

STUDY OF ALTERNATIVE METHODS TO MITIGATE THE ECOBIOTOTOXICOLOGY OF LEACHATE WATER

Natela Dzebisashvili^{1,2} *, Darejan Dughashvili^{1,2}

¹Institute of Hydrometeorology, Georgian Technical University, D. Aghmashenebeli 150g, Tbilisi, 0112, Georgia

²R. Agladze Institute of Inorganic Chemistry and Electrochemistry, Iv. Javakhishvili Tbilisi State University, Mindeli str 11, Tbilisi, 0186, Georgia

Abstract

The largest official municipal solid waste disposal site (SWDS) in Georgia has been serving the capital since 2011. In 2018, a reverse osmosis system was installed at the landfill for the treatment of leachate water, the capacity of which was 12 m³/day, which was insufficient, and accordingly, it was out of order at the end of 2018. At present, since it is not possible to clean the leachate for discharge into the sewage system in accordance with the legal norms, the leachate is collected in open tanks, where sedimentation takes place and then returns to the body of the landfill (circulates), which on the one hand partially limits the pollution of surface waters, and on the other hand accelerates the process of decomposition of mixed waste, but also daily enriches leachate water with both chemical and biological toxins. The goal of our research was to determine the dynamics of the microbiological indicators of the leachate water generated at the largest SWDS in Georgia during the years 2022-2023 and alternative complex treatment of leachate, through which the microbiological indicators will be reduced to the norm without additional measures. The carbon sorbents of different origins and fractions (under static conditions) were used in the framework of the research to treatment of highly polluted waters. It was determined that the sorption of the studied microbiological indicators (Total Coliform, E. coli, Enterococci) on the example of the carbon sorbents used by us is fluctuating and highly dependent on the size of the sorbent, and it should be noted that the optimal result is obtained when using a micro-sorbent and the degree of sorption of all three microbiological indicators reaches 98 %.

Keywords: Waste, Landfills, Leachate, Microbiological Indicators, Sorption

1. INTRODUCTION

In developing countries, including in Georgia, the main part of the solid waste generated throughout the country is placed in the so-called - open landfills. This type of waste disposal leads to pollution of environmental components (soil, water, air), which in turn affects human health as mostly does not comply with the principles of sustainable waste management and circular economy protocols. Nowadays, improving solid waste management (MSW) is one of our country's priorities, that aims to harmonize the development process of waste management of European and the World's waste management policies. Currently, about 50 official landfills of open type are registered in Georgia, the largest of which serves the population of the capital city [1,2].

2. MATERIALS AND METHODS

2.1. Materials

The largest official landfill was commissioned in April 2010 and is located southeast of Tbilisi, east of Didi Lilo village (30 km from Tbilisi). The population of Didi Lilo demands the conservation of the Tbilisi municipal solid waste (MSW) landfill and its relocation. The proximity of the landfill to the locals creates unbearable living conditions due to environmental pollution [3-6]. The total area of the landfill is 84 ha and its main facilities are:

- Waste storage cells (3 cells in total at this stage), equipped with a waterproofing structure using high-strength polymer film (2 mm Geo-Membrane);
- Drainage channels and pipelines, wells, 2 mm Geo Membrane laminated ponds for filtrates and surface water;
- Fire pumping station with hydrants, located in different parts of the area;
- Filtrate reservoir and its treatment plant (that does not properly meet the requirements).

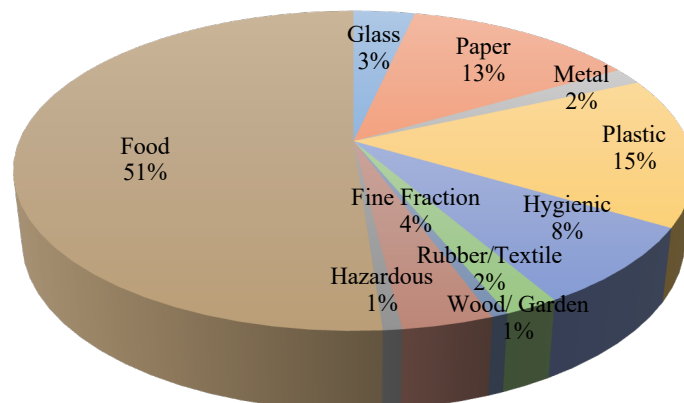
At present, the disposal of waste in cells 1 and 2 has been completed and the 3rd cell has been functioning since 2019. Waste dumped in the cell area in a 0.5-meter-thick layer by means of a bulldozer and loader is distributed and compressed with special compactors. In the process of work, the waste is moisturized with existing fluid at the contaminated water's puddle (waste storage cells are equipped with a filtration system and a collector network through which water flows into the storage ponds, where part of the collected water is circulated in the cells by means of special pumps). When the compacted waste reaches a height of 2 meters, the garbage layer is covered with a 30-50 cm thick layer of compacted insulating local clay soil. A second layer, already arranged by a similar system, is added to the layer of garbage and land up to 2.5 meters thick.

