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 on fractured quartzite, which is not sealed off before it's starting up. The aquifer thus risks contamination by the leachate. Indeed, four years later, a study detected the beginning of groundwater's downstream pollution from the landfill, with reduced extension.
During the actual study, a hydro-chemical campaign was carried out, on 2001. Groundwater was collected on aquifer 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 the sealing off neither 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 Mediouna landfil. 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 bordering 3 million m^3 out 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, an intense traffic road.

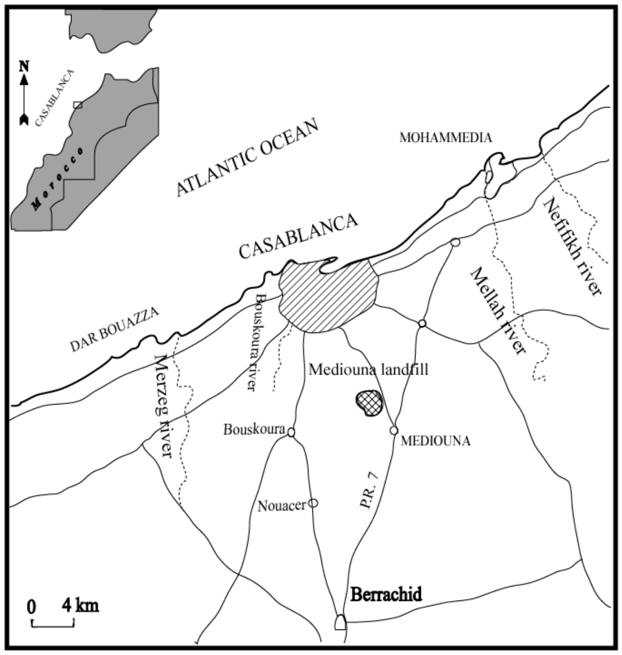

Figure 1: landfill site location

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 risen to Acadian green schist surmounted by quartzite, between psammitic series (Ruhard [8]). They were folded, faulted and immersed. Their reliefs were eroded, peneplained with a well marked surface constituting a diastheme. The Pliocene higher tertiary sector and the quaternary are also marine formations with lumachellic or conglomerate's facies covered by sandstones. The hydrogeological study shows that water circulation is carried out primarily in the quarzite, due to fracturation. The sandstones, though permeable, are generally dry. Close attention was paid to the lineaments, with origin on the aquifer quartzite's fracturing. 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]).

