

Analysis of leachate and water resource quality surrounding municipal solid waste landfill of Tamellast (Agadir, Morocco)

Saadia Asouam^{1*}, Farid Faik¹, Zine El Abidine El Morjani²

¹Department of Earth Sciences, Faculty of Sciences, Ibn Zohr University, Agadir, Morocco

²Polydisciplinary Faculty of Taroudant, Ibn Zohr University, Taroudant, Morocco

Abstract. The aim of this work was to study the physicochemical characterization and heavy metal testing results carried out for leachate generated by the landfilling of household and similar waste in the Tamellast landfill of Agadir. The surface and groundwater resource (often used as drinking source) samples collected from Tamellast and different water sources wells surrounding the landfill were used to find out the impact of leachate percolation on surface and groundwater quality. The Physico-chemical parameters analyzed were, pH, Electrical Conductivity (EC), Dissolved oxygen, Sodium, Potassium, while biological parameters tested were Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), E.Coli and Coliform tot. The contamination was investigated by measuring the concentration of heavy metals (Pb, Zn, Cr, Ni, As, and Fe). The Electrical Conductivity (EC), COD, BOD, Sodium, Potassium, in leachate were found to be 13180 $\mu\text{s}/\text{cm}$, 3150 mgO_2/l , 1000 mgO_2/l , 2000 mg/L , and 10700 mg/L , respectively. The concentration in the surrounding dug wells varied from 8.33 – 9.13 mg/L for Dissolved Oxygen, 9.8 – 18 mg/L for potassium, 0.22 – 0.6 mg/L for Fe, and 0.012 – 0.1 mg/L for total Mn. The concentration of Mn, Fe, and other parameters decreased with increasing distance between the landfill and wells.

1 Introduction

Municipal Solid Waste (MSW) is constituted of solid waste generated from the households, commercial sectors, industries and Institutions. Wrongful management and elimination have harmful impacts on the environment and human health. This creates many serious issues, including contamination of groundwater and surface water resources [2]. The management of MSW is governed by norms that the operator must respect, otherwise the user will be indirectly confronted with the pollution it causes [3]. In recent years, public policies have focused on the management of landfills, particularly in large urban areas where their impact on water and soil has become a serious problem.

Our research focuses on the city of Agadir's public landfill, where waste is the result of human activities and can have various impacts such as: On human health by emitting odours and toxic gases; to water and soil by infiltration or leachate stagnation. These interactions between the landfill and the receiving environment increased the risk of contamination and pollution [3].

The pollution can alter the quality of surface and groundwater. The rainwater, which carries the waste generate leachate that, is infiltrated, enriched the water with metals such as mercury, chromium, lead and many others.

The leachate volume of the Tamellast landfill, which was approximately 148,000 m^3 as of 12/31/2018, was still increasing; the current leachate treatment was not efficient; in addition, the emplacement of the landfill in

a talweg has made the surface area of the site very limited. The continuation of leachate treatment by this process was increasingly limiting the landfill's operational life; therefore, an intensive leachate treatment is urgently needed.

The stock of the landfill leachate in Agadir has a large impact on the environment including the air quality in some areas of the city of Agadir. Unpleasant smells from this stock and weather (winds) are causing smells. Moreover, saturation locker N2 and storage ponds present risks of leachate overflow in case of heavy rainfall.

Given this critical situation a solution is urgently necessary and indispensable to solve this situation. In this context, the aim of this paper was to study the physicochemical characterization and heavy metal testing for leachate generated by the Tamellast landfill of Agadir, to find out the impact of leachate percolation on surface and groundwater resource quality.

2 Materials and methods

2.1 Study area

The Tamellast site is located about 6 km as the crow flies Northeast of Agadir, it is 4.5 km north of the old Bikarane dump and is located in the foothills of the High Atlas between the Oued Tamellast and Oued Smoumène valleys (Figure 1). This site lies between the coordinates (X: 389 and 390) and (Y: 104.5 and 105.5). It corresponds to the contact zone between the Western High Atlas and the plain of Souss.

* Corresponding author: saadia.asouam@email.com



Fig. 1. Localisation of the current Tamellast discharge on the satellite image of Agadir

The Tamellast landfill started up in 2010; with a total surface area of 41 ha, it was composed of two tanks on a surface area of 12 ha and six leachate storage basins, which include the installation of an active waterproof system: Bentonite, Geomembrane and Geotextile to avoid the infiltration of leachate.

