CHAPTER

5

MONITORING OF THE REHABILITATED SITES

5.1. Introduction

An open dump similarly to landfill site, after its closure and rehabilitation, continues to be a threat to the environment. Many biological and chemical processes still take place in the collected waste. Therefore, special care, proper maintenance and monitoring are necessary.

The monitoring of the open dumps after rehabilitation is similar to monitoring of landfills after closure. From the legal point of view all rules for monitoring of landfills must be followed and are valid for the open dumps after rehabilitation accordingly.

Monitoring of an open dump as well as municipal waste landfill includes several elements important from the point of view of its impact on the broadly understood natural environment. We can distinguish here leachate and landfill gas, ground and surface waters, the amount of precipitation, the structure and mass of the collected waste, subsidence of the landfill surface and noise.

Monitoring of open dumps is a long process that is carried out during development, operation and management after all landfills have been closed. Open dumps containing biodegradable waste or other contaminants should be monitored for up to 50 years or even more.

Landfill monitoring should take place in all phases of its life cycle (MŚ2002):

- pre-exploitation phase - the period of site preparation and development – before use;
- exploitation phase - the period from the date of starting operation of the landfill to the date of its closure;
- post-exploitation phase - a period of usually 30 years from the landfill closure.

If the landfill has been run without meeting the relevant standards and permits, then after its reclamation, monitoring should follow the same rules as in the post-exploitation phase.

Requirements for the monitoring system of landfills are subject to legal regulations of each country, which define the principles and method of its operation.

5.2. Monitoring of open dumps after rehabilitation and waste landfills

Landfills should be monitored at all stages of the life cycle. This means that from the planning stage to the stage of their closure, rehabilitation and post-exploitation phase, a planned monitoring mechanism should be implemented, ensuring the highest possible level of environmental protection.

Monitoring in the **pre-exploitation phase** is aimed at assessing the initial state, i.e. determining the background, and includes (ME 2002):

1. determining the average meteorological data appropriate for the location of a waste landfill;
2. checking the correctness of the implementation of the elements of the waste landfill used for monitoring, in particular the correctness of the observation holes for groundwater and the stabilization of geodetic benchmarks;
3. measurement and assessment of compliance with the groundwater level in the observation holes provided for in the waste landfill construction project;
4. designating in the instruction for managing a waste landfill the places of sampling and substances for further monitoring tests for landfill gas;
5. designation in the instructions for running a landfill of sampling sites and index parameters for further monitoring tests separately for surface, leachate and groundwater, in accordance with the type of waste deposited, taking into account the composition of surface and ground waters identified before the landfill is operated; for groundwater indicative parameters are set as for leachate waters;
6. determination of the geochemical background of surface waters and groundwater in places that, according to the approved instructions for managing a waste landfill, are indicated for monitoring in further phases;
7. designation in the instruction for managing a landfill of places to measure the presence of mercury vapors for landfills.

Monitoring in the **operational phase** consists of (MŚ 2002):

1. the study of the amount of atmospheric precipitation from measurements carried out in the landfill or outside of it, if during the assessment of the initial state a meteorological station representative for the location of the landfill was indicated;
2. measurement of groundwater level in observation wells;
3. measuring the flow of surface waters;
4. control of subsidence of the landfill surface based on the established benchmarks;
5. testing of indicator substances and parameters in surface waters, leachate waters, underground waters and landfill gas;
6. measuring the emission of landfill gas;
7. control of the structure and composition of the landfill mass in terms of compliance with the permit for the construction of the landfill and the instructions for managing the landfill;
8. mercury vapor measurement for landfills;
9. visual inspection of the storage site and containers for landfills, in terms of detection of possible leaks or other irregularities posing potential threat to human health or to the natural environment.

Monitoring in the **post-exploitation phase** consists of (MŚ 2002):

1. the study of the amount of atmospheric precipitation from measurements carried out in the landfill or outside of it, if during the assessment of the initial state or the procedure of closing the landfill, a meteorological station representative for the location of the landfill has been indicated;
2. measuring the level of groundwater;
3. measuring the flow of surface waters;
4. control of subsidence of the landfill surface based on the established benchmarks;
5. testing indicator parameters in surface waters, leachate waters, underground waters and landfill gas;
6. measuring the emission of landfill gas;
7. checking the efficiency of the landfill gas utilization system;
8. mercury vapor measurement for landfills;

9. visual inspection of the storage site in terms of detection of possible leaks or other irregularities posing potential threat to human health or to the natural environment.

