

How do non-sewered public toilets operate in Beijing? An evaluation with Fuzzy Comprehensive Evaluation Model

Cheng, S. *, Ma, T. *, Zeng, H. *, Li, D. **, Mang, H-P. * and Li, Z. *

*School of Energy and Environmental Engineering, Beijing Key Laboratory of Resource-oriented Treatment of Industrial Pollutants, University of Science and Technology Beijing, Xueyuan Road No.30, Haidian District, Beijing, 100083, PR China

**Academy of Agricultural Planning and Engineering, No. 41, Maizidian Street, Chaoyang District, Beijing 100125, China

Highlights:

Eight non-sewered public toilets (NSPTs) are evaluated in Beijing.

Hierarchical analysis and fuzzy mathematics methods were employed.

NSPTs in Beijing basically meet the needs of users but still require improvement.

Full compliance with ISO30500 standards remains a challenge for Beijing NSPTs.

Keywords: fuzzy comprehensive evaluation; public toilets; non-sewered

INTRODUCTION

As of 2022, 57% of the global population utilized safely managed sanitation services, and the coverage will reach 65% by 2030 (United Nations, 2023). The sanitation improvement in the public sector in Beijing is noticeable after several rounds of toilet retrofitting campaigns, along with a series of international events such as the Asia Games in 1990, the World Toilet Summit in 2004, the Olympic Games in 2008, and the Olympic Winter Games in 2022. Unlike other emerging cities, many areas in Beijing are protected and cannot be upgraded to flushing toilets connected to sewers. In such cases, non-sewered public toilets (NSPTs) are essential for local residents.

However, knowledge about these new NSPTs or NSSSs in China is quite limited and is worth investigating. In this study, we comprehensively evaluated eight NSTPs in Beijing across five aspects: economy, service, hygiene, environment, and humanity. Based on the evaluation results, we benchmarked against ISO 30500 to comprehend the issues in the construction and management of NSSS. We then proposed new countermeasures and recommendations for sanitation in low and middle-income countries.

METHODOLOGY

An evaluation system for NSPT is established with five primary indicators and 16 secondary indicators (Fig.1). Distribution of NSPT locations is shown in Fig. 2. 30 questionnaires were distributed in each NSPT, of which 28 were user questionnaires and 2 were staff questionnaires. A total of 240 questionnaires were distributed; 233 questionnaires were collected, and 200 questionnaires were valid, resulting in a validity rate of 83.3%. Analytic hierarchy process (AHP) was selected to determine the index weights. After determining the weights of the indicators, we

employ the fuzzy comprehensive evaluation method to calculate the data obtained from the research and generate the final evaluation results.

