Larhyss Journal, ISSN 1112-3680, n°24, Décembre 2015, pp. 77-84

PHYSICOCHEMICAL AND BACTERIOLOGICAL CHARACTERIZATION OF A LEACHATE OF A CONTROLLED DISCHARGE

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ABSTRACT

The objective of this study is to determine the physicochemical and bacteriological characteristics of an untreated leachate so as to analyse the environmental risks related to the direct disposal of this type of effluent in the natural medium without any prior treatment.

The analytical results obtained from a series of leachate samples of a controlled discharge revealed high contents in nitrates (NO_3^- =1298,4 mg/L), phosphates (PO_4^{3-} =143 mg/L) et Chlorides (Cl^- =1221 mg/L).

This mineral pollution is manifested in a high electrical conductivity that reaches 28752 µS/cm. Concerning organic pollution, the COD reached 11312 mgO_2/L and the BOD is of 2623 mgO_2/L. The BOD/ COD ratio being 0,23. The leachate studied is situated at an intermediate state of stabilisation.

RESUME

L'objectif de cette étude est de déterminer les caractéristiques physico-chimiques et bactériologiques d'un lixiviat brut afin d'analyser les risques environnementaux liés au rejet de ce type d'effluent directement dans le milieu naturel sans aucun traitement préalable. Les résultats analytiques obtenus d'une série d'échantillons de lixiviat d'une décharge contrôlée, ont révélé des teneurs élevées en nitrates (NO_3^- =1298,4 mg/L), phosphates (PO_4^{3-} =143 mg/L) et Chlorures (Cl^-=1221 mg/L). Cette pollution minérale est traduite par une forte conductivité électrique qui atteint les 28752 µS/cm. Concernant la pollution organique, la DCO a atteint 11312 mgO_2/L et la DBO_5 est de 2623 mgO_2/L. Le rapport DBO_5/DCO étant 0,23. Le lixiviat étudié se situerait ainsi dans un état intermédiaire de stabilisation.

Key words: physicochemical and bacteriological characteristics, landfill, leachate

INTRODUCTION

Originally, landfill constituted the most used technique of elimination in the world, easy to implement, relatively cheap (Saadi et al., 2013), technically very flexible and easy to exploit the burying sites. These sites constitute a potential source of contamination of underground and surface water by the percolation of materials deposited in them. The leachates come from the percolation of rain water through the waste dumps as well as the water contained in this waste and that of its degradation (Hakkou et al., 2001). The leachates appear as important vectors of pollution. Their study is justified through the evaluation of the risk that the discharges present to water.

In fact, since the deposit phase, the waste is subject to a process of degradation related to complex biological and physicochemical reactions (Kouassi et al0., 2014). Under the conjugate action of rain water and fermentation, the waste produce a leachate that cannot be directly rejected in the natural milieu without any prior treatment because of its composition rich in organic and mineral substance, in microorganisms and even in heavy metals.

The understanding of the genesis of the leachate implies not only the knowledge of the nature of buried waste and the mode of exploitation of storage centers, but also the study of the interactions between the water and waste. The mechanisms of the genesis of Leachate are very complex and are of a biological and physicochemical nature (Kulikowska et al., 2008).

At the moment of the implementation of waste, the present oxygen is consumed. The activity of aerobic bacteria strictly allows the degradation of organic substance easily degradable and oxidisable. On average, 5 to 15 % of the biodegradable organic substance is consumed. Moreover, this phase is characterised by a temperature increase between 50 and 70 °C. It lasts a few days up to a few weeks (Aguilar et al., 1999).

Later, the leachate enters a transitional phase which is characterised by a drop in the redox potential and an increase in the COD, proportionally to the concentration in organic substance. This phase lasts a few days up to a few weeks (Chen et al., 1996).

