Physical and Chemical Characterization of Different Stages of Landfill Leachate from Ain Temouchent Engineered Landfill (Algeria)

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ABSTRACT

One of the most important problems with regard to the design of the maintenance of a landfill is the landfill leachate which is produced when water passes through waste. The landfill leachate includes a mass of organic and inorganic components which can be dissolved or suspended. Independently of the nature of the components, it poses a potential problem of pollution on the local grounds and surface water. The objective of this work is to understand the genesis of the landfill leachate while following its evolution to the level of the engineered landfills of Ain Temouchent (Algeria). For this reason we characterized from a physicochemical and bacteriological viewpoint four samples coming from various points located at the level of the basin from accumulation of the landfill leachate: (entered of the landfill leachate, surface of the basin of accumulation of landfill leachate and depth of the basin of accumulation to 1 and 5m). Physico-chemical analyzes carried out on these samples were related to: the temperature, pH, electric conductivity, proportioning of various minerals (chlorides, calcium’s, magnesium’s, sulfates, sulfites), proportioning of total hydrocarbons, organic matter (the BOD5, the COD, suspended matter). We could understand the evolution of our landfill leachate studied dice its arrival with the basin of accumulation; according to the recorded results of the physicochemical and bacteriological analyzes carried out on the four samples, we can say that the landfill leachate passed through four phases: aerobic phase, transition phase, acetogenic phase and methanogenic phase. Thus we could note that this center of engineered landfills is a young discharge (report/ratio BOD5/COD lies between 0.32 and 0.51). The determination of the physical, chemical and bacteriological characteristics of the landfill leachate of the engineered landfills of Ain Temouchent will thus make it possible to direct the die of its treatment to meet the strictest standards of rejection.

INTRODUCTION

In the developing countries, the elimination of household waste presents a main issue. The dies of valorization of waste are not controlled yet and the incineration is not adapted taking into account it’s enough high cost and of the strong water content as of this waste. Dumps and raw discharges are the final disposal of waste including storage conditions do not respond to the safeguards necessary to prevent contamination of water, soil and ensure effective management of sites. Waste storage, amounts concentrating in a volume reduces a varied whole of evolutionary materials. As of the phase of deposit, waste is subjected to processes of degradation related to complex bio-physico-chemical reactions. Part of the breakdown products is found in gas phase, biogas, in charge of substances organic or mineral, the other is transported by the rainwater which infiltrates in waste: it’s the landfill leachate. The landfill leachate generates primarily three types of pollution: pollution by the organic matters and/or mineral, pollution by heavy metals and pollution by the micro-organisms [34,18]. For the best controls this pollution, the realization again standard of discharge, in fact the engineered landfill, seems to be a partial solution if it is controlled. Indeed the engineered landfill is to it a form of controlled discharge. It is characterized by the presence of a large rack of storage of the refuse packed mechanically and especially waterproofed using a geo-membrane preventing the infiltration of the landfill leachate in subterranean water. This landfill leachate is drained towards a basin of accumulation. Nevertheless, the management of this basin poses problem. The strong vintages cause overflows on the neighboring grounds.
Also which would be to become to it landfill leachate? The current Algerian legislation regulates the rejections of effluents, discharges or matter deposits of any nature not presenting risks of toxicity or harmful effect in the hydraulic public domain. The management of the landfill must thus obey this legislation. Of this fact the knowledge of its physico-chemical composition is essential. Our work falls under these problems of management of the landfill leachate and its evolution in the engineered landfill of Ain Temouchent.

MATERIAL AND METHODS

1. Presentation of the study site:

The engineered landfill of Sidi Ben Adda is localized to 4 km in the North-West of Ain Temouchent (Algeria), latitude: 35° 18' 19'' Nord and longitude: 1° 10' 53'' Ouest. This commune extends on 72,9km² and counts 14.086 inhabitants. The engineered landfill is located at 1 km hardly urban fabric of Sidi Ben Adda.

