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Spatiotemporal evolution of physicochemical parameters in the landfill leachate of Berkane city (Eastern Morocco)

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Abstract: Leachate from municipalities' landfills represents a potential health risk to ecosystems in generally and human populations in particularly. This study which was taken during year from 2006 to 2007 was focused to study the physicochemical evolution of the leachate from the technical enfouissment center of the Berkane city (eastern of Morocco). The analyses of the sampled leachate revealed strong content of biodegradable organic matter (BOD = 264.38 mg/l), mineral matter (conductivity = 23.33 ms/cm) and of suspended matter (SM = 38.38 mg/l). Contents in nitrate (NO_3 = 53.96 mg/l) were also revealed. The long-term monitoring of the evolution of physicochemical parameters in polluted leachate, on how environmental conditions change over time, could then lead to models useful in the prediction of natural attenuation in aquifers.

Key Words: landfills, health, monitoring, leachate, Morocco

Introduction

Water is going to be the dominant world issue into the current century. The supply of water may threaten the social stability of the world (Belle, 2008; El Morhit *et al*., 2012). Indeed, the aquatic ecosystem is threatened more and more by different sources of pollution that decrease its economic potentialities and have ominous repercussions on the human health (El Morhit *et al*., 2009). Many organic pollutants introduced into an aquatic environments (well water, river) are likely to concentrate in plants and animals at levels sometimes considerably higher than rates recorded at their biotope (water and sediment) and can cause environmental problems, health and economic (El Morhit *et al*., 2013; Meissara

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et al., 2013).

In recent years, the landfill of the household remains the most common method used in Morocco. Then, the need appropriate choice of the landfill method is to avoid any damage to the environment. The underlying soils must necessarily be sealed and have a high capacity containment of contaminants (ADEME, 1999; Freyssinet *et al.*, 2002; El Morhit *et al.*, 2008).

The leachate is a polluted liquid emanating from the base of the landfill, which contains innumerable organic and inorganic compounds. The improper collection, segregation, and disposal practices of municipal solid waste produce highly concentrated leachates. The dispersal of leachates poses potential threats to local ecosystems especially to soils and ground-waters (Kale *et al.*, 2010).

In the landfills center, from the deposition phase, the waste is subject to degradation processes related to biological and physicochemical complex reactions (Saadi *et al.*, 2013). The water penetrates into the soil and produces leachate and biogas containing organic and mineral substances. Thus, this could generate pollution mainly organic and metal type in relationship with the natural biodegradation of waste confined and their anthropogenic activities. This phenomenon release many toxic substances into the environment, including the atmosphere, groundwater and effluents (Rivas *et al.*, 2003; Daoudi *et al.*, 2013; Saadi *et al.*, 2013).

The main objective of this study is the physicochemical evolution of leachate controlled discharge in the Berkane city, and to assess its impact on groundwater and the health of the riparian population.

Materials and methods

Study Site

The technical enfouissment center (TEC) is located about 7 km west from Berkane city (in road Nador), at 6 km from Sidi Slimane Cherrâa, 18 km of Aklim, 6 km from the rural town of Boughriba and 10 Km from the rural town of Zegzel. It is accessible from the RN2 at PK 508 with a track about 1.4 km; its area is about 10 hectares.

The site receives daily about 200 tons of household waste, having a high fermentable element. The leachate from the biodegradation of the waste is accumulated at three storage bays for their evaporation and aeration treatment. In addition, so as to develop this study, four sites were chosen and defined as below (Fig. 1). The cashier (S1) having a depth 6m, the decantation pond (S2) having a depth 5m, The evaporation pond (S3) insert the depth with the length is 26.31 m and width is 11.26 m and the will water (S4) it's located near the leachate.

Sampling

The leachate samples were collected in four sites according to the AFNOR methods. The

