Life cycle assessment (LCA) of water treatment sludge disposal methods

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The water and wastewater sector is responsible for 5% of global greenhouse gas emissions [1]. However, global warming is not the sole environmental issue this sector contributes to – heavy metals contamination of source water and improper utilization of waste (sewage and water treatment sludge) can cause adverse human health impacts.

Most studies that performed life cycle assessments of water supply systems indicate that electricity and chemical consumption are the top contributors in almost every impact category [2]. Yet, the inventory of those studies excluded water treatment sludge characterization and the effect of its disposal, which is usually done by dehydrating and landfilling or direct discharge to the water bodies. Because the former is often associated with additional energy and labor costs, discharge is preferred, especially in developing countries. This study compares the two options to provide the background for cost-environmental impact trade-off decisions.

Almaty and Astana water supply systems were considered for dehydration-landfilling and discharge scenarios correspondingly. Both systems utilize conventional water treatment technologies, including coagulation, flocculation, sedimentation, and disinfection. The plants' operating companies provided the electricity and chemical consumption data, and sludge samples were analyzed using the XRF equipment to obtain detailed sludge content. Identical sludge contents and amounts were considered. Due to the absence of sludge generation rates, the value was estimated using the appropriate literature [3]. The inventory was assembled in the SimaPro 9.4.0.2 software, and energy/materials production-related impacts were taken from the ecoinvent database. The life cycle impact assessment followed the ReCiPe 2016 Endpoint methodology, and the effect was aggregated to a single score value for an adequate comparison.

Table 1. Endpoint impact comparison of discharging dehydrating-landfilling 100 g of sludge.

Damage category	Unit	Dehydration -landfilling	Discharge
Human health	DALY	4,90E-08	4,58E-07
Ecosystems	species. yr	4,05E-11	2,94E-10
Resources	USD2013	2,99E-04	-

As indicated in Table 1, the direct discharge method has 9.34 times more human health impact and 7.23 times more damage to ecosystems than the dehydration-landfilling option. Yet, it has no effect in the resources category as no energy or material inputs are required given that the WTS is discharged to the nearby Ishim River. Such high differences in the human health impact and damage to ecosystems are due to the varying effects of contaminants released to the water and soil media (the top contributors are zinc and arsenic). The aggregated single score results in Figure 1 indicate that direct discharge has a 9.5 times higher impact than dehydration-landfilling.

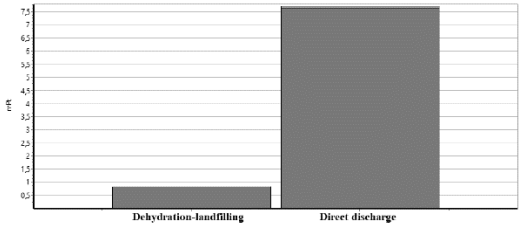

Figure 1. Single score comparison of discharging and dehydrating-landfilling 100 g of sludge.

The results of this study highlight the importance of including the WTS disposal impacts in the inventory of the LCA of water supply systems and suggest choosing the dehydration-landfilling disposal method.

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References

[1] UNEP. (2021). *Infrastructure for climate action*. UNOPS, Copenhagen

[2] Boldrin, M.T., Formiga, K.T., & Pacca, S.A. (2022). *Science of the Total Environment, 835*, 155213.

[3]Ahmad, T., Ahmad, K., & Alam, M. (2017). *Environmental Monitoring Assessment, 18*

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