ENVIRONMENTAL PROBLEMS

Vol. 2, No. 1, 2017

THE DECISION OF LANDFILL LEACHATE TREATMENT

Serhiy Huhlych, Myroslav Malovanyy, Vasil Dyachok

Lviv Polytechnic National University, 12, S. Bandery str., Lviv, 79013, Ukraine
zvit.reagent@gmail.com; mmal@polynet.lviv.ua; dyachokvasil@gmail.com

Received: 19.07.2016

Abstract. This work is an attempt to analyze the theoretical and practical aspects of landfill leachate treatment and analyze the pros and cons of the most widespread methods leachate treatment and suggest the method of complex purification of high-concentration sewage waters from solid domestic wastes (SDW) for example of Hrybovychi municipal solid domestic waste.

Key words: Leachate, Purification, Heavy metal, Exceed permitted concentration.

Introduction

Nowadays the problem of handling with solid domestic waste (SDW) is of great concern for the entire world. There are around 2000 landfill sites and garbage dumps in Ukraine that were mainly organized without basic designs and engineering-groundwater explorations (Derzhbud Ukrainy, 2005).

A great number of environmental issues had arisen as a result of these mistakes, since one of the basic ways of pollution prevalence from landfill site and simultaneously the active component which influences the environmental pollution is propagation of filtered material and surface waters, which flow off the landfill sites during rainfall.

Likewise, ground waters' contamination by filtered material takes place by means of seepages of contaminated water into underground water-bearing formations and migration of polluting agents along with streams of filtered material (Lviv Polytechnic National University, 2010).

Lviv region enters the group of 4 regions of Ukraine which characterize themselves by highest values of waste agglomeration, where the city of Lviv plays significant part. Total volume of accumulated domestic waste at Hrybovychi landfill of Lviv (city's area – 171 km^2, number of citizens – 813 ths.) during the last 3 years had constituted 1 mln m^3/year, what makes up 1.15 m^3/year per 1 citizen (0.77 kg per day/person). This landfill got to the list of hundred major environmentally hazardous objects of Ukraine (Popovych et al,. 2010).

Waste waters from the landfill are not purified; due to this the level of hazardous substances exceeds maximum allowable concentrations hundredfold and thousandfold (Lviv Polytechnic National University, 2011).

The leachate pertains to "hazardous" pollution class and is characterized as high-concentration multicomplex aqueous solutions. The content of basic constituents including heavy metal ions exceeds permitted concentrations tenfold, what prevents their centralized purification with municipal sewage.

The amount of heavy metals present in the leachate varies significantly and has an impact on the water and ground. As well as lead, cadmium, nickel and chromium are known to be toxic and harmfull for humans, animals and plants (European Commission, 1991).

1. We had carried out theoretical evaluation of the existing methods of processing high-concentration aqueous solutions, in particular leachate from SDW dumps, taking into account their multicomponent configuration and structure. The pros and cons of various methods had been identified from the viewpoint of their technological and economic application. Among the most widespread methods one shall highlight the following ones:

2. Purification of leachate from landfills with application of reverse osmosis (wide range of compounds of organic and inorganic nature defines the possibility of their interaction with formation of systems with non-stable aggregative state, what develops necessity to employ special membrane modules; thus the cost of such technologies rises significantly. The task of decontamination of formed concentrate does not solved either) (Wiszniowski et al,. 2006);

3. Processing of leachate from landfills by means of combination of several methods: biological treatment – filtering – absorption (the presence of high concentrations of general biologic poisonous substances in drain waters, which inhibits organic evolution and

activity, limits the possibilities to employ suggested technologies) (Zapolskiy et al,. 2000);

4. Biological treatment by higher aquatic plants (requires large areas; operation is feasible only in warm season and does not provide fine purification of filtered material, what supports salinization of bottom sediments in bioponds) (ETC/RWM 2008);

5. Thermal treatment with the help of evaporator apparatuses (it is quite power-consuming method; environmental requirements to hazardous emissions with flue gases are not met, at that. Disposal of produced waste is problematic);

6. Method that includes lime-milk solution treatment, elutriation, aeration to air strip ammonia with subsequent filtering (does not provide high-level purification of filtered material, since it provides no complex impact on components of different chemical nature, degree of dispersion and concentration; it does not provide recovery of SAA, oil products and detergents) (Petros et al,. 2003) (Torocheshnikov et al,. 1981);

7. Purification method that includes the following sequence of actions: ammonia air stripping – pH correction – coagulation – filtering (low efficiency of ammonia recovery in conditions of high mineral content degree) (Amokrane et al,. 1997).