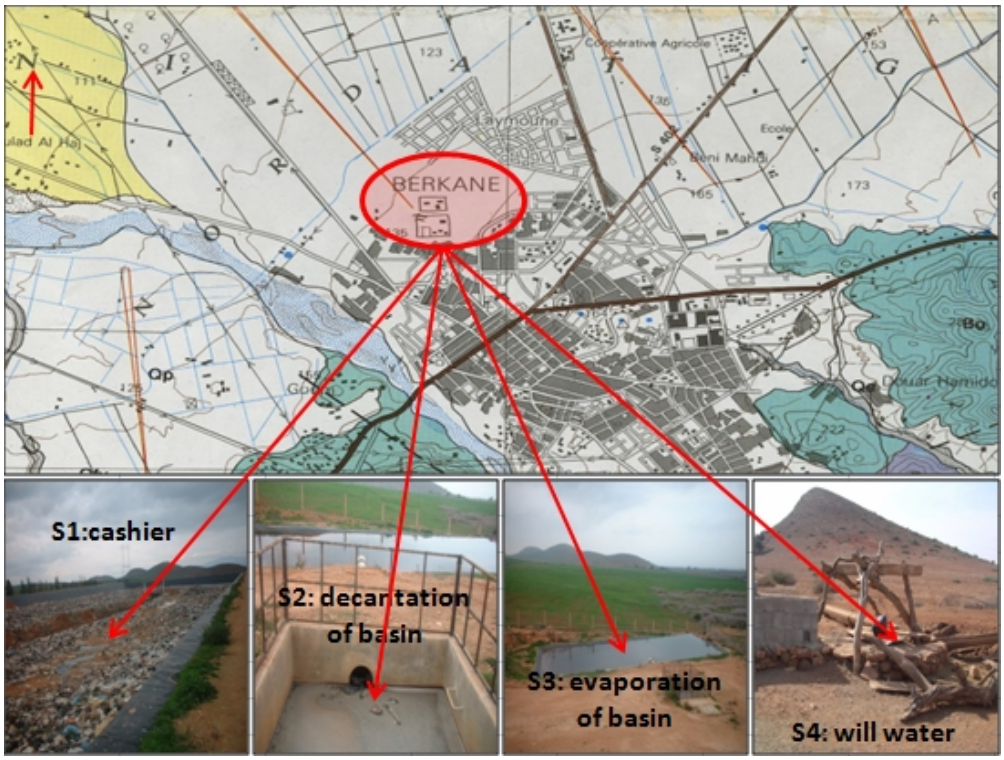

Figure 1: Site of sample collection (Berkane-Morocco)

mean volume of each sample is 1 liter. The leachate samples were filled into polyethylene bottles.

Analysis methods

The samples were taken during six periods (3 campaigns per year during 2006-2007 and 3 campaigns per year for 2007-2008). Thus, for physicochemical parameters, 15 parameters were analyzed especially; T°C, pH, PR, Sal, Cond, BOD, NH_4, NO3, NO_2, Ptot and SM, SM, TM, MF and OF.

Results

Spatiotemporal evolution of physicochemical parameters

To study the spatial and temporal evolution of physicochemical parameters, we analyzed, initially, the evolution of the mean value of each parameter. The results are presented in figures 2, 3, 4 and 5.

The evolution in the mean temperature (°C) of the Leachate of Berkane city follows closely the evolution in atmospheric temperature. Indeed, it varies between 16.30°C found in Station 1 (02/10/2006) and 32.30 °C noted in Station 3 (17/06/2007 and 12/07/2007) with a mean concentration (23.91°C). The temperature in our study is relatively homogeneous. The monthly evolution of the

