IMPACT OF DEBRIS FROM DEMOLITION OF BOUMERDES ON THE QUALITY OF GROUNDWATER

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Abstract

The public discharge of Boumerdes city is at 5 km from downtown at Tidjelabine site and marly-calcareous formation. This formation shows crack porosity that facilitates pollution of groundwater reserves. The slope character of the field also favours the movement of pollutants. Leachates penetrating from the discharge towards the water table result in water quality deterioration. Chemical analysis carried out on samples from three piezometers show large concentration of chromium, zinc and lead, thus confirming the high groundwater deterioration. To assess the degree of pollution caused by this discharge, a comparison with other similar discharge was studied. This shows that the site is ancient of the discharge and is not stabilized yet and an acidic phase of anaerobic degradation is still going on. bacteriogical analysis carried out on groundwater show a microbiological contamination.

Key words : discharge ; leachate ; heavy metals ; groundwater ; infiltration.

I- INTRODUCTION

The solid waste management is governed by standards the user must respect otherwise they expose themselves to pollution that may follows. For instance, it is common sense, that water pollution may be due to industrial effluents such as exhaust fumes and gases liquid or solid wastes that strongly contribute to water quality impoverishment. Same applies for extensive agriculture which requires fertilizers that induce increasing water pollution risks.
But, the pollution generated by solid waste from house demolition has long been underestimated as presenting no danger in the short term.
This work is a contribution for the assessment the impact on groundwater pollution by demolition debris generated by the may 23rd, 2003 earthquake of Boumerdes. To face the emergency and urgency, demolition debris were quickly buried in temporary sites (which still remain untreated) in places that poses no difficulty for approval (generally state owned agricultural lands) without any preliminary study of impact. Indeed, this disaster has caused severe damage to facilities that generated tens of millions of tons of debris and rubble. Thus, there are 22 landfills totalizing some 30 million cubic meters and occupying a total area of 100 hectares

Our study focuses on the landfill of the city of Boumerdes and surrounding communities (Boudouaou, Corso, Figuier and Tidjelabine), where more than 23 00 demolished homes have been stored.
This landfill may affect the quality of surface and underground as rainfalls cause leaching of stored debris which, in turn, generate lixiviates, which infiltrate the soil and cause chemical pollution of water by the ETM. All of these inter-actions between the dump and the receiving environment exacerbate the risks of pollution.

Our investigation concerns cross impact of possible pollution by the landfill on:

- health and environment caused by unpleasant smoke and odour, and/or toxic fume inhalation
- water and soil contamination caused by lixiviates.

2- Location of landfill

There are five landfills for Boumerdes and its communities, one in Tidjelabine, two in Figuier another one in Corso and the last one in Boudouaou.
Figure 1 below maps the different landfills across the territory of the Wilaya of Boumerdes, and figure 2 shows the location of the landfills of the city of Boumerdes and its communities.

