Investigation of the effects of waste leachate on the quality of soil, air and groundwater resource

Taghizadeh, Mohammad[1]
1. **PhD,Urban- planning, Tehran university**
t.mohammad93@yahoo.com

Bahmani, Reza[2]
2. PhD student, Excutive managemeant, Islamic azad university central Tehran branch
Waste Management Organization of Robatkarim

RaheliNamin, Behnaz3*
3*. PhD, Environmental pollution, Waste Management Organization of Robatkarim
Raheli.Nami.b@gmail.com

Abstract

open dumping of waste or disposal without waste engineering principles in the environment along with precipitation, increase the leachate from these wastes. The main and fundamental reason is the attention of scientific societies to the issue of leachate pollution, the possible risk of contamination of water and soil resources by leachate and gases emitted from it, that cause to the dangerous and deadly consequences. Therefore, in this paper, the destructive effects of leachate on the environment and ways to reduce leachate production are discussed.

Keywords: Waste Managmaent, leachate, Soil quality, groundwater resource

Introduction

Environmental protection is one of the basic principles in human survival, controlling environmental pollution, including human waste, is one of the most important issues in urban communities. waste production in human life, is inevitable and population growth increases its production rate. In developing countries, most of the produced waste is being dumped into open environment [7,40]. One of the major problems caused by municipal waste is the management of leachate, which contains various physical, chemical and biological pollutants [10,46]. The leachate produced from solid waste in uncontrolled landfills has a great impact on the environment and human health. Environmental problems in general and waste problems in particular are among the problems of today's societies. The aim of the present paper is to evaluate and investigate the destructive effects of leachate on the environment and ways to control and reduce leachate. Leachate is a dark brown, foul-smelling liquid that seeps out of the waste and contains soluble and suspended substances. In most landfills, leachate comes from the decomposition of organic matter and liquids that may come from external sources such as surface water drainage, rainwater, groundwater, and water from groundwater sources. One of the major problems of leachate is the toxic substances and heavy metals in leachate that should be considered before disposing of leachate. Heavy metals due to their stability, cause special problems in the environment [9,27].

Environmental impact of municipal dumpsite leachate

Groundwater Pollution

The most important environmental effects of leachate of landfills are, surface and groundwater pollution. The leachate of the landfills is formed from rainfall, water from melting snow, moisture in the waste and the biological decomposition of waste [29,33]. Infiltrated water may also dissolve the water created by the compression of the waste due to their weight, resulting in contamination of groundwater .In many parts of the world, people are facing water shortages due to rising water consumption and harvesting, as well as human activities that are increasingly polluting these declining resources and reducing the amount of fresh water available (2004). , Bou-Zeid E). the toxic leachate rich in organic and inorganic compondes negatively influence the composition of the groundwater making it unsuitable for the human consumption [4,30,46]. Horizontal movement of leachate in landfills can cause leachate to leak from the soil surface at low altitudes and contaminate surface water. Vertical movement of leachate from different layers under the burial ground causes soil pollution and in case of high groundwater level, it causes groundwater pollution [8]. Numerous resources have the potential to penetrate the earth and contaminate groundwater. This potential depends on various factors such as groundwater level, pollutant physical and chemical properties, other associated pollutants, its concentration in the source of pollution and the physical and chemical texture of the soil. The risk of infiltration of leachate is higher when landfills are located in sandy soils and on shallow groundwater. Ross or bentonite soil, which is more impermeable, is used to prevent leachate from penetrating groundwater [41].

The Water Quality Index (WQI) is one of the techniques used to evaluate water quality. This index is usually obtained from the amount of general water parameters including soluble oxygen, acidity, hardness, soluble solids, temperature,

turbidity, nitrate, nitrite and some major ions [28]. The main objective of computing of water quality index (WQI) is to turn the complex water quality data into information which is easily understandable and usable.

WQI calculations include the following three steps:

The first step is "weighting", for each water quality parameter, a specific weight is assigned according to its relative importance.

The second step, "relative weight calculation," is calculated using Equation 1

$$w_i = \frac{w_i}{\sum_{i}^{n=1} wi} \qquad (1)$$

In this equation, wi is the weight of each parameter and n is the number of parameters.