2.2 Study area geology

According to the geological map of Agadir at 1/50 000, The Tamellast controlled landfill was based on marl-limestone formations of the Campanian with porous fissures, facilitating the infiltration and pollution of underground water reserves [1].

2.3 Sampling and analysis

To carry out this study, a sampling and analysis campaign was carried out on leachate, groundwater and dam water around the Tamellast landfill site. Four (04) control wells were used as control piezometers. The samples taken concerned the month of March and included major ions, heavy metals, nitrogen, Chemical Oxygen Demand (COD) and Biological Oxygen Demand, organic and mineral matter and some bacteriological analyses. Physical parameters such as temperature, electrical conductivity, total dissolved salts and pH were measured directly in situ using a HACH multi-parameter conductivity meter, model 443600 and a WTW pH meter, pH 522 with combination electrode.

3. Results and Discussion

3.1 Tonnage of waste

The tonnage of waste buried from the commissioning of the Tamellast landfill until the end of 2018 was in the

order of 2,521,420 tons. And the daily tonnage of waste was around 850 to 900 tons.

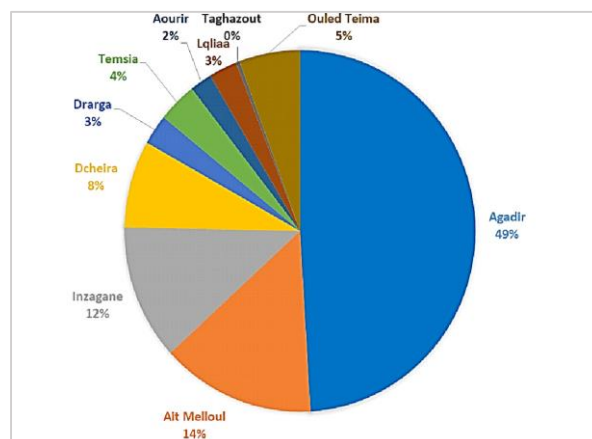


Fig. 2. Total quantities of waste per municipality received at the Tamellast landfill from its operational start to 31 /12/2018.

Between 2015 and 2017, the commune of Agadir produced more than 48% of the waste treated in the Tamellast landfill (Figure 3). The tonnage of waste in the communes of Inezgane, Ait Melloul, Dcheira Ouled Teima was between 19.000 tons and 40.000 tons each year (Figure 3).

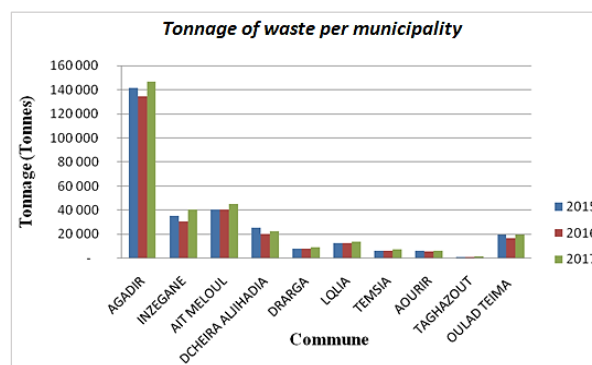


Fig. 3. Tonnage of waste per municipality

The municipalities of Drargua, Lqliaa, Tamsia, Aourir and Taghazout each produced less than 11,000 tons each year.

3.2 Characterization of waste

The municipal solid waste of Tamellast landfill of Agadir were characterized by the predominance of organic matter (Table 1).

Table 1. Characterization of household and similar waste from the divisions of Agadir-Idaoutanane and Inezgane Ait Melloul

matter	Urban environment	Rural environment
Organic	65%	85%
Plastics	5%	3%
metals	1,5%	0,4%
Glass	3%	1%
Paper / cardboard	6%	3%
Other	18%	9%

Note that the percentage of organic matter in household waste goes up to 85% in rural areas as well as in urban areas up to 65%.

The composition of household waste in the municipalities of the study area did not differ from that of the other regions of Morocco; they were characterized by the predominance of organic fraction [4].

