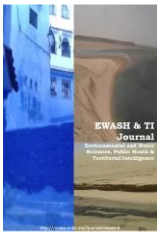

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Physicochemical treatment of Tangier public landfill leachate by clay powder and by other natural materials

Traitement physico-chimique du lixiviat de la décharge publique de Tanger par l'argile en poudre et par d'autres matériaux naturels

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KEY WORDS
Chemical oxygen demand, Biochemical oxygen demand, Fecal Coliforms, Filtration, Sand, Sawdust, Clay.

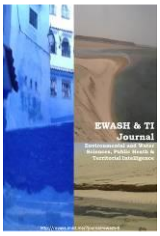
Abstract The work presented focuses on the leachate from the uncontrolled landfill of the city of Tangier .The massive production of the latter creates risks of soil pollution, rivers and groundwater. It is necessary to collect and treat it before discharging into the natural environment. For this reason, we have conducted a physicochemical and biological characterization of the crude leachate, analyzing the physicochemical and biological parameters of the sample taken from the leachate flowing north.

The results revealed strong mineral filler, metallic, organic and biological. We thought to use several methods of treatment : sand filtration, sawdust filtration, adsorption by chemically activated sawdust using sodium hydroxide 3N and adsorption by powdered clay. We will prove that leachate of Tangier's landfill could be effectively treated using adsorption by powdered clay. The average yield of treatment is influenced by the porosity of clay.

MOTS CLES
Demande chimique en oxygène, Demande biochimique en oxygène, Coliformes Fécaux, Filtration, Sable, Sciures de bois, Argile.

Résumé Le travail à présenter se focalise sur l'étude de lixiviat de la décharge publique (non contrôlée) de la ville de Tanger. La production massive de celui-ci engendre des risques de pollution des sols, des rivières et des nappes phréatiques, Il est donc nécessaire de le collecter et de le traiter avant son rejet dans le milieu naturel. Pour cette raison, nous avons réalisé une caractérisation physico-chimique ainsi que biologique du lixiviat brut, en analysant les paramètres physico-chimiques et biologiques de l'échantillon prélevé du cours de lixiviat en direction vers le nord (en écoulement).

Les résultats obtenus ont révélé une forte charge minérale, métallique,



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organique ainsi que biologique. Nous avons pensé à exploiter plusieurs méthodes de traitement ; filtration sur sable, filtration sur la sciure de bois, l'adsorption par la sciure de bois activée chimiquement par la soude 3N et l'adsorption par l'argile en poudre. Nous sommes arrivés à montrer que le lixiviat de la décharge publique de Tanger pourrait être efficacement traité par l'adsorption sur l'argile en poudre. Le rendement moyen de traitement est influencé par la porosité de l'argile.

1. Introduction

The term leachate refers to meteoric waters percolating through the landfill, loading with mineral and organic pollutants. However, the leaching is the migration of soluble substances and flushing corresponds to the migration of suspended particles.

The qualitative and quantitative composition of the leachate depends on rainfall, coverage of the landfill, the sites topography, compaction rate, water content of waste, or field capacity, the filling mode and temperature [1].

In Morocco, the predominant method of waste treatment is landfilling. This method of treatment generates a large volume of leachate, which causes negative consequences to the environment and public health [2].

In fact, from the deposing stage, the waste is subjected to processes of degradation associated with complicated biological and physicochemical reactions. The water infiltrates and produces leachate containing organic, inorganic and bacteriological substances which primarily generates an organic, inorganic and microbiological type of pollution, in relation to the natural biodegradation of the confined waste. These leachates are a source of environmental contamination if they are not collected and treated [3].

In this context, the first objective is to determine the quantity and quality of crude leachate from Tangier's landfill which are essential for characterizing the pollution load and to estimate the risks of this leachate on water quality of the surrounding groundwater [4]. For this purpose, this study will use methods of a physicochemical analyzes (pH, conductivity, TSS, COD, BOD5, TKN…) and microbiological (Fecal Coliforms and Fecal Streptococci).

For the treatments, our intention is to propose and study an inexpensive and effective method of treatment of these leachates. An adequate leachate treatment system should provide an effective treatment and retention capacity to handle the leachate quantity.

Best available technology should be applied in order to prevent and minimise further environmental impacts [5].

