Leachate Treatment Plants Used Inside Compliant Landfills, Solutions to Comply with Technical Environmental Protection Standards

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Abstract. The purpose of this paper is to present solutions chosen for the treatment of leachate resulting from the storage of non-hazardous solid wastes, from a landfill site. The technical characteristics of the installations dealing with the leachate of the compliant landfills must be designed so that the characteristics of the effluent correspond to the limits of pollutant loading of industrial and urban waste water into the discharge into the treatment plants or natural receptacles. From a technical point of view, water management solutions at the compliant landfill site provide a distinct separation of the rainwater from the site and the compliant landfill leachate resulting from wastes moisture content and rainwater that percolates the waste cell in operation. The sewage treatment plants aim to treat the leachate from the body of the landfill and do not interfere in the water balance in the related service area inside the landfill location.

1. Introduction
In assessing the quality of groundwater in the area of a landfill, it must be taken into account the provisions of the normative act on the storage, GD no. 349/2005 [1], Annex no. 4 namely: a. prior to the entry into service of new landfills, samples shall be taken from at least three points to establish reference values for subsequent withdrawals (Article 2.3.4), b. the indicators to be analyzed in the samples are chosen on the basis of the ground water quality and the predicted composition of the leachate (Article 2.3.5).

The alert thresholds are determined taking into consideration the hydrogeological formations specific to the area where the landfill is located and the water quality of that water body. The level of pollution control is based on the average composition determined from the local variations of groundwater quality for each control drilling. The threshold values for groundwater bodies in Romania were established by Government Order 621/2014 [2]. In order to highlight the quality of the underground water during the period of operation, water samples were taken from the monitoring drills.

The obtained results are compared with the reference values - the groundwater quality assays in the 1-4 drilling - before commissioning - 2002 and the threshold values for the groundwater body to which the analyzed site belongs, namely the body of water for ground water and the body of water for deep
underground water, (according to Order 621/2014 regarding the approval of the threshold values for groundwater bodies in Romania).

The amount of leachate and its degree of contamination are dependent on: the type of waste stored, the age, the height of the deposit, the weather characteristics of the location, the quality of the insulation at the surface of the deposit.

a. time shift of the leachate composition. The composition of waste by the high degree of diversification generates similarly a high degree of diversification of the leachate composition. Thus, waste with a high content of biodegradable materials influences the quality of the leachate.

b. the age of the deposit. Over time, the concentrations of the leachate compounds decrease the content of water, dissolved gases and biomass. Quantitative leachate increases in the first 4 years, decreases until the 8th year and reaches a constant value of about 1 % of the maximum amount.

c. temperature. Temperature influences biological processes and chemical reactions occurring in the mass of the deposit. In landfill with particular heights, waste at depths exceeding 15 m are not influenced by seasonal temperature variations.

d. the available oxygen content of the waste. Waste decomposition and release of chemicals occur differently under aerobic or anaerobic conditions resulting from the coating of waste deposited with inert material. Larger waste deposits are favored by anaerobic conditions.

e. humidity of waste. The placement of deposits in areas characterized by predominantly rainy weather conditions generates higher quantity and quality of leachate if coverage is not adequate. Climate conditions also lead to seasonal variations.

f. uniformity of stored mass. A municipal waste repository is not homogeneous, with waste water that readily adsorbs water such as cardboard or paper, as well as wastes at the far end such as plastics, glass, or construction waste.

2. Materials and method

The technological flow for the leachate treatment plant must involve efficient and state-of-the-art unitary wastewater treatment processes.

The raw leachate collected by drainage systems built of PEHD-perforated tubes and mounted in each operational sector of the landfill is transported by a collecting drain, also made of PEHD, to the pump house and then pumped into the leachate collection tank. The leachate flow generated can be managed either by storage in the storage or by pumping into the raw leachate collection tank. The leachate is after that pumped from the storing tank into the treatment plant.

The modern installation used is designed in modular form and often only requires a foundation made of concrete prefabricated. Containers should be provided with electrical connections, leachate feed, concentrated exhaust and permeate exhaust.

The leachate should be brought from the initial value of pH to 6.0-6.5 for which reason the pH is adjusted with 96% sulfuric acid in a recirculation vessel. This is done to prevent precipitation of salts.

After adjusting the pH, the leachate is passed through the sand filter and the "cartridge" filters, where all particles larger than 10μm are retained.

After pre-filtration, the leachate is passed through the membrane filtration modules by means of a high-pressure pump, this being the first reverse osmosis step.
It distributes the leachate through the radial-channel-disc-tube module (RCDT). The resulting concentrate is sent back to the warehouse. The permeate is passed to the second reverse osmosis purification step in the second block of modules.

A phase of the permeate is required when the quality of the leachate treated in the first stage does not meet the required discharge limits. The permeate of the first reverse osmosis purification phase is again filtered through the membranes. The components dissolved in the water that passed the first stage of reverse osmosis are again reduced in a proportion of 80-90% so that the discharge conditions are met safely.