The set of different useful indicators for monitoring open dumps after rehabilitation and for landfills during other phases is discussed in the table 5.1.

Table. 5.1. The scope of indicator parameters and the minimum frequency of tests of surface waters, leachate waters, underground waters and landfill gas in individual phases of landfill operation (MŚ 2013).

Measured parameter	Pre-operation phase	Operation phase	Post-exploitation phase
Surface water flow rate	once	every 3 months	Every 6 months
Composition of surface waters	once	every 3 months	Every 6 months
Seepage water volume	lack	every 1 month	Every 6 months
The composition of the seepage waters	lack	every 3 months	Every 6 months
Groundwater level	once	every 3 months	Every 6 months
Landfill gas emission	lack	every 1 month	Every 6 months
The composition of the landfill gas	lack	every 1 month	Every 6 months
Efficiency of the landfill gas discharge system	lack	lack	every 12 months

As each landfill is different and located in a different environment, the monitoring process should be designed individually, taking into account the local specificity. A risk analysis should also be performed. The risk assessment should provide structured, practical help for decision-makers. The initial stage of risk assessment includes the development of landfill model that identifies the nature of the investment and its hydrogeological conditions, and covers potential sources, pathways as well as impact receptors. The susceptibility of those receptors should be assessed in relation to the hazard of the source (like leachate or landfill gas) and whether there are any methods of impact migration available.

5.3. Landfill gas monitoring

Landfill gas is a mixture consisting mainly of methane and carbon dioxide and small amounts of hydrogen. It may also contain some amount of nitrogen as well as oxygen.

The typical composition of a landfill gas is as follows (EA 2004):

- Methane - 63.8%,
- Carbon dioxide - 33.6%,
- Oxygen - 0.16%,
- Nitrogen - 2.4%,
- Hydrogen - 0.05%,
- Water vapour - 1.8%.

Landfill gas could contain many trace components. This number could be as high 550. They belong to different chemical groups. Most of the components of landfill gas are greenhouse gases, therefore monitoring of its emissions is very important.

The Landfill Directive and other landfill legislation require the landfill operator to carry out monitoring during the landfill operation phase. It is required that the operator must implement monitoring during the closure and maintenance period till that time when appropriate authority takes the decision that the landfill is no longer posing a risk to the environment.

Landfill gas monitoring is essential for proper management of any landfill. The monitoring plan must be developed and placed in the relevant documents.

The monitoring plan should define objectives and describe a monitoring program for specific site. This includes (EA 2004):

- type of monitoring;
- monitoring methods;
- location of monitoring tools;
- the frequency of monitoring;
- relevant actions / trigger levels to require action;
- the action plans which should be implemented in case if any levels above the levels are reached.

Items that should be monitored for landfill gas are:

- collecting and monitoring wells,
- surface and transverse (side) emissions,
- flares or/and installations for energy recovery from landfill gas,
- odours,
- meteorological data (weather conditions).

For landfill gas, there is a correction to monitor the substance onset:

- methane (CH_4);
- carbon dioxide (CO_2);
- oxygen (O_2).

Landfill gas emissions are measured in representative parts of a landfill, set out in the landfill management instructions, at the places of its collection, upstream of the landfill gas treatment and use or disposal installation.

The frequency of monitoring depends on many factors. These include the following items that relate to the conceptual model:

- landfill age
- type of waste stored
- control tools installed
- geology of the surroundings
- potential threat from emitted gases
- sensitivity of the environment and receptors
- results of previous monitoring activities.

Measurement of mercury vapours for landfills is carried out in the tank, with the use of sensors located at the bottom of the tank and at a height of 1.7 m, located in places ensuring reliable monitoring of the entire surface of the tank; sensors for measurement should have a sensitivity of at least 0.02 mg of mercury / m3. An integral part of the mercury vapor monitoring system is the optical and audible alarm system.

The parameters related to landfill gas emission for open dumps after rehabilitation and landfills during other phases is given in table 5.2.

Table. 5.2. Type of sampling site and typical frequencies of landfill gas monitoring (EA 2004).

