IMPACT OF CASABLANCA MUNICIPAL LANDFILL ON GROUNDWATER RESOURCES

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ABSTRACT

Since 1986 the municipal solid wastes produced by the city of Casablanca are stockpiled in a landfill installed on old quarries located 10 km out of the city's periphery. The bottom of the landfill consisted of fractured quartzite, which was not sealed off before its starting up. The aquifer thus risks contamination by the leachate. Indeed, four years later, a study detected the beginning of groundwater pollution downstream the landfill, with limited extension.

During the present study, a hydro-chemical campaign was carried out, on 2001. Groundwater was collected on aquifer from wells upstream and downstream the landfill. The results showed an important disparity concerning the measured parameters. In addition, water of a certain number of wells meets no more neither the drinking water supply standards nor the irrigation standards.
The analysis of these campaigns permitted to distinguish the contaminated wells from those that are not. Then, plumes of mineral and organic pollution are delineated. The comparison of the last results with the ones determined by the 1990 study showed an advance of the pollution plume towards the city, through a zone of agricultural vocation, according to the faults affecting the fractured aquifer matrix.

Keywords: Landfill, Contamination, Aquifer, Casablanca, Morocco

1. INTRODUCTION

The Urban Community of Casablanca exploited the landfill without carrying out neither the sealing off the substratum, nor the implementation of any leachate drainage system and biogases collection.

A study in 1990 (Elghachtoul and al [5]) detected the beginning of groundwater contamination downstream from the leachating of leaking Mediouna landfill. The aims of this study are, first, to characterize the groundwater quality downstream from the landfill and, second, to determine the limits of pollution plume, in order to analyze its progression and the parameters which condition it.

2. SITE DESCRIPTION

Located 10 km SE of Casablanca (Figure 1), this landfill is composed of 13 quarries which add up a volume of nearly 3 million m^3 over an area of 78 hectares, of which 60 are assigned to the landfill. Nearby passes the main road (P.R.7), which is considered as a high quality axis connecting Casablanca to Marrakech, characterized by an intense traffic.

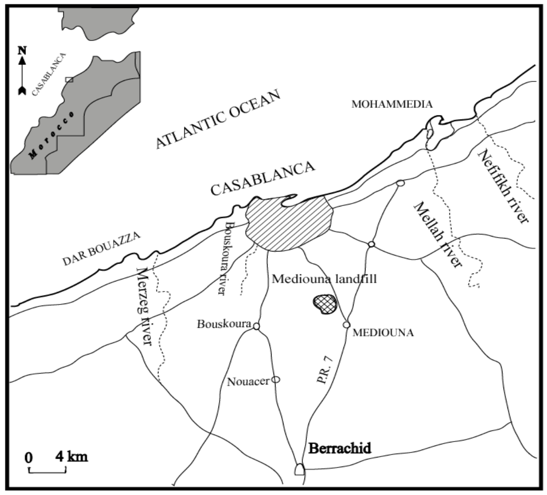

Figure 1. Landfill site location

3. GEOLOGICAL AND HYDROGEOLOGICAL SETTING

The primary formations constitute the substratum of the landfill. They are Cambrian and Ordovician marine sediments affetced by the Hercynian Orogeny (Destombes and Jeannette [4]). They were compressed and their transformation gave rise to Acadian green schist surmounted by quartzite, between psammitic series (Ruhard [8]). They were folded, faulted and tilted. Their reliefs were eroded, peneplained with a well marked surface constituting a diastheme.