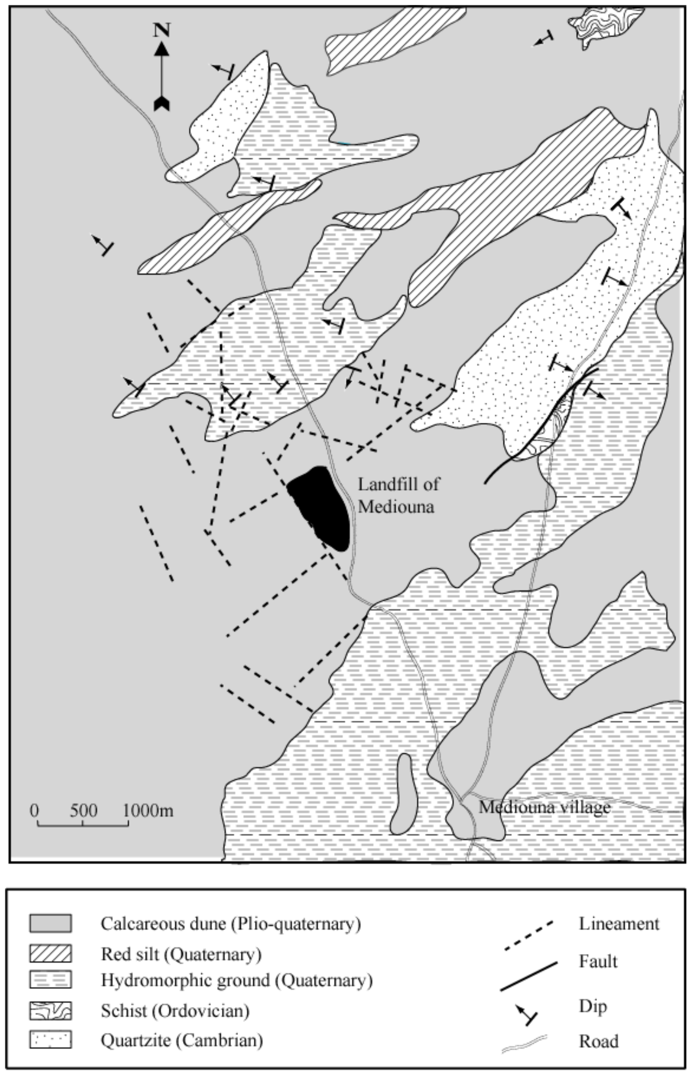

Figure 2: Geological map of the landfill's setting

The piezometric contours map (Figure 3), established from data taken in 2002, show a flow according to two orientations. One is located at West and presents a strong hydraulic gradient of about 0.4 %, indicating a difficult circulation of the water on the aquifer. The other is located at East, with a weak hydraulic gradient of about 0.01 %, indicating a good circulation of groundwater in this sector.

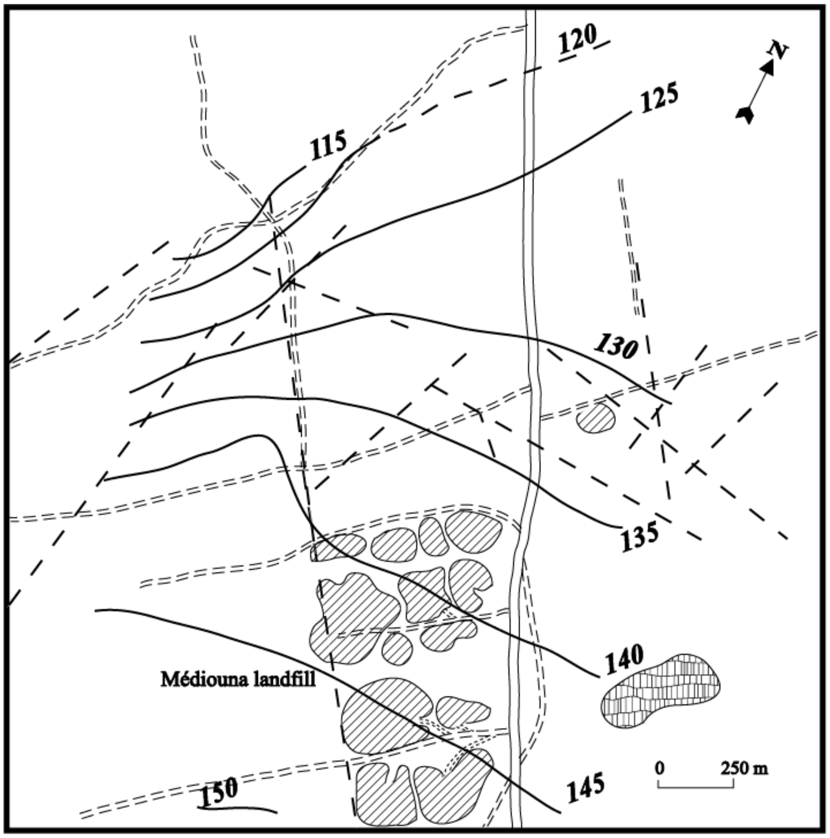

Figure 3: Peizometric contours map

3. 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 are elaborated.

3.1 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 bordering the 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 structural control that the fracturing exerts on the flows and consequently on the advance of the pollutants from the landfill.

