IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 12 Ver. I (Dec. 2016), PP 41-50
www.iosrjournals.org

Physico-chemical treatment of landfill leachates Case of the Landfill of Fkih Ben Salah, Morocco

Merzouki Hasna[1], Hanine Hafida[1], Lekhlif Brahim[2], Mandi Laila[3], Merzouki Mohammed[4]

[1]*(Bioprocess and Biointerface Laboratory / Faculty of Science and Technology, University of Sultan Moulay Slimane Benimellal, Morocco)*
[2]*(Research team Hydrogeology / Treatment and Treatment of Waters and Climate Change, Laboratory of Environmental Engineering, Hassania School of Public Works, Casablanca, Morocco)*
[3]*(National Center for Studies and Research on Water and Energy (CNEREE), Cadi Ayyad-Marrakech University, Morocco).*
[4]*Bioengineering laboratory Faculty of Science and Technology, Sultan moly Slimane University, Beni Mellal, Morocco.*

Abstract: *The landfill of Fkih Ben Salah presents a typical example of environmental degradation. It generates a significant amount of waste (85.51 T / J in 2016), and therefore a leachate volume which can reach 3996 T / J (July 2015), these are characterized by a high polluting load; The EC (32.67ms / cm), Turbidity (5190FTU), MES (8,119g / l) and COD (68170mgO2 / l), the treatment of which is essential.*
Coagulation is a technique that reduces pollutant concentrations, the selection of the coagulant and the optimum conditions are essential. For these reasons, our work consists in presenting a comparative study of four precipitation products (Ca (OH)2, Al2 (SO4)3, FeCl3 and Al (OH) xCly) To improve the rates of reduction of the most effective coagulant. The results obtained show that lime is the most effective coagulant with reduction rates of turbidity, COD and TSS respectively, Lime (83%, 87%, and 71.06%), Al (OH) xCly (52%, 68%, and 26.72%), FeCl3 (48%, 33%, and 25.70%) and Al2 (SO4) PH adjustment and increasing sedimentation time, we found a final abatement rate of 90% (Turbidity), 90.27% (COD), and 81.79% (TSS).
Keywords: *leachate, Treatment, lime, COD, turbidity, Coagulation.*

I. Introduction

Leachates refer to the water that has percolated through the waste by being loaded with pollutants. These contaminated effluents must be treated to avoid environmental and / or sanitary impacts and to meet the increasing requirements of discharge standards [1]. The treatment of leachates is a traditional water treatment technique. Physico-chemical processes, such as coagulation-flocculation processes, are used for the removal of suspended solids and the color which has been essentially provided by the organic materials with insoluble forms [2]. Chemical precipitation is the most widely used because of its ease of use [3]. In this approach, the dissolved metal ions are converted to the solid insoluble phase via a reaction with a chemical. Thus, precipitates of low solubility are produced, such as heavy metal hydroxides [4]. Coagulation, therefore a clarification treatment, aims to eliminate the colloidal suspended matter present in the water. This type of suspended matter is in fact not decanted without physicochemical treatment. In fact, this treatment also removes some of the fine suspended solids and some dissolved substances.

The choice of this technique is due to several factors; it is efficient, relatively simple and inexpensive. However, pH is an essential element for the removal of colloids; the optimum coagulation pH must also be studied.

The landfill of Fkih Ben Salah is among the wild dumps, which suffer from waste management problems. This is mainly an uncontrolled and open-cast landfill, where all types of waste are discarded and mixed: urban, industrial, hospital and agricultural [5],[6]. The implementation of these "wild" landfill sites was not preceded by any environmental impact assessment. It generates a significant amount of household waste and assimilated. In 2015, a quantity in the order of 83.84T / J, which translates into 996.62m3 / year of leachate, is released into the environment.

For this reason, and in order to reduce the pollutant load of the leachate (EC (32.67 m / s), Turbidity (5190 FTU), MES (8.11 g / l) and COD (68170 m 2 O / l)), the coagulation technique (OH) 2, FeCl3, Al2 (SO4) 3, and Al (OH) xCly), is implemented to improve the optimal conditions by studying the effects of the concentration of the coagulant, PH, and settling time.

II. Materials And Methods

2.1 Site Description

The dump of Fkih Ben Salah is a wild dump located at 12Km from the town on the road to Khouribga on the rural town of Krifat, it receives 85.51 tons per day (in 2016). The local population is 104,000 in 2016 (census estimate 2004), ie a waste production ratio of 0.63 Kg / person / day.

2.2 Determination of waste quantity and volume of leachate

The quantity of waste is determined from the weighing tickets of the waste trucks in the weighbridge at the end of the collection rounds.

The leachate volume was determined in the landfill at the end of the waste collection tours and prior to garbage unloading, recovering the leachate produced, and measuring the volume of each truck in a graduated vessel and deduct the total at the end of the day.

2.3 Sampling

The sampling of the leachates was carried out from the packers collecting waste from the various districts of the town of Fkih Ben Salah. Then, these samples of the same volume were mixed to form a homogeneous and representative sample of the leachates coming from the fresh waste. PH, electrical conductivity and temperature were measured in situ.

The samples were stored at a temperature below 4 ° C and transmitted to the laboratory within 24 hours.

2.4 Coagulation tests

All precipitation / coagulation tests were carried out at room temperature and the experiments were carried out in a jar test apparatus consisting of a 6-stirrer flocculator. To determine the optimal dose of the products used. For each test, 500 ml of the leachate are added to which are added doses ranging from 0 to 12 g / l for the four products used, with rapid stirring of 250 rpm for 5 min and slow stirring at 25 rpm for 20 min, Followed by decantation. After, the supernatant samples were taken to carry out the analyses.