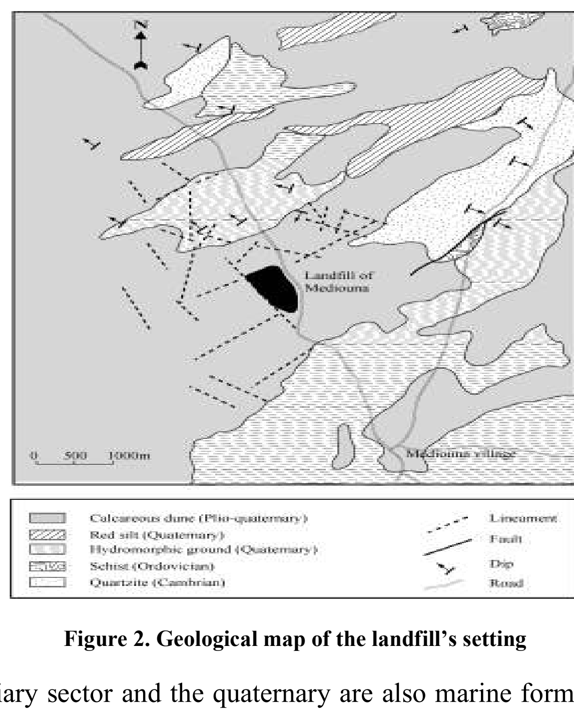

Figure 2. Geological map of the landfill's setting

The Pliocene higher tertiary sector and the quaternary are also marine formations with lumachellic or conglomerate facies covered by sandstones. The hydrogeological study shows that water circulation occurs primarily in the fractured quartzite. The sandstones, though permeable, are generally dry.

Close attention was paid to the lineaments, with origin of the aquifer's quartzite. The results show the predominance of two families of discontinuities, one ranging between N20-N40 and the other ranging between N120 and N140 (Figure 2). This result suits the structure of the site (Laamrani [7]).

The piezometric contours map (Figure 3), drawn from data taken in 2002, shows a flow according to two orientations. Te western one presents a strong hydraulic gradient of about 0.4 %, indicating a difficult circulation of the water in the aquifer. The eastern one has, a weak hydraulic gradient of about 0.01 % indicating a good circulation of groundwater in this sector.

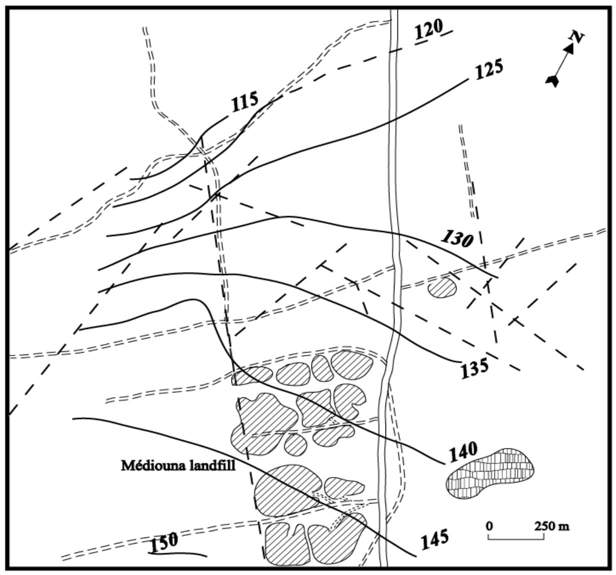

Figure 3. Piezometric contours map

4. RESULTS AND DISCUSSION

In this study of a groundwater pollution plume caused by landfill leachate infiltration, the parameters used for its detection, are mayor elements, EC, chemical oxygen demand (COD) (Chofqi and al. [2] ; Hakkou [6]). Thematic maps were elaborated.

4.1 ELECTRICAL CONDUCTIVITY

The examination of the electrical conductivity contour map, in downstream landfill area, shows values which exceed 7000µs/cm in the proximal zone, to reach values close to 1000 µs/m in the distal zone (figure 4). This is normal insofar as pollution decreases according to the depth downstream from landfill (Barker et al. [1]).

The curves take an ellipsoidal form around two axes defined by the F1 fault and its junction, thus testifying to the structural control that the fractures exert on the flows and consequently on the advance of the pollutants from the landfill.

