-301 (in Ukr.)

7. Korobeinykova, Ya.S. (2013), "Ecological problems of tourist destination areas", *Ekologichna bezpeka ta zbalansovane resursokorystuvannia*, no. 1(7), pp. 91-94 (in Ukr.)

8. Korobeinykova, Ya.S. (2015), "The problems of water supply and sewerage in mountainous tourist destination", *Materialy I mizhnarodnoi naukovo-praktychnoi konferentsii "Vodopostachannia ta vodovidvedennia: proektuvannia, budova, ekspluataziia, monitoring"*, Lviv, ZUKZ, p. 156 (in Ukr.)

9. Korobeinykova, Ia. and Murava, Iu. (2015), "Regulatory mechanisms for ensuring ecological safety of tourist destination territories", *Naukovyi visnyk KRNU*, no. 19, pp. 17-21 (in Eng.)

10. Murava, Iu. and Korobeinykova, Ia. (2016), "The analysis of the waste problem in tourist destinations on the example of Carpathian region in Ukraine", *Journal of Ecological Engineering*, no. 17 (2), pp. 43-51 (in Eng.)

11. Tourist flows in Ivano-Frankivsk region, available at: www.ifstat.gov.ua (accessed August 20, 2016) (in Ukr.)

12. Mandryk, O.M., Arkhypova, L.M., Pobigun, O.V. and Maniuk, O.R. (2016), “Renewable energy sources for sustainable tourism in the Carpathian region”, *International Conference on Innovative Ideas in Science (IIS2015)*, 12-13 November 2015, Baia Mare, Romania. Volume 144 (in Eng.)
13. National report on the state of environment in Ukraine in 2012, available at: <http://www.menr.gov.ua/dopovidi> (accessed September 16, 2016) (in Ukr.)
14. Arkhypova, L.M., and Pernerovska, S.V. (2015), “Forecast of hydrological parameters by singular spectrum analysis method”, *Naukovyi visnyk NGU*, no. 2(146), pp. 45-50 (in Eng.)
15. Management plan for pilot river basin of Prut, available at: <http://blacksea-riverbasins.net/sites/default/files/> (accessed September 16, 2016) (in Ukr.)
16. Murava, Iu.I., Korchemliuk, M.V., Arkhypova, L.M., and Korobeinykova, Ya.S. Exhaust ventilation system for dry composting eco-toilet. Patent Ukraine, UA 108256, 2016. (in Ukr.)