A double degassing is required to remove the dissolved gases in the permeate after the second reverse osmosis step. The permeate is directed to the first degassing tower and then collected in a tank where the pH is raised to 10.5 and then pumped into the second degassing tower and then collected in another tank where the pH will be brought to 6.5-8.00. The first degassing tower removes CO$_2$ and H$_2$S, and second, NH$_4$. Afterwards, the permeate is pumped into the water tank for fire. Because in the modern leachate treatment plants, the pond meets the requirements of NTAPAO01 [3], it can be used not only for extinguishing fires, but also for watering green areas, recultivated areas and waste during dry periods.

![Figure 1. Treatment of leachate by reverse osmosis osmosis. Process flow](image)

In many cases in the area where the landfill is located historical pollution due to anthropogenic activity, can be encountered before the deposition was put into operation, with overstepping of the concentration of sulphates, chlorides and nitrates registered. These facts are demonstrated in the site analysis form the current period and the reference period as shown in the Table 1.

In order to establish the environmental impact and the effects of site activity on environmental factors, the groundwater quality is monitored by sampling from monitoring wells 1, 2, 3, 4 and 5. The frequency of monitoring according to the Regulatory Acts is half-yearly (2 measurements/year) for groundwater level and yearly (1 sample/year) for the indicators listed in the Table 2.

The main water monitoring installations in the operational phase of a landfill:
- a. observation drills 1, 2, 3, 4, 5 for underground water, they are placed on the perimeter contour of the deposit;
- b. manholes for pumping the leachate collected from the landfill;
- c. the leachate collection basin;
- d. septic tank - for domestic water coming from administrative and auxiliary personnel;
- e. surface monitoring usually includes 2 upstream points 1 point upstream and 1 point downstream of the deposit on the emissary.
Table 1. Underground water quality (monitoring drills) 2014-2016 compared to the reference values (year 2002) and the water quality limits of the water body

| Year       | Monitoring drills | Analyzed indicators |
|------------|-------------------|---------------------|
|            | Monitoring drills | pH (unit. pH) | Ammoniacal nitrogen (mg/l) | Nitrate (mg/l) | Sulfates (mg/l) | Chloride (mg/l) | Calcium (mg/l) | Lead (mg/l) | Phosphates (mg/l) | Organochlorine pesticides (mg/l) |
| Dec. 2014  | 1                 | 6.97            | 0.28 | 1.32 | <0.003 | 1460 | 484.5 | <0.011 | <1 | 0.093 | - |
|            | 2                 | 6.78            | <0.01 | 1.26 | <0.003 | 1156 | 398 | <0.011 | <1 | 0.14 | - |
|            | 3                 | 6.80            | <0.01 | 1.48 | <0.003 | 1270 | 380.7 | <0.011 | <1 | 0.13 | - |
|            | 4                 | 6.82            | 0.24 | 1.55 | <0.003 | 1407 | 519.1 | <0.011 | <1 | 0.12 | - |
|            | 5                 | 6.72            | <0.01 | 1.19 | <0.003 | 1237 | 398 | <0.011 | <1 | 0.27 | - |
| July 2015  | 1                 | 6.4             | <0.016 | <0.05 | 0.02 | 2075 | 179.39 | <0.04 | <0.04 | 0.1 | <0.005 |
|            | 2                 | 6.5             | <0.016 | 0.87 | 0.02 | 1532 | 192.15 | <0.04 | <0.04 | 0.13 | <0.005 |
|            | 3                 | 6.6             | <0.016 | 0.07 | 0.02 | 1424 | 167.33 | <0.04 | <0.04 | 0.10 | <0.005 |
|            | 4                 | 6.8             | 0.02 | 0.07 | 0.02 | 1567 | 186.48 | <0.04 | <0.04 | 0.16 | <0.005 |
|            | 5                 | 6.6             | 0.04 | <0.05 | <0.013 | 1601 | 96.43 | <0.04 | <0.04 | 0.08 | <0.005 |
| Dec. 2016  | 1                 | 6.7             | 0.134 | 0.388 | <0.006 | 6393 | 209 | <0.14 | <0.13 | <0.015 | <0.001 |
|            | 2                 | 6.7             | 0.157 | 0.343 | 0.033 | 4895 | 272 | <0.14 | <0.13 | <0.015 | <0.001 |
|            | 3                 | 6.6             | 0.262 | 0.533 | 0.034 | 3996 | 315 | <0.14 | <0.13 | <0.015 | <0.001 |
|            | 4                 | 6.6             | 1.34 | 0.489 | <0.006 | 4236 | 209 | <0.14 | <0.13 | <0.015 | <0.001 |
|            | 5                 | 6.2             | 2.46 | 0.407 | 0.032 | 4216 | 244 | <0.14 | <0.13 | <0.015 | <0.001 |
| Reference values 2002 | 1 | 6.82 | 1.03 | 0.014 | 7.02 | 1500 | 248 | - | - | 0.01 | - |
|            | 2                 | 7.19 | 0 | 0.014 | 2.03 | 1200 | 319 | - | - | 0.09 | - |
|            | 3                 | 7.52 | 0 | 0.002 | 1.17 | 1350 | 284 | - | - | 0.05 | - |
|            | 4                 | 7.51 | 0.62 | 0.15 | 0.89 | 1495 | 319 | - | - | 0.13 | - |
| Threshold values (Order 621/2014) | - | - | 1.9 | - | 0.5 | 250 | 250 | - | 0.2 | 0.6 | - |
Table 2. Indicators monitored annually to determine the quality of groundwater

