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Groundwater Contamination Due to Landfill Leachate—A Case Study of Tadla Plain †

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Abstract: In many parts of the world, the impact of open landfills on soils, the biosphere, and groundwater has become a major concern. This study was carried out on an uncontrolled landfill in the Tadla plain, Morocco's main agricultural region. The study of physicochemical parameters of water resources sample suggests that the evaluation of water quality parameters as well as water quality management practices should be carried out periodically to protect water resources and, on the other hand, to confirm groundwater pollution due to a pollution plume. Physicochemical analyses of leachate were thus carried out in order to determine the leachate nature of the landfill

Keywords: physicochemical parameters; landfill; water

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1. Introduction

Open dumps have been identified as one of the main threats to groundwater sources [1]. The open waste disposal system is the most common disposal method in Morocco [2] and specifically in the Tadla region. The Tadla region represents a pilot region in agriculture, but there are several problems that threaten the sustainability of agriculture in this region, such as salinity [3] and an open dumpsite. It is a kind of system where waste is disposed of by backfilling depressions on land that may include valleys and excavations, regardless of the composition of the waste [4]. Waste disposed of in an open landfill can be subject to precipitation infiltration. As water seeps into the waste, it absorbs a variety of organic and inorganic compounds that drain from the waste and accumulate at the bottom of the landfill [5]. The resulting contaminated leachate can migrate to soil and contaminate groundwater if not managed properly [6]. Such contamination of groundwater resources can pose significant health risks, including waterborne diseases, such as typhoid, cholera, and infectious dysentery, to local groundwater users.

Monitoring the physicochemical quality of the surrounding waters is therefore essential in order to determine the impact of these discharges on the waters, and thus good management of water resources.

2. Materiels and Methods

2.1. Study Area

Souk Sebt Ouled Nemma is a small town that is becoming very populated, located in the plain of Tadla in Morocco, the main region of agricultural production, with a dense population and fast. These changes have often been made at the expense of environmental balances. Among these balances is the abundance of wild landfills [7]. The city of Souk Sebt Ouled Nemma, like most other towns in the region, relies on agriculture.

On a regional scale, the Tadla plain is characterized by an arid to semi-arid climate; the amount of precipitation varies between 300 and 750 mm depending on the year [7]. The summer is very hot because of the hot winds of the southwest–east, known as 'chergui'. Water from the mountains is fed from the Atlas to the south. In addition to this natural supply, there is a powerful irrigation system from the Bin El Ouidane Dam, located about 100 km upstream of the region.

The Tadla plain, a syncline gutter, is filled with mio-plio-quaternary deposits consisting of alternating conglomerates, sandstone, and marls and ending in lacustrine deposits [8].

The plain is drained by the river Oum Er Rbia, which crosses it in its center from east to west (Figure 1). The study site is on the left bank, and the water table, at a depth of 5 to 6 m under an indurated limestone crust, flows regionally to the north–northwest. Regionally, it fluctuates due to recharge during irrigation periods. On the surface, the soils have a fine texture and moderate permeability. Land use is intense, and the population in the scattered colonies also uses well water for washing, drinking, and cooking. There are many unauthorized landfills, and poor soil and groundwater quality can affect agricultural production in the region and irrigation water quality [9]. Water quality monitoring and study are important.

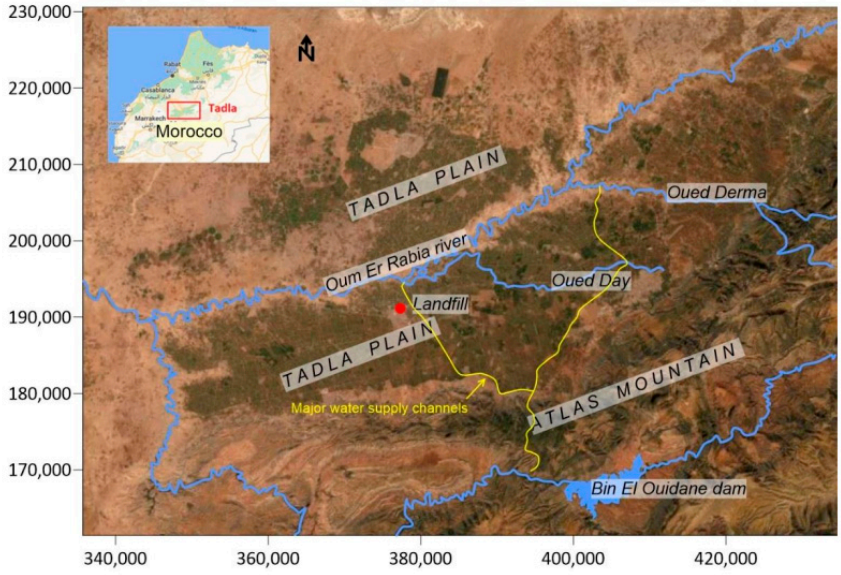

Figure 1. Geographical framework and location of the Souk Sebt landfill in the Tadla plain. UTM coordinates in meters using Lambert conical conformal projection (Morocco zone 1).

