DIFFUSION OF INNOVATION – IMPLEMENTATION OF CONSTRUCTED WETLANDS IN THE KATHMANDU VALLEY, NEPAL

Z. BOUKALOVÁ[1,2], J. TĚŠITEL[2,4] & B. D. GURUNG[3]
[1]VODNÍ ZDROJE, a. s.; Czech Republic.
[2]METCENAS o. p. s.; Czech Republic.
[3]University of Life Sciences, Faculty of Tropical and Subtropical Agriculture, Czech Republic.
[4]AMBIS, Czech Republic.

ABSTRACT
Constructed wetlands (CW) can be considered an efficient municipal wastewater treatment technology, suitable to be used on a local level in both rural and urban environments. This technology is popular and normally used in Europe having the attributes of a success story – cheap in investment and simple in operation. Nevertheless, the transfer of this technology to developing countries is a challenge of some kind, the main reason being a different technological and cultural context there. The paper discusses the implementation process of CWs in the Kathmandu Valley, Nepal, the East. The concept of diffusion of innovation is used as the guideline, namely two of its perspectives – motivation of end-users to implement the technology, and the way the information about the technology is spread. Empirical data were obtained by use of semi-standardized interviews with the three types of stakeholders involved, the end-users themselves, local authorities, and pertinent NGOs. On this basis, three main reasons (motivations) to implement CWs for municipal sewage water treatment were found, which can appear in a combination – environmental-religious, pragmatical and prestigious. In parallel, three communication channels were identified which can be metaphorically named professional enlightenment, peer influence (or exempla trahunt) and direct external aid.
Keywords: communities, constructed wetlands, diffusion of innovation, land management, Nepal, pollution control, water management.

1 INTRODUCTION

In Nepal, as in other Southeast Asian countries, the urban areas are spontaneously expanding. Regional and urban planning is obviously not enough to keep up, including the design of infrastructure for wastewater management [1].

As to the Kathmandu Valley, the major sources of wastewater are domestic, industrial, commercial, agricultural and storm waters [2]. The High-Powered Committee for Integrated Development of Bagmati Civilization (HPCIDBC) was established in 2009 to work with the objective of keeping the Bagmati River and its tributaries clean by preventing, or at least minimizing, the direct discharge of solid and liquid wastes into the river and conserving the river system within the Valley. The Committee planned to construct a trunk sewer pipeline along either bank of the river, secondary sewer pipelines and wastewater treatment plant (WWTP), along with the river training works [2]. Subsequently, five centralized municipal WWTPs were constructed within the Kathmandu Valley [3].

However, considering the volume of wastewater production, the volume of treatment is not satisfactory [4]. In 2013, a comprehensive solution to the situation was proposed: The Kathmandu Valley Wastewater Management Project (KVWMP) of the government of Nepal, which, however, was still not completed in 2019 (in December 2019, testing of its part, the newly reconstructed Guheshwori WWTP, was launched) and during the COVID pandemic stagnated. This project was aimed at improving wastewater services in Kathmandu

ISSN: 2398-2640 (paper format), ISSN: 2398-2659 (online), http://www.witpress.com/journals
DOI: 10.2495/EI-V5-N4-331-341

Valley through extensive investment in rehabilitating and expanding the sewerage networks, modernizing, and constructing WWTPs, and supporting operational and financial improvements and capacity building. The work included the rehabilitation and construction of new WWTP at Kodku (Patan), Sallaghari (Bhaktapur), Dhobighat (Kathmandu) and Guheshwori (Kathmandu). All WWTPs designed under this project were supposed to be rehabilitated or constructed on the land area owned by the government. This should have ensured their proper operation, continuous specialist supervision as well as sufficient electric power supply [5].

Nevertheless, the centralized wastewater treatment systems appeared to be questionable, mainly due to the high cost of operation, discontinuous power supply, lack of proper maintenance and lack of proper technical workforce to address the problem [3]. Instead of the centralized municipal wastewater treatment systems, decentralized systems (DEWATs) that imitate the purification function of natural wetlands, started to be promoted in Kathmandu at varied levels, including households, institutions and communities [2]. The systems are designed to treat the greywater from the household through a well-designed and aesthetically pleasing wetland, pond and water fountain systems. The treated water is reused for gardening, agriculture, or domestic use. The efficiency of the system is measured from 80% to 98% removal of both biological oxygen demand and chemical oxygen demand [6]. In addition to its efficiency in removing pollutants, this technology is cheap in investment and simple in operation. As such it can be considered appropriate for application in Nepal, as these attributes seem to help in overcoming obvious obstacles new high-tech technologies face when implemented in situations that do not meet the European standard.