2.5 Methods of analysis

During the tests, the main parameters indicative of the pollution were studied. These are temperature, pH, electrical conductivity (CE), turbidity, suspended solids, chemical oxygen demand COD. All experimental analyzes were carried out in accordance with the AFNOR standard. In this study, pH, temperature, and conductivity were measured by a milt parameter type of WTW multi 340i / set (WTW Büro-weilheim, Germany), MES was determined by the filtration method, and COD was analyzed by bichromates [7]. The turbidity measured by a turbid meter of type HI93703.

III. Results And Discussion

3.1 Evolution of the quantity of waste produced:

The number of households estimated in 2016 at the level of the town of FKIH BEN SALAH is 104 000. The production of waste, as carried over to the commune level, is estimated at 31 212 tonnes in 2016, Or 85.51 T / day (Table 1), an increase of 1,67T/J from the year 2015, and 3.32T/J from the year 2014. This notable increase is mainly due to urban growth, population growth, and changes in lifestyles, production and consumption.

According to the same table1, it is deduced that the ratio of waste production per person is 0.82 Kg / person / day, this ratio is identical to that of Mostaganem (Algeria) which is of the order of 0.82 Kg/person/day[8], and is higher than the national ratio of 0.76 kg / person / day [9].

Table 1: Annual evolution of population and quantity of waste

Year	***2 014***	***2 015***	***2 016***
Estimated population	100000	102 000	104 000
annual quantity (T)	30 000	30 600	31 212
Daily quantity (T)	**82,19**	**83,84**	**85,51**

On the other hand, the population of the city of Casablanca generates more waste (0.89Kg / Person / Day) [10], while the cities of Kasba Tadla and Temara-Skhirat-Harhoura generate less than the city of Fkih Ben Salah by a ratio of 0.73Kg / person/day[11], and 0.65 kg/ Person /day [12].

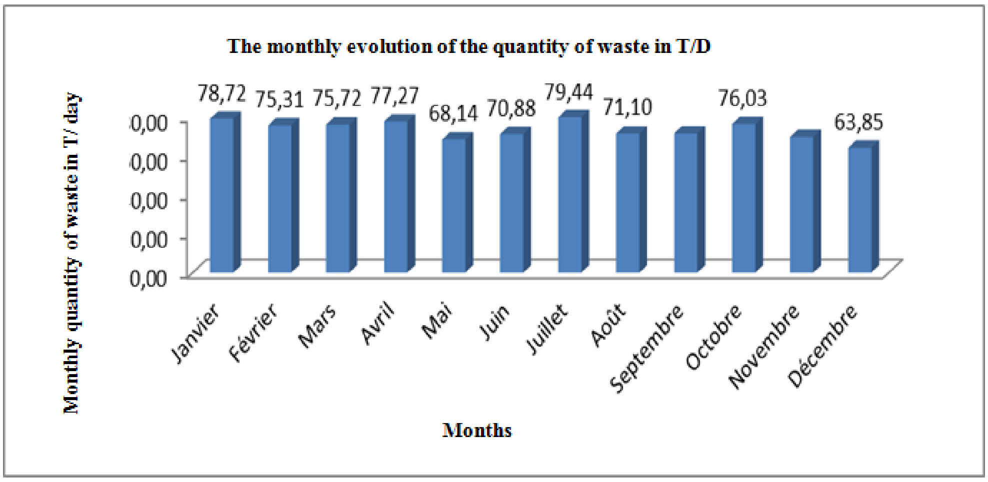

Fig.1: Monthly change in the quantity of waste 2014

Figure 1 shows a significant seasonal variation in the amount of waste generated, the maximum amount of waste is collected in the dry period (79,44T/J in July) followed by the wet period (78,72T/J in January), While the minimum is reached in December (63,85T/J).

Other factors influence the production of waste, namely; The level of economic activity which plays an important role in a causal relationship between growth and the quantities of waste produced, as well as meteorological events (storms, drought, etc.), population variations (tourist areas, exceptional events ...) [13].

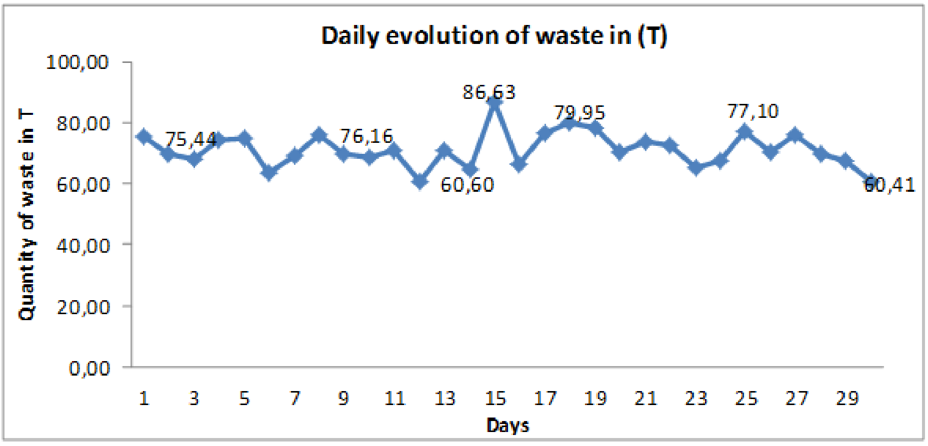

Fig.2 : Evolution Journalière de la quantité des déchets produite en Kg Mois Septembre 2014

It can be seen from the figure 2 that the daily production of waste is varied between a minimum achieved on 30/09/2014 (60.41 T / J) and a maximum produced on 15/09/2014 (86.63 T /).