Monitoring sites	Monitoring frequency during the operational phase	Post-maintenance monitoring frequency	Measured parameters
Surface emissions	Annually	Annually	CH_4 concentration Meteorological data Atmospheric pressure Temperature The general structure and condition of the surface
Measurement boreholes (outside the landfill)	Monthly	Every 6 months	CH_4, CO_2, O_2 Atmospheric pressure Differential pressure Temperature Meteorological data
Collecting wells	Every 2 weeks	Every 6 months	CH_4, CO_2, O_2 Atmospheric pressure Differential pressure Temperature Gas flow rate Meteorological data
Gas collection system	Annually	Annually	Composition of landfill gas including trace components received directly from the landfill before the utilization/disposal system
Flares or/and energy recovery installations	Annually	Annually	NOx, CO, VOCs, NMVOCs

Landfill gas should be monitored for the following components:

- source
- emissions
- air quality
- meteorology.

The purpose of **source monitoring** is to characterize the quantity and quality of gas in all parts of the landfill.

The purpose of the routine monitoring to reveal the composition of landfill gas and is usually performed using portable instruments. These instruments measure the mass components in the landfill gas and the associated physical parameters.

There are two different types of source monitoring points in landfills and open dups after rehabilitation: collection wells and monitoring wells.

In addition to monitoring of landfill gas concentration, its composition and pressure the gas flow rates should also be monitored. This is done to obtain good enough control of the gas collection and utilization systems. The rate of active gas measured in production wells can range from up to several hundred cubic meters per hour.

Monitoring of emissions at landfills and open dups after rehabilitation will typically include:

- emissions from the gas collection system
- surface emissions
- side emissions
- combustion emissions.

The monitoring of **surface emissions** is carried out for the purpose:

- identify problems in the gas management system and prioritize required repairs,
- measuring total methane emissions, which is important greenhouse gas.

A qualitative estimate of methane emissions from the sealing layer at the top of the landfill's surface can be done using a hand-held instrument such as a flame ionization detector (FID).

It is difficult to detect and measure a very small stream of gases permeating through the layers covering the landfill and open dups after rehabilitation. Current research work suggests that special measurement boxes (Flux-boxes) are currently the most economically efficient technique for verifying surface emission sources. These are closed chambers used to measure the rate of changes in methane concentrations over a specific, small area of the landfill's and open dups after rehabilitation surface. Measuring the flux at various (representative) sampling points, the total emissions from the entire zone can be estimated.

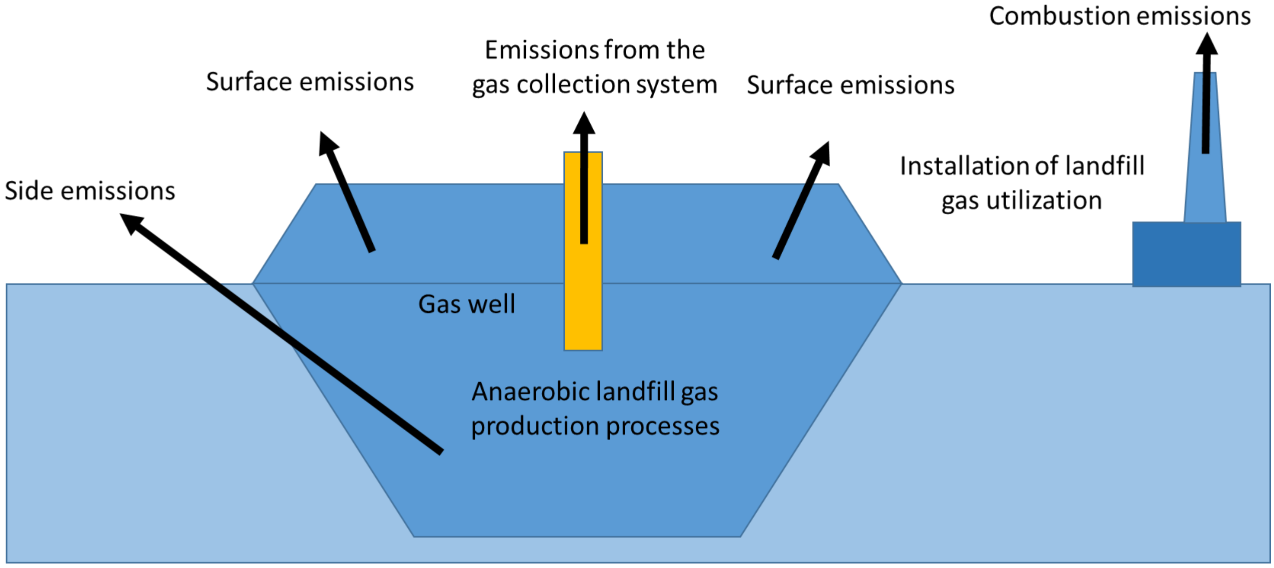

Figure 5.1. Landfill gas emission monitoring sites.