The pilot-scale constructed wetland (CW) technology was implemented in Nepal in 1997, by the Environment and Public Health Organization (ENPHO), in collaboration with the Institute for Water Provision, University of Agricultural Sciences, Vienna, Austria. Local government units, UN-Habitat, ENPHO and users' community groups supported the use of CW technology [1].

The CW technology is popular and normally used in Europe. Although it has the attributes of a success story – cheap in investment and simple in operation – its transfer to developing countries is a challenge of some kind, the main reason being a different cultural context there. It can be documented, among others, by experiences the ENPHO obtained when evaluating the first decade since the technology had been introduced into the country. They found that this simple and cost-effective system can be used to treat various types of wastewaters, ranging from greywater to leachate and septage. However, despite the enormous potential for the use of CWs for wastewater treatment, there are still some challenges that slow down the process of the practical application of this technology in Nepal. These challenges can be found discussed at length in the pertinent professional literature [7], [8], [9], [10], and many others, and simply listed in the following way:

- The CW technology is relatively new to Nepal, and thus, it is unknown to most of the population. Due to the lack of awareness of this technology, it is often difficult to convince people that it will work;
- although CWs are cheaper than centralized wastewater treatment systems, the CW technology still can be expensive for low-income populations. Hence, it is still difficult to convince people to invest in the technology instead of just discharging effluent into the river;
- it is a low maintenance system, nevertheless, people often think it is a no-maintenance system. This sometimes leads to carelessness in operation and maintenance requirements such as checking for blockage in the pipes, harvesting the plants, etc;

- wastewater treatment is not a priority for the city governments, private industrialists, or institutions, due to the lack of strong legislation and standards; and
- on the individual level, one of the biggest challenges is the lack of land for CW construction since land is very expensive in city areas and people occupy land only for house building construction, and no open free space is available.

The present situation does not differ from the picture drawn above, the practical implementation of CW technology into practice sustains still a challenge.

The problem of the application of new technologies, obviously called the application of innovations, is a more general theme, however. The process of adopting new technologies has been studied for over 30 years, one of the most popular adoption models being explained by Rogers [11]. Much research from a broad variety of disciplines has used the model as an explanatory framework. The papers [12] and [13] mention several of these disciplines as political science, public health, communications, history, economics, technology and education, and define Rogers' theory as a widely used theoretical framework in technology diffusion and adoption. In fact, much diffusion research involves technological innovations, so Rogers usually used the words "technology" and "innovation" as synonyms and defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system [11]. As can easily be derived from the definition, the nature of innovation, communication channels, time and social system can be considered the four key components that form the process by which the new technology is supposed to spread out.

In the context discussed here, it is important to point out that for Rogers, the technology is composed of two parts: hardware and software. While hardware is "the tool that embodies the technology in the form of a material or physical object", software is "the information base for the tool" [1]. The "software", in our case, can be interpreted as the social and cultural context in which the technology is discussed and interpreted, and, consequently, decided to be or not to be implemented. The paper addresses the two components of Rogers model, namely communication channels and social system in terms of the motivation of users with the aim to understand ways by which the technology is promoted, and reasons that led users to apply this technology in practice.

2 METHODS USED

The aim of the research was to understand the situation; therefore, qualitative methods were preferred for information gathering and processing [14] and [15]. The identification of the unit of analysis was based on the theoretical presumption that refers to the Thomas theorem [16] and early works of the Chicago School [17], namely that social reality is dynamic, and socially constructed by all actors involved in a particular situation. Based on that, a particular CW, either functioning or out of operation, was used as the unit of analysis, defined as a situation in which three actors participate:

- Users, i.e. local communities, institutions (both governmental and non-governmental), and private owners,
- local authorities, that set the political and economic context, i. e. mayors, regional politicians, etc., and
- NGOs (from local to internationally recognized) that mediate financing, building and operation of the CW.

The basic set was defined as the CWs in the Kathmandu Valley, identified by the list elaborated by the ENPHO. In total, it was comprised of 60 CWs existing within the Kathmandu Valley operated by a variety of users. Having the list at disposal, the next step was the try to contact the persons responsible and arrange a meeting in situ. It appeared, however, that out of the total 60 CWs, only 23 responded in some way which enabled us to visit these respondents and consider them as the sample (see Table 1).

