Qualitative Analysis of Leachates from the Restored Landfill Site in Osowo, Karsin Commune

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Abstract
The article presents the qualitative analysis of leachates from the restored landfill site of non-hazardous and inert wastes in Osowo in the Commune of Karsin. The study was conducted on a semi-annual basis from 2012 to the first half of 2014 in compliance with the Polish law. The analysis concerned the variability of pH and proper electrolyte conductivity (PEC), the content of total organic carbon (TOC) and the sum of polycyclic aromatic hydrocarbons (PAHs) as well as selected heavy metals. The study of leachate waters indicated that the site is stabilised and it does not have a negative impact on the underground waters. There were no exceedances of permissible values for any of the analysed parameters; however, the content of most heavy metals as well as the sum of PAHs were below the limit of quantification of the analytical methods.

1. Introduction

One of the problems related to waste deposition is the management of emerging leachate waters [1]. Leachates are defined as any liquid passing through the deposited wastes, which is exuded or squeezed in the landfill site [2]. The composition and quantity of leachates depend on many factors, of which the type of deposited wastes and the age of landfill site are the most important. The largest amount of leachate waters is recorded in the period of landfill operation. The intensity of their exudation increases with the age of waste deposition until the moment of stopping waste reception. This inherently involves saturation of waste retention capacity while reducing its water-holding capacity due to mineralisation of organic matter. Afterwards, the amount of leachate waters is significantly reduced. Quantitative changes are associated with qualitative changes as the value of most pollution indicators decreases, including the content of heavy metals. The nature of changes is highly dependent on the intensity of changes occurring in wastes as well as on the material composition and particle-size distribution of the waste deposition. [3,4]. Wastes vary widely in terms of structure and composition which then determine the physical and chemical properties of leachates. A high percentage of biodegradable organic fraction falls on wastes produced in cities [5] and because of that, leachates are characterised by higher values of oxygen parameters and higher concentrations of ammoniacal and organic nitrogen in contrast to rural landfill sites, depositing wastes with a low content of biodegradable fractions.

Leachates of acidogenic phase, which are characteristic for young landfill sites, have higher values of oxygen indicators and nitrogen compounds than those of methanogenic phase, known as elder. Other factors influencing the quality of leachates are: the way of landfill operation, the height of waste deposition, the rate of increasing in height and the rate of depositing the first layer of wastes at the landfill bottom [6].

Cyclical leachate water testing is imposed on the landfill administrator by the Ordinance of the Minister of Environment of 30th April 2013 on landfill sites [7]. This document regulates the scope and frequency of conducting tests as well. Among the major parameters are tests on pH, PEC, TOC and the sum of PAHs as well as the content of selected heavy metals, i.e. Cu, Hg, Pb, Cd and Zn. The tests are conducted in an accredited analytical laboratory which guarantees the reliability of results and possibility of comparing them.

2. Study area and methods

2.1 Characteristics of the landfill site in Osowo

The analysed leachate waters were collected from the communal landfill site of non-hazardous and inert wastes in Osowo (Karsin Commune, Pomorskie Province). The landfill had received wastes since 1995, and in 2012 it underwent restoration. In the landfill were deposited mixed communal solid wastes collected from the Commune. The total area of the landfill site is 2.45 ha, while the waste deposition covered the area of 1.05 ha. The landfill received approximately 1700 m^3 of mixed communal solid wastes per year, mainly from rural areas. The wastes were characterised by a very low percentage of organic and flammable fractions, but they had a high content of ash and slug from household furnaces, glass as well as mineral and plastic packaging wastes which are hardly flammable [8].

2.2 Study methods

The leachates are deposited in a well-sealed concrete tank located in the landfill site in Osowo. The study data was collected within Spring and Autumn series from 2012 to the first half of 2014. The measurements of pH and proper electrolyte conductivity were conducted immediately after collecting the samples. The analyses of the content of TOC and the sum of PAHs as well as the content of heavy metals, i.e. Pb, Zn, Cu, Cd and Hg were conducted in the accredited analytical laboratory. The data was compared to the relevant legal standards and analysed statistically by using MS Excel programme. The variation of selected parameters was presented graphically as well.

3. Study results and discussion

There were no clear trends of changes for pH in the analysed monitoring period. The lowest pH value was recorded in Autumn 2012, and the highest pH value was noted for Autumn 2013. The average pH value oscillated at the level of 7.57 (Fig. 1). Saarela [4] reports that the pH value for a restored landfill site in Finland varied in the range between 5.1 and 7.1. The pH value at the level between 10.7 and 10.9 [3] were in turn reported for the leachates from landfill sites in Zabrze and Gliwice. The obtained diversity of results highlights the complexity of biochemical processes occurring in the landfill and in products of waste transformation so that there is no steady trend for this type of communal management establishments.