3.2 Evolution of the quantity of leachate produced in the town of Fkih Ben Salah:

Table 2: Monthly change in the quantity of waste and volume of leachate produced 2015

Days	Janaury		Avril		Juily		October	
	Quantity Waste (T)	Volume Leachate (L)	Quantity Waste (T)	Volume Leachate (L)	Quantity Waste (T)	Volume Leachate (L)	Quantity Waste (T)	Volume Leachate (L)
1	77,66	2807±68,16	68,42	2290±45,30	83,66	3660±76,10	67,94	2038,2±46,80
2	84,91	3490±98,50	73,88	2464±66,25	78,11	2977±39,15	73,5	2205±70,05
3	91,18	3845±70,21	77,32	2574±78,00	84,01	3772±85,30	74,96	2248,8±76,50
4	79,78	2900±61,00	83,31	2665±30,12	86,19	3844±90,05	75,17	2255,1±65,30
5	83,36	2784±49,60	77,64	2484±46,23	83,8	3565±76,60	66,49	1994,7±34,80
6	81,895	2638±50,10	84,94	3717±72,50	97,59	4102±85,05	78,25	2347,5±59,20
7	85,79	3659±37,20	83,24	2663±55,20	75,38	2487±46,20	67,21	2016,3±56,65
8	68,98	2150±91,30	73,77	2460±69,10	92,78	3861±67,90	72,61	2178,3±61,70
9	74,97	2375±83,20	73,19	2642±58,60	77,92	2596±46,95	71,28	2138,4±49,80
10	76,76	2479±89,15	79,13	2932±75,60	81,39	2985±56,20	81,21	2436,3±63,95

11	67,66	2097±45,00	91,92	3996±80,00	79,46	2822±70,05	72,79	2183,7±59,25
12	71,05	2202,5±98	78,95	2826±50,00	78,64	2695±38,00	73,93	2217,9±63,20
13	68,93	2010±98,50	78,92	2980±45,65	80,17	3123±81,20	73,475	2204,25±67,05
14	77,59	2415±98,50	74,21	2695±61,65	87,04	3879±72,35	74,77	2243,1±57,30
15	74,18	2299±98,50	72,58	2390±70,25	78,39	2586±58,10	75,087	2252,61±51,90
Average	**77,646**	**2676,734±55,95**	**78,095**	**2785,2±58,10**	**82,969**	**3263,6±67,60**	**73,245**	**2197,344±53,50**

Table 2 shows the evolution of the volume of leachate generated in the different seasons of the year. The large quantity of leachates is produced in July (3263.6L on a daily average), while the minimum quantity is noticed in October (2197, 344 L on a daily average). These results are comparable to those of developing countries, [8] have shown in their seasonal waste study that organic matter has increased from 65.5% to 83.3% in summer [8]. This is justified by the increased consumption of fruits and vegetables. These values are confirmed by the results obtained in FIG. 3, which shows the evolution of the rate of leachate in the waste, 3.93% of leachate in July is the maximum value and 3% in October as the minimum value.

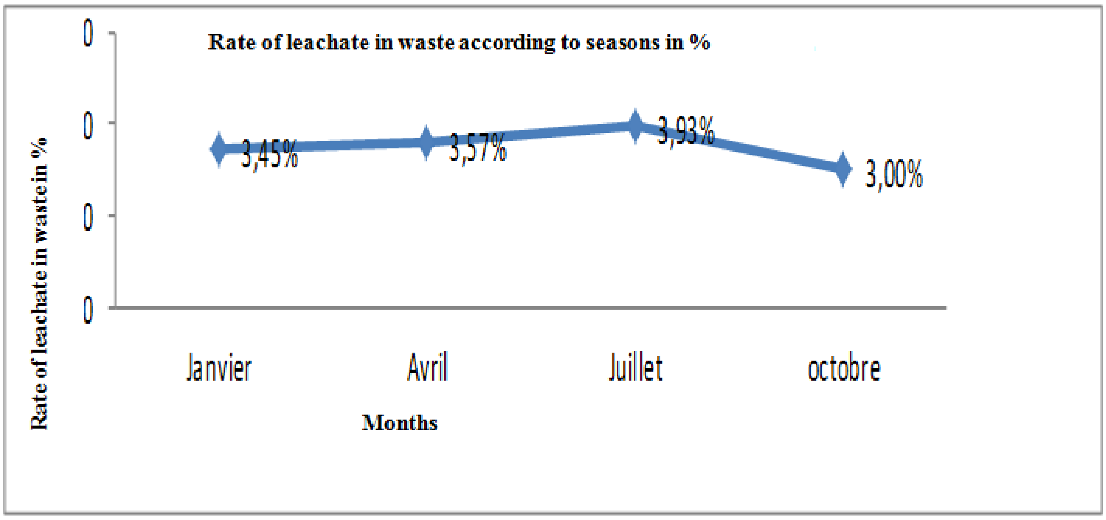

Fig.3: Evolution of the rate of leachate in waste of the year 2015

3.3 Technique for the treatment of leachate by coagulation

Several tests of Jar Test were carried out on the leachate of Fkih Ben Salah by changing; The type of coagulant, pH, coagulant dose, rotational speed and settling time, to choose the most effective coagulant, and optimum conditions for reducing pollutants.