The field campaign was realized in the form of semi-structured interviews with key informants in situ, i.e. next to the CW, or in the office of a pertinent authority or an NGO (Fig. 1). The narration was structured primarily along with the following themes, the scheme however was flexible enough to cope with local peculiarities:

Table 1. The structure of the sample.

Type of the user	**State of the constructed wetland**			
	Fully functioning	**Partly functioning**	**Not functioning**	**In total**
Schools	1	1	3	5
Communities	1	1	3	5
Private houses	1	1	1	3
Research institutions	2	0	4	6
Hospitals	1	0	1	2
Monasteries	0	0	1	1
Industry	1	0	0	1
In total	**7**	**3**	**13**	**23**

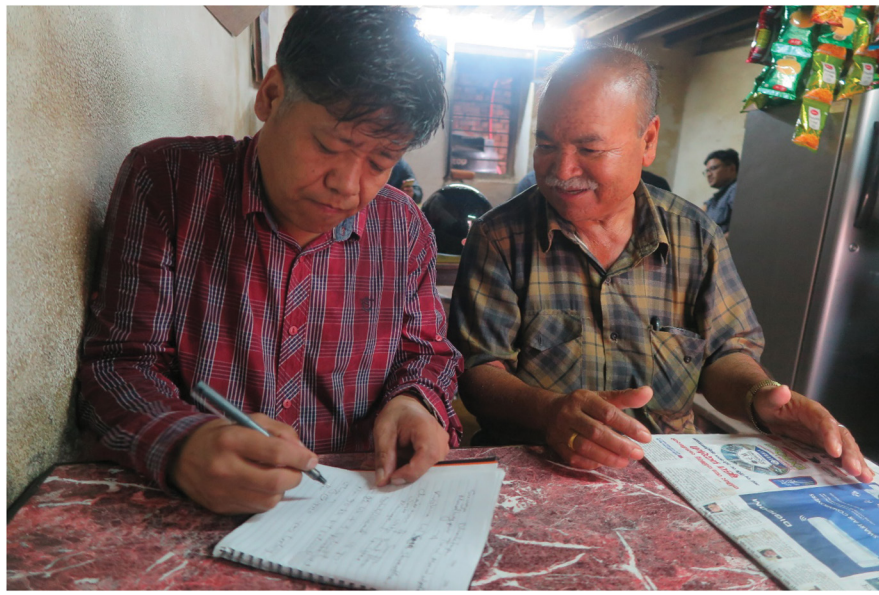

Figure 1: The interview in Sunga Thimi village.

- "Ownership" of the CW and stakeholders involved, as well as the reasons to decide for choosing the technology, and
- conditions of the system maintenance, and the prospect of the future (more details about the narratives can be found in [18].

Being there enabled us to combine interviewing with observation. We were fully aware of the fact, that Nepal is "another world" distant from our understanding both in terms of language and, particularly, in terms of culture. To cope with the challenge, three interviewers were present in situ together, two Czech, and one Nepali, the latter playing the role of "interpreter" mediating the questions asked in English to fit the local context. All the interviews were then ultimately held in Nepali, audio-recorded, subsequently transcribed verbatim, and translated into English. The short films and photo documentation of the terrain research were made. Finally, all the texts became the subject of thematic analysis.

3 RESULTS

3.1 Channels of communication

As said earlier, the technology was installed for the first time in the Kathmandu Valley in 1997. Since it started to spread out in various ways. Behind the variability, however, three more general patterns can be identified.

3.1.1 ENPHO – interested end-user

National NGO named ENPHO (Environment and Public Health Organisation) appeared to play a pivotal role in the process of CW technology propagation both in terms of direct construction and promotion among the public, including capacity building, as it can as well be documented by their webpage, where these activities represent an important part of their portfolio [19].

This to some extent unique position can be explained by the fact that "ENPHO was there" when the technology was for the first time introduced into the country. The external professional assistance provided by BOKU at that time, and further even pronounced the chance of the ENPHO to take the almost monopolistic position at the market or at least the position of the indispensable actor operating there. ENPHO identifies the potential user and addresses it with the offer that it (ENPHO) can mediate the whole process, i.e. establish the consortium of financing the project, including co-financing by the end-user, organize the building of the CW, and assist in monitoring the CW operation. The alternative variant is that the interested potential user addresses the ENPHO with the request. The other steps are identical to the above. This channel can be metaphorically called a "professional enlightenment with the business aspect" since ENPHO partly lives from this money. Over time, as well other NGOs, such as e.g. LUMANTI, entered the market, however as cooperating institutions only, without any factual effect on the leading role of the ENPHO in this field of activities.