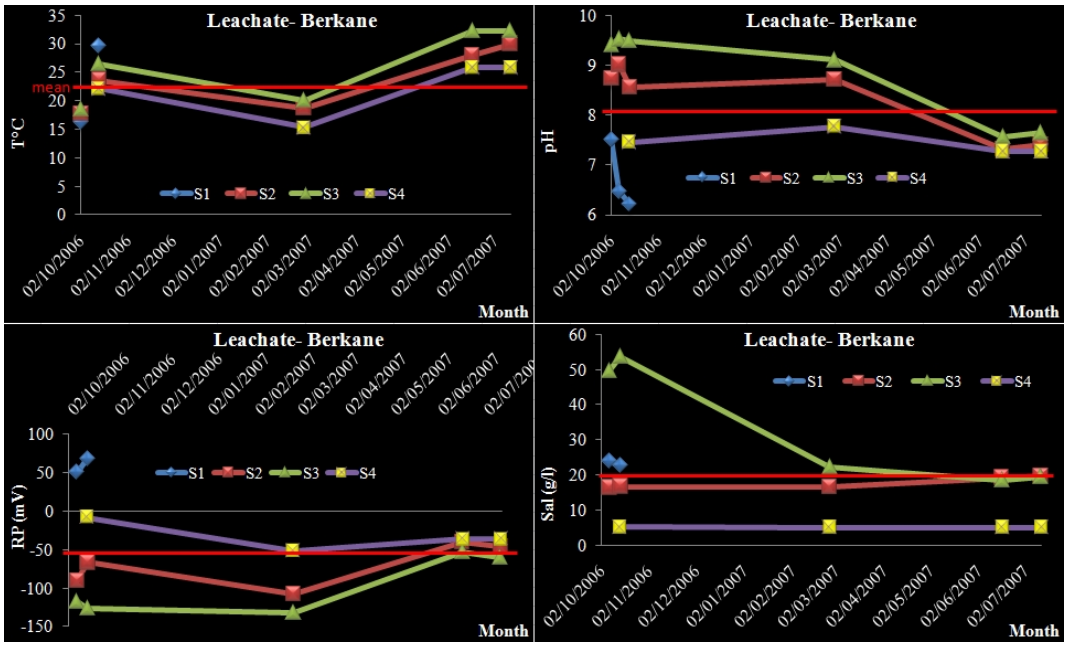

Fig. 2: Spatial and temporal evolution of the physicochemical parameters (T°C, pH, RP, Sal) of the Berkane's Leachate

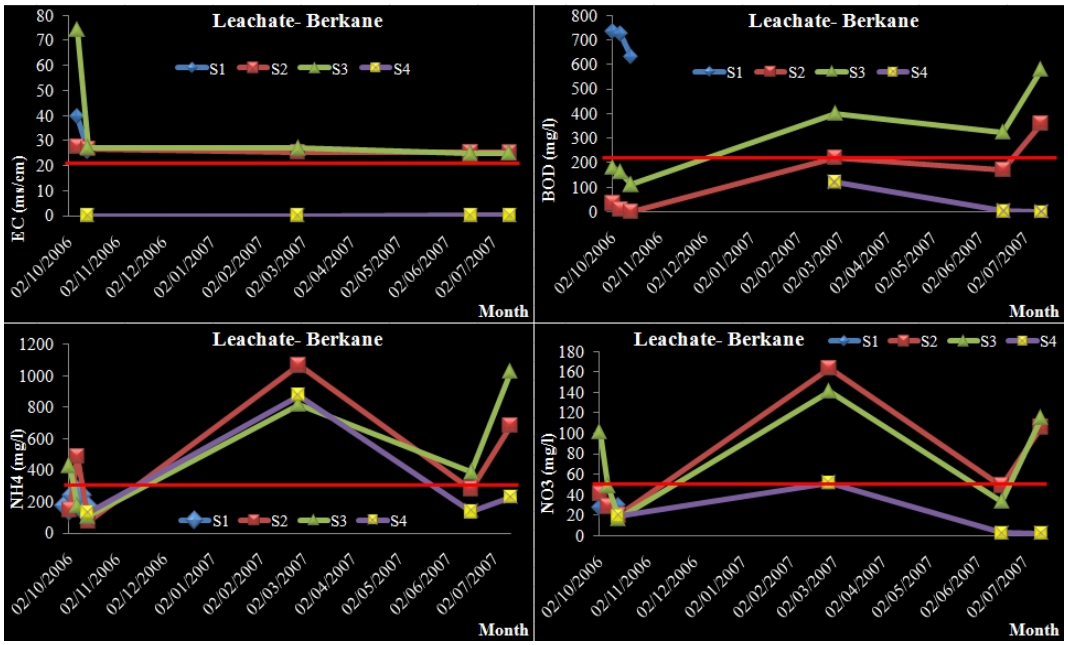

Fig. 3: Spatial and temporal evolution of the physicochemical parameters (EC, BOD, NH_4, NO_3) of the Berkane's Leachate