The searched process seeks to achieve a very significant reduction of the organic load of the leachate and could be implemented on a large scale. [6]

The Traditional treatment of leachate by an aerobic biological process (activated sludge, trickling filter) or anaerobic (conventional digester, UASB reactor Upflow Anaerobic Sludge Blanke) are often associated with physicochemical processes (coagulation-flocculation, chemical precipitation, chemical oxidation and adsorption by different materials) [7].

Our contribution will consist on a physicochemical treatment by batch adsorption of organic matter on a natural material using sawdust; natural and chemically activated [8], beach sand or clay [9].Knowing that the most commonly used adsorbent is the powdered activated carbon (PCA) or in grains (GAC), it eliminates on average 50 to 90% of COD and nitrogen and also allows to decrease a very satisfactory components responsible for the coloration of leachate.

The main disadvantages of activated charcoal are the manufacturing cost and its regeneration when the carbon is saturated.

Comparing the effectiveness of natural materials with the activated carbon, adsorption techniques are very useful especially the clay adsorption for the treatment of certain pollutants existing in the leachate, especially those with difficult biodegradability like colorants.

Considering the initial costs, the flexibility, and the conception simplicity as well as for the operation, these methods are interesting.

They are also effective in the reduction of chemical oxygen demand (COD) and biochemical oxygen demand (BOD5) (abatement of 62% of the clay adsorption).

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2. Material and methods

2.1. Tangier's landfill localization

Tangier's landfill is located south-east of town at 5km from the center on the regional road (N.R.2) to Tetouan. It started to function in the early 70s on a private property of the state. To reduce its visibility from the N.R.2, the landfill has been pushed back gradually to the northern side hills [10].

The choice of the landfill location complied to that era standards which could be summarized in its isolation from the city. Today, the landfill is caught by it due to rapid urbanization.

2.2. Sampling and conservation

Taking the samples was executed by a 500 ml flacon and also using a 1L capacity polyethylene bottle previously washed with nitric acid and then with distilled water. On the field, before filling the bottles, they were washed with the sample. Bottle filling was made to the brim and then the plug is used to prevent gaseous exchanges with the atmosphere.

The leachate samples were stored in a cooler (4°C) during transportation to laboratory and then were analyzed within the next 24 hours [11].

2.3. In situ analyzes

During the sampling, the physical parameters (pH, conductivity and temperature) were measured in situ. The equipments used in the field are a conductivity meter multi-parameter ProfiLine Cond 3110 WTW® [12] for electrical conductivity measurement (EC) and temperature, pH-meter 3210/3310, WTW® [13] for the pH measurement.

2.4. Laboratory analyzes

2.4.1. Physicochemical analyzes

The total suspended solids TSS were measured by gravimetric method of vacuum filtration using a fibrous paper filter WATMAN (47 mm diameter).

The chemical oxygen demand COD [14], total nitrogen TKN [15], total phosphorus TP [16] and nitrates NO_3^- [17] were determined by the potentiometric method Test Tubes Spectroquant® but each tube contains a certain dosage of specific reagents, then the parameters are measured by a spectrophotometer WTW® PhotoLab 6600 UV-VIS.

The biochemical oxygen demand BOD5 is measured by a manometric method of OxiTops flacons OxiTop® WTW® IS 12 [18].

2.4.2. Microbiological analyzes

The Fecal Coliforms are estimated by a research method and enumeration by seeding in a liquid environments (Most Probable Number MPN) using a culture environment for presenting and confirming test A1-Broth.

Fecal streptococci are estimated by the same method as fecal coliforms but using sodium azide as presenting test and Litsky as confirming test. [19,20].

2.5. Exploitation of different treatment methods

2.5.1. Sand Filtration

A 500 ml volume of sample was filtered through a 750 g of sifted sand on a funnel provided with a small piece of sponge at its tip to avoid the passage of solid matter to our obtained filtrate in the Erlenmeyer flask.

After ten hours of decantation we have obtained a 300 ml volume of filtrate.

2.5.2. Sawdust Filtration

A 500 ml volume of sample was filtered through a 200 g of sifted sawdust on a funnel provided with a small piece of sponge at its tip to prevent the passage of solid matter to our resulting filtrate in the Erlenmeyer flask.

After three hours of decantation, we had a 100 ml volume of filtrate.