Table 3: Variation of the physicochemical parameters of the pretreated leachate by the various coagulants at 2g/ l

Parametre	EB	Ca(OH)2		Al (OH)xCly		FeCl3		Al2 (SO4)3	
pH	3,78	4,08	6	3,78	6,31	3,75	6,68	3,76	6,45
T	33,48	33,47	33,55	33,92	33,82	33,46	33,36	33,45	33,49
Cond ms/cm	32,67	23,15	23,15	31,75	57,53	26,99	54,13	15,7	53,82
Turbidity FTU	5190±24,12	2997,9±15,06	2500±12,56	4110±21,96	2640±13,65	5040±26,03	3200±19,89	4530±21,55	2950±16,23
DOC mgO2/l	68170±98,12	48240±52,69	40010±56,02	65110±89,23	50230±71,69	67280±56,26	56256,5±49,23	66225,5±59,95	58679,5±64,44
suspended solids (g/l)	8,119±0,951	7,001±0,762	6,65±0,569	7,85±0,628	7,21±0,856	7,96±0,596	7,54±0,892	8,01±0,722	8±0,793

In this work, precipitation of pollutants was studied using lime, aluminum polychlorides, iron dichloride, and aluminum sulphate. The effect of the pH and the settling time are also studied.

Several doses of lime, aluminum polychlorides, iron dichloride, and aluminum sulphate from 0 to 12 g L-1 were added to the leachate to determine the optimum dose and conditions of the four materials.

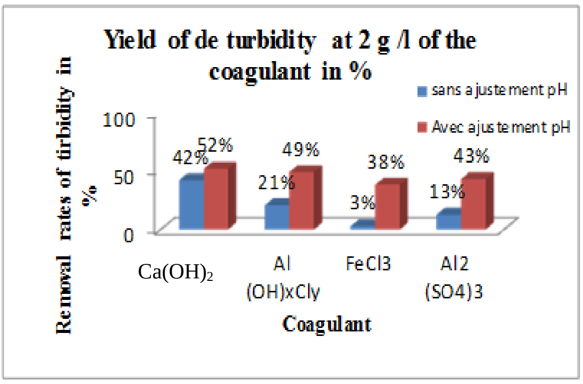

FIG. 3: Variation in the efficiency of the turbidity of the various coagulants at 2 g / l

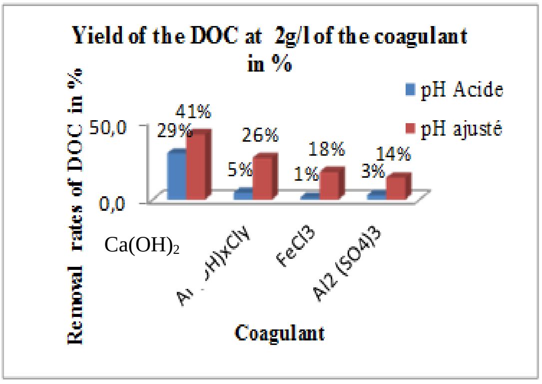

FIG. 4: Variation in the efficiency of the DOC of the various coagulants at 2 g / l

FIG. 5: Variation in the yield of the suspended solids of the various coagulants at 2 g / l

Table 1 shows the results of the determination of the physico-chemical parameters with a small amount of coagulants and the effect of the pH on these tests.
Figures 3, 4, and 5 show that lime gave the highest abatement rate in all parameters, followed by aluminum polychloride, while the other two coagulants gave Low yield.
The increase in the pH of the lime supernatant is explained by the addition of OH- ions in solution.
After adjusting the pH of the leachate to be treated and adding the same concentration of coagulants (2 g / l) under the same stirring and decanting conditions, an increase in the lime turbidity yield of 42 to 52% Aluminum polychloride of 21 to 49%, iron trichloride of 3 to 38% and aluminum sulphate of 13 to 43%. It is deduced that the coagulation pH is an important factor which affects the increased coagulation, as a function of the variation of the zeta potential in the coagulation process

- Effect of concentration of coagulant

Table 4: Variation of the physicochemical parameters of the pretreated leachate with 10g/l coagulants with pH adjustment

Parametre/pH	**EB**	**Chaux**	**Al (OH)xCly**	**FeCl3**	**Al2 (SO4)3**
pH	**3,78**	9	6,18	5,76	5,57
T	33,48	32,37	33,83	34,14	34,19
Cond ms/cm	32,67	20,84	33,83	56,14	52,58
Turbidity FTU	5190±24,12	459±8,12	1041,9±12,68	1680±18,32	1350±15,05
DOC mgO2/l	68170±118,12	9100±41,23	21950±89,32	45347,5±102,32	39820±94,32
suspended solids (g/l)	8,119±0,951	1,15±0,03	4,31±0,130	5,03±0,234	6,09±0,295

After finding favorable pH values, several other Jar tests were carried out with increasing doses of coagulants (between 2 and 12 g / L), in order to define the optimal doses of each product (Table 4).

At 10 g / l of each coagulant we found the best purifying yields; Turbidity at 83% for lime, 52% for aluminum polychloride, 48% for iron trichloride, and 39% for aluminum sulphate (FIG. 6), the yields of the suspended matter (FIG. 8) Is 71.06% for lime, 26.72% for aluminum polychloride, 25.73% for iron trichloride, and 18.83% for aluminum polychloride, and the abatement rate of The COD (Figure 7) is about 87% for lime, 68% for aluminum polychloride, 33% for iron trichloride, and 42% for aluminum polychloride.