Objects and research methods

The chemical oxygen demand (COD) were used as criteria of water treatment and were analyzed for incoming leachate, after first, second, third stages treatment (COD was measured by a standard dichromate method using a HACH spectrophotometer), fhosphates was determined by molybdate method. The concentration of heavy metals was determined by atomic absorption spectrophotometry CA-10MP.

In table 1 the concentration of particular pollutans in leachate from municipal landfill are presented. The information about analyses of leachate samples from Hrybovychi municipal landfill was taken from the State Department of Environment Protection in Lviv Region (SDEPLR) and from the Department of Ecology and Environment Protection of Lviv Polytechnic National University.

Table 1

Result of analyses of leachate samples

Parameter	Dimensions	08.2005 (SDEPLR)	07.2010 (own analysis)	08.2011 (own analysis)
Color		Brown	Brown	Brown
Smell	Point	5	6	6
pH		7.91	7.05	7.82
Mineralisation	mg/dm^3	9753.57	10411.04	11875.48
COD	mg/dm^3	7345.2	10761.2	11040.0
Total Iron	mg/dm^3	10.0608	14.7514	14.6910
Zink	mg/dm^3	1.0774	1.5243	1.6085
Cadmium	mg/dm^3	1.0114	1.1934	1.3518
Nickel	mg/dm^3	1.6386	2.8535	2.9373
Copper	mg/dm^3	2.1511	2.2296	2.3294
Chromium	mg/dm^3	4.4856	7.1583	7.2395
Lead	mg/dm^3	24.4753	26.1785	26.3462

On the basis of the reviewed approaches, the method of complex purification of high-concentration sewage waters (leachate) had been developed and it is now implemented on Hrybovychi's SDW landfill. This method includes the following:

- coagulation;
- chemical and dynamic precipitation and coprecipitation;
- ion-exchange sorption;
- oxidation (deoxidization) under the action of chemical agents;
- diaphragm electrolysis;
- desorption (to recover components) and chemisorption (to utilize components).

Fig. 1 shows the combination of high-concentration aqueous solution's methods of treatment, specifically filtered materials of SDW dumps eliminates the drawbacks of each method, what enables to perform purification more effective, and also to intensify processes of physical and chemical transformation of substances by means of adjustments of solution properties. The essential requirement to polishing of leachate is their total decontamination.

In the first stage the leachate is treated in reactor-mixer 1 by corresponding chemical agents, which assist coagulation of silted substances and transition to water-insoluble condition of separate organic and inorganic components, substances that responsible for coloring of leachate, and some toxic compounds. Produced blend is transferred to precipitation box 2, where solid phase is being separated from mainstream.

Residual matter enters anaerobic stabilizer 13, where it decontaminates and transforms to mineral fertilizers. Suspension of solid particles segregates into liquid and solid phases in press-filter 14. The centrifuge 15 dehydrates solid phase to promote convenience of its agricultural utilization. Associate waters return to process head for recleaning. It is obvious that with significant content of heavy metals, the major portion of which is produced in the first stage, the use of even stabilized residual matter shall be restricted by corresponding regulatory documents. Clarified water for recleaning goes through filter 3.