It should be noted that good methods for determining diffuse greenhouse gas emissions from municipal landfills have not yet been developed (Klimek 2010).

A standard for the assessment of methane emissions into the air is prepared - ISO / TC 146 / SC 1 / WG 22. Measurement method of releases to air for CO2 - ISO 12039: 2001 applies only to stationary, and therefore point sources of emissions and cannot be used to measure diffuse emissions from the landfill and open dups after rehabilitation.

The qualitative and quantitative measurements of landfill gas emissions have been carried out using various methods for many years. However, there is no method yet to solve the problems associated with the high variability with time that occurs during the research. There is also no reference measurement method that would allow to accurately determine the amount of landfill gas emissions from the entire landfill during the year. The examples of studies carried out so far using various methods show that the range of emission values measured in one landfill is very large and the results may differ by even several orders of magnitude.

Sideline emissions are monitored using gas monitoring wells outside the landfilled area. These wells can be located both on-site and off-site. They provide information on the flow of landfill gas under the surface of the landfill and open dups after rehabilitation from the mass of waste. Monitoring of external boreholes is essential to demonstrate effective gas management on the site and to detect any gases migrating from the site.

Monitoring of the combustion is carried out in relation to emissions from equipment and installations for the neutralization (flare) or the energetic use of biogas (e.g. gas engines). Devices of this type are subject to separate regulations and must meet the relevant emission standards.

It is becoming increasingly important to **monitor air quality** in and around landfills and open dups after rehabilitation. Measurements of this type confirm and verify the emission measurements from the site itself.

Odour monitoring has a number of different purposes, including:

- development of input data for risk assessment and predictive dispersion modelling,
- development of a gas monitoring plan,
- prioritizing odour sources to alleviate or reduce,
- selection of odour reducing agents,
- evaluation of the effectiveness of odour limiting and mitigating measures.

Odour measurements shall be made from the farthest point from the site to the wind direction towards the site boundary or to the site itself. The persistence of the smell should be recorded along with its location from the border of the site. The odour monitoring can be accompanied by techniques like gas chromatography, olfactometry, or mass spectrometry. The air samples taken should be assessed for odour strength and potential source. Olfactometry presents air samples of varying dilution to the fragrance panel.

Atmospheric pressure is an important parameter when checking source monitoring points. It should be measured regularly to facilitate understanding of gas pressure readings in the mass of waste deposited. Rapid drops in atmospheric pressure can cause the pressure of the landfill gas to be significantly higher than the ambient atmospheric pressure, causing possible migration. Monitoring the pressures in the mass of waste indicates the higher probability of gas migration to occur.

The migration of landfill gas could be affected by the changes of pressure, in the mass of waste itself and in atmospheric pressure.

Monitoring of the pressure and composition in waste requires the installation of permanent sampling points distributed in selected locations. The atmospheric pressure should be monitored continuously or regularly (e.g. hourly) to make proper use of the pressure data. This can be achieved with an automatic weather station.

5.4. Leachate monitoring

Leachate is a liquid that can have a detrimental effect on groundwater and surface water. For this reason, it should be properly managed and / or cleaned, and then introduced into the environment in a controlled manner. The permits related to the operation of landfills and open dups after rehabilitation include a requirement to ensure that the leachate does not pose a risk to the environment and human health and therefore an appropriate monitoring system should be implemented.

Leachate and groundwater monitoring as well as surface water monitoring in landfills and open dups after rehabilitation are aimed at:

- determining whether the landfill is operating as designed;
- determining whether the leachate is an environmental hazard;
- determining whether the inspection and monitoring requirements in accordance with the applicable legislation are met;
- determination that the requirements of the legal regulations on groundwater are met;
- determine if further testing is needed and, where the risk is not be accepted, indicate the need for measures to reduce or prevent as well as remove contamination from leachate;
- determining when the site no longer poses a very high risk to human health.