The third step is to "calculate the quality rate scale." This scale (qi) is calculated by dividing the concentration of each parameter in each water sample by the standard value of that parameter.

$$q_i = \frac{c_i}{s_i} \times 100 \qquad (2)$$

Where ci is the concentration and si standard of each chemical parameter in the water sample in mg / L. Then, to estimate WQI, SI (sub-indication of nm parameter) is determined for each chemical parameter with equations 3 and 4:

$$sl_i = w_i \times q_i \qquad (3)$$

$$WQI = \sum sl_i \qquad (4)$$

The value of obtained WQI is classified by determining the water quality classification. In this classification, waters with a WQI of less than 50 in a very good category, 50 to 100 in a good category, 100 to 200 in a weak category, 200 to 300 in a very weak category and above 300 in a category of unsuitable for drinking.

Soil pollution

Soil is one of the most important environmental factors. Without healthy soil, life on earth would not be possible. Contamination of the soil causes contamination of groundwater aquifers and changes in the condition of structures located on the soil. Any change in the specifications of the soil layer can lead to a decrease in load-bearing capacity and an increase in the overall and relative subsidence of the structure. As a result, the structures break down and become unusable [6]. Burial and open accumulation of waste causes the leachate to be released into the soil and the surrounding environment, which, if not properly guided and collected, has irreversible effects on the environment and surrounding soils [20,42, 44,47]. Chemical substances from leachate are either absorbed by the soil particles as adsorbents or trapped as insoluble liquid between the soil particles. Over time, wastewater leachate that has been absorbed by soil particles spreads into the soil tissue, causing soil contamination to become more widespread, which has a significant impact on environmental behavior and soil engineering (D.E. Foreman et all, 1986 and A.K. Khan, 1994). When leachate collection systems are not implemented and the end layer of landfill is not covered, leachate penetration into surrounding soils increases, which has a direct impact on soil geotechnical parameters and changes the behavior of volumetric changes, shear strength and soil hydraulic resistance [19].

Contamination factor (CF)

It is used to illustrate the contamination of a given toxic element and assess the soil contamination.

$$c_f = \frac{c_i}{c_b} \qquad (5)$$

C_i: concentration of metal in the soil under the influence of waste leachate

C_b: is the concentration of the metal in the control soil (the measured concentration in soils that are not affected by leachate).

In this formula Cf <1 indicates low pollution 3 ≤Cf <1 moderate pollution, 3 ≤Cf <6, high pollution and Cf≥6 very high pollutions [21].

Air pollution and the cause of the bad smell of leachate

One of the important parameters is the control of the exhaust gases from the waste. Accumulation of waste in a place with proper humidity and temperature is one of the factors that cause aerobic and anaerobic bacteria to decompose waste. Methane, carbon dioxide, nitrogen, hydrogen, paraffinic hydrocarbons, cyclic hydrocarbons, hydrogen sulfate, carbon monoxide, chloroathylene, chlorobenzene, toluene, tetrachloroethylene, ethyl benzene, and dichloroethylene are the gases that can be the result of waste decomposition. The most important problem related to the gases produced from the landfill is odor. While methane and carbon dioxide are odorless gases, the emissions from solid waste include large amounts of odorous compounds that are also present in low concentrations and very disgusting. Methane is the most important gas produced in the waste decomposition process at landfills. If the methane produced is not controlled, it has harmful environmental effects. It also penetrates the roots of trees and destroys them [39].

The effect of leachate on trees and vegetation

Leachate is highly toxic and contains many dangerous substances and pathogenic bacteria, so it can have a negative effect on the ecosystem of its pathway. The leachate either enters the soil and the plant, which eventually leads to many changes in the building and their physical and chemical properties, or it drains into the paths and valleys around it, and its harmful effects, such as drying plant species can be more visible. Waste leachate contaminates the soil with cadmium. Cadmium is an unnecessary nutrient for plants and relatively low concentrations can have toxic effects on plants [23]. Of course, the nutrients in leachate can increase the productivity of forest trees and cause more trees to grow, but it has a negative impact on the growth of trees that are exposed to irrigation with leachate and has reduced the growth of trees [18].

Leachate pollution index (LPI)

An index known as leachate pollution index (LPI) is a method for quantifying and assessing the leachate contamination potential of municipal landfills. It is a quantitative tool that used leachate pollution data of landfill sites and can be reported uniformly. LPI has been formulated based on the Delphi technique and it is an increasing scale index that provides a convenient means of summarizing leachate pollution data [26].