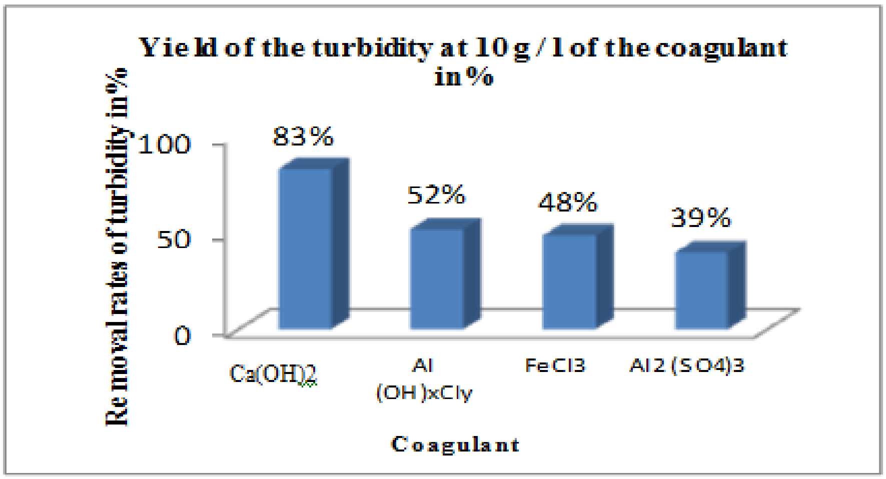

FIG. 6: Variation in the turbidity efficiency of the various coagulants at 10 g / l

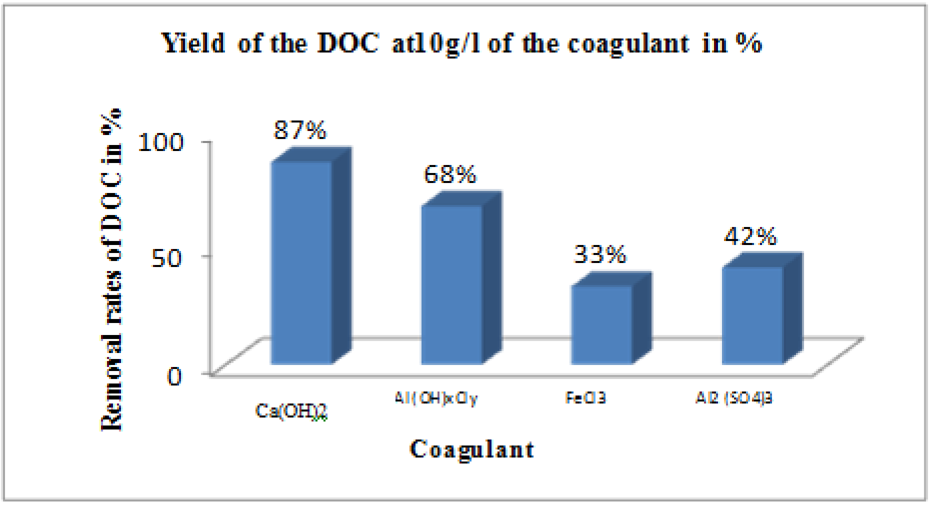

FIG. 7: Variation of the COD yield of the various coagulants at 10 g / l

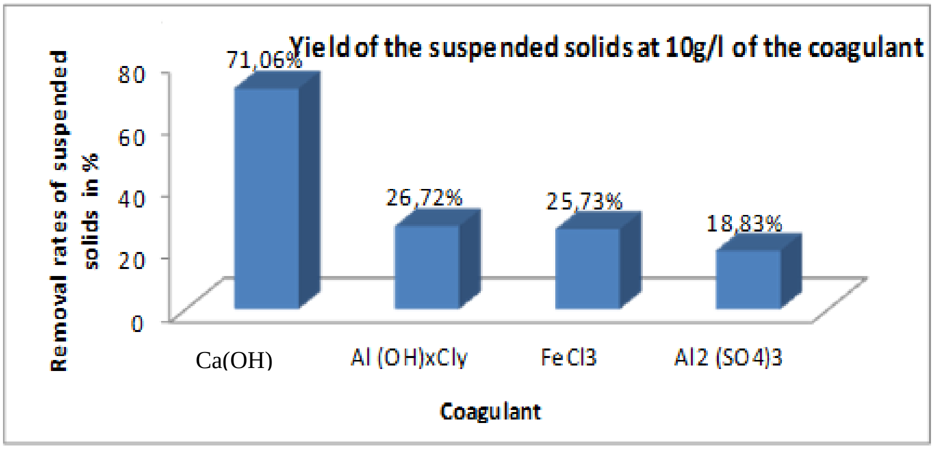

FIG 8: Variation in the suspended solids turbidity efficiency of the various coagulants at 10 g / l

These results enabled us to choose lime as the most effective coagulant for our physicochemical treatment. These results are comparable with those found by N. EL BADA et al.,[14], they showed that lime precipitation is very remarkable compared to soda and calcite, this effect was also observed by several other auditors working on the treatment of leachates, Groundwater and organic solutions of lime synthesis [15].

- Effect of pH

After finding that lime is the most efficient coagulant and that pH is a very important factor in the precipitation process, we have carried out explicit tests - under the same conditions of coagulation by lime, and we have followed by changes in physico-chemical parameters as a function of pH.

As Table 1 shows, at pH = 5.5 we found very high turbidity abatement rates of 85.09% (Figure 9), COD 77.21% (Figure 10) and MES 77.21 % (Figure 11).