In order to design an effective monitoring program, an awareness of the overall "water balance" is needed. The water balance can be summarized with the following simplified equation (EA 2003):

L = sum of inputs of all liquid - sum of all outputs of liquid

The “L” in the equation above is the total volume of liquid in the waste stored in the landfill and open dups after rehabilitation.

This equation should be adapted to make possible site-specific design of leachate collection and management systems, taking into account inter alia infiltration into open and closed cells, waste absorption properties and waste introduction rates.

Leachate monitoring programs typically consist of five steps (EA 2003):

- preliminary monitoring of the characteristics of ground and surface waters;
- routine monitoring of ground and surface waters;
- assessment monitoring including groundwater control and all trigger levels;
- monitoring of the leachate characteristics;
- monitoring of closure.

At the stage of **preliminary monitoring of ground and surface waters characteristics**, sampling should be carried out in at least three places. The aim is to determine the characteristics and the usual range of variability for surface and ground waters parameters. The frequency and scope of collected data form monitoring must be sufficient to be able to characterize, inter alia, seasonal factors.

The **routine stage of groundwater and surface water monitoring** is carried out in order to maintain the continuity of environmental monitoring.

Monitoring of groundwater and soil is intended to signal the spread of leachate and pollutants in aquifers. The network of piezometers, located in the landfill, should be used to monitor the level and composition of groundwater. The study of the groundwater level will consist in measuring the distance from the water table to the reference point - leveled orifice of the piezometer. Use a measuring whistle or electronic devices for the measurement. After measuring the groundwater level, a test sample should be taken. Rinse the container before taking a sample with withdrawn water. The water sample should be taken with equipment that will allow it to be taken from a certain depth without changing its quality. It should be made of inert materials (e.g. stainless steel). Scoops and various types of samplers can be used to collect groundwater samples. The following indicator will be tested in groundwater:

1. Cu, Zn, Pb, Cd, Cr_6, Hg;
2. Total Organic Carbon (TOC);
3. Sum of polycyclic aromatic hydrocarbons (PAHs).

4. pH reaction;
5. Specific electrolytic conductivity;

Measurements should be carried out every 6 months.

The breakpoints for groundwater pollution indicators may differ from country to country.

An exemplary size range for cleanliness classes I and V are as follows (Kapelewska 2018):

- General:
    - Reaction (pH) 6.5-9 - 6.5-> 9.5
    - Temperature 10 - 25 ^{o}C
    - Specific electrolytic conductivity 700 -> 3000
    - Total iron 0.2 -> 10 mg / L
    - Total chromium 0.01 -> 10 mg / L
- Inorganic cations:
    - Ammoniacal nitrogen 0.5 -> 3 mg / L
    - Sodium 60 -> 300 mg / L
    - Potassium 10 -> 20 mg / L
    - Iron 0.2 -> 10 mg / L
    - Aluminum 0.1 -> 1 mg / L.
- Inorganic anions
    - Nitrate nitrogen (V) 10 -> 100mg / L
    - Nitric nitrogen (III) 0.03 -> 1 mg / L
    - Phosphates 0.5 -> 5mg / L
    - Chlorides 60 -> 500mg / L
    - Cyanides 0.01 -> 0.1 mg / L
    - Sulphates (VI) 60 -> 500mg / L

- Organic
    - Total organic carbon 5 - >20 mg/L
- Trace substances
    - Copper 0.01 -> 0.5 mg / L
    - Lead 0.01 -> 0.1 mg / L
    - Nickel 0.005 -> 0.1 mg / L
    - Zinc 0.05 -> 2mg / L
    - Bor 0.5 -> 2 mg / L

The monitoring of the characteristics of the leachate is carried out in order to obtain qualitative information on the impurities present in the leachate. Remember that leachate formation is a complex and time-varying process. Therefore, significant changes in physical properties and the composition over time and between the different sections of the landfill should be taken into account and an appropriate measurement system should be selected.

Monitoring the assessment is based on a greater intensity of monitoring, the need for which may arise when significant deviations from baseline are identified.

Closure monitoring is a process carried out at the end of the use of the landfill and open dups after rehabilitation (in the case of illegal landfills subject to rehabilitation) service life to demonstrate that the site does not harm human health and the environment.