$$\text{LPI} = \sum_{i=0}^{n} wipi \qquad (6)$$

$$\sum_{k=0}^{n} wi = 1 \qquad (7)$$

$$LPI = \frac{\sum_{i=1}^{m} wipi}{\sum wi} \quad (8)$$

LPI: Leachate pollution index

wi: Weight for each contamination parameter i

pi: The value below the index for each contaminant parameter i

n: The number of leachate contaminant parameters used in LPI

Leachate management by preventing leachate production

Currently, according to statistics released by the Tehran Waste Management Organization as the metropolis and capital of Iran, the most common type of waste that leads to the production of leachate is organic waste left over from household waste [31,34]. The reduction of leachate produced by citizens and the drying up of waste, and then their disposal, will gradually reduce the process of leachate production. Prevention Returns to home sinks, restaurants, and offices to drain more waste. Wet and dry waste should be disposed of separately in glass, plastic and paper tanks. In other words, all citizens must help urban management to reduce leachate and take a more serious step toward separating waste from source

Methods of preventing leachate production

- Drying wet waste
- The food containers must first be completely emptied and then washed. This allows less moisture to enter the waste.
- Baskets in the sink are very important in reducing waste.
- Proper separation of the source by separating wet and dry waste in glass, plastic and paper tanks

Recycling after reduction (prevention of leachate production) is the second priority in waste management strategies. Recycling is the process by which part of the waste produced is separated and used as raw material to produce new products [1,2,32].

Separation from the source of waste production is one of the most important and low-cost methods of waste separation, which can be institutionalized among the people by spending a little time on training. By separating organic waste, less leachate is produced and will have less environmental impact. G et all,1993.

Recycling reduces the problems of urban waste management, including collection and disposal, especially combustion and burial. In addition, recycling reduces the spread and contamination potential of leachate.

According to studies on the destructive effects of leachate on the environment and efforts to prevent the production of leachate, different ways to control leachate have been considered.

collecting and returning leachate in Landfill: One of these methods is collecting and returning leachate in Landfill, which is implemented in Iran due to its efficiency and affordability. When leachate is returned to the landfill, the concentration of its combined components decreases as a result of biological activity and other physical and chemical reactions within the landfill. The main advantage of returning leachate to the landfill is the recovery of the landfill gas, which contains methane [16, 47,49].

Leachate evaporation: In this method, the leachate is directed to the liner evaporation ponds to evaporate over time. This method is one of the simplest leachate management systems. The evaporation method has many advantages, including compliance with output standards with fewer operating units than conventional treatment plants, which have more operating units and processes [5,14].

Leachate treatment: On sites where leachate evaporation or collecting and returning is not used, it is not possible to treat the leachate and dispose of it directly to wastewater treatment facilities, and some pre-treatment or complete treatment of that is required. Because the characteristics of the collected leachate are usually very diverse. But almost all of the used methods to treat wastewater can be used to treat leachate. The type of selected treatment system for leachate, firstly depends on the characteristics of the leachate, and secondly on the physical and geographical location of the landfill [3,17,36].

Conclusion

In general, it can be concluded that leachate from urban waste has a high potential for environmental pollution that must permanently be controlled and monitored. According to the results, prevention of adverse environmental effects of solid waste is a priority. This is achieved by applying appropriate management methods, public education to separate waste from the source, reducing the volume of produced waste that cause to reducing the volume of leachate and the correct way of recycling, collection and disposal. An effective way to manage and eliminate leachate, after preventing its production, is to collect and recycle it on the landfill. When the leachate is returned to the landfill, the concentration of its components decreases due to biological activity and other physical and chemical reactions that take place inside the landfill. The main advantage of turning the leachate to Landfill is increasing the evaporation level of the leachate and reducing the surface of the pond and eliminating the adverse environmental effects. Source separation waste and recycling reduces leachate production and consequently less environmental pollution, reduces the transmission of various diseases related to solid waste, reduces treatment costs by increasing people's awareness of the problems and difficulties of solid waste, reducing waste volume and consequently, it reduces the municipality's costs of collecting waste and using recycled materials by returning them to the production cycle and helping the community's economy.

References

[1] Abdoli M.A., 1995. Municipal Solid Waste Management, Control Systems and Methods. Tehran: Organization of Materials Recycling and Transformation of Tehran Municipality, (in Persian).
[2] Abdoli M.A., 2005. Municipal Solid Waste Recycling. Tehran. University of Tehran Press, (in Persian).
[3] Aderemi A.O, Oriaku A.V, Adewumi G.A, Otitoloju A.A., 2011. Assessment of groundwater contamination by leachate near a municipal solid waste landfill. Afr. J Environ Sci. Tech 5(11), 933–940.
[4] Al Sabahi E, Abdul Rahim S, Wan Zuhairi W.Y., 2009. The Characteristics of Leachate and Groundwater Pollution at Municipal Solid Waste Landfill of Ibb City, Yemen. American Journal of Environmental Sciences 5 (3), 230-240.