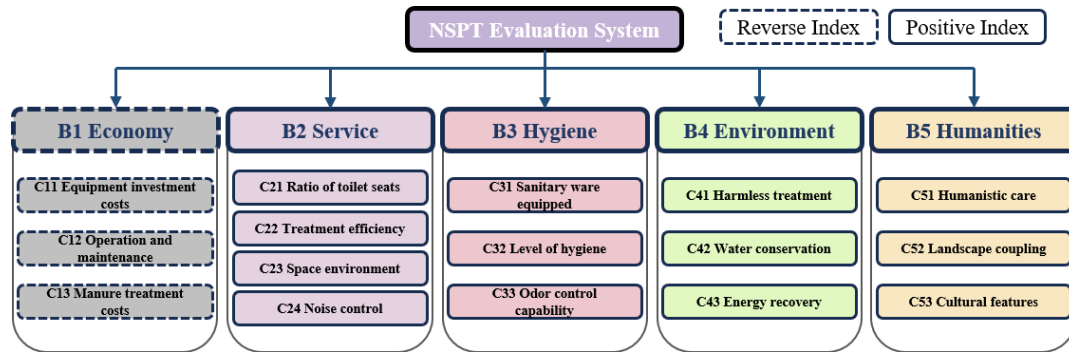


Fig. 1. NSPTs evaluation index system

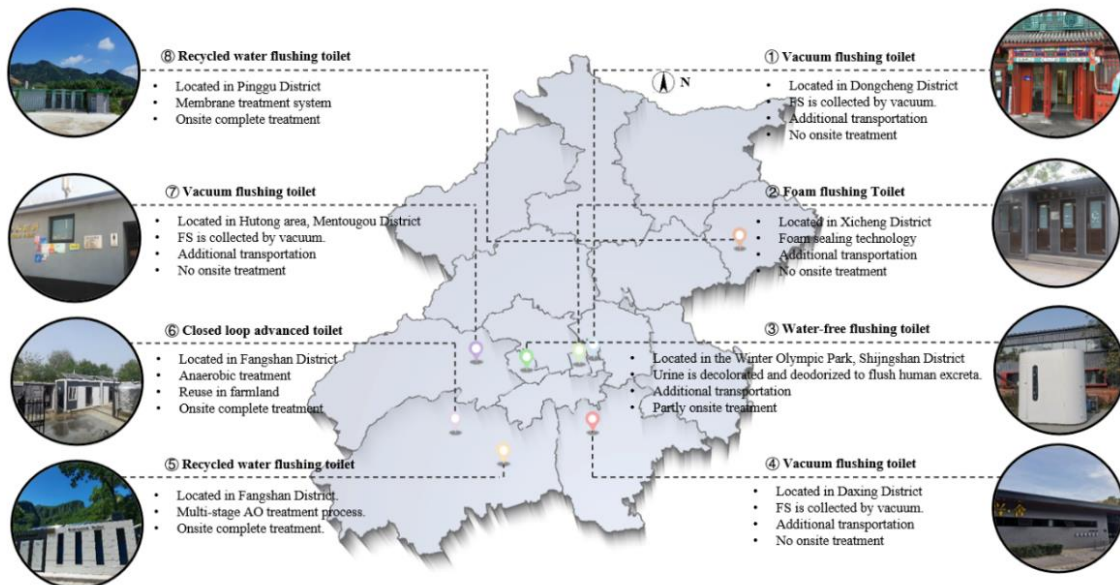


Fig. 2. Selected NSPT Distribution Infographic in Beijing

RESULTS AND CONCLUSIONS

Following the principle of maximum membership, all five indicators of NSPTs in Beijing are rated at Level 3, indicating a medium level. Observing Fig. 3(a), it is evident that certain toilets have hygiene indicators with an affiliation level of five, signifying an excellent level. Additionally, some toilets have a service indicator evaluation level of Grade I, representing a poor level. Public toilets should establish a systematic cleaning and maintenance operation to ensure a high-quality service level. Concerning the evaluation indicators, scores were assigned to different levels to evaluate the overall scores of the five indicators' strata for all research subjects. In Fig. 3(b), we observe the result of the highest score for the humanistic care indicator, which is 3.096, followed by the environmental indicator, scoring 3.057. The economic indicator is a reverse indicator, with a lower score indicating better economic performance. When converted to a positive indicator, the

score is 2.094, remaining the lowest scoring indicator. This suggests that NSPTs require substantial investment in both pre-construction and post-operation maintenance. The proposal presented by Delaire et al. for building safe sanitary facilities involves selecting the appropriate sanitation approach and financing universal sanitation goals (Delaire et al., 2021).