| Indicator                               |
|-----------------------------------------|
| Ammonium (NH\(_4^+\))                  |
| Nitrates (NO\(_2^-\))                  |
| Nitrites (NO\(_3^-\))                   |
| Fosfați (PO\(_4^{3-}\))                |
| Phosphates (SO\(_4^{2-}\))             |
| Chloride                                |
| pH                                      |
| Residue filtered on 105°C               |
| Heavy metals (Cd\(^{2+}\), Pb\(^{2+}\), As\(^{3+}\)) |
| Active substances from pesticides, including metabolites, relevant degradation and reaction products |

Table 3. Monitoring of the water environment factor on the location of the landfill

| Crt. no | Potential pollution sources of the water environment factor | Reference values | Tracking in the operating phase | Follow-up in after the landfill closure | Place of sampling / monitoring |
|---------|------------------------------------------------------------|------------------|---------------------------------|------------------------------------------|---------------------------------|
| 1.      | Leachate volume                                            |                  | Daily                           | Semester                                 | Collector tank levigat           |
| 2.      | Leachate composition: pH, solids in suspension, chemical oxygen demand, biochemical consumption of oxygen, ammonia, organic nitrogen, total nitrogen, nitrates, nitrites, sulfates, chlorides, heavy metals, total phosphorus | Quarterly         | Semester                        | Collector tank                      |
| 3.      | Volume of generated leachate                               | Quarterly         | Semester                        | Water meter mounted on the permeate exhaust pipe from the leachate treatment plant. |
| 4.      | Permeate composition: pH, solids in suspension, chemical oxygen demand, biochemical oxygen demand, ammonium, total phosphorus, organic solvents extractable. | NTPA 002/2005    | Quarterly                        | Semester                        | Permeate collection basin       |
| 5.      | Groundwater composition: pH, ammonium, chlorides, sulfates, cadmium, lead, arsenic, nitrates, nitrites, phosphates, filterable residue at 105 °C, organochlorine pesticides | Order 621/2014 water bodies and reference values. | Annual                          | Annual                          | Observation boreholes 1, 2, 3, 4, 5 |
| 6.      | Groundwater level                                           |                  | -                               | Semester                                 | Observation boreholes 1, 2, 3, 4, 5 |
| 7.      | Pluvial water: pH, CBO5, extractable substances in petroleum ether, petroleum products, fixed residue, suspended matter. | NTPA 001/2005    | Annual                          | Annual                          | emissary                        |
3. Results and discussions
In the case of the studied site, no waste water is discharged directly into a natural receiver. In the natural emissary only uncontaminated pluvial water is discharged. As with the environmental factor – groundwater, the surface water, it was imposed by the current Environmental Authorization, to be monitored once a year of by sampling water from the discharge zone

The quality of surface water - in relation to the quality limits imposed by NTPA 001 - 2005, in the period 2014 - 2016, is shown in the Table 4.

As shown in Table 4, water from the point of discharge is maintained within the defined quality limits NTPA 001-2005.

Table 4. The quality of surface water in the discharging area in relation to the quality limits imposed by NTPA 001 - 2005, between 2014 and 2016

| Crt.no | Indicator analyzed | MU           | Established value | Limit value according to NTPA 001-2005 |
|--------|--------------------|--------------|-------------------|----------------------------------------|
| 1      | pH                 | Unit. pH     | 7.39 7.12 6.7    | 6.5 - 8.5                              |
| 2      | CBO5               | mg/l         | 16.9 14.4 <6     | 25                                     |
| 3      | Extracts of petroleum ether | mg/l | <20 <20 <20 | 20                                     |
| 4      | Petroleum products | mg/l         | 0.05 <0.05 <0.1 | 5                                      |
| 5      | Fixed residue      | mg/l         | 572 574 135      | 2000                                   |
| 6      | Suspended matter   | mg/l         | 56 28 54         | 60                                     |

4. Conclusions
Appropriate exploitation strategies are adopted that can reduce or even avoid the danger of accidents endangering the status of groundwater or surface water quality. The use of permeate as greenhouse spraying water will be done only under the conditions required by pedological and agrochemical permits from the competent institutions in the area under the Water Management Permit in force. During dry periods, the water from the fire reserve can be used to spray the landfill. Filling and refreshment of the volume of water from the fire reserve is also accomplished with the permeate resulting from the treatment of the leachate in the leachate treatment plant. The main reasons for landfill spillage during periods of drought are: fire prevention, biogas production, better waste compaction and reduced particle trapping.

References
[1] Govermental decision no.349/2005 regarding waste landfill
[2] Government Order 621/2014 regarding the approval of threshold values for groundwater in Romania
[3] Normative on the determination of limits for pollutant loading of industrial and urban waste water to evacuation to natural receptors, NTPA-001/2002, of 28.02.2002.