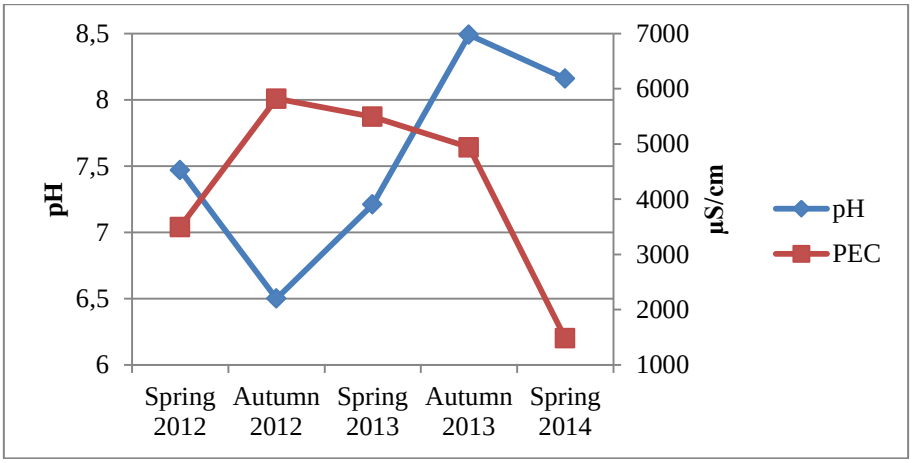

Fig.1. Seasonal variability of pH and PEC in the leachates from the landfill site in Osowo

The PEC values recorded over the analysed period of time were varied (Fig. 1). A significant increase in the analysed leachates was observed in the Autumn of 2012, and then the proper electrolyte conductivity values were decreasing in the next study series. In 2013, there were small declines; however, it was reported in the first half of 2014 that the PEC value decreased in comparison to the previous study series (by 3455 μS/cm). During Spring, the obtained PEC value was lower than the average value from the analysed period of time by 2762 μS/cm. Ziyang et al. [9] claim that the PEC values decrease together with the landfill age, but determining relevant trends for the landfill site in Osowo will be possible after conducting a few subsequent study series. The same trends in the PEC and pH distribution were indicated by Koc-Jurczyk and Rożek [1] who conducted studies on the leachates from the landfill site in Paszczyn.

The content of TOC indicated a significant variation in the analysed study series. The maximum values were recorded for the Autumn 2013. The content of the analysed parameter, which was at the level of 2.98 mg/l, oscillated on the acceptable border according to the Ordinance of the Minister of Environment [10, 11] and was nearly twice higher than the average value noted for the analysed period of time (Tab. 1). The average TOC value was lower in Spring than in Autumn, which is also reported by Koc-Jurczyk and Różak as well as Abu-Daabes et al. who conducted studies on the leachates from the landfill sites in Paszczyn and Russeifah, respectively [1, 12]. The low content of TOC, along with alkaline pH, clearly indicates that the landfill site in Osowo should be classified as being stabilised [13].

Table 1

Content of TOC in the landfill leachates in the analysed period

No.	Monitoring cycle	TOC content [mg/l]	Permissible value according to the Ordinances of the Minister of Environment
1	Spring 2012	9.22	30 mg/l
2	Autumn 2012	15.3	
3	Spring 2013	15.4	
4	Autumn 2013	29.8	
5	Spring 2014	9.70	
6	Average	15.8	

The content of PAHs in leachates is formed at different levels which is proved, among others, by Zakarie et al. [14] and [15]. Xenobiotic substances are usually studied in groups [16]. While analysing the sum of PAHs in tested leachate waters, it was noticed that the values of xenobiotics in each study series were below the limit of quantification of the analytical method as the obtained results were at the level of <0.0001 mg/l.

Heavy metals belong to the group of elements whose testing is essential for carrying out monitoring of landfill sites. The maximum concentrations of heavy metals are noted for landfill sites being in a phase of acid fermentation. In the later stage of landfill operation, the solubility of heavy metals decreases because of neutral pH [2]. The summary of the obtained results in comparison to literature data is shown in Table 2.

Table 2

Average content of selected heavy metals in the leachates from landfill sites

No.	Heavy metal	Average range of values [mg/ l] [17]	Landfill site in Osowo [mg/l]	
1	Cd	0,004–0,375	min	0,007
			max	<0,03
2	Pb	0,034–2,89	min	0,0062
			max	0,06
3	Cr	0–0,271	min	<0,010

			max	
4	Cu	0,004–0,357	min	0,005
			max	0,056
5	Hg	0–0,0045	min	<0,0001
			max	
6	Zn	0,02–168	min	<0,03
			max	0,054

According to monitoring studies (Tab. 2), the content of heavy metals in leachate waters is formed at a low and stable level. It was found in all analysed study series that the content of Cr and Hg was below the limit of quantification of the analytical method. The content of Pb and Cd was also at a low level. The largest differences of values were observed for Cu and Zn. These metals are frequently noted in studies on leachate waters [12, 18]. But also in this case, their concentrations were lower than permissible values specified by the Ordinance of the Minister of Environment [10, 11]. Likewise the other analysed indicators, the highest metal concentrations are found in leachates from operated landfill sites being in a phase of acid fermentation, as a low pH value facilitates the process of leaching metals from the waste deposition [19].

4. Conclusions

Monitoring studies carried out in Osowo indicate that the landfill site is in a stabilised phase. This is evidenced by the values of indicators analysed thoroughly in terms of exceeding legally permissible standards. There were no clear trends concerning the values of pH. The pH of leachates is at a similar level to that noted in natural waters and adopts the value in the range between 6.5-9.0. In the case of PEC and TOC, a clearly downward trend was observed in the Spring of 2014. Because of a high variability of parameters analysed within previous study series, determining relevant trends will be possible after conducting a few subsequent study series. The values of most heavy metals as well as the sum of PAHs in all analysed monitoring series were below the limit of quantification of the analytical method.

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