3.3 Landfill Leachate Quality

The current treatment of the leachate from the Tamellast was not adequate; thus it is necessary to adopt immediately a new intensive leachate treatment process to operate the controlled landfill of Agadir (Tamellast) in accordance with the standards and regulations in force. The recovery of biogas as heat for the treatment of leachate by forced evaporation made it possible to control and treat the two essential pollutants of technical landfill centres. The development of the treatment process proposed in this study can be used as a solution for the treatment of leachate from the public landfill of Agadir in general. The stock of leachate from the Tamellast landfill, which was around 148,000 m³ from the 12/31/2018, was still increasing.



Fig. 4. Saturation of leachate storage ponds up to 6 ponds

The results of the analysis of the leachate sample have been presented in Tables 2 and 3. Tables 4 and Table 5 present the parametric results for surface and groundwater. The results of the leachate discharge control are summarized in the following Tables 2 and 3.

Table 2. Results of testing for leachate samples for physicochemical parameters.

Settings	Odour	Color	pH	EC ($\mu\text{s}/\text{cm}$)	DO (mg/l)	COD (mgO_2/l)	BOD ₅ (mgO_2/l)
leachate	Unpleasant	greenish	3,1	13180	0,04	3150	1000
Standard*	--	--	6,5 -	2700	--	500	100

Table 3. Results of testing for leachate samples for heavy metals.

Settings	Iron (mg/L)	Zinc (mg/L)	Lead (mg/L)	Arsenic (mg/L)
Leachate	1,3	ND	0,02	0,21
Standard *	3	5	0,5	0,1

* General limit values for direct discharge in the hydraulic public domain

This is a release of leachate with a greenish color and a strong unpleasant odor, presenting an acidic pH (3.1), high contents in dissolved salts, and a practically zero amount in dissolved oxygen (0.04 mg/L).

In addition, this discharge had a significant load of biodegradable and non-biodegradable organic pollutants (COD) 3150 mgO₂/L and (BOD₅) 1000 mgO₂/L, greatly exceeding the general limit values for direct discharge in the hydraulic public domain. The leachate stock of the Agadir landfill had a negative impact on the environment, especially on the air quality of the neighborhoods of the city of Agadir and which were adjacent to the site. The unpleasant odors resulting mainly from this stock and the weather conditions (winds) were the source of olfactory nuisances. The risk of leachate overflowing in the event of heavy rainfall was a real danger, especially since locker n ° 2 of the Tamellast landfill and the storage basins were almost of limited capacity. Thus the treatment and disposal of this stock were required. The Tamellast landfill was made up of several landfill bins which were hydraulically independent units. The leachate which percolated inside the mass of waste must be drained and collected in storage basins. The watertightness of the basins and lockers were ensured by a multilayer structure consisting of a passive safety barrier (clay layers) and / or an active safety barrier (geomembrane). Layout of the final cover of locker n ° 1 and installation of the degassing system of the Tamellast landfill.

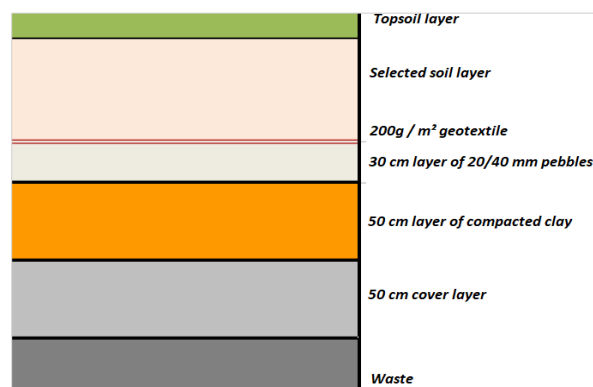


Fig. 5. Layers of the final cover.