Table 5: Evolution of leachate parameters as a function of pH

Parameters /pH	**3,78**	**4**	**4,5**	**5**	**5,5**
pH	3,78	4,8	5,23	9,31	10,13
T°C	33,48	28,47	28,34	28,55	23,2
Cond ms/cm	32,67	14,46	19,99	22,12	27,69
Turbidity FTU	5190±24,12	2100±41,23	1950±38,12	982,1±29,32	774±24,95
DOC mgO2/l	68170±118,12	19210±103,52	17376,5±100,35	16000±89,32	13130±81,21
suspended solids (g/L)	8,119±0,951	2,85±0,26	2,31±0,15	2,019±0,15	1,85±0,12

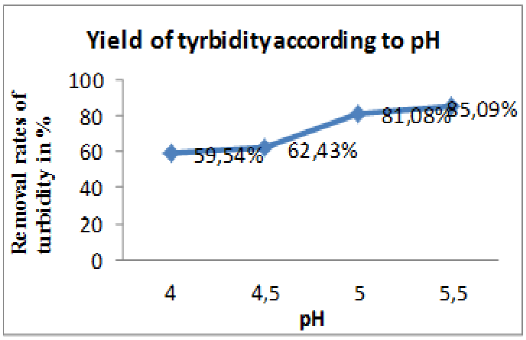

FIG 9: Evolution of yield Turbidity (%) as a function of pH

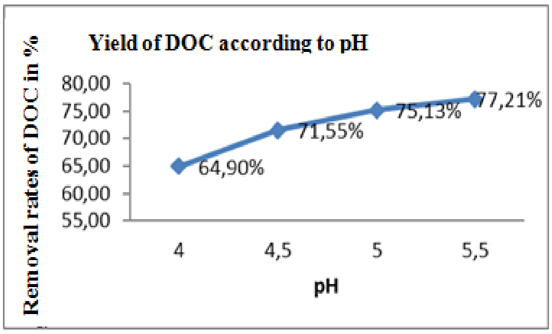

FIG. 10: Evolution of yield COD (%) as a function of pH

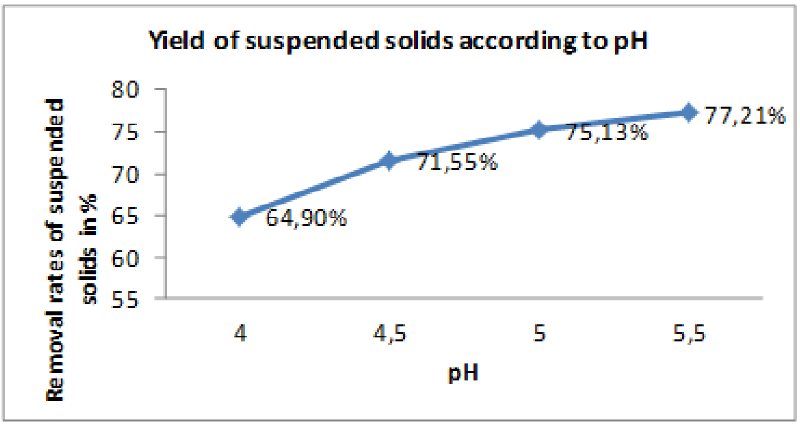

FIG. 11: Evolution of the yield of the suspended solids (%) as a function of the Ph

➢ Effect of settling time

In addition, we studied the decantation time factor to further improve the optimum conditions, and we found encouraging results for the adoption of this technique in leachate treatment.

The present study is based on the monitoring of the pollution indicators as a function of the settling time (Table 6). Each 30 min, the supernatant is recovered and the abatement rates of the pollutants are measured.

FIG. 11 shows the variation in volume of sludge settled as a function of time. It is noted that with time the volume of the sludge decreased, and one observes a very important evolution over time. After 4h30 we found a 32% decrease in sludge volume (Figure 11), an abatement rate of 90.30% of the turbidity (Figure 13), 90.29% of the COD and 81.79% of the MY. Also, the rate of sedimentation was calculated (FIG. 12), and the results show 13.82 ml / min in the first 30 minutes, this velocity decreased progressively over time and reached 1.04 ml / min after 4:30. [16] Found comparable results.