For surface and leachate waters for municipal waste landfills and open dups after rehabilitation, monitoring of the following indicator parameters is required:

1. reaction (pH);
2. specific electrolytic conductivity.
3. total organic carbon (TOC);
4. content of individual heavy metals, including copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr+6) and mercury (Hg);
5. total polycyclic aromatic hydrocarbons (PAHs).

Tests of the above-mentioned parameters should be performed in specialized research laboratories having an appropriate quality assurance system implemented.

The amount of precipitation is tested once a day in the exploitation phase and in the post-exploitation phase.

If the results of the monitoring carried out for five years from the date of closure of a waste landfill show that the landfill has no environmental impact, the competent authority may reduce the frequency of testing individual indicative parameters, but not less frequently than once every two years, and for specific electrolytic conductivity - no less frequently than once a year; this condition does not apply to hazardous waste landfills

Measurement of the flow rate and composition of flowing surface waters, provided they occur in the immediate vicinity of the waste landfill, shall be carried out at no less than two points: one upstream of each watercourse, above the landfill, and the other downstream, below the landfill and open dups after rehabilitation.

Measurement of the volume and composition of leachate waters takes place at each collection point, prior to treatment.

If a landfill or open dups after rehabilitation is equipped with an installation for purifying leachate, the composition of the treated leachate is measured at each point of discharge of treated leachate from the landfill in order to control the effectiveness of the treatment process.

The limit values of pollution indicators that must be characterized by leachate introduced into the environment after the treatment process in a municipal wastewater treatment plant may differ from country to country. Examples of sizes are as follows (Kapelewska 2018):

- General:
    - Reaction (pH) 6.5-9
    - Temperature 35 oC
    - Total suspensions 35 mg / L
    - Easily falling suspensions 0.5 mg / L
    - Total nitrogen 30 mg / L
    - Total phosphorus 3 mg / L
    - Total iron 10 mg / L
    - Total chromium 0.5 mg / L

- Inorganic cations
    - Ammoniacal nitrogen 10 mg / L
    - Sodium 800 mg / L
    - Potassium 80 mg / L
    - Iron 10 mg / L
    - Aluminum 3 3 mg / L.
- Inorganic anions
    - Nitrate nitrogen (V) 30 mg / L
    - Nitric nitrogen (III) 1 mg / L
    - Chlorides 1000 mg / L
    - Cyanides 0.1 mg / L
    - Sulphates (VI) 500 mg / L
    - Sulphates (IV) 1 mg / L
- Organic
    - Chemical Oxygen Demand 125 mg / L
    - Biochemical oxygen demand 25 mg / L
    - Total organic carbon 30 mg / L
- Trace substances
    - Copper 0.5 mg / L
    - Lead 0.5 mg / L
    - Nickel 0.5 mg / L
    - Zinc 2 mg / L
    - Bor 1 mg / L
    - Chromium (VI) 0.1 mg / L

The number, depth and method of construction of openings for sampling and testing the composition of groundwater are specified in detail in the permit for the construction of a waste landfill; the number of holes cannot, however, be smaller than 3 holes for each of the aquifers, one of which should be in the inflow of groundwater, the other two - in the expected groundwater outflow.

If there is more than one aquifer below a landfill or open dups after rehabilitation, including useful aquifers, monitoring of the aquifers up to and including the first usable aquifer is necessary.

Water ends up in the landfill and open dups after rehabilitation mainly as rainfall going from the surface. In some cases as surface or groundwater inflows. Generated leachate, which is not collected and removed on site, can seep through the base or sides or leak to the surface. Effluents can also be moved out of the site for cleaning or recirculation or disposal.

Leachate monitoring is based on measurements of samples obtained from monitoring points. Leakage monitoring points can be classified according to their distinguishable location:

- as part of leachate drainage systems;
- in storage lagoons, storage tanks or discharge points;
- within leak detection layers underneath the base lining systems;
- in the mass of deposited waste.

Anywhere, monitoring points can be in one location or in a combination of several locations. The most frequently used are monitoring points within the deposited waste.

The preferred method of **meteorological monitoring** is data collection via a local weather station with automatic logging. If this is not possible then data obtained from the local weather station can be used.

A large number of substances are present **in trace amounts** in leachate. These compounds contribute significantly to the potential impact of environment. Usually the regulatory institutions are identifying the priority compounds which should be measured in leachate.

