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# TWO-YEAR GROUNDWATER QUALITY EVOLUTION AT TWO CLOSED NON-COMPLIANT LANDFILLS IN ROMANIA

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## *Introduction*

Groundwater quality is essential for protecting public health and the environment. However, there are a number of factors that can affect groundwater quality, including inappropriate waste disposal. Waste generated by industrial, agricultural, and household activities is commonly disposed of in municipal landfills. Leachate is generated when water percolates through the waste, dissolving and transporting soluble compounds, including organic matter and heavy metals.

The groundwater can penetrate the base of the landfill, thereby increasing the amount of leachate generated and, consequently, the costs associated with its management. Monitoring groundwater quality provides information on contamination resulting from waste disposal. Groundwater quality control is carried out by control drilling at least three points, one point located upstream and two downstream of the landfills, in the direction of groundwater flow. The parameters to be analyzed in the collected samples are selected based on the groundwater quality in the area and the expected composition of the leachate. The appropriate selection of the parameters to be analyzed, together with information on groundwater flow in the area, enables the rapid identification of changes in groundwater quality. The alert thresholds are determined based on the hydrogeological formations specific to the area in which the landfill is located, as well as the groundwater quality.

## *Materials and methods*

In this paper, the evolution of the monitored parameters was assessed over a two-year period at two closed, non-compliant landfills located at a distance of approximately 280 km from each other. The values determined for selected chemical parameters were compared with the groundwater quality standards established by Order No. 621/2014 on the approval of threshold values for groundwater bodies in Romania. The comparison was performed for the groundwater bodies associated with the study areas: waste storage 1 – groundwater body code ROOT02 (Figure 1) and waste storage 2 – groundwater body code ROMU07 (Figure 2).

## *Results and Conclusions*

The results are presented for 3 drillings at each waste storage site: F1 – upstream, and F2 and F3 – downstream of the waste storage site.

Waste storage 1 occupies an area of 2.15 hectares and received municipal waste generated by commercial, industrial, and institutional activities, including separately collected waste fractions, serving a population of approximately 30,000 inhabitants. Waste storage 2 occupies an area of 1.1 hectares and served a population of approximately 50,000 inhabitants, receiving municipal waste generated by households, institutions, and economic activities.



**Figure 1-** Waste storage 1



**Figure 2-** Waste storage 2

The following tables present the results for the parameters for which reference values are established by legislation, based on semi-annual sampling conducted in June (S1) and October (S2) in 2024 and 2025, at the closed, non-compliant landfills D1 (Table 1) and D2 (Table 2).

**Table 1 -** Results obtained in comparison with threshold values according to ROOT02 for waste storage D1

| Nr. crt | Quality indicators | Values according to **ROOT02** (mg/L) | 2024 sem. 1 | | | 2024 sem. 2 | | | 2025 sem. 1 | | | 2025 sem. 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | F1 | F2 | F3 | F1 | F2 | F3 | F1 | F2 | F3 | F1 | F2 | F3 |
| 1 | Ammonium | 1,6 | 1.72 | 0.02 | 0.17 | 5.59 | 0.28 | 0.56 | 0.07 | <0.07 | 0.40 | 5.0 | <0.07 | 1.01 |
| 2 | Nitrites | 0.5 | 0.73 | 0.02 | 0.01 | 0.02 | <0.01 | <0.01 | 1.85 | <0.01 | <0.01 | 11.9 | 0.13 | <0.01 |
| 3 | Phosphates | 0.5 | 0.09 | 0.09 | 0.07 | <0.05 | 0.07 | <0.05 | 0.09 | <0.05 | <0.05 | 0.05 | 0.06 | 0.08 |
| 4 | Chromium | 0.05 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | 0.0018 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 |
| 5 | Nickel | 0.02 | 0.0035 | <0.0012 | <0.0012 | 0.0076 | 0.0027 | 0.0049 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 |
| 6 | Copper | 0.1 | 0.014 | 0.012 | 0.0064 | 0.011 | 0.012 | 0.012 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 |
| 7 | Zinc | 5.0 | 0.026 | 0.035 | 0.018 | 0.012 | 0.023 | 0.018 | <0.0021 | <0.0021 | <0.0021 | <0.0021 | <0.0021 | <0.0021 |
| 8 | Cadmium | 0.005 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 |
| 9 | Lead | 0.01 | 0.0042 | 0.0023 | <0.001 | 0.0054 | 0.0052 | 0.0029 | <0.001 | <0.001 | <0.001 | 0.01 | 0.011 | 0.007 |

**Table 2** - Results obtained in comparison with the threshold values according to ROMU07 for waste storage D2

| Nr. crt | Quality indicators | Values according to **ROMU07** (mg/L) | 2024 sem. 1 | | | 2024 sem. 2 | | | 2025 sem. 1 | | | 2025 sem. 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | F1 | F2 | F3 | F1 | F2 | F3 | F1 | F2 | F3 | F1 | F2 | F3 |
| 1 | Ammonium | 1,2 | 0.08 | 10.9 | 0.81 | 0.05 | 11.2 | 1.51 | <0.07 | 2.32 | 1.06 | <0.07 | 3.72 | 0.34 |
| 2 | Nitrites | 0.5 | 0.08 | 0.94 | 0.02 | 0.04 | 0.79 | 0.39 | <0.04 | <0.04 | <0.04 | <0.04 | 0.82 | 0.14 |
| 3 | Chromium | 0.05 | <0.0014 | 0.0041 | <0.0014 | <0.0014 | 0.01 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 |
| 4 | Nickel | 0.02 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | 0.017 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 | <0.0012 |
| 5 | Copper | 0.1 | 0.049 | 0.073 | 0.065 | 0.0074 | 0.02 | 0.0053 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 | <0.0014 |
| 6 | Zinc | 5.0 | 0.032 | 0.074 | 0.042 | 0.015 | 0.032 | 0.01 | <0.0021 | <0.0021 | <0.0021 | <0.0021 | <0.0021 | <0.0021 |
| 7 | Arsenic | 0.01 | 0.0087 | 0.014 | 0.0039 | <0.0028 | <0.0028 | <0.0028 | <0.0028 | <0.0028 | <0.0028 | <0.0028 | <0.0028 | <0.0028 |

*"<" represents the value below the method's detection limit*

This study evaluates the two-year evolution of selected groundwater quality indicators at two closed non-compliant landfills and compares the measured concentrations with the groundwater-body-specific threshold values established by Romanian legislation. For landfill 1, significant values exceeding the limits set by Order No. 621/2014 were recorded only for ammonium (limit: 1.6 mg/L) and nitrites (limit: 0.5 mg/L), detected at the monitoring points upstream (F1) and downstream (F3) of landfill D1. The concentrations of the analyzed metals were below the limits established by legislation. For landfill 2, significant values exceeding the limits set by Order No. 621/2014 were recorded only for ammonium (limit: 1.2 mg/L) and nitrites (limit: 0.5 mg/L) in the downstream monitoring boreholes F2 and F3. The concentrations of the analyzed metals were below the limits established by applicable legislation.

The presented model suggests a possible influence of leachate infiltration from the landfill into the aquifer, resulting in impaired groundwater quality/potentially due to inadequate sealing of the municipal landfill base or an insufficient number of leachate collection drainage systems. The degree of groundwater quality deterioration associated with non-compliant landfills exceeded established limits for ammonium and nitrites during the monitored periods. Monitoring results indicated fluctuations in the concentrations of these parameters, potentially attributable to climatic factors.