[5] Al-Hadithi M., 2012. Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao–Pathri Rao watershed, Haridwar District, India. The American Journal of Scientific and IndustrialResearch 3(6), 395-402.

[6] Athanasopoulos G, Grizi, A., Zekkos, D., Founta, P., and Zisimatou, E., 2008. Municipal solid waste as a reinforced soil: Investigation using synthetic waste, in: ASCE-Geoinstitute Geocongress, Geotechnics of Waste Management and Remediation, New Orleans, pp. 168-175.

[7] Aziz S.Q, Aziz H.A, Yusoff M.S, Bashir M.J.K, Umar M., 2010. Leachate characterization in semi-aerobic and anaerobic sanitary landfills: a comparative study. J Environ Manage 91(12),2608–2614.

[8] Bagheri M, Bazvand A, Ehteshami M, 2017. Application Of Artificul Inteligerce For The Management Of Landfill Leachate Penetration Into Groundwater, And Assessment Of Its Environmental Impacts, Gounal Of Cleaner Production.

[9] Bhambulkar A.V., 2011. Effects of Leachate Recirculation on a Landfill. Int J AdvEngSci Tech 11(2),286–291.

[10] Blight G, Fourie A, Shamrock J, Mbande C, Morris J, 1999. The effect of waste composition on leachate and gas quality, a study in South Africa. Waste Manag Res 17,124-40.

[11] Bou-Zeid E., El-Fadel M., 2004. Parametric sensitivity analysis of leachate transport simulation at landfills. Journal of Waste Management, no. 24, 681-689.

[12] Brady J.P, Ayoko G.A, Martens W.N., and Goonetilleke A. 2015. Development of a hybrid pollution index for heavy metals in marine and estuarine sediments. Environmental Monitoring and Assessment. 187(5), p.306.

[13] Brown RM, McClelland NI, Deininger RA, O'Connor MF, 1972. A water quality index- crashing the psychological barrier. USA: Springer.

[14] Bull P.S, Evans J.V, Wechsler R.M, Cleland K.J., 1983. Biological technology of the treatment of leachate from sanitary landfills. Water Research 17, 1473–1481.

[15] Calli, B, Mertoglu B, and Inanc B., 2004. "Landfill leachate management in Istanbul: applications and alternatives." Chemosphere 59, no. 6, 819–829.

[16] Derco J, Gotvajn AZ, Zagorc-Koncan J, Almasiova B, Kassai A., 2010. Pretreatment of landfill leachate by chemical oxidation processes. Chemical papers, 64(2), 237–245.

[17] Dollerer J, Wilderer P.A., 1996. Biological treatment of leachates from hazardous waste landfills using sbbr technology. Water Science and Technology, 34 (7–8), 437–444.

[18] Doyle, T. W., and Day, J. W., 1998. Long-term growth enhancement of bald cypress from municipal wastewater application: Environmental Management, v. 22, n. 1, p. 119-127.

[19] Dutta J., Mishra., A.K., (2016). Consolidation behaviour of bentonites in the presence of salt, solutions Applied Clay Science, 3(7), 61-69.

[20] Fadel, Findikakis M, N, 1997. Environmental impacts of solid waste landfilling, Environment management, 50, 1-25.

[21] Hakanson L, 1980. An ecological risk index for aquatic pollution control. A sedimentological approach. Water Research, 14(8), 975-1001.

[22] Hakanson, L. and Janson, M., 1983. Principles of Lake Sedimentology: Springer, Berlin, 316 p.

[23] Kabata A., and Pendias. H. 2002. Trace elements in soils and plants .3ndEdition. Boca Raton (FL): CRC Press.

[24] Kale S.S, Kadam A, Kumar S, Pawar NJ, 2010. Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic aquifers. Environ Monitor Asses 162, 327–346.

[25] Krzysztof, L., Danuta, L. and Irena, K, 2004. Metal contamination of farming soils affected by industry: Environment International, v. 30, p. 159-165.

[26] Kumar,D.And Alappat, B,J. 2005. Evaluating Leachate Contamination Potential Of Landfill Sites Using Leachate Pollution Index, Clean Techonology And Environment, 7, 190-197.

[27] Kurniawan, T.A, Waihung Lo, and G Chan, 2010. "Biological processes for treatment of landfill leachate." Journal of Environmental Monitoring 12, no. 11.

[28] Lobato T, Hauser-Davis R, Oliveira T, Silveira A, Silva H, Tavares M, et al,2015. Construction of a novel water quality index and quality indicator for reservoir water quality evaluation: A case study in the Ama. zon region. Journal of Hydrology,522, 674-83.