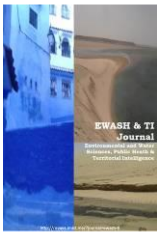
2.5.3. Treatment by activated sawdust with NaOH

- **Chemical activation of sawdust**: An amount of 50 g of sawdust is mixed with a volume of 250 ml of NaOH 3N, the mixture is stirred for one hour and then vacuum filtered. The obtained solid is dried in an oven at 110°C type Binder E28 -Gemini BV.
- **Sample treatment**: A volume of 100 ml of leachate is mixed with an amount of one gram of chemically activated sawdust by NaOH 3N. The mixture is magnetically stirred and receives vacuum filtration.

2.5.4. Clay filtration

A 500 ml volume of leachate was filtered through 300 g of clay (Taken from the Jbel Kbir region in the vicinity of Tangier) which was previously dried in an oven and crushed using a mortar.

On a funnel provided with a small piece of sponge to its tip to prevent the passage of solid matter to our obtained filtrate. After five hours of decantation we obtained a volume of 250 ml of filtrate.



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3. Results and discussion

3.1. Electrical conductivity and pH

The leachate from Tangier's landfill is basic since the sample was taken approximately in the summer, even after its treatment using different materials with the exception of the clay where it has become slightly acid (Cf. Tab. 1).

Tab.1 shows a high electrical conductivity of the crude leachate; this is due to the presence of a high content of soluble salts.

There is a significant reduction of the electrical conductivity (which means the reduction of soluble salts) after leachate treatment with clay and sawdust comparing to other treatment methods.

A reduction using activated sawdust (29.1 mS/cm to 16.1 mS/cm) and a reduction using clay (29.1 mS/cm to 18.3 mS/cm).

Tab. 1 : pH and conductivities of leachate before and after treatment

Treatment method	A	B	C	D	E
pH	8.21	8.3	7 .9	8.72	6.97
Conductivity (mS/cm)	29.1	32.6	26.5	16.1	18.3

Source: Personal work

A: Crude leachate ; B: Sand filtration ; C: Sawdust filtration;
D: Treatment by activated sawdust ; E: Clay filration

3.2. Suspended solids SS

The crude leachate is loaded with suspended solids (1270 mg/l), after sand and clay treatment there was a significant decrease in the SS rates (Cf. Tab.2) especially for clay (204 mg / l) which is defined by its elevated solids content but it requires a long time for decantation [21]. The abatement rate for the clay process is 83%.

Tab. 2 : SS of leachate before and after treatment

Treatment method	A	B	C	D	E
SS (mg/l)	1270	420	1050	870	204

Source: Personal work

A: Crude leachate ; B: Sand filtration ; C: Sawdust filtration;
D: Treatment by activated sawdust ; E: Clay filration

3.3. COD and BOD_5

Table 3 shows the effect of clay filtration on the leachate; a significant decrease was observed, bringing it from 19380 mg/l to 7550 mg/l, or an abatement rate of 61% .Which shows a large reduction of the organic pollutant matter.

The significant decrease of BOD5 by the different treatments methods of leachate (Cf. Tab. 3) which goes from a concentration of 14920 mg O_2/l to 140 mg O_2/l for the process of filtration treatment with clay shows that the existing organic matter in this type of leachate is easily oxidizable and biodegradable. This organic matter is probably formed by a predominance of small molecules [22].

The most significant reduction of BOD_5 is the one obtained by clay filtration of 98%.

Tab. 3 : COD and BOD_5 of leachate before and after treatment

Treatment method	A	B	C	D	E
COD (mg/l)	19380	10425	10900	10275	7550
BOD_5 (mg O_2/l)	14920	180	200	150	140

Source: Personal work

A: Crude leachate ; B: Sand filtration ; C: Sawdust filtration;
D: Treatment by activated sawdust ; E: Clay filration

3.4. Total nitrogen TKN, Total phosphorus TP and nitrates NO_3^-

After the four treatments performed on the crude leachate, the value of the total nitrogen has decreased on average to 18.7 mg/l, which corresponds to 54% of the initial value of 34.5 mg/l (Tab.4). Its decrease in the leachate treated by clay (14.3 mg/l) is more significant compared to other treatments with an abatement rate of 24%.

The total phosphorus existed in the leachate with an initial concentration of 9.5 mg/l. This concentration decreased after clay filtration (4mg/l) in comparison with other treatment methods of a 58% reduction rate (Cf. Tab. 4).

Nitrates constitute the final stage of nitrogen oxidation and represent the highest oxidation form of nitrogen existing in the leachate. The values recorded after treatment oscillate between 12.2 mg/l and 19 mg/l, with an initial content of 24.5 mg/l (Tab.4) .The most significant abatement rate is the one of clay of 50 %.