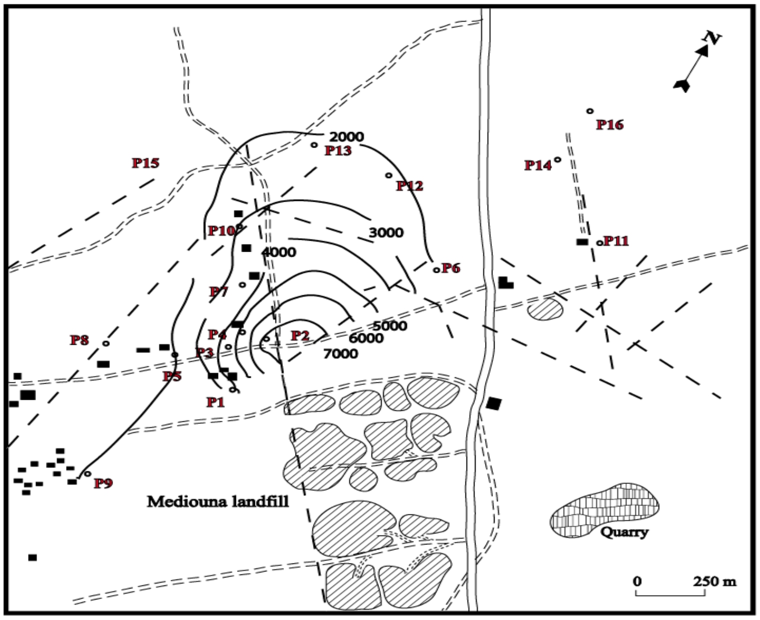

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Figure 4: electrical conductivity contour

3.2 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 not polluted groundwater. The map which we established shows that the maximum value of 150 mg O2/l recorded near the landfill. It decreases in the direction of flow, to reach 30 mg O2/l (Figure 5). The curve representing this value makes it possible to delimit the surface of the aquifer touched by organic matter pollution, since the contents lower than this are not detectable.

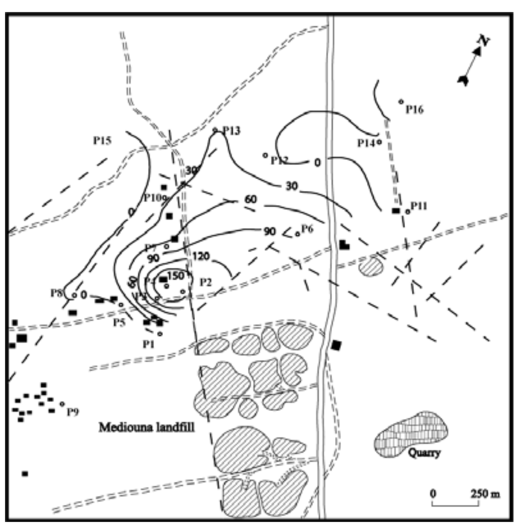

Figure 5: Chemical oxygen demand map

3.3 Schoëller-Berkalloff facies map

The sodic chlorinated facies observed on the level of the wells located on the front of the landfill. This facies passes with the direction of flow to a calcic chlorinated facies considered as a facies of transition before becoming again bicarbonated calcic downstream (Figure 6).
The calcic bicarbonated facies met upstream landfill, is transformed into a sodic facies chlorinated under the effect of the leachate of which the effect attenuates to give the calcic chlorinated facies. The disappearance of the effect of the lixiviats is materialized by the reappearance of the initial calcic bicarbonated facies.

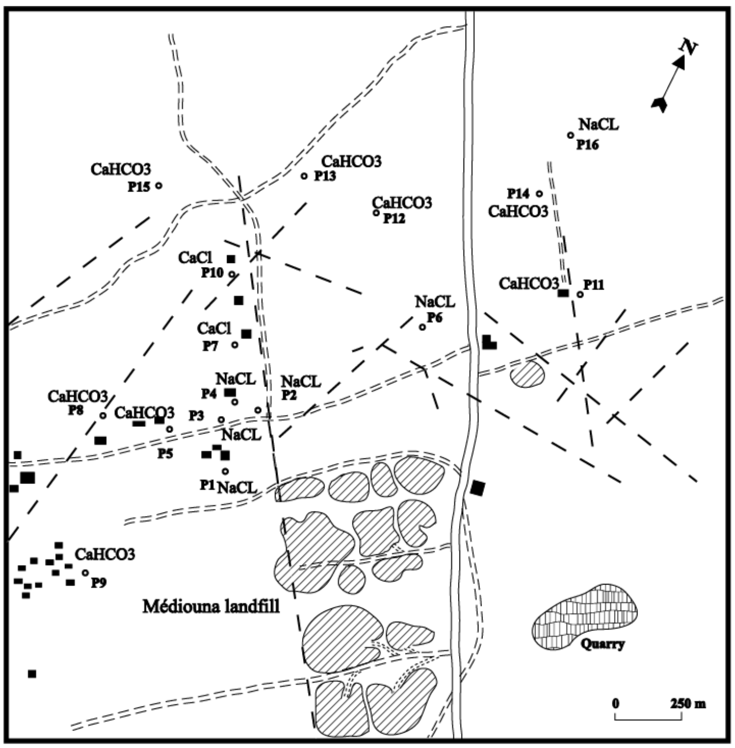

Figure 6: Schoëller-Berkalloff facies map

3.3 Groundwater irrigation quality map

The 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, gathers the wells P5, P8, P9, P11, P12, P13, P14 and P15. They are located in the zone nonaffected by pollution by the lixiviats 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 have the characteristic to have important depths;