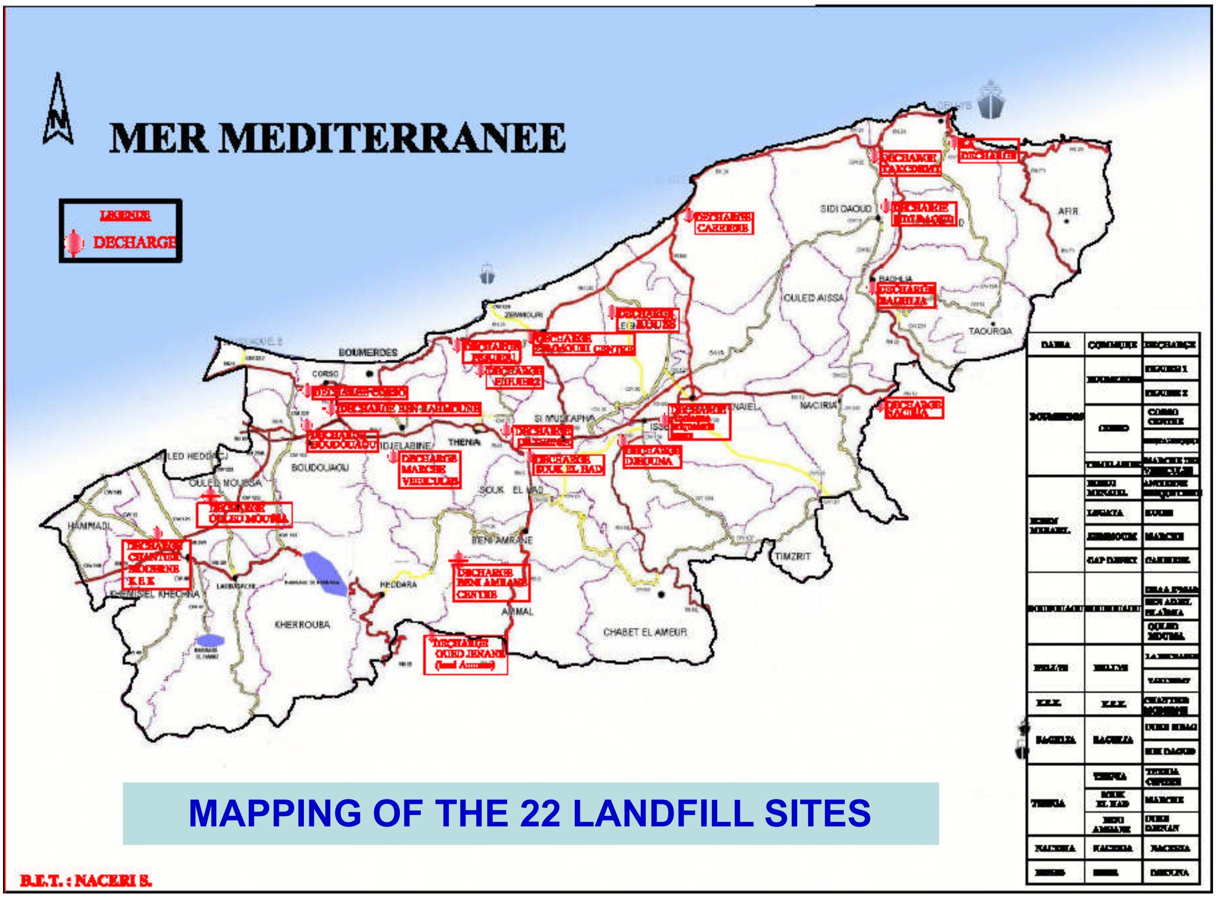

Figure 1: Map of the Wilaya of Boumerdes and its 22 temporary landfills.

Figure 2 : Location of The Tidjelabine landfill of the city of Boumerdes

All of these sites are in the form of low slope of about 5% to 10% and covers an area of 10 hectares, whereas their altitude varies between 850m and 900m.
The slope promotes water runoff [1]. Indeed, lixiviate or rainwater entering the waste is the source of runoff processes favouring pollution by infiltration through limy soil cracks. The selection of any current site for land-filling obeyed only to criteria of accessibility and proximity.

3- HYDROLOGICAL AND GEOLOGICAL CONTEXT

The geological formations at the outcrop in the studied area consist of marls with intercalations of fissured limestone and alluvium, respectively, of Cretaceous age and Mio-Plio-Quaternary.
These formations give the sites a variable permeability in the horizontal and vertical directions.
Indeed, frequent feature changes (transition from alluvial formation to cracked or compact limestone) are the reason for important variation in permeability.
As a matter of fact, we switch from a permeability of about 10-2 m / s to nearly 10-6 m / s.
Thus, the flow directions follow existing cracks.
However, the hydro-geological studies conducted in the area shows that there are two aquifer horizons. The first one has a relatively short depth (maximum 10 meters), the alluvial Mio-Plio-Quaternary being its bottom seat and which may be polluted by inputs from the landfill; on the other hand, the second For cons, the second is deeply located across the valangian-Albian sandstone.
Precipitations for the area average 410.5 mm / year (2005/2006) and accentuate the movement of pollutants either through infiltration or by surface runoff.

Waste Characterization

The town of Boumerdes covers an area of 1800 hectares occupied by inhabitants (2005). The estimated masses (tons) of various types of debris buried in the site.

Material Type	**Est. Tons**	**%**
Concrete (including iron framework)	399140	54.30%
Bricks (clay)	6200	0.85%
Gypsum	12680	1.75%
Paints and wall coatings	2500	0.35%
Lumber	3690	0.50%
Plastics*	63616	8.65%
Household waste**	212055	28.85%
Miscellaneous***	35342	4.80%

Table 1: Tonnage estimation of the most prevalent material types in disposed wastes. Tidjelabine landfill.

*Mainly beverage containers, grocery and trash bags, films and durable items.

** Includes food rests, stale fruits and vegetables leaves and grass, paper, textile, glass, plastic bags, domestic appliances and other small consumer electronics.

*** Includes used vehicle parts, batteries, used oil, ash, electronics, tires, asphalt, industrial sludges, glass.

4- MATERIELS AND METHODS

In our study, a sampling campaign and analysis was performed on the leachate from the landfill and three control wells that serve as piezometers. The collection is made to the month of March 2005 and covered the major ions, heavy metals, nitrogen, chemical applications and biological oxygen demand (COD and BOD_5), organic matter and minerals and some microbiological. Note that temperature, pH and conductivity were measured on site.