Fig: Geographical location of the engineered landfill of Ain Temouchent.

Biological material:

In order to follow the evolution of the landfill since their source, we have four points of sampling which represent each one a precise stage of the course of the landfill. Four samples are taken in October: sample A has (taken on the level of the access of the landfill to the basin of accumulation), sample B (taken on the level of the surface of the basin of accumulation of the landfill), sample C (taken with a depth of 1m of the basin of accumulation of the landfill) and sample D (with a depth of 5m of the basin of accumulation of the landfill). The samples are taken under sterile conditions and are led to the laboratory.

Physico-chemical analyzes:

Physical parameters such as the temperature, pH, and the electric conductivity of the samples of landfill were measured directly in situ using a pH measures numerical model WTW series INOLAB 720 and conduct meter model WTW INOLAB720.

The samples are then conveyed at the laboratory of SONATRACH, refinery of Arzew RAIZ section of water or they are the subject of several analyzes:

The content chloride (mg/l) of the landfill is determined by the volumetric method of Mohr (ASTM D 512). The sulfates and the sulfites are determined by visible spectrophotometer standard Perkin Elmer Lambda 20 respectively according to standards ASTM D515b and ASTM D1339, calcium is proportioned by complexometry with the EDTA according to standard ASTM D511, magnesium is calculated starting from the difference between total hardness and the total calcium, and hydrocarbons are proportioned according to the standard and AFNOR M07-203.

The content of the suspended matter was determined by the method of filtration. The chemical oxygen demand (COD) is analyzed using a standard COD-meter thermo reactor CR 2010 and the biological oxygen demand during 5 days (BOD₅) is measured using a BOD-meter Model BSB-Megerät 1002, respectively according to standards ASTM D1888, AFNOR T90-101 and AFNOR T90-103.
Concerning the organic load, the contents of the COD and the BOD$_5$ of the landfill are respectively 155mg of O$_2$/l and 50mg of O$_2$/l with arrived at the basin of accumulation of the landfills with a report/ratio BOD$_5$/COD 0.32, so that they reach their maxima in 1m of depth of the basin of accumulation of landfills with values of 219.3mg of O$_2$/l and 110 Mg of O$_2$/l and with a report/ratio BOD$_5$/COD 0.50, these contents tends to decrease in the depths.

With regard to the bacterial load we notice that it 118.108UFC/ml dice arrived of the landfill at the basin of accumulation (sample A), in the second sample of landfill (B) the bacterial load reaches its maximum with a value of 210.108UFC/ml. In the 3rd sample of landfill (C) the bacterial load decreases up to a value of 133.107UFC/ml, while it increases slightly in the depths of the basin of accumulation (sample D) without it reaching its maximum.

RESULTS AND DISCUSSION

In Algeria, standards were not established yet for the landfill of the discharges, but we referred to the current standard of the rejections of industrial liquid effluents (Algerian Official journal, 2013), since the juices of discharge or the landfills are comparable with industrial wastes complex [17,33,38].

The results of the physicochemical and bacteriological analyzes of the landfills taken starting from the engineered landfill of Ain Temouchent are illustrated in the following table.