2.2. Sampling Methodology

During the first campaign (June 2019 and September 2019), a sampling network was selected and consisted of 6 wells and boreholes symbolized by W and L (Leacheat Sample), respectively, and spread across the entire study area, around the wild landfill, and along the direction of groundwater flow. These well samples were selected according to their availability, proximity, and their distribution upstream and downstream of the landfill. This choice allowed for a general, credible characterization of pollutants and an identification of the sectors where water quality is the most problematic, as well as high representativeness of the results in addition to landfill leachate samples.

For the second sampling companion, we collected samples in February 2020 to cover the dry and rainy seasons of the leachate symbolized by L′ and surrounding surface water (irrigation canal and collector drain water), symbolized by SW. In situ parameters (T, Eh, pH) were measured during the first measurement.

Groundwater samples were also collected from surrounding boreholes. Leachate samples were taken at the bottom of the landfill. Plastic containers of 100 cl and 50 cl were used to collect groundwater and leachate samples, respectively. Before the samples were taken, the containers were washed with acid water to sterilize them, and then they were rinsed thoroughly with distilled water. The samples collected were sealed and properly labeled. The samples were stored at 4 °C and then taken to the laboratory for analysis. All samples were analyzed for physicochemical parameters and heavy metals.

3. Results and Discussion

3.1. Leachate Characterisation

Table 1 shows the results of physicochemical analyses (mg/L) of the leachate samples.

Table 1. Physicochemical characterization of leacheate in Souk Sebt landfill (in summer period, July 2019, and winter period, February 2021).

Parametrs	pH	EC (ms/cm)	$HCO3^-$	F^-	Cl^-	$PO4^-$	$SO4^-$	Na^+	$NH4^+$	K^+	Mg^{++}	Ca++	TOC	SiO^2	COD	NO^{2-}, NO^{3-}
July 2019	7.5	42.5	-	-	2178	78.42	-	1083	677.9	1181	64.13	113.3	-	-	31,929	0.02
February 2021	7	33.3	7110	395	3268	102	0.02	1741	696	1838	315	593	441	348	-	0.02

The leachate of Souk Sebt has a brownish-black color, and the strong smell of the landfill leachate may present the first pollution indicator, accompanied by strong mineralization by chemical elements (Table 1). The characterization of the leachate has shown the presence of mature leachates with high mineral and organic loads. Organic load is translated by the high values of COD and TOC. On the other hand, the mineral pollution is shown by the high values of $NH4^+$ (mg/L), $NO3^-$ (mg/L), and $PO4^-$ (mg/L).

3.2. Groundwater and Surface Water

The relatively high value of EC and dissolved solids in the samples indicated the presence of inorganic material in both seasons. Higher concentrations of chlorides were observed in wells close to the dumping site. The highest value was recorded in well located downstream hydrogeologically, which is 106 m away from the site. Pollution sources, such as domestic effluents and fertilizers, as well as natural sources, such as rainfall, can lead to high Cl (Figure 2).

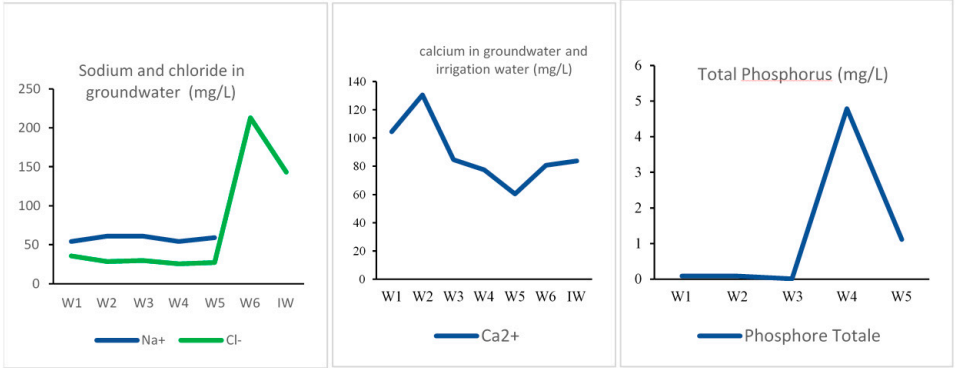

Figure 2. Sodium, Chloride, calcium and total phosphorus of groundwater samples in Souk-Sebt.

Nitrogen is mainly present in water as nitrate (NO_3^-), but under reducing conditions, it can be present as ammonium ($NH4^+$). Phosphorus is also present in water as a phosphate ion ($PO4^-$). Both nitrate and phosphate are an environmental concern as they are potential

sources of nutrient enrichment in rivers, lakes, and wetlands (Figure 2). The presence of nitrates (0.0–3.17 mg L^{-1}), ammonia (0–0.6 mg L^{-1}), and phosphates (0.65–9.9 mg L^{-1}) in groundwater are related to contamination by anthropogenic activities or infiltration of residual water [10,11]. These results can be confirmed by the delineation study of the pollution plume at the landfill level at Souk Sebt, which shows the geometry of the pollution plume in a north–north–west direction [12].

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