[29] Logeshkumaran A, Magesh N, Godson PS, Chandrasekar N, 2015. Hydro-geochemistry and application of water quality index (WQI) for groundwater quality assessment, Anna Nagar, part of Chennai City, Tamil Nadu, India. Applied Water Science,5(4), 335-43.
[30] Longe E.O and Balogun M.R., 2010. Groundwater Quality Assessment near a municipal Lndfill, Lagos, Nigeria. Research Journal of Applied Sciences, Engineering and Technology 2(1), 39-44.
[31] Mohajeri, S., Aziz H. A., Isa M. H., Zahed M. A., & Adlan M. N., 2010. Statistical optimization of process parameters for landfill leachate treatment using electro-fenton technique. Journal of Hazardous Materials, 176, 749-758.
[32] Nazem F, Abduli M, Riahi Bakhtiari A. assess priorities and potential recycling of urban waste Branch, Iran, Natural Resources. 61, 5.
[33] Nemerow N.L. 1991. Stream, Lake, Estuary, and Ocean Pollution. Van Nostrand Reinhold, New York.
[34] Nendza, M., 2002. Inventory of marine biotest methods for evalution of dredged material and sediments: Chemosphere, v. 48, p. 865-883.
[35] Oman, C. B. and Junestedt, C., 2008. Chemical characterization of landfill leachates-400 parameters and compounds. Waste Management, 28, 1876-1891.
[36] Pekey, H., Renou S., Givaudan J.G., Poulain S., Dirassouyan F., and Moulin P. 2008. Landfill leachate treatment: review and opportunity. *Journal of Hazardous Materials,* 150(3), 468–493.
[37] Report of waste separation from origin. 2019. Waste management organization.
[38] Rezaei M, Nikbakht M, Shakeri A, 2017. Geochemistry and sources of fluoride and nitrate contamination of groundwater in Lar area, south Iran. Environmental Science and Pollution Research.;24(18),15471-87.
[39] Robinson H, Luo M., 1991. Characterization and treatment of leachates from Hong Kong landfill sites. J Instr Water Environ Manage 5(6), 326–335.
[40] Sakawi Z, Sharifah, Mastura S.A, Jaafar O and Mahmud M., 2011. Community Perception of Odor Pollution from the Landfill. Research Journal of Environmental and Earth Sciences 3(2), 142-145.
[41] Singh, R.P. Singh, P. Araujo, A.S. Ibrahim, M.H. Sulaiman, O., 2011. Management of urban solid waste: Vermicomposting a sustainable option. Resources Conservation Recycling 55(7), 719-729.
[42] Sitaram Nayak, Sunil B.M, Shrihari S, Sivapullaiah P.V, 2010. Interactions Between Soils and Laboratory Simulated Electrolyte Solution, Geotech Geol Eng. 28, 899-906.
[43] Surmacz-Gorska J, 2001. Degradation of organic compounds in municipal landfill leachate, in: Environmental. Engineering Committee of Polish Academy of Science, Lublin.
[44] Tchobanoglous G, Theisen H, Vigil S., 1993. Integrated Solid Waste Management: Engineering Principal and Management Issues. New York: McGraw-Hill.
[45] Timur H, Ozturk I., 1999. Anaerobic sequencing batch reactor treatment of landfill leachate, in: Fenton process Water Research, pp. 3225-3230.
[46] Topcuoğlu, B., 2015. Determination and evaluation of heavy metal pollution in greenhouse regions of Antalya (Turkey): International Conference on Chemical, Metallurgy and Environmental Engineering, Istanbul (Turkey), June 3-4, p. 287-295.
[47] Vasanthi P, Kaliappan S, Srinivasaraghavan R., 2008. Impact of poor solid waste management on ground water. Environ Monit Assess, 143,227-38.
[48] Wang S., Wu, X., Wang, Y., Li, Q., Tao, M., 2008. Removal of organic matter and ammonia nitrogen from landfill leachate by ultrasound, Ultrasonics Sonochemistry, 15, 933-937.
[49] Yangin C1, Yilmaz S, Altinbas M, Ozturk I., 2002. A new process for the combined treatment of municipal wastewaters and landfill leachates in coastal areas. Water Sci Technol.46,111-8.
[50] Zazouli M.A, Mohseni Bandpei A, Eslami A,Sadeghi A., 2009. Survey on Paper Recycling Potential in the Head Offices of Mazandaran Province. Iran Health and Environmental. 1 (2), 99-104.


5th International Conference on
Agricultural Science,
Environment,Urban and Rural Development
17 July 2020
urdconf.ir