These stored values are not very satisfactory, since we did not conduct an aerobic treatment for the denitrification [23].

The organic and ammoniacal nitrogen released can be oxidized to NO_3^-. These ions are little retained by the

adsorbant power of the soil and can be easily leached away with the drainage water [24].

NO_3^- ions are poorly complexing and can associate with monovalent cations of the alkali metals present in the treated leachate such as K^+, Na^+ and Li^+ to form $NaNO_3$, KNO_3 and $LINO_3$. The NO_3^- anions can also associate with divalent metals In the leachate such as Zn^{2+}, Pb^{2+} ,Cu^{2+} and Fe^{2+} to form metal nitrates $Zn(NO_3)_2$, $Cu(NO_3)_2$, $Pb(NO3)_2$ and $Fe(NO_3)_2$ [25].

Tab. 4: TKN, TP and NO_3^- of leachate before and after treatment

Treatment method	A	B	C	D	E
TKN (mg/l)	34.5	20.4	21.1	19	14.3
TP (mg/l)	9.5	5.1	5.6	4.3	4
NO_3^- (mg/l)	24.5	19	19.3	18.2	12.2

Source: Personal work

A: Crude leachate ; B: Sand filtration ; C: Sawdust filtration;
D: Treatment by activated sawdust ; E: Clay filration

3.5. Fecal Coliforms (F.C) and Fecal Streptococci (F.S)

In crude leachate, the fecal coliforms and fecal streptococci are very abundant and come on top of germs. The initial values of coliforms and streptococci are of $1,3.10^5$ F.C/100 ml and 3.10^6 F.S/100 ml respectively. The results obtained with the process of clay filtration of crude leachate (4.10^4 F.C/100ml and $7,2.10^5$ F.S/100ml) (Cf. Tab. 5), we can conclude that the clay is able to remove a large part of fecal pollution germs since the abatement rate is up to 70% for Fecal Coliforms and 76% for Fecal Streptococci [26].

Tab. 5: F.C and F.S leachate before and after treatment

Treatment method	A	B	C	D	E
F.C (F.C/100 ml)	**$1,3.10^5$**	**$5,7.10^4$**	**7.10^4**	**$5,3.10^4$**	**4.10^4**
F.S (F.S/100 ml)	**3.10^6**	**$8,1.10^5$**	**$8,3.10^5$**	**$7,9.10^5$**	**$7,2.10^5$**

Source: Personal work

A: Crude leachate ; B: Sand filtration ; C: Sawdust filtration;
D: Treatment by activated sawdust ; E: Clay filration

4. Conclusion

The characterization of leachate generated by the uncontrolled landfill of the city of Tangier revealed strong inorganic, organic and microbiological loads. The obtained values (EC of 29.1 mS/cm; SS of 1270 mg/l ; BOD_5/COD of 0.76; TKN of 32.5 mg/l ; NO_3^- of 24.5 mg/l; TP of 9.5 mg/l; F.C of 13.10^4 F.C/100 ml and F.S of 3.10^6 F.S/100 ml) far exceed national and international standards.

These results allowed us to conclude that we have a '' young '' leachate with an important biodegradability and contaminate the groundwater that flows to low depths [27].

The development of technologies using biomaterials as adsorbents, gave satisfactory results in terms of reduction of organic pollutant load with COD reduction rate of 46%, 44%, 47% and 61% respectively for filtration sand, sawdust, activated sawdust and clay as well as elimination of fecal matter in terms of the F.C with an abatement rate of 67%, 17%, 31% and 84% respectively for sand filtration, sawdust filtration, treatment with activated sawdust and clay filtration.

The preliminary treatment with powdered clay carried out on the leachate allows the abatement of the pollutant load but unfortunately the values obtained remain above the Moroccan Standard Norms of rejection (COD 500 mg/ l, BOD_5 100 mg O_2/l, MES 100 mg/l) [28] because of the high polluting load present in the raw leachate.

To complete the treatment, it is essential to supplement with other biological or chemical treatments.

From these results it can be concluded that adsorption by clay is the most suitable method for the treatment of leachate as it gives more similar results to those of activated carbon (treatment efficiency reaches 90%) compared with other adsorbents .In order to transpose this study on a large scale it is necessary to study the influence of the porosity of clay on the treatment efficiency.

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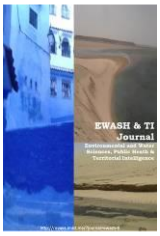

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