Journal of Advanced Research (2015) 6, 579–586

Cairo University

Journal of Advanced Research

ORIGINAL ARTICLE

Impact of landfill leachate on the groundwater quality: A case study in Egypt

Magda M. Abd El-Salam [a,b,*], Gaber I. Abu-Zuid [c]

[a] Environmental Chemistry and Biology, Environmental Health Department, High Institute of Public Health, Alexandria University, Egypt
[b] Public Health Sciences, Biology Department, College of Science and Humanity Studies, Salman bin Abdulaziz University, Saudi Arabia
[c] Environmental Engineering, Environmental Health Department, High Institute of Public Health, Alexandria University, Egypt

ARTICLE INFO

Article history:
Received 20 October 2013
Received in revised form 4 February 2014
Accepted 6 February 2014
Available online 12 February 2014

Keywords:
Environmental impacts
Groundwater pollution
Heavy metals
Leachate
Solid waste disposal

ABSTRACT

Alexandria Governorate contracted an international company in the field of municipal solid waste management for the collection, transport and disposal of municipal solid waste. Construction and operation of the sanitary landfill sites were also included in the contract for the safe final disposal of solid waste. To evaluate the environmental impacts associated with solid waste landfilling, leachate and groundwater quality near the landfills were analyzed. The results of physico-chemical analyses of leachate confirmed that its characteristics were highly variable with severe contamination of organics, salts and heavy metals. The BOD_5/COD ratio (0.69) indicated that the leachate was biodegradable and un-stabilized. It was also found that groundwater in the vicinity of the landfills did not have severe contamination, although certain parameters exceeded the WHO and EPA limits. These parameters included conductivity, total dissolved solids, chlorides, sulfates, Mn and Fe. The results suggested the need for adjusting factors enhancing anaerobic biodegradation that lead to leachate stabilization in addition to continuous monitoring of the groundwater and leachate treatment processes.

Introduction

The social and environmental impacts imposed by municipal solid waste (MSW) received attention in recent decades [1]. Consequently, several policies, strategies, plans and methods have been developed in the field of MSW management. These include waste reduction and waste recovery for reuse, recycling, composting and incineration for energy generation in addition to landfilling of final rejects [2]. Landfills and/or open dumpsites were the common practice for MSW disposal all over the world [3]. Currently, sanitary landfill represents a viable and the most commonly used method for solid waste disposal all over the world because it may achieve the reclamation of derelict land [4]. Also, properly designed and operated sanitary landfills eliminated some adverse environmental impacts that result from other solid waste final disposal alternatives such as burning in open-air burning sites and open-pit dumping. However, other impacts may arise from gas and

* Corresponding author. Tel.: +966 599869717.
E-mail address: mmagdy_hiph@yahoo.com (M.M. Abd El-Salam).
Peer review under responsibility of Cairo University.

Production and hosting by Elsevier

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http://dx.doi.org/10.1016/j.jare.2014.02.003

leachate formation if not well controlled. These impacts include fires and explosions, vegetation damage, unpleasant odors, landfill settlement, groundwater pollution, air pollution and global warming [1]. In developing countries, landfills have been largely unsuccessful because the landfill sites have a very limited time frame of usage [2]. It is also receiving MSW, commercial and industrial wastes which may contain hazardous substances and can increase the health risks emanating from the leachate and gases [4].

In 1999, 23% of the collected solid waste from Alexandria, Egypt, was recovered for compost production. The remaining 77% was open dumped in an uncontrolled manner on both the banks of Maryout Lake and three open dump sites, causing detrimental effects [5]. Nowadays, sanitary landfilling became the main disposal method where 78% of the generated solid waste is transferred to sanitary landfill and the remaining 22% is recovered for compost production [6].

Over 20–30 years MSW in closed landfill cells is converting into gases, liquid and inert solids. Landfill leachate is one of the main sources of groundwater and surface water pollution if it is not properly collected and treated and safely disposed as it may percolate through soil reaching water aquifers [7]. Therefore, the current study focuses on the characteristics of leachate generated from landfill sites in Alexandria, Egypt and its impacts on the groundwater quality.