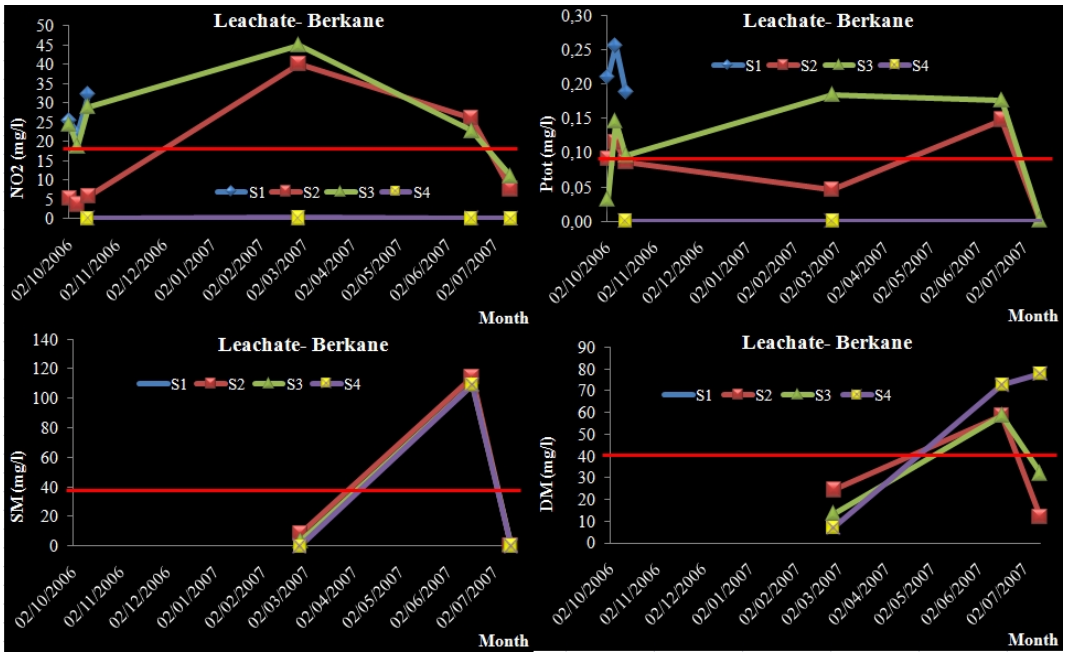

Fig. 4: Spatial and temporal evolution of the physicochemical parameters (NO_2, Ptot, SM, DM) of the Berkane's Leachate

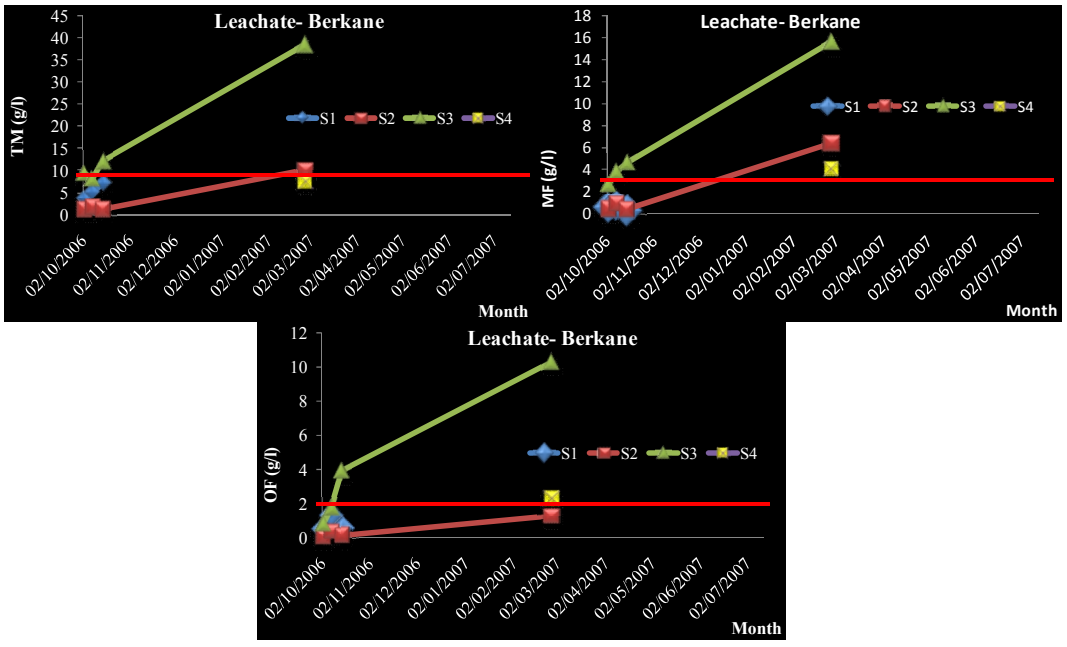

Fig. 5: Spatial and temporal evolution of the physicochemical parameters (NO_3, SO_4, Ptot, SM) of the Berkane's Leachate

temperature concentrations fluctuates during the two years in the same way from the month (02/10/2006) until (12/07/2007) in all stations of this study.