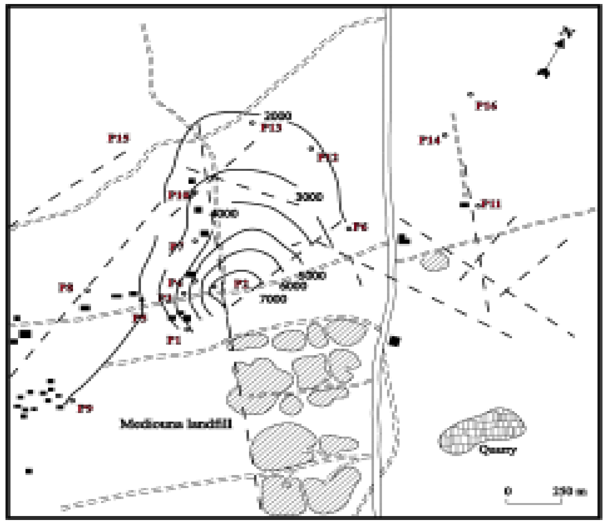

Figure 4. Electrical conductivity contour

4.2 CHEMICAL OXYGEN DEMAND

The chemical oxygen demand (COD) is a parameter which indicates the content of organic matter into water. It is almost zero in non polluted groundwater. The map which we established shows that the maximum value of 150 mg O_2/l recorded near the landfill. It decreases in the direction of flow, to reach 30 mg O_2/l (Figure 5).

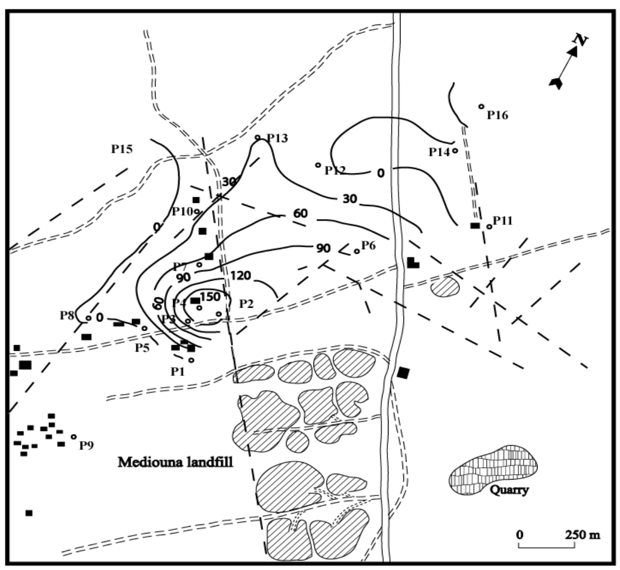

Figure 5. Chemical oxygen demand map

Since the content lower than this is not detectable, this curve can be considered the limit reached by organic matter pollution.

4.3 SCHOËLLER-BERKALLOFF FACIES MAP

The sodium chloride facies is observed in the wells close to the landfill. This facies passes along the flow direction to a calcium chloride facies considered as transition before becoming again calcium bicarbonate downstream (Figure 6).
The calcium bicarbonate facies met upstream landfill, is transformed into a sodium chloride facies due to contamination with landfill and whose attenuated effects give the calcium chlorinated facies. The disappearance of the effect of the leachate corresponds to the reappearance of the initial calcium bicarbonate facies.

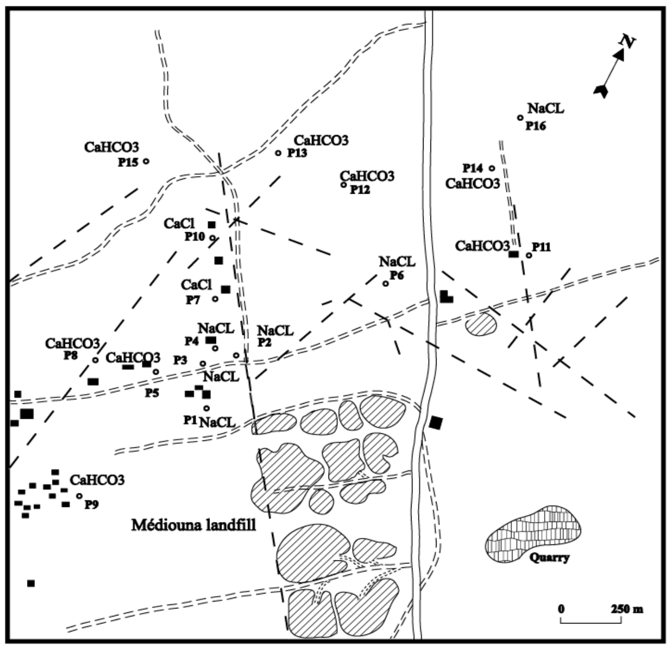

Figure 6. Schoëller-Berkalloff facies map

4.4 GROUNDWATER IRRIGATION QUALITY MAP

Figure 7, presenting the distribution of the wells, according to the classes defined by their projections on the diagram of Riverside, shows that:

- Class C3-S1, characterized by a low level of sodisation and a moderate risk of salinisation, comprises the wells P5, P8, P9, P11, P12, P13, P14 and P15. They are located in the zone nonaffected by pollution by the leachetes and the wells located upstream the landfill.

- The wells P6 and P16 belong to class C3-S2 characterized by an average risk of salinisation and a rate of moderated sodisation. These two wells are characterised by important depths.

- The wells affected by the leachetes and which are located just downstream from the landfill have water which presents a very strong risk of salinisation and sodisation. This is the case of the wells P1, P2, P3, P4 and P7.

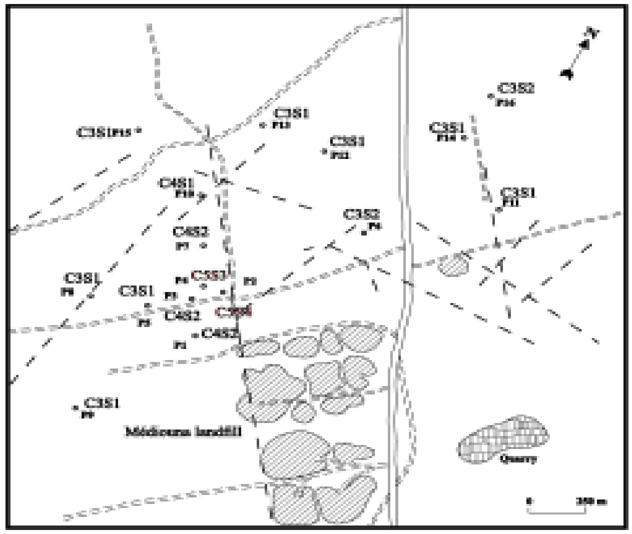

Figure 7. Groundwater irrigation quality map

5. CONCLUSIONS

The current study highlights the progressive movement of the pollution plume towards the Casablanca town, and the permanent loss of groundwater quality, since the majority of water samples taken from wells are of bad quality.
The analysis of pollution showed that it is of mineral and organic nature and affect two sectors. The first is proximal, where contamination is highly accentuated and materialized by the very bad smell and brown color of the water extracted from wells This zone is of smaller extension (Christensen et al. [3]). The second, located downstream, is characterized by a primarily mineral pollution with low organic matter content (Figure 8).

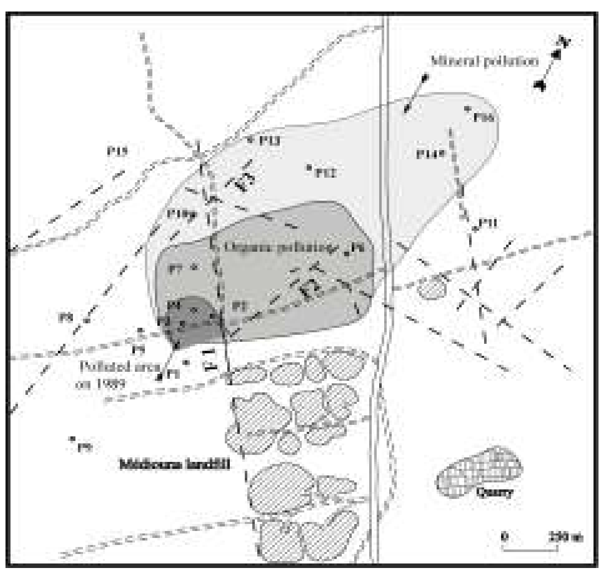

Figure 8. Front of pollution evolution

The groundwater pollution levels is not influenced by the direct structural control, where the faults favor pollution progression, but also to the presence of the pumping wells, which constitutes a curtain against the propagation of pollution downstream the landfill.

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