Background information

Waste and leachate quantities

In 2010, Alexandria region had a population of 4.42 million and a total area of 2679 km^2 [8]. It produces 2700 tons of solid waste every day which may increase to 3400 tons/day during summer. Municipal waste, mainly derived from households sector, also includes some institutional, commercial and industrial sources which represent around 1600 tons/day [6].

All the generated solid wastes (2700 tons) are collected daily and transported to 3 transfer stations: Oum Zgheiou, Moharam Bey, and Montazah. They serve three districts west, middle and east of Alexandria. Biodegradable organic waste that represents around 600 tons of the daily MSW generation is transferred to 3 compost plants (Montazah, Abis 1 and Abis 2); 150,000 tons/year of compost is produced and sold to farmers as a fertilizer or soil conditioner contributing to the development of agricultural activities. The remaining wastes are transported to Borg El-Arab Landfill site during winter and El-Hammam landfill site during summer [6,9]. The quantity of leachate produced in Borg El-Arab and El-Hammam landfills is about 6000 m^3/month for each one [10].

Landfill sites description

Borg El-Arab landfill site locates parallel to the Mediterranean sea shoreline and also parallel to the Northern Coast Road "Alexandria-Matrouh Road". It distances around 850 m south the Mediterranean sea coast shoreline and 250 m south the Northern Coast Road "Alexandria-Matrouh Road". The eastern border of the site is at the sign of km 53 and the western border is at the sign 56 km on the Northern Coast Road "Alexandria-Matrouh Road". El-Hammam landfill site locates around 30 km south of Borg El-Arab Landfill site (Fig. 1).

Borg El-Arab site occupies an area of 0.75 km^2 (3 km length, 250 m width, and 9–25 m depth) [11]. The total area of El-Hammam landfill site is 1.19 km^2 (1700 m length, 700 m width, and 11.5 m depth) [10]. Borg El-Arab site includes 7 landfill cells while El-Hammam landfill site includes 13 landfill cells [5,10]. Each cell is large enough for one to two years of MSW generated by Alexandria governorate.

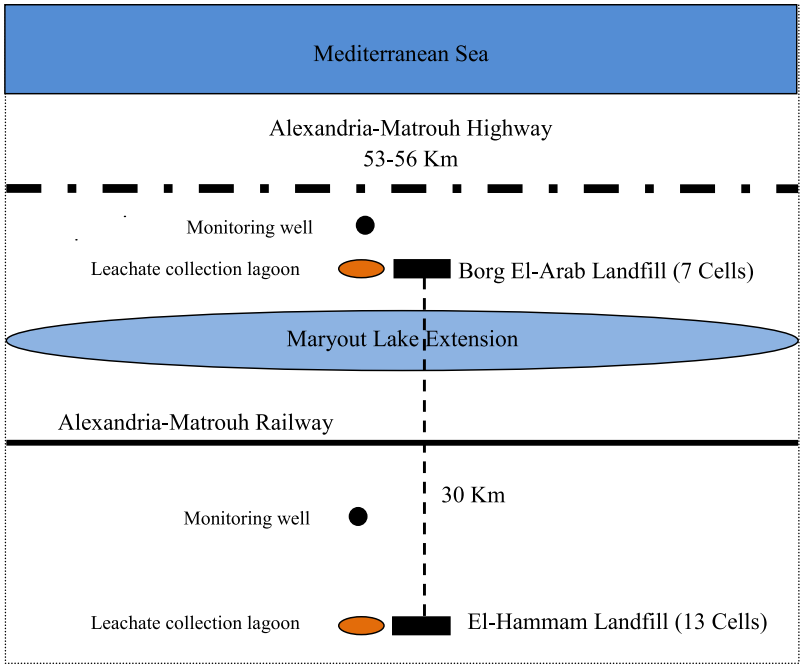

Fig. 1 Lay-out of the study area in Borg El-Arab and El-Hammam Landfills sites.