The pH is relatively stable and alkaline for all stations. It fluctuates from 6.21 was recorded in station 1 (14/10/2006) to 9.52 was noted in station 3 (07/10/2006) with a mean concentration (pH=8.02) was detected relatively high in our study. The mean values of this parameter remain relatively high in the Berkane's leachate except at station 1 where it was a slight decrease from contributions of runoff discharges.

The redox potential (RP) shows that the minimum values (RP=-131.60 mV) were recorded for this S1 (26/02/2007). The maximum concentration of RP (68.60 mV) was observed in S1 (14/10/2006). The mean (-53.25 mV) in all stations is due to the influence of marine waters well oxygenated.

The salinity (Sal) values of the Berkane leachate was fluctuated from 5 g/l detected in S4 during any year 2007 to 53.70 g/l recorded in S3 (14/10/2006) with higher mean salinity concentrations (19.93 g/l) were obtained in all stations.

The evolution of the conductivity (cond.) on months from 14/10/2006 to 12/07/2007 is stable and the concentrations range between 0.03 mS/cm and 74.20 mS/cm. It is important with a maximum in the S3. However, at stations S4, the concentrations of the measured conductivity were practically low. This case can be explained by their distance from marine influences and dilution by rainwater.

The biological oxygen demand (BOD) expresses the quantity of oxygen required for biodegradation of organic matter from water. General, all wastewater is heavily loaded with organic matter. A maximum concentration of 733 mg O_2/l was recorded in the S1 (02/10/2006) and a minimum of about 0 mg/l in the S2 (14/10/2006) and S4 (12/07/2007). The mean values were 264.38 mg O_2/l. This can be explained by behaves like streams that are converted to house the outlet wastewater rich in organic matter and nutrients.

The ammoniacal nitrogen (NH_4) is often encountered in water and usually reflects a process of incomplete degradation of organic matter. The mean content was found 327.77 mg NH_4/l. The monthly evolution of the NH_4 concentrations fluctuates during the two years in the same way with higher values of NH_4 (1064.61 mg/l) were noted in S2 (26/02/2007) and lower values of NH_4 (072.73 mg/l) were recorded in the S2 (14/10/2006).

The Nitrates (NO_3) constitute the final stage of the oxidation of nitrogen. Their presence in water certifies that, if the source of pollution is organic, the assimilative is active. The mean concentration NO_3 was noted 53.96 mg/l in all station. Higher values of NO_3 (163.86 mg/l) were noted in S2 (26/02/2007) and lower values of NO_3 (2.47 mg/l) were recorded in the

S4 (12/07/2007).

Higher mean The Nitrites (NO_2) concentrations (16.87 mg/l) were obtained in our station with concentrations fluctuate from 45.10 mg/l in S3 (26/02/2007) to 0.09 mg/l in S4 (12/07/2007).

The Phosphorus (Ptot) is one of the indicators of pollution parameters. The evolution of total phosphorus recalls that observed for NH^{4+}. The mean values were detected 0.09 mg P/l in all study stations. The maximum is 0.26 mg P/l was recorded in the S1 (07/10/2006). The minimum of 0.00 mg P/l was detected in the S4 during in all months.

Suspended matters (SM) represent all the mineral and organic particles contained in water. The values of the SM were ranged from 0 mg/l in the S4 (26/02/2007) to 114.60 mg/l in the S2 (17/06/2007). The mean concentration SM (38.38 mg/l) was detected in all stations. This can be explained by the result of a brutal hydrological event.

Higher mean the dissolved matter (DM), total matter (TM), mineral fraction (MF) and organic fraction (OF) values of 39.57 mg/l, 8.81 g/l, 3.35 g/l and 1.94 g/l were obtained in all stations, respectively. Indeed, the DM concentrations fluctuate from 7.25 mg/l in S4 (26/02/2007) to 77.70 mg/l in S4 (12/07/2007), the TM concentrations fluctuate from 1.21 g/l in S2 (02/10/2006) to 38.34 g/l in S3 (26/02/2007), the MF concentrations fluctuate from 0.39 g/l in S2 (14/10/2006) to 15.60 g/l in S3 (26/02/2007) and the OF concentrations fluctuate from 0.07 g/l in S2 (02/10/2006) to 10.30 g/l in S3 (26/02/2007).

Discussion

Landfill leachate from of the Berkane city contains many minerals often highly toxic contaminants. Their composition is specific to each discharge, and it varies depending on the type of waste, the age of the landfill and the weather. They come from the waste water, the meteoric precipitation and the groundwater water (Matejka, 1994).