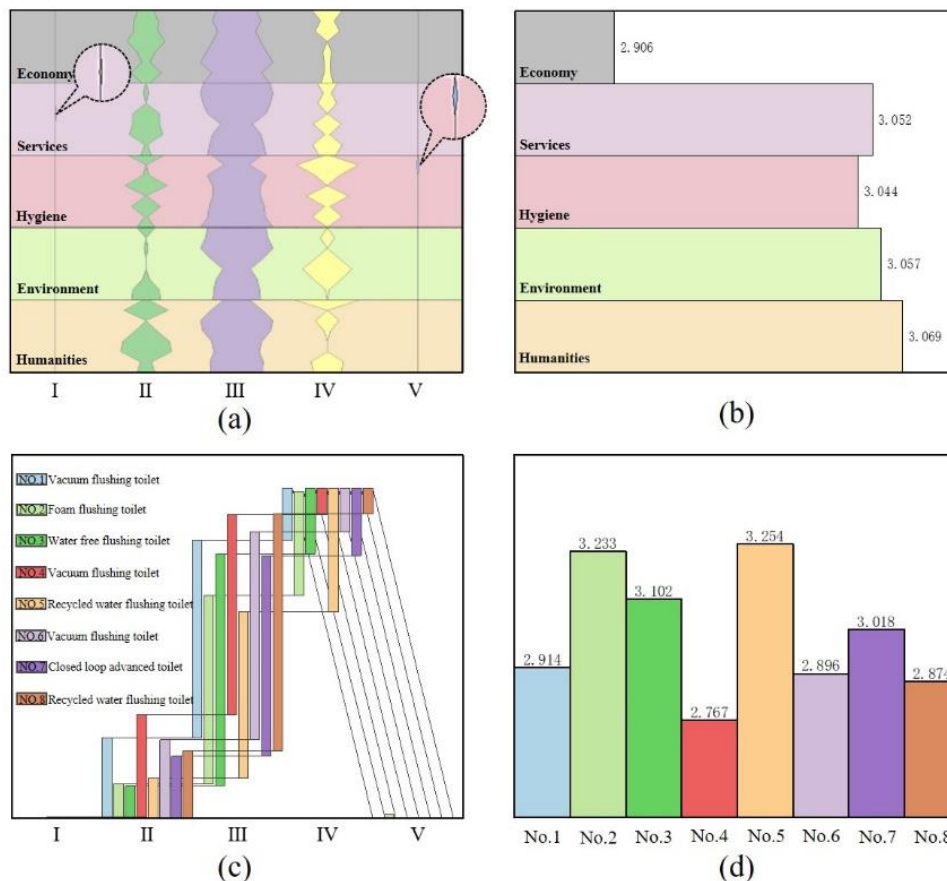


Fig. 3. Comprehensive evaluation results

Fig. 3(c) and 3(d) analyze the combined evaluation results for each research participant, showing the affiliation of each toilet at different evaluation levels and the assigned score, respectively. Fig. 3(c) shows that No.5 (Recycled water flushing toilet) has a stronger affiliation at level 4 compared to the other toilets, indicating a higher standard of construction and management. This is closely associated with its elevated affiliation to level 4 for the hygiene and environmental indicators. The hygiene indicator for No.2 (Foam flushing toilet) exhibits a low affiliation at level 5. However, it indicates that some users are highly satisfied with the availability of cleaning facilities and odor management in this toilet. The results obtained after the score assignment align with those presented in Figure 3(c). The highest score was given to No.5 (Recycled water flushing toilet), followed by No.2 (Foam flushing toilet), and No.4 (Vacuum flushing toilet) received the lowest score. This could be attributed to the lack of noise control, impacting the user's toileting experience. We recommend for these developing countries when they build NSSSs: (1) Choose the appropriate technology. (2) Affordable for residents. (3) Actively publicize and promote.



10th-14th November, 2024
Curitiba-Brazil

ACKNOWLEDGMENTS

This study was supported by the Natural Science Foundation of China (52261145693), the Bill and Melinda Gates Foundation (Grant number OPP 1153400) and National Environmental and Energy Science and Technology International Cooperation Base.

REFERENCES

United Nations. (2023). *Blueprint for Acceleration SDG 6 Synthesis Report on Water and Sanitation 2023*. New York. 2023.

Delaire, C., Peletz, R., Haji, S., et al. (2021). How Much Will Safe Sanitation for all Cost? Evidence from Five Cities. *Environmental Science & Technology*, 55(1), 767-777.