3.1.2 Exempla trahunt

Meaning replication of the technology based on "following already existing and proved example". The information on the (somewhere) functioning CW is crucial in this case. Hence the publicly accessible CWs seem to play a pivotal role, or the information spread in the hearsay mode. The story of the CW designed by the Shreekandphur community is somewhere in the middle and can serve as a typical example. The community in fact replicated the model

existing in the Dhulikhel Hospital. The chef of the community saw the CW when visiting the hospital and was inspired. As he was in very good personal relations with the manager responsible for the hospital wastewater treatment, he was explained informally about the pros and cons of this kind of wastewater cleaning and, consequently, provided by the appropriate contacts which in the end enabled to build and operate the CW in the Shreekandphur.

3.1.3 Direct foreign aid

This model represents initiatives realized and funded by international projects and can be applied not only to CWs but more generally. It is a matter of fact, that these projects follow their own logic dictated by donor agencies. It is not surprising then, that their objectives are defined to meet requests of particular calls, rather than local conditions and needs. Only afterward they are negotiated with local or regional potential end-users with the aim to find the compromise – to fulfil the project main objectives and satisfy local needs. It, in some cases, may lead to the situation when the end-user does not feel to be the "owner" of the project output and cease to take care of it immediately after the project life is over. There are of course success stories, usually in the cases, where the historical and cultural role of a community is placed at the centre of the process via 'community-led' planning [20]. Horizontal CW, combined with rainwater harvesting for the Dhapakhel municipality can be mentioned, realized under the EUREKA BIORESET project, as the solution of the water scarcity in the area, and the Nala CW, financed by UN-HABITAT, Nepal, as demonstration projects for community-based wastewater treatment. CW in Nala addresses the problems experienced in the previous examples of Sunga and Sreekhandapur and adopts alternative solutions accordingly [21].

3.2 Motivation

As the channels of communication, the motives as well represent a relatively broad array of reasons to be found behind the building and operating of CWs. These categories or classes, however, exist in a non-exclusive way. In fact, the classification is arbitrary in the sense that reasons named below exist, however in the case of particularly CW they can appear in combination, with one motivation obviously prevailing.

3.2.1 Environmental religious

This category represents the viewpoint merging two dimensions "expert" and spiritual, both addressing, in fact, the same issue – humility. The expert dimension is based on the conviction, that pollution negatively affects the river and that only clean water should be released to the watercourse to keep the river living. The community of Sano Kokhana can be used as an example of this approach. With the comment, they made that it is a pity, that they are the only village on the Bagmati riverbank that goes this way and others, either up or downstream, do not follow this way.

The spiritual dimension addresses the same issue but uses different "language". Assessed from this standpoint, any pollution of water, regardless underground or in the river, is a transgression, a sin against God's will (Fig. 2). In the case of Satya Sai Sikshya Sadan ecclesiastic school, the care of water adopted as well educational aspects, as the CW as an appropriate system of wastewater treatment is used for demonstration in teaching as can be illustrated by Fig. 3.

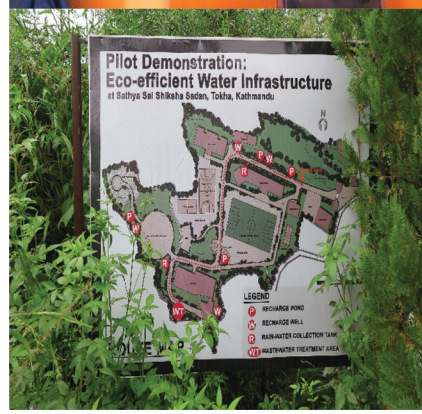

Figure 2 and 3: Satya Sai Sikshya Sadan.

3.2.2 Utilitarian

This type of motivation prevails in terms of the frequency in which appears. As in the Kathmandu Valley, the water supply is a challenge for most of the inhabitants, it is not surprising, that people try to use the treated wastewater for irrigation. This source of utility water is frequently combined with rain harvesting as is the case of Dhapakhel.

The utility of CWs is, in the situation when it is possible, enhanced by producing biogas from solid parts of the wastes. Such a combination is seen as a good investment and often becomes a subject of local business – especially selling gas for heating and cooking for community members. This kind of utilization of a CW was found when analysing the situation in the Sano Kokhana and the Shreekandphur communities (see Fig. 4 and 5).

