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SANITATION AND ENVIRONMENTAL PROBLEMS IN HASSI-MESSAOUD CITY (LOWER SAHARA - ALGERIA)

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ABSTRACT

The dysfunction of the liquid waste sanitation systems is noticeable in the city of Hassi-Messaoud: wastewater stagnates in empty spaces (sludge). The consequences of this dysfunction on the living environment and the natural ecosystem are becoming more and more serious and call for appropriate decisions from all the actors involved. In addition, the development of oil activities will lead to significant changes in the environment, particularly in water resources. Industrial pollution has very negative effects on the quality of water resources. It has to be treated at the plant level, especially to remove toxic elements. This situation suggests that if nothing is done to correct the situation, pollution could become a serious cause of water shortages in the future.

KEYWORDS

Hassi-Messaoud, Water, Sanitation, Pollution, Environment

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Introduction.

Because of rapid population growth, human activity and the development of the oil industry, the city is leading to intense exploitation of groundwater resources and heavy pollution, and the environment is undergoing increasingly rapid and widespread degradation. The town of Hassi-Messaoud has been described as an industrial hub of extreme importance for the entire national territory (Bouselsal 2017). This Saharan city is characterized, on the one hand, by its strong dominant oil industry vocation, and on the other hand, by the diversity and heterogeneity of the component of its urban perimeter (a poly-functional perimeter: living base, residential center, production center, industrial zone...etc.). These two characteristics have caused the town of Hassi-Messaoud to experience a number of problems in managing and supplying drinking water to its various users. Due to the complete absence of agriculture, which is the primary water-consuming sector in most Algerian cities, and the direct effects of the new hydrocarbon law introduced in 2002—allowing unrestricted private investment in the hydrocarbon sector, both national and foreign—there will be an increasing demand for water resulting from the expansion of industrial activities. Specialists identify four major risks associated with Hassi-Messaoud: fire, explosion, pollution, and contamination.

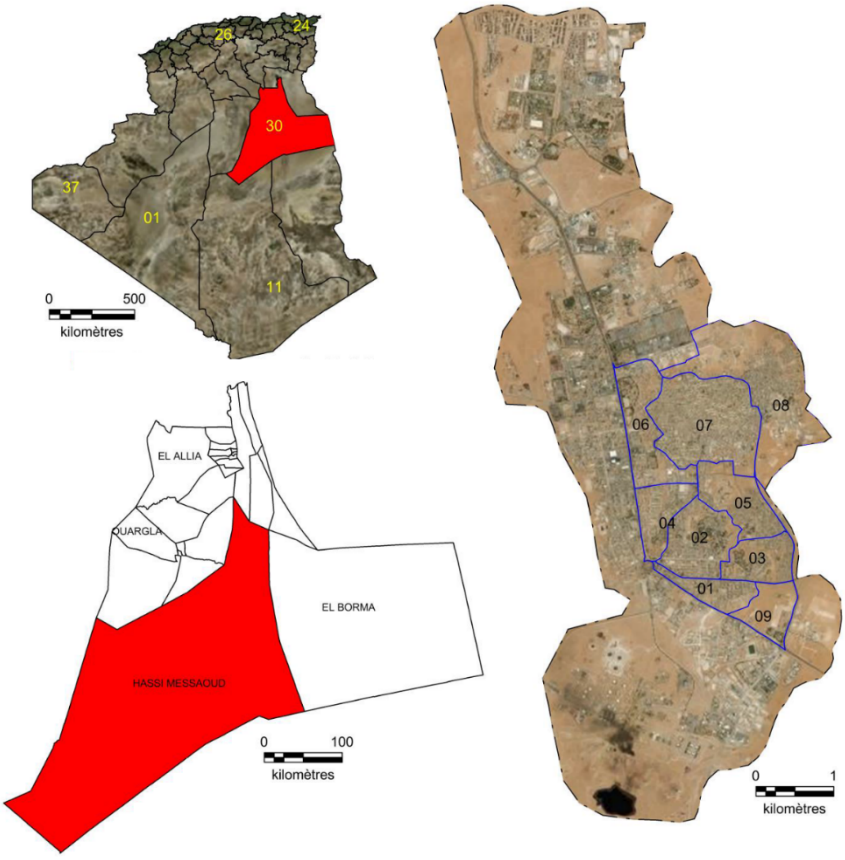
This study will focus on the risks of groundwater pollution and contamination. Rapid population growth and the expansion of a polluting petroleum industry in the Hassi-Messaoud region have resulted in intensive groundwater exploitation, leading to elevated levels of anthropogenic and industrial pollution. The increased volume of distributed water has generated significant amounts of untreated wastewater, which is released into the environment (sludge). Furthermore, the city faces considerable challenges in wastewater evacuation due to the highly permeable sandy soil and a topography that does not facilitate effective runoff.