5.5. Monitoring of the surroundings

Soil contamination around a municipal waste landfill or open dups after rehabilitation may come from improper use of the site, incorrect drainage of water or uncontrolled spread of landfill gas. The area around the site may be a place of periodic or permanent occurrence in soil of bacteria, cysts of pathogenic elements. For this reason, soils should be examined for contamination with the elements of cadmium, zinc, lead, mercury and arsenic. The grain size composition, pH and organic carbon content should also be examined.

Sampling will be carried out in the areas adjacent to the landfill. Usually 3 - 5 incremental samples weighing approx. 500 g each are taken from each measuring point. The samples should be taken at a distance of 10 - 50 m from the landfill from a depth of 5 cm. Moreover, it is recommended to collect one sample in the direction of prevailing winds at a depth of 30 - 40 cm and in the direction of water runoff from the landfill area at a distance of approx. 100 m from the object at a depth of 30 - 40 cm. The samples should not contain stones, major plant debris and other contaminants.

5.6. Monitoring of the stability of the landfill and open dups after rehabilitation

Landfills as well as open dups after rehabilitation are not stable engineering structures. Due to the biological and chemical reactions occurring in the mass of deposited waste, the volume of the landfill may change. This causes the surface to settle. For this reason, for the sake of security, stability monitoring should be carried out.

As part of the stability monitoring, the course of subsidence of the landfill surface should be tested at least once a year. The evaluation covers the course of subsidence of the landfill surface, determined with the use of geodetic methods, with the use of established benchmarks. After carrying out the reclamation procedures, it is necessary to place min. 2 benchmarks at permanent points, used to measure the amount of detachment of the object.

The control of subsidence of the landfill and open dups after rehabilitation surface consists in the assessment of the course of subsidence of the landfill surface, determined with the use of geodetic methods, with the use of established benchmarks, and on the assessment of slope stability determined by geotechnical methods.

Geodetic marks should be made of durable material and physically define the points of the geodetic control network - that is, a set of points stabilized in the field, the mutual location of which is strictly defined.

Geodetic signs are therefore a very important element during works monitoring the stability of the site of a reclaimed landfill. They must be very durable, therefore they are usually made of various types of metals, such as steel, aluminum and brass, and are protected against the negative effects of corrosion. Most of these points look like screws and nails of various shapes and sizes.

Currently, the measurements are carried out with the use of the Geographic Satellite Positioning System (GPS) technique.

The study of the structure .and composition of the mass of deposited waste consists in determining the area and volume occupied by the waste and the structure of the deposited waste.

References

Environment Agency (EA), Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water, 2003, available in the internet: www.environment-agency.gov.uk

Environment Agency (EA), Guidance on the management of landfill gas, 2004, available in the internet: www.environment-agency.gov.uk

Gardło M., „Reclamation of waste landfills "under the project:" Construction of a modern waste management system, reclamation of inactive landfills and removal of asbestos in municipalities belonging to the municipal union of Lubartów lands" (Rekultywacja składowisk odpadów" w ramach projektu: „Budowa nowoczesnego systemu gospodarki odpadami, rekultywacja nieczynnych składowisk oraz usuwanie azbestu na terenie gmin należących do związku komunalnego gmin ziemi lubartowskiej), 2010.

Kapelewska J., Leachate from municipal landfills as a potential source of pollution of the aquatic environment, University of Białystok, Faculty of Biology and Chemistry, doctoral dissertation (Odcieki ze składowisk odpadów komunalnych jako potencjalne źródło zanieczyszczenia środowiska wodnego, Uniwersytet w Białymstoku, Wydział Biologiczno-Chemiczny, rozprawa doktorska), 2018

Klimek A. et al., Methodological guide in the field of PRTR for municipal waste landfills - Study financed by the National Fund for Environmental Protection and Water Management at the request of the Minister of the Environment (Poradnik metodyczny w zakresie PRTR dla składowisk odpadów komunalnych - Opracowanie finansowane ze środków NFOŚiGW na zamówienie Ministra Środowiska), 2010

Ministry of the Environment (Ministry of Environment), Regulation of the Minister of the Environment, 1 of 9 December 2002 on the scope, time, method and conditions of monitoring waste landfills (Ministerstwo Środowiska (MŚ), Rozporządzenie Ministra Środowiska, 1 z dnia 9 grudnia 2002 r. w sprawie zakresu, czasu, sposobu oraz warunków prowadzenia monitoringu składowisk odpadów), 2002