When the storage cells are filled, they close, each cell is covered with an insulating coating containing a special geomembrane (2 mm GeoMembrane) and the surface is recultivated. Landfill gas is collected through gabion shafts (100 wells of landfill gas extraction are installed on cells 1 and 2), which are set as soon as the cell is arranged, and whose main function is to prevent methane ignition (landfill gas is not used it is emitted in to the atmospheric air).

In 2018, a reverse osmosis system was installed at the landfill for the treatment of leachate water, the capacity of which was 12 m³/day, which was insufficient, and accordingly, it was out of order at the end of 2018. To solve this problem, the Leachate water from sedimentation system is pumped to the surface of the working waste storage cell by using pumping machines, therefore it circulates: sedimentation system - the body of the compressed waste/landfill. This activity moistens the waste and, consequently, activates the biodegradation process, and also, significantly increases the degree of pollution of Leachate water. In addition to all of the above, there is a high risk of environmental pollution, which is mainly due to the high probability of emergent discharge of the Leachate water, namely: in the case of heavy precipitation, water bodies (sedimentation systems) are the most likely to overflow and discharge contaminated water into the collector and then to the river Norikheva, that flow in the natural ravine nearby, and then in Lochini, and finally to the transboundary river Mtkvari, the main river of the Capital city.

From 2015 through 2017, through the gravimetric method, we investigated the quantity and morphological composition of the MSW in all region of Georgia including in the capital city - Tbilisi [7]. It was established that the average of 250 kg/cap/year of MSW are generated in Georgia, while the annual growth in the amount of MSW is 1.7% (with that Georgia there has been no population growth for the last 3 years), at the same time the main fraction of MSW is the food fraction -51% (Fig. 1).

Figure 1: Morphological composition of MSW of Tbilisi city (Georgia)



The aforementioned feature of the dispose and process of such MSW (Fig.1) accelerates the decomposition of their and, accordingly, increases the values of both chemical and microbiological environmentally toxic indicators in wastewater.

2.2. Methods

The field experience in the World shows that purification of wastewater from microbiological pollutions includes many classical methods such as chlorination, ozonation, etc. But they are not effective for other chemical pollutant, such as heavy metals and organic impurities. Leachate water by reverse osmosis is quite effective, but it is better to the use this technology with an integrated approach that involves the use of chemical, biological and sorption processes. Existing cleaning technologies are quite expensive, both in terms of complex design and consumables, and in terms of high cost of raw materials and high energy costs of production. The use of various filters, sorbents or reagents to purify large volumes of water without regeneration is economically and ecologically impractical. Therefore, to date, many studies are underway to find and promote alternatives, for example, cheap carbon-containing sorbents [8-15].

The goal of our research was to determine the dynamics of the microbiological indicators of the leachate water generated at the largest SWDS in Georgia during the years 2022-2023 and alternative complex treatment of leachate, through which the microbiological indicators will be reduced to the norm without additional measures.

2.2.1. Methods of Analysis and Treatment of Microbiological Indicators

From May 2022 till May 2023 on the basis of monthly expeditions, samples of leachate water were taken.. 3-3 ml of water samples were analyzed using the IDEXX Quantitray enumeration procedure. All samples were analyzed for total coliforms, E. coli and enterococci. This method is intended for use in the detection and confirmation of Total coliforms, E. coli, Enterococci in wastewater. Any positive sample is an indication of contamination. [16]. The results of the analysis are shown in Tables 1.

To treatment 100 ml sample of leachate water from microbiological pollutants, we used 2 g carbon materials obtained from 3 types of food waste (Hazelnuts shell, Walnuts shell and Nectarine pit), as well as polymer waste (polypropylene) [17]. The study was carried out under static conditions with a delay of 1, 24 and 72 hours, on nano- and micro-sorbents (<500 μ R). The results of the analysis are presented in Table 2.