Then the leachate enters the acetogenesis characterised by the presence of acetogenic bacteria which hydrolyse and transform the organic substance by fermentation producing simple and soluble molecules (fatty acids, ammonia). This phase can extend to many years, even decades (Kurniawan et al., 2006). During this period, the produced leachates possess strong values in BOD and a pH acid. These aggressive properties facilitate the dissolution of other compounds like iron, manganese, zink, calcium and magnesium (Wu et al., 2011). Also ,under the action of methanogenic bacteria and the class of archaebacteria, the leachate begins the production phase of methane , CO_2 and H_2 from the biodegradation of organic substance originating in the preceding metabolic except the formation of biogas, the leachate presents a weak COD not easily biodegradable called hard COD. The degradation of organic substance ends by the metabolism of acetic acid which produces a rapid increase in pH. Finally, once the methanogenesis is done, the production of biogas decreases and the hard COD stabilizes.

Concerning the heavy metals content, the study of the characteristics of the leachate of the discharge of El Jadida (Morocco) realized by Chofqi et all, clearly showed the importance of metallic charge in this effluent. Iron being the most abundant metal, followed by manganese and zinc, present important contents. The other metals such as cobalt, Chrome and nickel presented some relatively important contents (Chofqi et al., 2007). Similarly, the work of Mokhtaria et al. , 2007 (Bennama et al., 2010) and Bennama et al. ,2010 (Mokhtaria el al., 2007) showed that the leachates contain numerous metallics (Pb, Zn, Cd, Ni, Cr) beyond the allowed norms.

MATERIALS AND METHODS

The sampling of the leachate was performed with the help of a flacon of 500 ml while ,in hard-to-access zones, we used a telescopic perch ,fixed with a bottle of 500 ml at its extremity. The samples were taken in polyethylene bottles with a capacity of 5 L and 1, 5 L. The bottles were filled to the brim, and then the cork was screwed to avoid all gaseous exchange with the atmosphere.

The analysis of nutritious elements (NO_3^-, NO_2^-, NH4+, PO_4^{3-}) and organic elements (DCO, DBO5) was conducted in a laboratory with the analysis methods HACH-LANG.

The samples of the leachate were sent in polyethylene flacons that were kept cool during the transportation. These samples were later stocked in a refrigerator at 4°C in such a way as to eliminate all biological activity. The analyses of global parameters were realized upon reception of the samples. As for the study of organic substance and its splitting, it was realized as soon as possible in such a way as to limit an eventual evolution of the effluents. Indeed, leachate comes from an anaerobic medium but is neither conserved nor treated in these conditions; it is, therefore, not excluded that slight transformations of organic substance might be produced during the phase of transportation or conditioning. However, even if the organic substance of the leachate is constituted of compounds considered as refractory to oxidation. The samples of the leachate stemming from a bacteriological analysis are prepared from a series of dilution of a tenth of untreated leachate up to 10-9 so as to broaden the scope of research. The method used is that of lactose agar in TTC and Tergitol 7.

RESULTS AND DISCUSSIONS

The leachate composition is extremely variable. The leachate can be thrown in the natural milieu only if it respects certain values-limits proposed by the legislation.

The discharge leachate, object of the present study, is of a blackish color and a fecaloide odor. The results of physicochemical analyses as reported in Table 1, show that the leachate studied produce_a diversified and high polluting charge. In fact, the average electrical conductivity is of 28752 µs/cm order, indicating the strong mineralization which is attributable mainly to the chlorides content (1221 mg/L).

Table 1: Results of physicochemical analyses

Parameter	Analysis results	Unit
pH	8,12	
Conductivity	28752	µS/cm
O_2 dissolved	0,22	mg/L
BOD_5	2623	mgO_2/L
COD	11312	mgO_2/L
PO_4^{3-}	143	mg/L
NO_3^-	1298,4	mg/L
NO_2^-	383,1	mg/L
NH_4^+	0,42	mg/L
Chloride	1221	mg/L
Coliforms	15.10^5	coliform/ml.