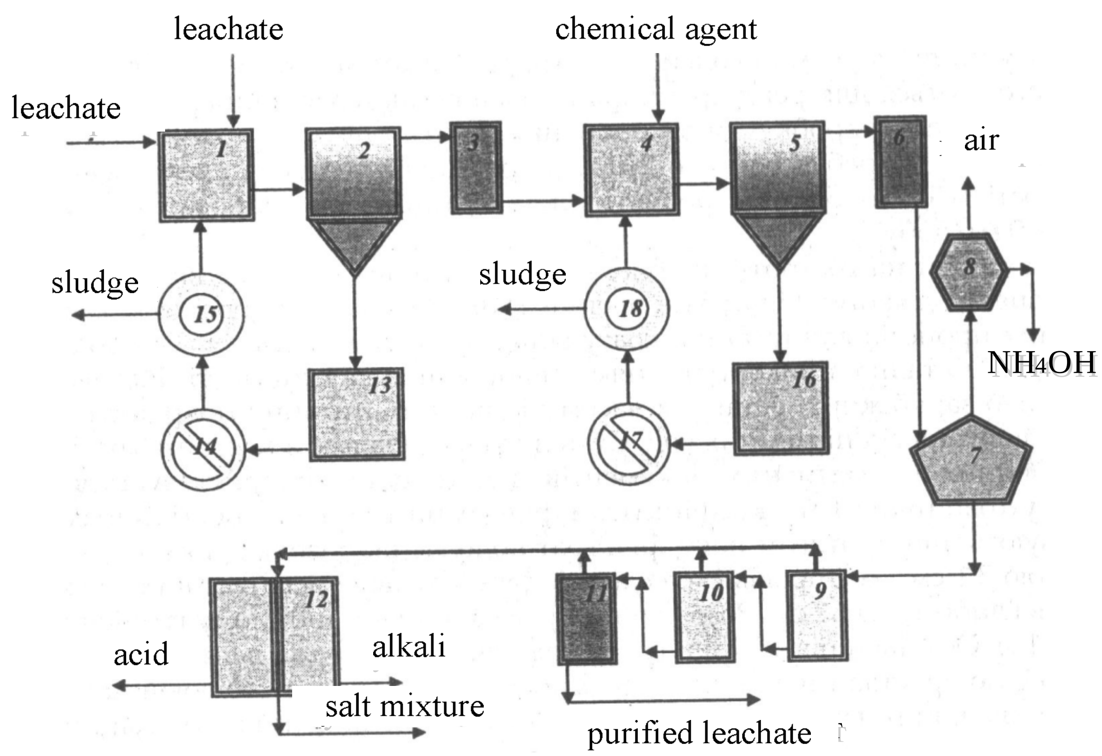

Fig. 1. Process chart of physical-chemical purification of leachate from SDW dumps
1,4 – reactor-mixer; 2,5 – precipitation box; 3,6 – filter; 7 – ammonia stripper; 8 – ammonia recovery installation; 9 – zeolite filter; 10 – cationite filter; 11 – anion-exchange filter; 12 – block of diaphragm electrolyzers; 13 – anaerobic stabilizer; 14, 17 – press-filter; 15, 18 – centrifuge; 16 – garbage compactor

In the second stage, the semi-purified leachate in reactor-mixer 4 is treated by chemical agents, which lead to oxidation of toxic components and their transition into safe condition. Solid phase that is formed at that is separated into precipitation box 5, while clarified water is polished in filter 6. The settled solid phase is transferred into compactor 16, separates from water in the press-filter 17 and dehydrates in centrifuge 18. The treated water leaving filter 6 virtually does not contains suspended particles, while the phosphates' content exceed the value.

In the third stage, deammoniation of leachate is carried out by means of ammonia desorption in stripper 7. For this purpose the filtered material under certain conditions is blown through with air, which is then directed into ammonia recovery and air purification installation 8. The saturated ammonia solution and purified air come out at the installation's outlet. Both these components are reutilized in processing. After that the leachate is treated by adsorbents in zeolite filter 9, cationite filter 10 and anion-exchange filter 11.

Results and Discussion

One of the most used phisicaly-chemical method for treatment of leachate is coagulation-floculation (the first and second stage). Aluminum sulphate, ferrous chloride and ferrous sulphate are the most famous coagulants. These treatment stages allows removing small colloidal particles by creation of flocs which are readily sedimented.