### Table: The results of physicochemical analysis of the four samples of landfill leachates.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Analysis</th>
<th>Sample A</th>
<th>Sample B</th>
<th>Sample C</th>
<th>Sample D</th>
<th>Algerian standards of rejections</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Fecaloid</td>
<td>7.42</td>
<td>7.69</td>
<td>5.91</td>
<td>10.33</td>
<td>30°C</td>
</tr>
<tr>
<td>Conductivity (s/cm)</td>
<td>Fecaloid</td>
<td>4050</td>
<td>4310</td>
<td>4760</td>
<td>4700</td>
<td>2500-35000</td>
</tr>
<tr>
<td>HAPs (ppm)</td>
<td>Fecaloid</td>
<td>7.81</td>
<td>0.67</td>
<td>0.48</td>
<td>0.33</td>
<td>20</td>
</tr>
<tr>
<td>Chlorides Cl (mg/l)</td>
<td>Fecaloid</td>
<td>477.12</td>
<td>556.64</td>
<td>715.68</td>
<td>695.80</td>
<td>700</td>
</tr>
<tr>
<td>Total hardness TH (mg/l)</td>
<td>Fecaloid</td>
<td>460</td>
<td>500</td>
<td>560</td>
<td>400</td>
<td>700</td>
</tr>
<tr>
<td>Calcium Ca$^2+$ (mg/l)</td>
<td>Fecaloid</td>
<td>340</td>
<td>360</td>
<td>380</td>
<td>260</td>
<td>500</td>
</tr>
<tr>
<td>Magnesium Mg$^{2+}$ (mg/l)</td>
<td>Fecaloid</td>
<td>120</td>
<td>140</td>
<td>180</td>
<td>140</td>
<td>300</td>
</tr>
<tr>
<td>Sulfites (mg/l)</td>
<td>Fecaloid</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.381</td>
<td>1</td>
</tr>
<tr>
<td>Sulfates (PPM)</td>
<td>Fecaloid</td>
<td>329</td>
<td>312</td>
<td>271</td>
<td>207</td>
<td>400</td>
</tr>
<tr>
<td>Matter in suspension (mg/l)</td>
<td>Fecaloid</td>
<td>33</td>
<td>45</td>
<td>61</td>
<td>76</td>
<td>30 - 40</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>Fecaloid</td>
<td>155</td>
<td>210</td>
<td>219.3</td>
<td>173.6</td>
<td>120</td>
</tr>
<tr>
<td>BOD$_5$ (mg/l)</td>
<td>Fecaloid</td>
<td>50</td>
<td>90</td>
<td>110</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>Report DBO/DCO</td>
<td>Fecaloid</td>
<td>0.32</td>
<td>0.42</td>
<td>0.52</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>Total flora</td>
<td>Fecaloid</td>
<td>118.108</td>
<td>208.108</td>
<td>133.107</td>
<td>125.107</td>
<td></td>
</tr>
</tbody>
</table>

- The color and the smell of the four landfills leachate studied constitute the first indicator of pollution. The analyzed landfills have a brownish color and a stinking smell indicating the influence of waste on water quality.
- The temperature of the landfills measured in situ is 15°C for the sample took on the surface of the basin. On the other hand it decreases in the depths until it reaches 10°C with approximately 5m depth of the basin (sample D).
- The pH of the landfill has 7.42 with had arrived at the basin of accumulation, acid (5.91) with a depth of 1m (sample C), and finally basic (8.17) with 5m of depths (sample D).
- The electric conductivity of the sample of landfill is 4050µs/cm and it increases with 1m depths of the basin of accumulation (sample C), and finally basic (8.17) with 5m of depths (sample D).
- The ions chlorides, calcium’s, sulfates and magnesium’s arrived at the basin of accumulation with a value of 477.12mg/l for chlorides, 340mg/l for calcium’s, 329mg/l for sulfates and 120mg/l for the magnesium ions, and reach their maxima with a value of 715.68 mg/l for chlorides, 380mg/l for calcium’s, 207mg/l for sulfates and 180mg/l for the magnesium ions with 1m of depth of the basin of accumulation, while the contents sulfates decrease in the depths, the sulfites present with a value of 0.381mg/l whereas they be null at arrived of the basin.
- The total hydrocarbons are present dice arrived of the landfill at the basin of accumulation (sample A) with a value of 7.81mg/l a rather important value which does not exceed the Algerian standards, this value decreases until it reaches a value of 0.33mg/l in last sample D.
- Concerning the organic load, the contents of the COD and the BOD$_5$ of the landfill are respectively 155mg of O$_2$/l and 50mg of O$_2$/l with arrived at the basin of accumulation of the landfills with a report/ratio BOD$_5$/COD 0.32, so that they reach their maxima in 1m of depth of the basin of accumulation of landfills with values of 219.3mg of O$_2$/l and 110 Mg of O$_2$/l and with a report/ratio BOD$_5$/COD 0.50, these contents tends to decrease in the depths.
Discussion:

It comes out from it from the analysis of the whole of the physicochemical results of the landfills of the engineered landfills of Ain Temouchent, that the master key through four stages: aerobic stage, transition stage, acetogenic stage and tends towards that of the methanogenesis.