3.2.3 Image-making (prestige)

Unlike the two previously mentioned motivations that can be attributed mainly to local communities and institutions, image-making is the dominating reason for implementing CWs in places oriented outwards. Two types of such places were identified during the analysis – prestigious schools and tourist-oriented places. Shuvatara International School in Lalitpur, the private boarding high school, trying to attract rich clientele can be used as an example to

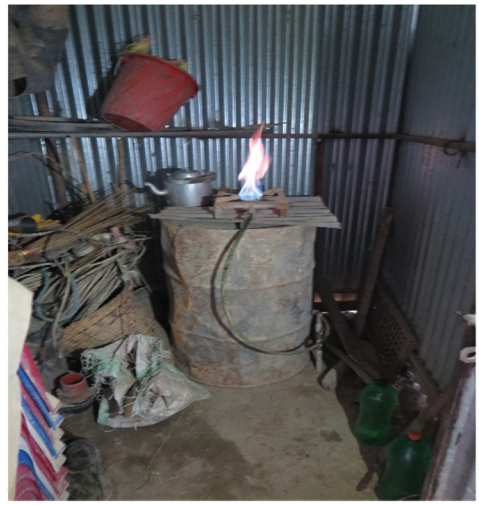

Figure 4: Shreekandphur.

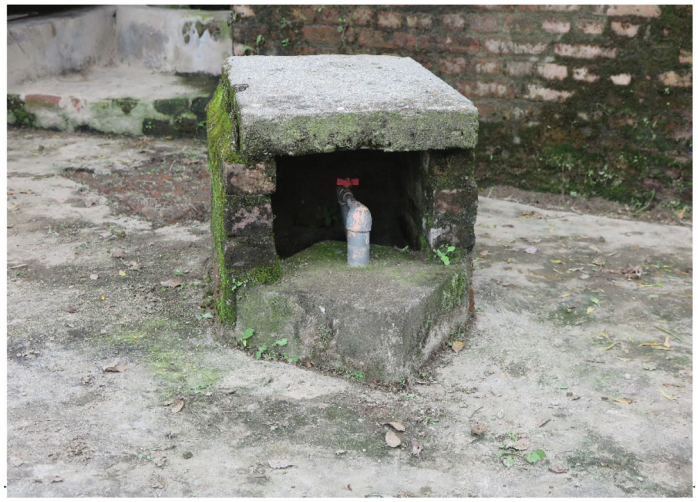

Figure 5: Sano Kokhana.

document the statement. The school uses the "environment-friendly" way of treating wastewater as a "trademark" to demonstrate its exceptionality to attract rich students.

Tourist-oriented places are in our sample represented by the Namo Buddha Resort and Chandra Ban Eco tourist localities. They are examples of private investment that builds on the image of Nepal as a spiritual country (sometimes referring to the hippie era). And the indispensable attribute of such an image is environment-friendly behaviour. Nature-based technology, as the CW is, serves to manifest this standpoint with the aim to attract (rich) clientele. As in many other businesses, the image, the pretending, is more important than reality. Having it in mind, you cannot find surprising the fact, that the nicely looking basin with flowering water plants is situated in the front. However, this basin is used for cleaning the

Figure 6 and 7: Namo Buddha Resort.

water from the kitchen only, while the black water is being freely released to nature through non-functioning wetland by pipelines in the back (Fig. 6 and 7).

4 CONCLUSIONS

Based on the information obtained by the research we suggest stating that CWs as a technology for household wastewater treatment is getting recognition within the Kathmandu Valley, slowly but continuously. It is despite the fact, that the government support is still not adequate both in terms of direct (financial) support for building CWs and missing legislation as to the environmental standards.

Given the situation, the process of diffusion cannot be seen as a top-down, officially supported process. It can rather be interpreted as network-based diffusion using personal contacts, sometimes based on the peer model.

The array of motivation to use this technology is relatively broad, spanning from the very pragmatical reasons induced partly by the lack of other utility water available up to purely spiritual arguments. The tendency to pretend environment-friendly behaviour can be hypothesized to be related to the opening of Nepal to globalization trends, misusing to some extent the image of Nepal as a trademark of "spirituality" on the global market.

We are fully aware of the fact, that the sample we used for our research was limited as any other sample, hence outputs derived from the data gathered can be seen as contingent. Nevertheless, they represent a probe of some kind to the value system of the Nepali society. It would be then challenging to conduct such research in European conditions for comparison.