3. RESULTS

The determination of microbiological indicators in samples of the studied leachate water showed (Table 1) that the average concentrations of Total Coliforms in research water samples do not meet the standards for maximum permissible discharges (MPD) into water bodies and the average content of Total Coliforms in leachate of Tbilisi landfill exceeds the national standards for wastewater 5-6 times. The results also showed the presence of very high concentrations of Enterococci, although these impurities in sewerage water are not standardized in our country [18, 19].

Table 1. Total coliforms, *E. coli* and Enterococci (MPN/100ml) in Leachate of MSW Landfill of Tbilisi, Georgia

Month, Year	Total Coliforms	<i>E. coli</i>	Enterococci
May, 2022	9 800	24	>24 195
June, 2022	80 653	400	>24 195
July, 2022	59 950	500	12 243
August, 2022	28 250	500	>24 195
September, 2022	71 500	500	>24 195
October, 2022	3 750	100	8 710
November, 2022	4 650	100	3 543
December, 2022	5 950	100	4 637
January, 2023	3 927	118	14 507
February, 2023	3 650	<100	80 653
March, 2023	3 820	577	5 757
April, 2023	1 326	193	>24 195
May, 2023	96 784	20	>24 195
MPD [19]	5 000	400	7*

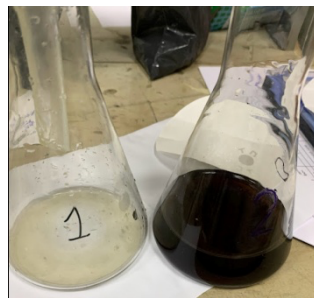
*MPC for marine water, no norms for wastewater

The studies of carbon sorbents obtained from polymer waste have shown that carbon materials obtained from polymer (polypropylene) fraction of MSW were characterized by the best adsorption capacity to some chemical and microbiological impurities of wastewater. Thus, based on the foregoing, we used this carbon materials and as a result the sorption indicators varies from 75 till 99%.

Table 2. Degree (%) of Sorption of Microbiological Indicators (Microsorbents <500 µR).

Carbon Sorbent	Total Coliforms	<i>E. coli</i>	Enterococci
Walnut shell	95	99	91
Hazelnut shell	91	99	89
Nectarine pit	98	99	95
Polymer	89	99	76

The use of nano sorbent did not give practical results due to resinification of sample. In addition, treatment of leachate water with the micro- carbon sorbent significantly reduces its organoleptic indicators (odor, color), picture 1.



Picture 1. Leachate water sample before treatment (Right) and after treatment (Left) with carbon sorbent (Hazelnut Shell)

4. DISCUSSION

It had been established that leachate of MSW landfill's of Tbilisi on average is characterized by several times higher data than the requirements of the European directives for the standards set for the quality of treated wastewater (EU Directive on urban wastewater treatment (91/271 / EEC)), that is a matter of concern for examining the further ways of purification.

5. CONCLUSIONS

It was determined that the sorption of the studied microbiological indicators (Total Coliform, E. coli, Intestinal Enterococci) on the example of the carbon sorbents used by us is fluctuating and highly dependent on the size of the sorbent, and it should be noted that the optimal result is obtained when using a micro-sorbent and the degree of sorption of all three microbiological indicators reaches 98 %.

ACKNOWLEDGMENTS

This research FR-21-12546 has been supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG)

REFERENCES

1. Waste Management Code, Georgia
<https://matsne.gov.ge/en/document/view/2676416?publication=10> , (in Georgian)
2. Waste Management National Strategy 2016-2030 and National Action Plan 2016-2020
<https://mepa.gov.ge/Ge/PublicInformation/20> (in Georgian)
3. Dvalishvili (Nowadays N.Dzebisashvili), Impact of incineration of municipal solid waste on climate change in Georgia, 5th World Convention on Recycling and Waste Management, 2017,
<https://www.longdom.org/proceedings/impact-of-incineration-of-municipal-solid-waste-on-climate-change-in-georgia-38662.html> ;
4. Dvalishvili N.L. (Nowadays N.Dzebisashvili), Tabatadze M.S. (2019) The Influence of Municipal Solid Waste of Georgia on Climate Changes. In: Ghosh S. (eds) Waste Management and Resource Efficiency. Springer, Singapore.
https://doi.org/10.1007/978-981-10-7290-1_16 ;