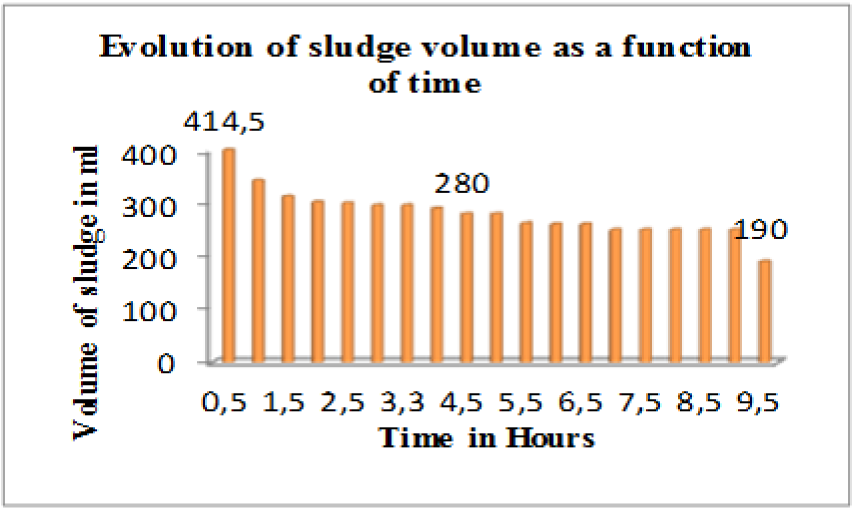

FIG. 12: Evolution of the volume of the sludge (ml / l) as a function of time

Table 6: Evolution of the parameters as a function of the settling time

Temps	*pH*	*Volume ml*	*Turbidity* FTU	*Sedimentation rate ml/min*	*DOC mgO2/l*	suspended solids *(g/l)*
0	3,68	0	6115±31,056	0	77292±154,32	10,16±0,890
0,5	9,71	414,5	1541±15,36	13,82	40326±115,62	5,588±0,280
1	9,66	342,5	1260±15,95	5,71	35673±106,95	4,317±0,190
1,5	9,68	312,5	1077±14,62	3,47	17925±94,84	2,554±0,150
2	9,66	302	755,9±13,62	2,52	10857±79,32	2,365±0,124
2,5	9,66	300	682,9±12,59	2	10340±78,87	2,298±0,131
3	9,66	296	658,7±9,39	1,64	9564,5±91,23	2,198±0,122
3,3	9,63	296	653,4±9,25	1,41	9306±87,32	2,159±0,358
4	9,68	290	648,9±8,29	1,21	8091,1±79,21	2,058±0,135
4,5	9,66	280	592,9±5,26	1,04	7522,4±67,92	1,85±0,103
5	9,62	280	555,8±5,39	0,93	7238±68,21	1,84±0,105
5,5	9,61	262	541,1±5,12	0,87	7324,2±70,32	1,98±0,095
6	9,62	260	527,7±4,95	0,79	6516±57,14	1,85±0,102
6,5	9,51	260	543,8±4,65	0,72	6268,6±58,15	1,799±0,089
7	9,6	250	537,3±4,21	0,64	6279±54,89	1,809±0,095
7,5	9,58	250	512,3±3,95	0,6	6330,2±49,21	1,93±0,084
8	9,56	250	489±3,52	0,56	6304,8±51,98	1,825±0,079
8,5	9,59	250	474,3±3,21	0,52	6340,5±61,24	1,86±0,0813
9	9,55	250	402,5±3,02	0,49	6314,6±51,12	1,799±0,064
9,5	9,49	190	395,1±3,35	0,35	6314,4±53,21	1,729±0,059