After the first and the second treatment stages the chemical oxygen demand (COD) of leachate decreases by 90 %, content of silted substances – by 85 %, phosphates' content – by 90 %, and total salt content – by 95 %.

The classical way to reduce the concentration of heavy metals is the application of chemical precipitation (the second and the third stages). The use of lime allows reducing heavy metal content by up to 100 % (Total Iron, Copper, Zink, Nickel, Chromium) with a low cost (*Fig. 2*). Also, COD reduction exceed the value (*Fig. 3*).

If the application of flocculation and chemical precipitation methods does not allow removing heavy metals to required level, the method of absorption applied as a polishing step (the third stage). The most widely used adsorbent for leachate treatment is activated carbon and zeolite, the use of which can reduce the treatment cost substantially (*Fig. 2*).

It needs to be said that the colority of leachate decreases by 95 % in comparison with inlet water (the first-third stages).

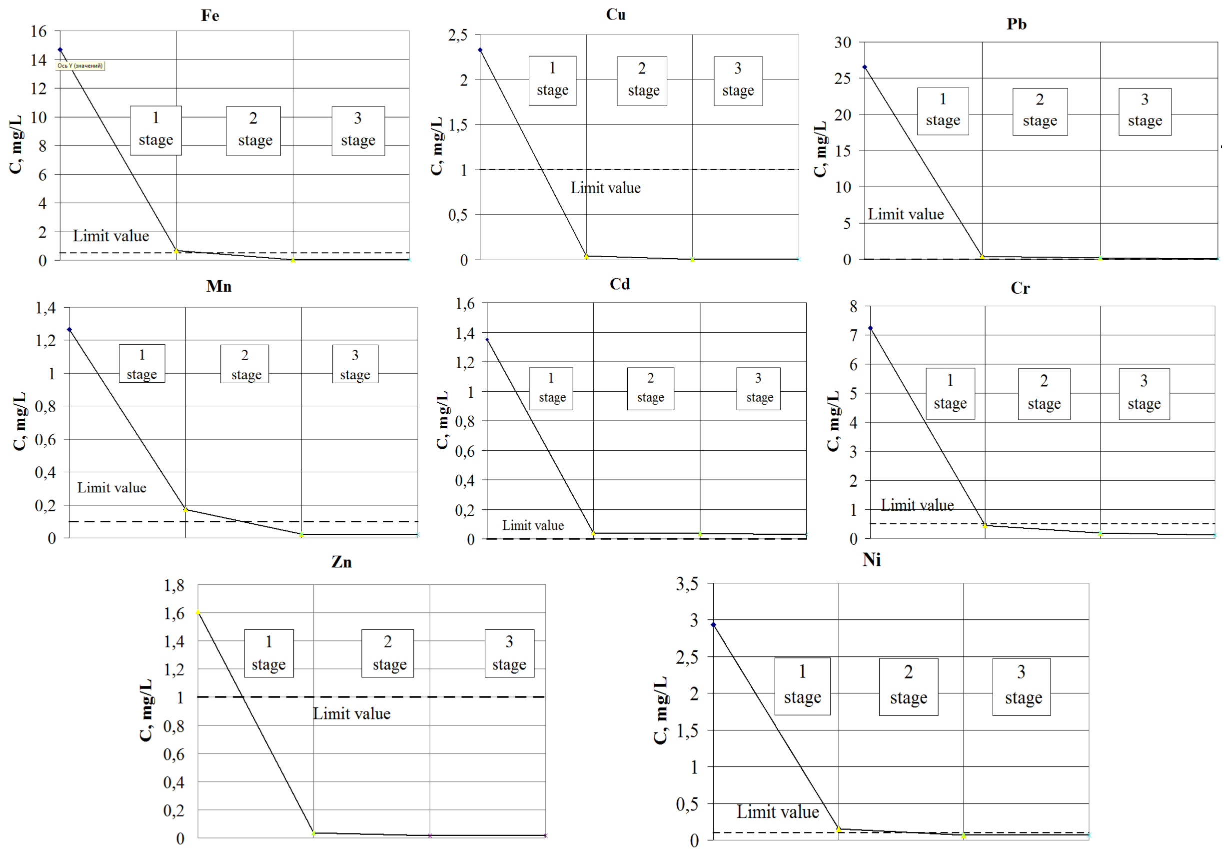

Fig. 2. Change in content of heavy metals ions in leachate

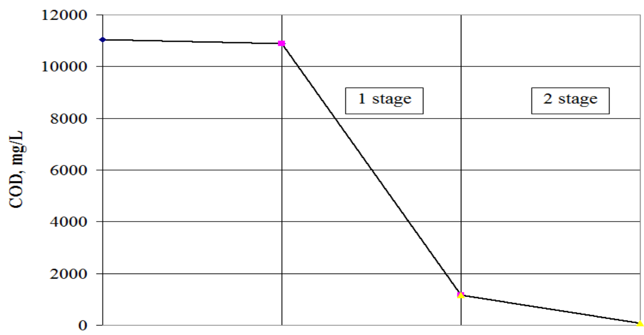

Fig. 3. COD change in leachate

We can see that the method of complex purification of high-concentration sewage waters (leachate) enable to remove any polluter out of leachate. The total iron, copper, mangan, chromium, zink concentrations usually exceeded the value. The amout of nikel did not exceed the value but the concentration of this metal is much closer to the permissible value allowed for water application. The existing treatment do not allow removal of lead and cadmium to the required level. It is also crucially important to consider the cost of such purification, especially taking into account the present condition of national economy.

Additionally, heavy metals have the ability to accumulate in sludge (the first and the second stages of purification) that is why the next stages of the investigations will focus on sludge neutralization, utilization and dewatering and implementation of anaerobic treatment would allow decrease the smell and improve economy of treatment. Implementation of biological processes of nitrogen removal.