Methodology.

For this problem, we based our research on a single axis: downstream problems (wastewater disposal, pollution, sanitation, reprocessing etc....) from our point of view that the city is located in an arid and fragile ecosystem that is subject to heavy industrial settlement, especially oil and chemical pollution.

Study Area.

Hassi-Messaoud city is located in the southeast of the Ouargla wilaya, is currently one of the largest in the region (Map n°. 1). It covers an area of 71,327 km2, representing 43.64% of the Wilaya's total surface area. At a latitude of 31°40 North and a longitude of 06°09 East. It rises to an altitude of 142m. Its region is characterized by a hot, arid desert climate. (YAHIACHERIF Halla 2018).



Map 1: City of Hassi-Messaoud, geographical location

The climate is classified as hyper-arid, typical of desert regions such as the Eastern Erg. Annual precipitation is less than 40 mm, far below potential evapotranspiration, with air temperatures exceeding 45°C, making Hassi-Messaoud one of the hottest regions in the Sahara.

The Region's Water Resources.

In our region, there is virtually no surface water network (surface water resources are non-existent), although there are names such as Oued Irara, Oued Sioudi and Oued Guenifida. These wadis are considered to be fossil watercourses dating back to the Quaternary period. The courses of these wadis have been used for

various constructions (shanty towns, road networks, living bases, etc.), and the Oued Guenifida is even used as a quagmire. The city's water supply relies exclusively on underground resources. As part of the ERSS studies, the Hassi-Messaoud region was identified as having a high potential for water resources. These are located in the two main nappes of the northern Sahara: the Continental Intercalaire (CI) and the Complexe Terminal (CT). The Continental Intercalaire (Albienne) nappe was discovered in the Sahara in 1945, during oil exploration work, at a depth of 1,357 m. (PERENNES Jean- Jacques1993). In the Hassi-Messaoud region, this water table is tapped at depths ranging from 800 to 1,548 m. It is an eruptive aquifer, exerting a pressure of between 14 and 21 bars, with temperatures in excess of 45°C. The intercalary continental water table, made up of freshwater in the Albo-Barremian sandstones, has a salinity of no more than 1 to 2 g/l, with an estimated potential of 2199 l/s (ERSS - UNSCO 1970). The terminal complex encompasses the most recent formations and covers an area of 350,000 km². The potential of this water table in the Hassi-Messaoud region is estimated at 15,296 l/s, while the water temperature varies between 18 and 25°C. The unconfined aquifer of the terminal complex is a multi-layered aquifer, with water moving between the aquifers of the following formations:

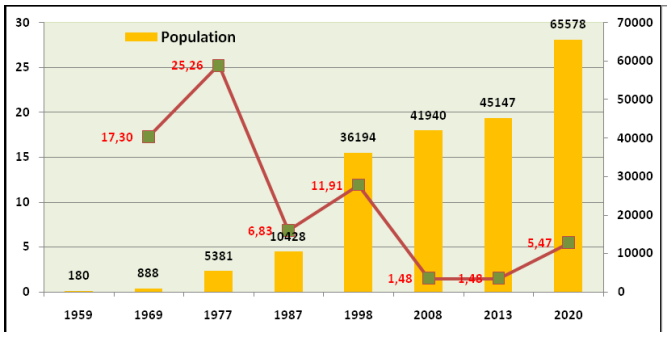
- **The Turonian nappe**: The Turonian forms the base of the terminal complex. The waters of the Turonian nappe, which are carbonate and dolomitic, are highly saline. The depth of this nappe varies between 838 m and 980 m, and the boreholes in this nappe are either closed or temporarily shut down.
- **The Senonian - Eocene nappe**: This groundwater, mainly composed of carbonates, is made up of dolomitic limestone with an average thickness of 90 m and is tapped at a depth of between 300 and 375 m. The water from this aquifer, which is less salty, is reserved for drinking water supply (AEP).
- **The Mio-Pliocene nappe:** It is composed of sand, with the presence of limestone and clay, with an average thickness of 230 m. This water table has been tapped at depths ranging from 36 to 225 m, and supplies the living quarters as well as the oil drilling probes. There is probably a risk of pollution due to the location of sloughs and poorly protected boreholes.
- **The water table:** This is the water table most used by caravans in the region. Above a depth of 8 m, it percolates with the Mio-Pliocene sand table.