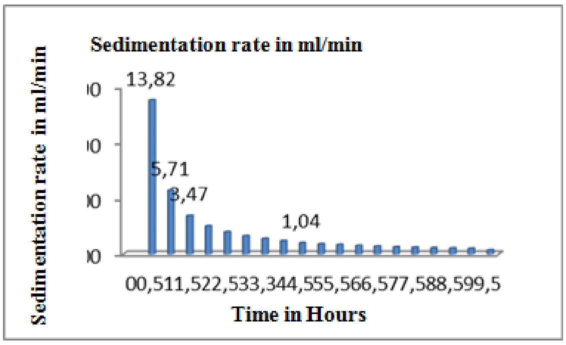

FIG. 12: Evolution of the decantation rate as a function of time

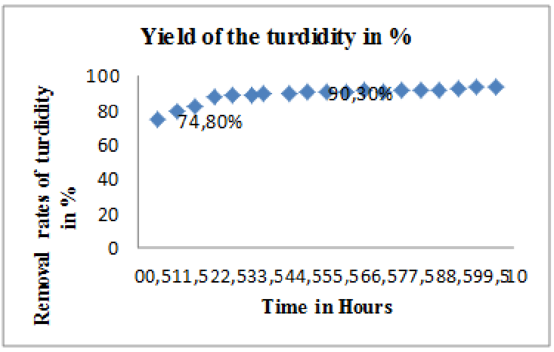

FIG. 13: Evolution of the yield (%) of the turbidity as a function of time

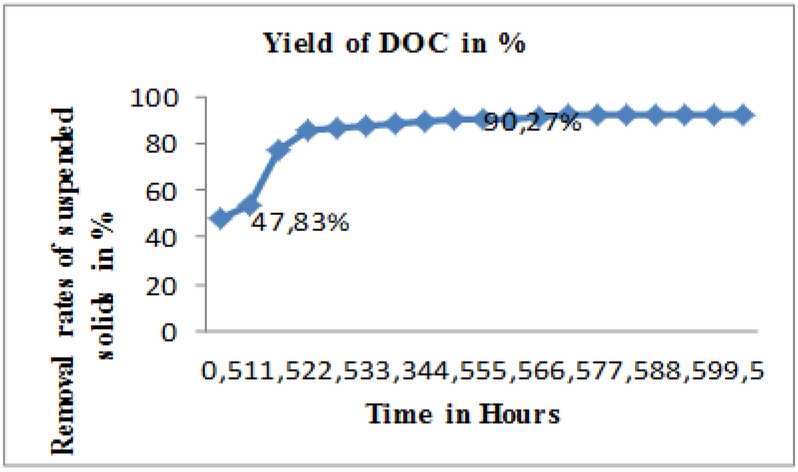

FIG 14: Evolution of the yield (%) of COD as a function of time

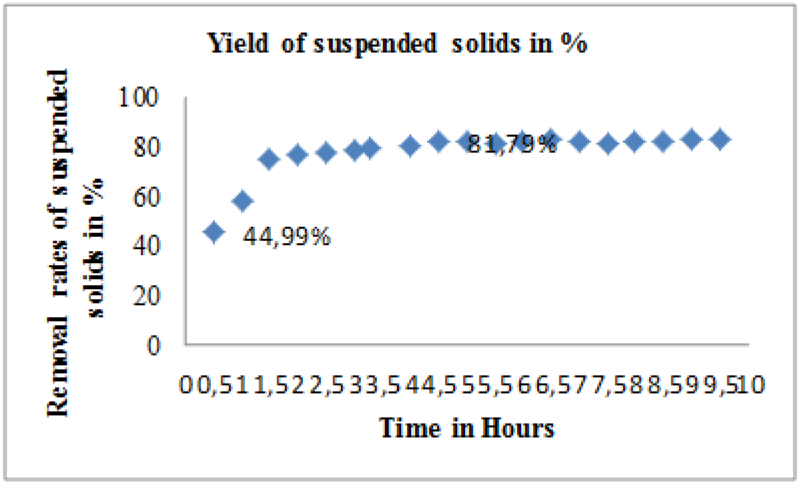

FIG. 15: Evolution of the yield (%) of the suspended solids as a function of time

IV. Conclusion

At the end of our work on the quantification and treatment of landfill leachate from Fkih Ben Salah, it is possible to draw the following conclusions:

The results of the calculation of the leachate quantity revealed a large amount generated and released into the environment, which can reach 4102 L / J and which are characterized by a high polluting load (EC (32.67 m / cm 2), Turbidity (5190 FTU) MES (8,119 g / l) and COD (68170mgO2 / l)), this quantity is in causal relation with the quantity of waste produced, and it varies according to the seasons and the days of the week.

Lime is the most effective product; it can further reduce the polluting load with a minimal cost compared to other materials. The optimum concentration is 10 g / l, after adjusting the pH and increasing settling time a significant reduction rate is found: 90.29% of the organic matter, 90.30% of the turbidity and 81.79% of The MES.

References

[1] D. Trebouet, A. Berland, J. P. Schlumpf, P. Jaouen, and F. Quemeneur, Treatment of stabilized discharge leachates by nanofiltration membranes, *Revue des sciences de l'eau /Journal of Water Science, 11(3),* 1998, 365-382.

[2] A.A. Hamidi, A. Salina, A.N. Mohd, A.H. Nordin, Faridah, M.Asaar, Z. Shahrir, Colour removal from landfill leachate by coagulation and flocculation processes, *Bioresource Technology, volume 98*, 2007, page 218.

[3] S. Renoua, S. Poulain, J.G. Givaudan, P. Moulin, Treatment Process Adapted to Stabilized Leachates, Lime Precipitation-Prefiltration-Reverse Osmosis, *Journal of Membrane Science, 313*, 2008, 9-22.

[4] J.F. BLAIS, S. DUFESNE, and G. MERCEIR,State of the art technologies for metal removal from industrial effluents, *Revue des sciences de l'eau, Rev, sci, Eau 12(4)*, 1999, 687-711.

[5] AND, Inventaire des décharges sauvages. Agence Nationale des Déchets, Ministère de l'aménagement du territoire et de l'environnement, Alger, Algérie, 2003.

[6] MATE, Rapport sur l'état et l'avenir de l'environnement, Ministère de l'Aménagement du Territoire et de l'Environnement, Alger, Algérie, 2003

[7] APHA Standard Methods for the Examination of Water and Wastewater, 21st ed., American public health association, Washington DC, 2005.

[8] N. Guermoud et A. Addou, Etude et caractérisation des déchets ménagers de la ville de Mostaganem (Ouest-Algérie). *Déchets Sciences et Techniques - N°66* - Mars 2014

[9] Ministère de l'Énergie, des Mines, de l'Eau et de l'Environnement Ministère de l'Environnement. Maroc, *Programme National des Déchets Ménagers*, PNDM, 2013.

[10] J. Ghalloudi, G. Zahour, M. Talbi, Evaluation de la première expérience de gestion déléguée des déchets ménagers à Casablanca, Maroc, *European Scientific Journal January 2015 edition vol.11, No.2* ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

[11] F. BENYOUCEF1, A. EL GHMARI1, et A. OUATMANE, Problématique des lixiviats des déchets ménagers et traitement par UASB: cas de la ville de kasba tadla, *International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 13 No*. 2 Oct. 2015, pp. 289-298

[12] Annuaire statistique au Maroc 2012, Haut Commissariat au plan, Royaume du Maroc. Site official de l'agence urbain de Rabat-Salé, www.aurs.org.ma

[13] Cédérom "*Élaborer un plan ou programme de prévention des déchets*" – Juin 2010.

[14] N. EL BADA, O. ASSOBHEI, A. KEBBABI, R. MHAMDI et M. MOUNTADAR, Caractérisation et prétraitement du lixiviat de la décharge de la ville d'Azemmour, *DÉCHETS, SCIENCES et TECHNIQUES - REVUE FRANCOPHONE D'ÉCOLOGIE INDUSTRIELLE - N° 58* - 2eme TRIMESTRE 2010

[15] M.Y. Liao, S.J. Randtke, *Removing Fulvic Acid by Lime Softening, J. Am.Water Works Assoc, 77*, 1985, 78–88.

[16] F. Benradi, A. El Yahyaoui, S. Bouhlassa, A. Nounah, E. Cherkaoui, F. Ghrissi, Epaississement des concentrats d'osmose inverse (Thickening of concentrates from reverse osmosis) *J. Mater. Environ. Sci. 4 (6)*, 2013, 832-839 Benradi et al. ISSN : 2028-2508 CODEN: JMESCN