The three wells are selected near the discharge. Table 2 summarizes some information concerning the status of wells from the landfill. The proximity of the wells from the landfill because they become very vulnerable to all forms of pollution

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Designation of taking point	Situation vis-à-vis centre (O) of the landfill	Distance (m) from O
S1	East. Well of 2 m depth domestic use. Piezometer.	300
S2	North in residential. Well of 8 m depth domestic use.	350
S3	South West in agricultural land. Well of 8 m depth irrigation use	420

Table2: Localisation and use of the selected piezomters close to the Tidjelabine discharge.

Leachate

The composition of leachate from a landfill

The leachate contains may many inorganic contaminants often very toxic. Thus, their composition varies depending on the nature of waste, age of discharge, the technical operating and climatic conditions. Farquhar [2] thinks that the leachate may come from either waste water or rain weather and also from the water of the aquifer. The colour is the first indicator of pollution. The analyzed leachate taken downstream of the discharge has a brownish colour and a faecal smell, thus influencing the quality of groundwater. The level of targeted pollution indicators proved to be high. Almost all of them are above the accepted standards proving leachate contamination by heavy metals. Results of the analysis are reported in table 3 below.

Erreur ! Source du renvoi introuvable. : Results of leachate samples analysis Tidjelabine discharge.

Concentrations	Sample1	Sample2	Sample3	Sample4	IANORStandard
pH	7.37	7.50	7.65	6.94	6.5-8.5
DCO in mg/l	36.40	49.90	53.76	22.80	120
DBO5 in mg/l	8.10	0.00	1.60	4.00	35
MES in mg/l	12.00	10.00	16.00	10.00	35
Nitrates in mg/l	0.30	0.10	0.30	0.20	50
Nitrites in mg/l	0.016	0.01	0.02	0.002	0.1
Chlorures in mg/l	62.40	60.98	31.19	25.52	500
Sulfates in mg/l	75.00	75.00	43.00	64.00	400
Phosphates in mg/l	13.00	8.00	0.39	0.74	10
Ammoniacal Nitrogen in mg/l	0.01	0.02	0.01	0.04	30
Pb en mg/l	0.03	0.02	< 0.01	0.51	0.5
Zn in mg/l	0.04	0.16	< 0.01	0.47	3
Cd in mg/l	< 0.01	< 0.01	< 0.01	2.78	0.2
Cu in mg/l	< 0.01	< 0.01	< 0.01	< 0.01	0.5
HC total in mg/l	< 0.01	< 0.01	< 0.01	25.79	10

5-RESULTS AND DISCUSSION

According to Parveau [4] and Keenan [5] et al., landfill leachates are similar to complex industrial waste containing both substances contaminating organic and inorganic. We note that the chemical oxygen demand (COD) in leachate exceed widely accepted standards. Indeed, it is above the average standard of Algeria which is about 120 mg / l and reached 1230 mg / l. As for BOD_5, it varies between 135 and 200 mg / l whereas the accepted standard is 40 mg / l, thus showing significant pollution. However, the actual concentration of BOD_5 is still higher than the values found because the medium is loaded with toxins.

The concentrations of heavy metals (cadmium, chromium, zinc and nickel are beyond acceptable standards. The concentration of lead is at the limit of the standard [10]. Heavy metals in leachate inhibit microbial growth.

The results of chemical characterization of raw leachate from Boumerdes landfill indicated a dual pollution:

- an organic pollution that results in a high load of COD in the leachate, in sample2 for instance, the COD is about 1136 mg / l O_2 / l and BOD_5 is approximately 200 mg / l O_2 / l

- a mineral pollution that results in high concentrations of target metals in leachate, as in sample1 for instance with values of 3.4 mg / l of chromium, 6.7 mg / l nickel and 6.7 mg / l of zinc.

It is therefore essential to treat the juice discharge to avoid any risk of environmental contamination by infiltration of the leachate.

Characteristics of heavy metal contamination of the discharge of Boumerdes

Heavy metals measured showed a metal pollution of leachate from the landfill. The results were compared with those obtained at other landfills (Table 4).

Table 4: Comparison of the levels of heavy metals in landfill leachate.

Target Metal	Tiaret	El Jedida	Wadi Akrech	Eteffont	Tidjelabine
Zn	0.5	0.0474	0.70	0.740	0.05
Cu	---	0.158	0.450	0.270	0.05
Ni	0.60	0.133	0.25	0.210	0.001
Cr	0.3	0.156	0.50	0.270	0.005

The metal composition of the leachate from the Boumerdes landfill is typical of a landfill of household dominant character. Indeed, the concentrations of metallic elements effluent studied are essentially identical to those of leachate generated by other garbage dumps except for certain elements such as nickel (discharge of Tiaret [9] 670 mg / l discharge of Rabat 133.6 mg / l [6] [7] and the discharge Eteffont 210 mg / l [8],

Physical-chemical composition of groundwater

To perform this study we used three observation wells located near the landfill. This arrangement will allow us to quantify the aquifer state and condition vis-à-vis the landfill. The results are compared with guideline values (standards) and given in table 4 below. It shows the following information shown in Table 5.