A Progressively Diversified Population.

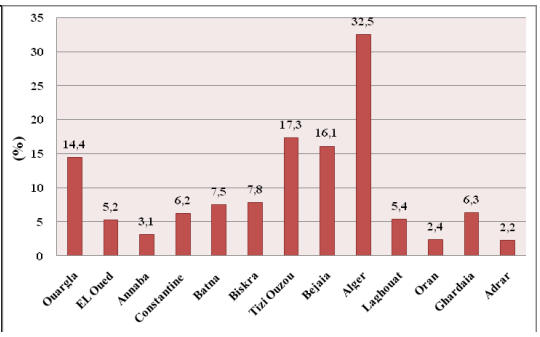
The town of Hassi-Messaoud was born out of the oil industry, and the development of its population has been linked to all the events and facts concerning oil. Hassi-Messaoud's position makes it a pole of attraction. It began life as a town of male workers (180 inhabitants in 1959). For a long time, their working hours were the same as those at most bases: 3 shifts of 8 hours each; 6 weeks on in the Sahara, 3 weeks off in the North (SEGHIRI Allaoua 2002). In 1970, “a total of just over 5,000 people, almost all of them men, lived in the Hassi-Messaoud region” (Lerat Serge 1971).

In addition, intensive groundwater exploitation, the discharge of domestic and industrial wastewater and the infiltration of irrigation water have a negative impact on groundwater quality (Mahmoud Touahri & all 2022). Prior to 1971, the population grew at a slow rate, averaging 82 people per year. The majority of these were people hired by French companies as part of the “Algerianization of recruitment” demanded by Algeria in the Evian agreements. These figures bear witness to the fact that Hassi-Messaoud was an industrial field limited to oil activities, and devoid of any urban life.

February 24, 1971, was an important date in the history of the city's urbanization, representing the first major event of the post-independence era: the nationalization of oil by the Algerian state, and the policy regarding oil exploitation. Since this event, Hassi-Messaoud has experienced a population decline that can be explained by socio-economic reasons that suddenly increased the need for labor. In less than 11 years, from 1987 to 1998, the population of Hassi-Messaoud quadrupled (Yaël Kouzmine and Jacques Fontaine 2018), increasing from 10,428 inhabitants in 1987 to 36,194 in 1998 to reach 65,578 inhabitants in 2020 (Graph n°1).



Graph 1: Population trends (1959-2020)



Graph 2 : Population origin

The population of Hassi-Messaoud is extremely diverse, attracting people from different parts of the country (Graph n°2), particularly from the East due to its geographical proximity. Among residents, 32% come from the Algiers region, while 6% are from Ghardaïa and 14% from Ouargla. The latter plays a strategic role as a supply base for Hassi-Messaoud, providing labor, food products and building materials. The population of Hassi-Messaoud is increasingly cosmopolitan, with people from all 58 Algerian wilayas seeking employment opportunities, as well as thousands of foreigners of 104 nationalities. These international workers are employed by 72 foreign companies operating in partnership and cooperation with the Algerian company SONATRACH (APC 2018).

Hassi-messaoud; From Oil Town to Mushroom Town.