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

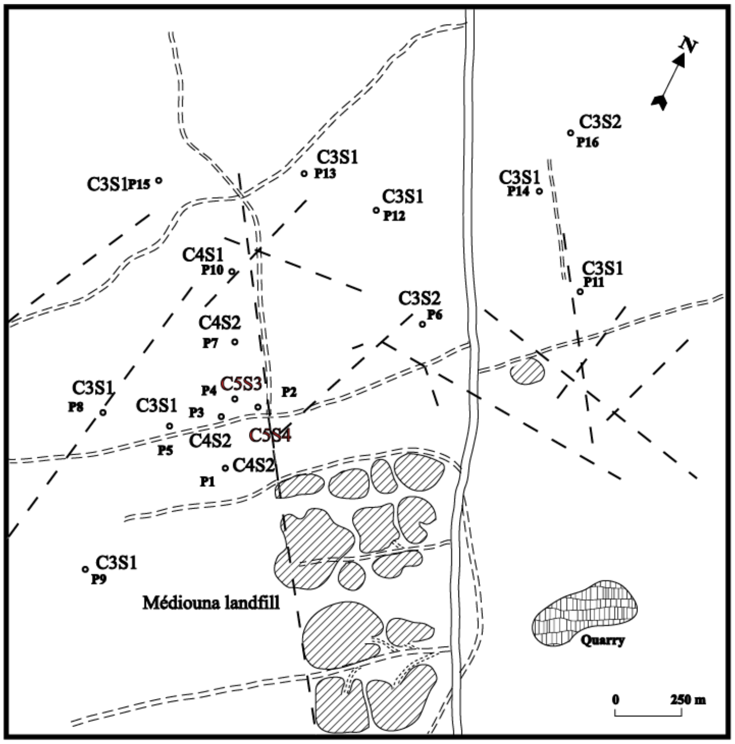

Figure 7: Groundwater irrigation quality map

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. First is proximal, where contamination is highly accentuated and materialized by a very bad smell and a brown color of the water extracted from wells This zone is in general of small extension (Christensen et al. [3]).

The second, located downstream, is characterized by a primarily mineral pollution with low organic matter content (Figure 8).

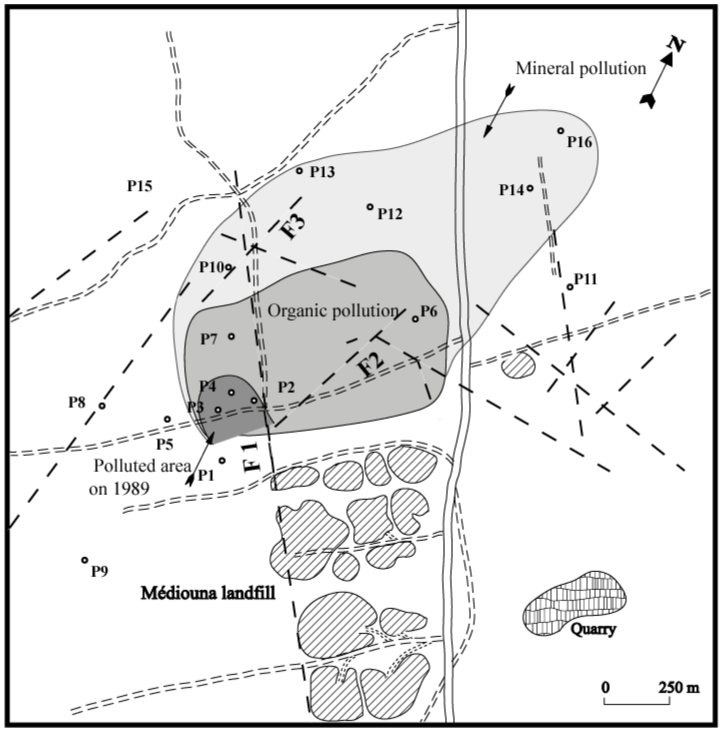

Figure 8: front of pollution evolution

The groundwater pollution levels is not only due to 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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