5. N.L.Dvalishvili (Nowadays N.Dzebisashvili), Establishment of Energy Potential of Norio Landfill of Municipal Solid Waste of Tbilisi, *Procedia Environmental Sciences*, Volume 35, 2016, Pages 377-380, <https://www.sciencedirect.com/science/article/pii/S1878029616301062>;
6. Change of conditions of operation of Tbilisi solid waste landfill located in the territory of Gardabani Municipality, scoping report <https://mepa.gov.ge/Ge/PublicInformation/11403> (in Georgian);
7. Elaboration of Methodology for Determination of Accumulated Amount and Morphological Composition of Municipal Solid Waste in Georgia and Database Creation <https://ecohydmnet.ge/narchenebi.html> (in Georgian);
8. Conceptual Leachate Treatment Scoping Study for New England Waste Services of Vermont (NEWSVT) Landfill, 2019, https://anrweb.vt.gov/PubDocs/DEC/SolidWaste/OL510/OL510%202019.10.15%20Conceptual_Leachate_Treatmnt_Scoping_Study.pdf (in Georgian);
9. Report to the Water Research Commission, J J Schoeman, A Steyn, J L Slabbed & E A Venter, TREATMENT OF LANDFILL LEACHATE FROM HAZARDOUS AND MUNICIPAL SOLID WASTE, <http://www.wrc.org.za/wp-content/uploads/mdocs/1167-1-031.pdf> ;
10. Abdhussain A. Abbas, Guo Jingsong, Liu Zhi Ping, Pan Ying Ya, Wisaam S. Al-Rekabi, Review on Landfill Leachate Treatments, *American Journal of Applied Sciences* 6 (4): 672-684, 2009, ISSN 1546-9239, <https://thescipub.com/pdf/ajassp.2009.672.684.pdf> ;
11. D. Kulikowska, M. Zielińska, K. Konopka, Treatment of stabilized landfill leachate in an integrated adsorption–fine-ultrafiltration system, *International Journal of Environmental Science and Technology* volume 16, pages 423–430 (2019), <https://link.springer.com/article/10.1007/s13762-018-1685-z> ;
12. Mir Amir Mohammad Reshadi a, Alireza Bazargan b, Gordon McKay, A review of the application of adsorbents for landfill leachate treatment: Focus on magnetic adsorption, *Science of The Total Environment*, Volume 731, 2020, <https://www.sciencedirect.com/science/article/abs/pii/S0048969720323809>;
13. Angelo Chianese, Rolando Ranauro, Nicola Verdone, Treatment of landfill leachate by reverse osmosis, *Water Research* 33(3):647-652, 1999 https://www.researchgate.net/publication/248157402_Treatment_of_landfill_leachate_by_reverse_osmosis ;
14. B. Weber & F. Holz, Landfill Leachate Treatment by Reverse Osmosis, *Effective Industrial Membrane Processes: Benefits and Opportunities* pp 143–154, 1991, https://link.springer.com/chapter/10.1007/978-94-011-3682-2_10 ;
15. Izabela Anna Tałałaj, Quality of Leachate from Landfill with Reverse Osmosis Concentrate Recirculation, *Journal of Ecological Engineering (JEE)*, Volume 20, Issue 8, 2019 <http://www.jeeng.net/Quality-of-Leachate-from-Landfill-with-Reverse-Osmosis-Concentrate-Recirculation,111711,0,2.html> ;
16. IDEXX COLILERT®-18 TEST METHOD FOR THE SIMULTANEOUS DETECTION OF TOTAL COLIFORMS AND E. COLI IN WATER, https://news.caloosahatchee.org/docs/DEX_COLLILERT_SOP_171005.pdf ;
17. N. DZEBISASHVILI, G. TATISHVILI, E. SURAMELASHVILI, D. DUGHASHVILI, Treatment of the Wastewater from Ammonia and Microbiological Components by using Carbon Materials, Book of Abstracts of 4th time to the International scientific and expert conference “Natural resources, green technology and sustainable development/4-GREEN2022” p116, https://www.sumins.hr/wp-content/uploads/2022/09/Green2022_Book_of_Abstracts.pdf ;

18. Regarding the approval of the technical regulation on the calculation of the maximum allowable discharge of polluting substances discharged together with wastewater into surface water bodies, #414 Ordinance of the Government of Georgia <https://matsne.gov.ge/ka/document/view/2188404?publication=0> ;
19. Order of the Minister of Labor, Health and Social Protection of Georgia No. 297/N, August 16, 2001, On the approval of norms for the qualitative state of the environment (in Georgian)