A pH of 8,19 shows ,on the one hand, a basic character of the leachate of the discharge studied and ,on the other hand, its strong mineral and organic charge.

Ammoniacal nitrogen NH_4^+ constitutes one of the links of the complex cycle of nitrogen in its primitive state. It is about a gas soluble in water. Its content is of 0,42 mg/L and constitutes the main reductive agent in the discharge leachate. In the long term, this gas constitutes a pollutant of great importance.

The nitrates constitute the final stage of nitrogen oxidation and represent the nitrogen form in its highest degree of oxidation present in water. The registered content is of 1298, 4 mg/L order, a value largely beyond the maximal concentration allowed by the WHO (1980) which is of 50 mg/L. The nitrites come either from the reduction of nitrates or an incomplete oxidation of ammonium ions (Rodier et al., 1996). The content in NO_2 of the leachate is as high as 383,1mg/L. The analyses of Orthophosphates show that the concentration in PO_4^{3-} at the level of the leachate is of 143mg/L, a value largely exceeding the rejection norms.

The COD represents the amount of oxygen consumed by the organic substances and oxydisable mineral salts (Makhoukh et al., 2011). The registered content is of 11312 mgO_2/L. It is 37 times higher than the value fixed by the legislator (COD = 300 mgO_2/L). This high value of COD indicates a high organic charge that can be related to the age, the nature and the amount of the waste as well as different climate factors like pluviometry, air and temperature humidity. In fact, these different factors are at the bottom of the variability of the polluting charges.

The BOD5 expresses the content in biodegradable organic substance. It is of 2623 mgO_2/L order. This value is 26 times higher than the one fixed by the rejection norms (BOD5 = 100 mgO_2/L).

Concerning the BOD5/COD ratio, it is included between 0,1 et 0,5. It is of 0, 23, which expresses a state of organic molecule contained in the leachate not yet reaching the final stage of degradation. These molecules are still in an unstable phase of fermentation, which favor's the phenomenon of anaerobiosis and the maintenance of the discharge in a phase of active degradation.

Concerning the results of the microbiological analyses, after the incubation at (36±2) °C during (44±4) h, the counting method used is that of hard milieu, but instead of number of colonies, the choice was oriented towards the MPN** according to Mac Graddy, since the results of the bacteriological test were difficult to read because of three colonies which are very condensed, near and illegible.

The microbiological results show the strong charge of the leachate in total coliforms, which increase the risk of contamination of underground and superficial water in case of infiltration or streaming.

This charge in total coliforms is part of the enterobacteria family (covering coliforms thermotolerants, E.Coli, Salmonella, streptococcus…). Therefore, it is susceptible that these latter might be present in the milieu.

CONCLUSION

The results of the study of characterization of leachate highlighted the organic and inorganic charge generated by controlled discharge, object of this study.

The results of physicochemical analyses mark a strong content in organic substance which results in strong values of COD (11312 mgO_2/L) and BOD5 (2623 mgO_2/L). The organic fractions (BOD_5/COD) reveal the biodegradability of organic molecules and the age of the leachate studied.

The value of 0,23 is in favor of a leachate not yet reaching the final stage of degradation. So, according to Amokrane (1994), the BOD_5/COD ratio is superior to 0,5 for the young leachates and inferior to 0,1 for the stabilized leachates (Amokrane, 1994). As for mineral pollution, it results in reduced values of NH_4^+ (916, 4 mg/L), and increased values of NO_3^- (1298,4 mg/L), PO_4^{2-} (143 mg/L) and of Cl^- (1221 mg/L). The contents obtained in these pollutants remain superior to the maximal concentration allowed by the WHO. The basic character of this leachate (pH = 8,12) and the BOD_5/COD ratio evaluated at 0,23 are in favor of an intermediate leachate, reflecting an age of discharge ranging between 5 and 10 years, which makes necessary a follow-up of the physicochemical parameters.

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