Examination of the results presented in Figures 2, 3 and 4 shows that the leachate studied accuses a diverse and high pollution load. Indeed, the EC is of the order of 74.20 mS/cm (07/10/2006) in the leachate leaving of the evaporation basin, indicating the strong mineralization of Landfill Leachate of the Berkane city. This mineralization is mainly due to salinity (19.93 g/L).

High concentrations of SM, Salinity, Nitrates and pH can only be explained by the basic character of Landfill Leachate studied and secondly, their strong mineral and organic load (Aluko *et al.*, 2003 Saadi *et al.*, 2013).

The mean temperature near to 23.91 °C remains related to the local conditions. These concentrations are similar to those found in other site (Saadi *et al.*, 2013, Belle, 2008), suggesting that this increase is due to natural influences and anthropogenic (Sarkar *et al.*

2007, El Morhit *et al*., 2012).

Leachate from the Berkane city decreased their values of the CE, T° and SM in the first campaigns before stabilizing, and show a relative stability of pH. The pH remained relatively stable and basic. The decrease in EC and T° show a decrease in bacterial biodegradation activity.

We clearly notice a decrease in organic content in the first campaigns for leachate in our study during 2006; this decline was more moderate for those of 2007. Overall, we note that there has been a decline organic matter for the Berkane city that reflecting a loss of power of the stock of biodegradable material.

The evolution of NO_3 is opposite with that of NH_4, this corresponds to bacterial denitrification mineralization from NH_4 to NO_3. This phenomenon is not observed in 2006. It is further noted lower overall trend of NH_4, but with significant variations. Ptot for the decline is free during the first campaigns before stabilizing; this evolution is similar for 2 years of leachate from Berkane city.

The mean values of EC observed in our study were high compared to those measured in the new Cashier in France leachate (Belle, 2008) where the mean concentration was detected of the EC 18.5 mS/cm. But lower mean content compared with in other study in morocco (Saadi *et al*., 2013) where the mean values were detected of the EC 37.6 mS/cm.

Our results for SM are lower to those detected by sever authors (Belle, 2008). But higher concentrations of SM were found in our study compared with those recorded by several authors (Saadi *et al*., 2008). The very higher SM values (114.60 mg/l) recorded exceptionally in 17/06/2007 is probably the result of a brutal event hydrological, which it shows a great difference between the minimum and maximum values recorded. This could be related to seasonal variations and also very important to the tidal dynamics. The mean increase of the suspended matter can be attributed to agricultural activity and to an intense erosion of the basin, due to sudden rain storms (El Morhit *et al*., 2011).

The mean values of NO_3 were relatively low compared to those observed in the same leachate landfill of the Berkane city (Belle, 2008) where the mean values were detected of the EC 55 mg/l. But higher mean NO_3 concentrations (36.70 mg/l dry mass) were obtained in the station 5. Another study showed that the agriculture and urban activities are major sources of phosphorus and nitrogen to aquatic ecosystems (Carpenter *et al*., 1998).

The waters in our study show a pH varies in relation to probable fluctuations in salinity following the tidal cycle and possibly fluctuations in organic load (El Morhit *et al*. 2008). The mean values are alkaline of pH. This alkalinity is due to the buffering effect of ocean waters. Other authors have shown that the pH of the leachate landfill of the Oujda city is

buffered. The pH is about 8 because of the buffer system developed by the carbonates and bicarbonates (Saadi *et al.*, 2013; Belle, 2008).

Throughout the site, the concentration of BOD is relatively high compared to that detected in other sites such as the leachate in France (Belle, 2008) where it was noted 155 mg/l in new cashier.

Conclusion

Domestic waste landfill is a complex system whose operation involves many interactions. Highlight the impact of a discharge cannot be confined to a single discipline, as the areas involved are different. Indeed, the evolution of the leachate generated by the landfill of Berkane city showed that leachate is unstable, conveying an important mineral and organic pollution load. Indeed, the study of physicochemical parameters (pH, RP, salinity, electrical conductivity) in our study showed that there was not an evolution in the quality of the leachate. But, the other organic and inorganic parameters were noted the evolution of leachate at the stage of biogas which corresponds to a decrease of their toxicity and thus improve the quality of the raw effluent.

Globally, the characterization of the leachate generated by the landfill technical center of the Berkane city showed that leachate of this area is unstable, conveying an important mineral and organic pollution load. Finally, leachate treatment and control of their potential groundwater infiltration can help to mitigate upstream pressure on the water surface.

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