References

[1] Amokrane A.,Comel C.,Veron J. (1997) Landfill leachate pretreatment by coagulation-flocculation. Water Resources 31. pp. 2775–2782.

[2] Derzhbud Ukrainy, (2005). Полігони твердих побутових відходів. Основні положення проектування. ДБН В.2.4-2-05 (Solid municipal waste landfills. The main issues of designing. DBN V.2.4-2-05).p 68.

[3] O. Popovych, M. Malovanyy, A. Malovanyy, E. Plaza (2010). Hrybovychi municipal solid waste landfill reclamation and coherent pollution prevention in holistic approach/ Research and application of new technologies in wastewater treatment and municipal solid waste disposal in Ukraine, Sweden and Poland. Report No 16, 149–156.

[4] ETC/RWM (2008), “Municipal waste management and greenhouse gases”, working paper 2008/1, Copenhagen. Available http://waste.eionet.europa.eu/publications [accessed Aug 14th 2009].

[5] European Commission, (1991) Directive 91/271/EEC concerning urban waste-water treatment. Available at http://ec.europa.eu/environment/water/water-urbanwaste/ index_en.html [accessed Aug 14th 2009].

[6] Lviv Polytechnic National University, (2010). Report on monitoring the environmental impact of Lviv municipal SDW landfill operation on pollution of soil, air, ground and surface waters and vegetation. – 540 p.

[7] Lviv Polytechnic National University, (2010). Report on expert assessment of Lviv municipal SDW landfill impact on environment. – 453 p.

[8] Petros. R., Malovanyy M., Varchol Y., Odnorih Z., Petrushka I., Leskiv H., (2003). Technologies of wastewater treatment with the use of natural sorbents. Хімічна промисловість України 2. pp 20–22.

[9] Torocheshnikov A. I., Radionov V. N., Klyshun M. I. Technichiks of Environment Protection: Chemestry, 1981. – 368p.

[10] Wiszniowski J., Robert D., Surmacz-Gorska J., Miksch K., Weber J.V., (2006) Landfill leachate treatment methods: A review. Environmental Chemistry Letters 4: 51–61.

[11] Zapolskiy A. K., Mishkova-Klumenko N. A., Astrelin I. M. – Physicaly-chemical technologies of wastewater cleaning. – K.: Libra, 2000. – 552 p.