The temperature plays a very important part in the increase in the chemical and bacterial activity and the evaporation of water. It is an essential component in the operation of the aquiferous systems, the solubility of salts and especially of gases. It conditions balances of dissociation [10]. It supports the development of various micro-organisms, the landfill taken on the level of its access to the basin of accumulation is hotter than the others landfills, this rise seems to activate the reactions of oxidation, hydrolysis and remineralisation of waste by the bacteria, and consequently, the accumulated landfills become increasingly rich in biogenic salts the such chlorides, sulfates, calcium’s and magnesium’s [20]. In general, a light reduction in the temperature is observed while going in the depths of the basin of accumulation, certainly related to the room temperature.

The hydrogen potential is an indicator of pollution par excellence. According to (Belle, 2008) a seasonal effect influences the pH with the fall during the periods winter which is related on the deceleration of the photosynthetic activity consuming the H+ proton and to the rise during the summer periods. The pH of the landfill with its arrived at the basin of accumulation is neutral, which define the aerobic supporting the development of a broad range of aerobic micro-organisms and acid phase to a depth of 1m which define the acetogenic, and finally basic phase with 5m of depths (sample D), a pH supporting the growth of the anaerobic micro-organisms and even the hydrocarbonoclastes bacteria being basophilic [8,15]. Certain authors express the concentration in proton according to the biochemical demand for oxygen (BOD5) and the concentration in acetic acid [46,36,6]. We know that during the acetogenic phase the pH decrease quickly while the concentration in acetic acid and the BOD5 increase. Also when the BOD5 decreases (methanogenic phase), the pH increases.

Electric conductivity makes it possible to evaluate total mineralization and to estimate the totality of water soluble salts [41], is the reverse of the electrical resistance [30]. Our samples of landfill present very important values of conductivity, it acts of a nature common to all the discharges of household refuse [5,20]. These strong values of electric conductivity indicate a strong mineralization of the latter (landfills). This mineralization is mainly ascribable to the ions chlorides, calcium’s, sulfates and magnesium’s. This close relationship between the contents chlorides and conductivity was shown by Khattabi [20] on the site of Etueffont. The presence of sulfates in the depths of the basin of accumulation of the landfill is explained by the acetogenic phase or the sulfito-reducing bacteria reduce sulfide at sulfates.

The hydrocarbons (HAPs) are molecules which one finds in all the products containing oil. A multitude of products of daily use consist of products which contain hydrocarbons. Most frequently used are: the tires, the residues of shredded cars, the shingles of asphalt roof, the disposable layers, plastic the scrap, glass fibers, oils (oil for engine, oil of refining, oils for food industry, oils rinsing, oils for paper machine…), the fluids for the work of metals, the solvents and the lubricants for slides… etc waste containing hydrocarbons represent nearly 34% of all the waste contained in the sites of hiding.

HAPs are present in the landfill dice its arrived at the basin of accumulation and decrease in the depths what explains why HAPs were solubilized in water and ranges by the bacteria, which depends on their nature, the light compounds are relatively soluble, very volatile and normally easily biodegradable. The heavier products from soluble and do not have in general that few organoleptic effects are degraded by hydrocarbonoclastics bacteria present in the landfill.

With regard to the organic load, the contents of the COD and BOD5 are important dice arrived of the landfill at the basin of accumulation, these contents tend to decrease in the depths. This decrease of the contents is dependant at the same time on physico-chemical processes (decantation, adsorption, flocculation, etc) and biological (bacterial biological breakdown). The decrease of the COD is more important than that of the BOD5 what indicates than the abatement of the organic matter depends more on the physico-chemical processes microbiological [43]. The real concentration of the BOD5 is limited because the medium is in charge in inhibiting metal poisons of the development of the bacteria.