ACKNOWLEDGEMENTS

This paper was developed thanks to the EUEKA project E! 12219 BIORESET, co-financed by the Ministry of Education, Young and Sports, Czech Republic (50%) and organization VODNÍ ZDROJE a.s. and thanks to the activity COST 17133: CIRCULAR CITY RE.SOLUTION, the project "Natural Based Solutions for Water management in cities", financed by the Ministry of Education, Young and Sports, Czech Republic

REFERENCES

[1] Shrestha, R. R., Application of constructed wetlands for wastewater treatment in Nepal – Dissertation Thesis, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria. 1999.

[2] Roka, R. B., Dongol, R., Kalavrouziotis, I. K., Historical Development of Wastewater Management in Kathmandu Valley. *Conference paper: 4th IWA International Symposium on Water and Wastewater Technologies in Ancient Civilization*, Coimbra, Portugal, 2016.

[3] Green, H., Poh, S. C., Richards, A., *Wastewater treatment in Kathmandu, Nepal*, Master Thesis: Massachusetts Institute of Technology, Cambridge: USA, 2003.

[4] Shrestha, N., Lamsal, A., Regmi, R. K., Mishra, B. K. (2015): Current Status of Water Environment in Kathmandu Valley, Nepal. Water and Urban Initiative Working Paper Series, United Nations University Institute for the Advanced Study of Sustainability. Available online: http://collections.unu.edu/view/UNU:2852

[5] Boukalova, Z., Těšitel, J. & Gurung, D. B., Nature-based water treatment solutions and their successful implementation in Kathamndu Valley, Nepal. WIT Transactions on Ecology and the Environment, vol. 242, WIT Press: Southampton and Boston, pp. 121–132, 2020.

[6] Shrestha, J., Kalu, S., Performance of DEWATS in Nepal. Journal of Environment and Public Health, 1(1): 21-26, 2017. Online available: https://www.scribd.com/document/458266773/ENPHO-Journal-V1-I1.

[7] Tuladhar, B., Shrestha, P., Shrestha, R., Decentralised wastewater management using constructed wetlands. Online available: https://es.ircwash.org/sites/default/files/Tuladhar-2008-Decentralised.pdf, 2008.

[8] WaterAid, *Decentralised wastewater management using constructed wetlands in Nepal*. WaterAid in Nepal, Kathmandu: Nepal, 2008.

[9] Gurung, A. and Oh, S-E., An overview of water pollution and constructed wetlands for sustainable wastewater treatment in Kathmandu Valley: a review. *Scientific Research and Essays,* 7(11), 1185-1194, 2012.

[10] Gurung, S. B., Geronimo, F. K. F., Lee, S., Kim, L. H., Status of constructed wetlands in Nepal: recent developments and future concerns. *Journal of Wetlands Research*, 19(1), 45-51, 2017.

[11] Rogers, E. M., *Diffusion of innovations (5th ed.)*. New York: Free Press, 2003.

[12] Dooley, K. E., Towards a holistic model for the diffusion of educational technologies: an integrative review of educational innovation studies. *Educational Technology & Society, 2*(4), 35-45, 1999.
[13] Stuart, W. D., *Influence of sources of communication, user characteristics and innovation characteristics on adoption of communication technology*. Dissertation Thesis, University of Kansas: Kansas, USA, 2000.
[14] Charmaz, K., *Constructing grounded theory – A practical guide through qualitative analysis*. SAGE Publications: London, Thousand Oaks, New Delhi, 2006.
[15] Kielmann, K., Cataldo, F., Seeley, J., Introduction to qualitative research methodology: a training manual, produced with the support of the Department for International Development (DfID), UK, under the Evidence for Action Research Programme Consortium on HIV Treatment and Care (2006–2011), 2012.
[16] Thomas, W. I., Thomas, D. S., The child in America: Behavior problems and programs. New York: A. A. Knopf, 1928.
[17] Park, R. E., Burgess, E. W., *Introduction to the Science of Society*, University of Chicago Press: Chicago, USA, 1921.
[18] Boukalová, Z., Těšitel, J. & Gurung D. B., Constructed wetlands implementation in Kathmandu Valley, Nepal. *International Journal of Environmental Impacts*, 4(4), 363-374, 2021. Online available: https://www.witpress.com/elibrary/ei-volumes/4/4/2849
[19] https://enpho.org/
[20] https://doi.org/10.1177/000271629956600105
[21] Arnstein, S. R., A ladder of citizen participation. *Journal of the American Institute of Planners,* 35(4), 216–24, 1969.