Table 5 : Results of physical-chemical analysis of groundwater

Parameters	S1	S2	S3
pH	7.37	7.56	7.85
T °C			
CO_3^{2-} mg/l	-	-	-
HCO_3^- mg/l	540.58	417.97	488
Ca^{2+} mg/l	144.92	116.712	126.973
Mg^{2+} mg/l	13.42	39.495	0
Cl^- mg/l	209.196	327.48	98.854
SO_4^{2-} mg/l	38.681	139.087	399.155

Parameters	S1	S2	S3
MES	$0.3\ 10^{-2}$	$1.7\ 10^{-2}$	$0.7\ 10^{-2}$
DCO	0	0	0
BDO_5	0.8	1.4	0
NO_2^- mg/l	0.019	0.01	0
PO_4^{2-} mg/l	0.02	0.04	0.14

Metal	S1	S2	S3
Cd mg/l	0.007	0.0078	0.0060
Cu mg/l	0.0140	0.0047	0.0122
Pb mg/l	0.0220	0	0
Zn mg/l	0.0790	0.0124	0.7790

Parameter	pH	T (°C)	Conduct. µs/cm	O_2 mg/l	DBO5 mg/l	DCO mg/l	MO mg/l	Turb. NTU	Cr mg/l	Cu mg/l	Zn mg/l
Well 1	6,62	15	5402	6.23	30	74	2.28	4.03	0.01	0.03	2.016
Well 2	6.74	12	3755	6.28	20	32	4.56	1.59	0.78	0.07	0.53
well 3	7.28	12	1071	4.49	40	82	2.96	19.3	0.75	0.15	2.93
standards	4.5-9		2500-35000		20-57000	140-152000			0.05	0.05	0.03

The pH

We note that both wells 1 and 2 contain weak acid waters showing the influence of the discharge on groundwater. On the other hand, well3 has a pH near neutrality. The measured values of pH show the impact of discharge on water samples collected in the wells.

The temperature

The temperature plays a very important role in increasing bacterial activity and evaporation of water. Indeed, temperature is a key element in the enumeration of aquifer systems. It varies depending on external temperature, seasons, the geological nature of the soil and the depth of the water level over the surface. The measured temperature varies between 12 ° C and 15 ° C. These temperatures are low for the month of March which the measurements were made for the development of microorganisms (coliforms and streptococci).

Bacteriological composition of groundwater

To determine the presence of germs, we used two methods. This choice allows a more precise approach. The experimental results are reported in Table 6 and 7.

Table 6 : bacteriological composition of groundwater by the method of the membrane filter

Germs	well 1	well 2	well 3
Coliforms	Presence > 300	Presence > 300	Presence > 300
Fecal Coliformes	presence	presence	presence
Fecal Streptococci	presence	presence	Presence

Table 7 : bacteriological composition of groundwater by the method of multiple tubes

Germs	well 1	well 2	well 3
Total Coliforms	11/100 ml	28/100 ml	1100/100 ml
Fecal Coliforms	11/100 ml	3/100 ml	7/100 ml
Fecal Streptococci	9/100 ml	7/100 ml	1100/100 ml

The obtained results by the methods show that water wells contain quantities of pathogens, showing a significant bacteriological contamination of groundwater. Well 3 is the most polluted due to its situation. The latter is located downstream of the discharge and flows follow this direction. Furthermore, the permeability sandstone formations of cracks would promote the infiltration of leachate. Pollution observed at the well 1 is due to its localisation close to an area of household waste accumulation which generates leachate.

6- CONCLUSION

This study conducted at a landfill showed a double impact on water quality:

- Direct impact: through their leachate runoff leading to pollution of surface waters.

Indirect impact: water flows and infiltrates through cracks causing groundwater pollution.

The levels found especially dissolved oxygen, NO_3, COD, BOD_5, Cr, Zn, Ni and Pb are higher than the accepted standards explaining the origin of organic and metal pollution. The presence of germs in the piezometers shows that water is not potable [11, 13], around the discharge and users have been immediately informed about it.

The concentration of target heavy metals of leachate from the landfill is typical of a dominant household waste discharge, though this discharge was originally a landfill for demolition and construction inert debris. A first explanation of this evolution may come from the presence of organic matters in the debris coming from demolished constructions by the earthquake at first hand, and from household waste later as the status of this discharge remain open.

Moreover, the BOD_5/COD ratio is an indicator of the fermentation stage of the discharge. Applied to the analysed leachate from the landfill, the ratio gives values ranging from 0.11 to 0.25, typical of an ancient but not yet stabilized landfill and corresponding to the acid phase of anaerobic degradation [8].

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