The calculation of report/ratio BOD5/COD enables us to estimate the biodeterioration of the organic matter [36] and to characterize the age and the state of the discharge, it should be recalled that BOD5/COD is a report/ratio which evolves moves in time, it gives information on the nature of the biochemical transformations which reign within the discharge [19]. Thus, for the young discharges or the biological activity corresponds to the acid phase of anaerobic degradation, reached the value of 0.83. On the other hand, for the old ones and the hurdy-gurdy discharges, this report/ratio decreases up to 0.05, for these discharges, the ultimate stage of fermentation. This stage of anaerobic digestion is characterized by the reduction in the COD and especially in the BOD5, with a basic pH [32,40,1,7]. The BOD5 can even become null during the years. We can deduce that our engeneered landfills is a young discharge (report/ratio BOD5/COD lies between 0.32 and 0.51).

The bacterial load is important in the landfill dice its arrived at the basin of accumulation, which is explained by the rise in the temperature of the landfill, the neutral pH and the immigrant contributions of substrates, this bacterial load reaches its maximum in the accumulated landfill, which coincides with the rise in
the contents of nutritive substances. In the depths the bacterial load decreases which is explained by the exhaustion of the organic matter and mineral, we can say that it is rather the pH which seems to control bacterial abundance, since the pH of the medium is neutral with basic in the samples has, B and D and acid in the sample C. It appears that bacterial manpower increase with the rise in the pH. This result is corroborated by the observations of several authors, highlighting a positive correlation between pH and bacterial abundances in the eutrophic mediums [39]. Indeed, the pH belongs to the factors which contribute to the bacterial clearance in such watery ecosystems. Thus, Oufdou et al., [31] showed that the pH alkaline support the development and the survival of certain species, like Vibrio cholerae.

**Conclusion:**

The comprehension of the genesis of the landfills implies not only the knowledge of the nature of hidden waste and the mode of exploitation of the center of storage of waste (height of waste, surfaces exploited, compaction…) but also the study of the interactions between water and waste. The mechanisms of the genesis of the landfills are very complex, they are natures biological and physicochemical [22]. The chemical composition of the landfills is specific to each discharge. Nature the type, the age of the discharge and the climatic conditions influence there [27,20,4,23,387].

The quantitative information and qualitative obtained on several sites shows a very great variability of the composition of the landfills. Generally, formation of landfills starting from waste brings into play a great diversity of phenomena, These various phenomena can be divided into two categories:
- Physico-chemical mechanisms: the evolution of the pH, the value buffer, the salinity and the potential of oxydo-reduction of the percolas is the result of the chemical mechanisms of solubilization, complexation, adsorption, neutralization and transfer of matter [42,52,13,24],
- Aerobic and anaerobic biological processes: thanks to the biochemical action of the enzymes secreted by the micro-organisms of the medium, the organic fraction of waste is degraded [47].

The composition of the landfills of household refuse is very broad and sometimes contradictory in the long run. It is the conclusion to which several authors arrived by studying several sites [5,14]. The mineral fraction is primarily made up of salts: chlorides, sulfates, bicarbonates of potassium, sodium and ammonium [9,18], whereas the organic part is related to the age of the discharge [12,9,13,21].

We can include and understand the evolution of our landfill dice its arrival with the basin of accumulation; according to the recorded results of the physicochemical analyzes carried out on the four samples (A, B, C and D), we can say that the landfill passed through four phases: aerobic phase, transition phase, acetogenic phase and methanogenic phase.

The determination of the physicochemical, bacteriological characteristics of the landfill of the engineered landfills of Ain Temouchent will thus make it possible to direct the die of their treatment to meet the most strict standards of rejection.

**REFERENCES**