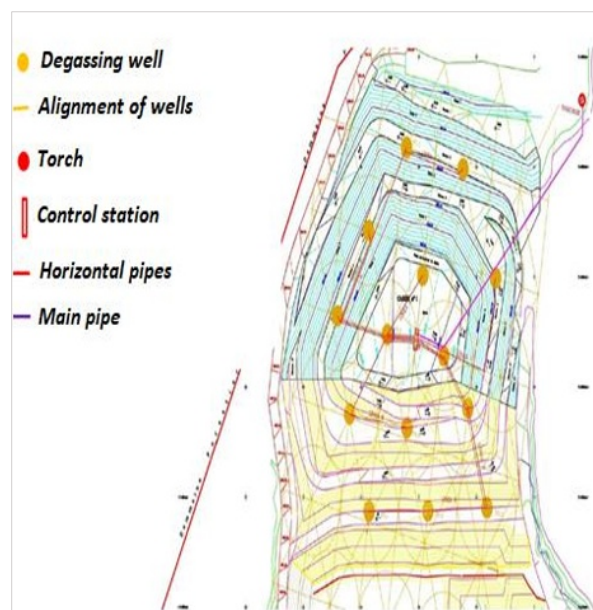


Fig. 6. Locker n ° 1 degassing plan

3.4 Surface and Groundwater Quality

Table 4. Results of testing for surface and ground water samples physicochemical parameters

Standard *	Dam of Tamellast	well 4	well 3	well 2	well 1	Settings
3	unpleasant	unpleasant	unpleasant	unpleasant	unpleasant	Odour
20	>90	0	10	10	7,5	Actual colour ** pt. (mg / L)
6.5<pH<8.5	7,9	8,4	7,9	7,8	7,9	PH
2700	329	1156	1578	2310	2187	EC (µs/cm)
5<=O2<=8	8,33	8,74	8,99	8,93	9,13	Dissolved oxygen (mg/L)
	5	2	6	2	2	COD (mgO ₂ /L)
	ND	ND	ND	ND	ND	BOD ₅ (mgO ₂ /L)

Table 5. Results of testing for surface and ground water samples for heavy metals

Parameters	Iron (mg/L)	Zinc (mg/L)	Lead (mg/L)	Coliforms tot (NPP/100mL)	Enterococci (NPP/100mL)	E.Coli (NPP/100mL)
well 1	0,22	ND	ND	>2419.6	<1	<1
well 2	0,5	ND	ND	>2419.6	<1	<1
well 3	0,6	ND	ND	>2419.6		<1
well 4	0,11	ND	ND	770,1	157,6	<1
Dam of Tamellast	ND	ND	ND	>2419.6	53,6	10,6
Standard *	0,3	3	25	0	0	0

* Moroccan standard No. 03.7001, 2006, relating to the quality of water supply No. 5404 of March 16, 2006.
 (1) WHO, France or European directive, ref. J. Rodier water analysis.
 ND: not detected ** yellowish

The various water samples had an abnormal odour and a slightly yellowish colour, especially for the dam water (<90). Their contents of dissolved salts, undesirable elements and heavy metals comply with the limit values for water intended for human consumption.

The heavy metals in the water samples were generally low. Although iron recorded the highest concentration. It was noticed that the iron exceeded the standard that was 0.3 mg / L in wells 2 and 3, it reached 0.6 mg/L in well 3 and 0.5 mg/L for well 2.



Fig. 7. View of Tamellast Dam showing polluted water, this water is used for livestock watering.

However, when its concentration in water exceeded 0.3 mg/L, iron can change the taste and colour of water. However, bacteriological analysis revealed the massive presence of total coliform bacteria in the well water samples and that of the dam. It was interesting to note that Coliforms was absent in leachate samples but the results of coliform testing showed that the surface and groundwater samples contained high concentration of coliforms. The presence of Escherichia coli (E. coli), faecal coliforms or enterococci in the water indicated that it had been contaminated by stool. The contaminated water can contain microbes (bacteria, viruses or parasites) that caused health problems. To be safe, drinking water should not contain any of these microorganisms. In particular, water contaminated with microorganisms can cause gastroenteritis, which manifests itself by the following symptoms:

- diarrhea;
- abdominal cramps;
- Nausea
- Vomiting.

4 Conclusion

The nature of the waste stored and the mode of operation of the landfill and the geology and hydrology of the site were the conditions that characterize each landfill from the others. The results showed that releasing leachate into the environment near the landfill was a source of contamination. In fact, the leachates of the Agadir dump were blackish in color with an unpleasant odor that was always present in the air. In this study, leachate, surface and groundwater samples were collected from waste dump site to find out the effect solid waste on the groundwater quality. From the results, it can be concluded that the metals present in solid waste can migrate into groundwater and pollute and contribute to degradation of land, water and air. Following interviews with the operating managers of the Tamellast landfill, it appeared that the leachate from the Tamellast landfill emanated, in particular, from industrial waste assimilated to wet household waste that the landfill periodically received from the various food and drink industries of Tamellast.

References

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