Hassi-Messaoud did not develop around a palm grove or a traditional ksar, but emerged directly from mining activity, stimulated by the discovery and extraction of oil (Marc Cote, 1996). Hassi-Messaoud belongs to the family of mining towns (Lerat Serge 1971), a town at the center of oil production (Yaël Kouzmine Et Jacques Fontaine 2018). The initial core is actually just the geographical heart of a petroleum basin covering some 2,000 km^2 (Jean BISSON 2003). The estate was essentially made up of groups of houses, isolated and arbitrarily laid out, resulting in a sprawling fabric. For a long time, the public authorities were reluctant to give it ordinary status, and in 1965 made it an “administrative center” under the centralized management of the wilaya of Ouargla. Prior to the 1980s, these areas were haunted only by SONATRACH employees (Marc COTE & Claude CASTEVERT 1970), an industrial zone, no commune, and only a few health and schooling facilities to meet staff needs. From 1984 onwards, the Saharan industrial center (C.I.S.) became a commune, with a rapid urbanization process that was essentially economic and demographic in origin. This new commune, with a surface area of 71,237 km2, has the same characteristics as other Algerian communes, but is financially privileged thanks to the substantial industrial taxes from which it benefits, enabling it to be amply endowed with high-quality equipment and infrastructure, as well as the various amenities of life, such as drinking water supply networks, covering the majority of the town's districts, and the presence of a sewage network for a large part of the town. The urban expansion of this new town in the Lower Sahara has been very rapid, and its population has doubled in 10 years, enabling us to classify it as a mushroom town. Our city is totally urbanized, as evidenced by the women and families in the streets (SEGHIRI Allaoua 2002). Urban life has undoubtedly become more commonplace. Hassi-Messaoud tends to resemble all the towns that exist in the Sahara today. Numerous construction projects have been launched and completed in a short space of time, with the sole aim of housing oil company families as quickly as possible. Without even considering the moral and human needs of the inhabitants. For this reason, Hassi-Messaoud can be described as a pilot town with an artificial creation or an industrial town with the mono-functional character of an oil town (map n°2). Hassi-Messaoud is an autonomous town that has been created by itself, without any planning. The excessive size of the site, year after year, is the result of an uncontrolled expansion that takes into account neither the site's hazardous location (located on an oil field and close to hydrocarbon infrastructures such as flares and pipelines....) nor its morphology (rugged terrain, plateaus and basins). The uncontrolled expansion of the town has prompted the relevant urban planning departments to consider delimiting the urban perimeter and creating a new town, bearing in mind that since April 2005, the perimeter of the town of Hassi Messaoud has been classified as a major risk zone (Executive Decree 05/127 of April 24, 2005). Article 4 of this decree prohibits any construction or investment in the Hassi-Messaoud perimeter not related to the hydrocarbon industry, including building permits for infrastructures such as schools, hospitals or hotels.

Map 2 : City of Hassi-messaoud

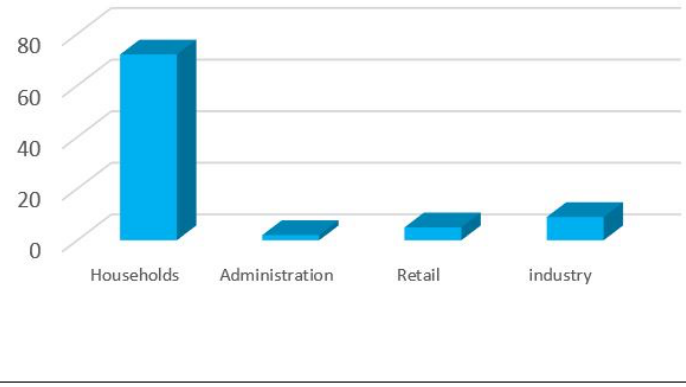
The consequences of this strong and uncontrolled (anarchic) urbanization are the non-hierarchization of urban roads, the moderately low degree of organization of urban centers and structuring of urban roads, and organization not based on the principle of hierarchization of urban centers. What's more, the city center is off-center in relation to the geometric center of the urban perimeter. Added to all these consequences is the problem of water supply: on the one hand, the increase in demand for water, and on the other, problems of connection to the main network and the planting of storage infrastructures, not to mention the problem of connection to the sewage network. Overall, a composite conurbation, spread out over a wide area, with an architecture and urban layout that bear little resemblance to the Sahara. The town of Hassi-Messaoud has no real urban form (it changes every time the town evolves), it's not circular, square, rectangular or leaf-shaped, it's not even the oil-spot shape that characterizes most Saharan towns. Rather, it's spread out.

Sanitation in Hassi-Messaoud.

Sewage disposal is a major problem in the city due to the topography of the region, the lithology of the soil... etc. The town's sewage system discharges wastewater into the natural environment without any prior treatment. L'état de ce réseau (système continu) est moyen, il couvre 88% du noyau urbain, sur une distance de 137206 ml.

According to the authorities, by 2020, there would be 5385 households connected to the sewerage network (Graph n°3). The precarious neighborhoods (EL Haïcha, Toumïat, and 136 housing units), which are gradually being transformed into sustainable housing, nevertheless continue to bear the stigma of poverty (Belguidoum Saïd 2002). These homes suffer from an inadequate sewage network and recurrent leaks, as evidenced by the large number of complaints (908) and interventions by the O.N.A. (1,354), not to mention the total absence of this network in a large proportion of precarious housing, which has led residents to use individual structures (septic tanks in the sand). On the other hand, the sanitation situation at the IRARA base has reached a satisfactory level, with almost all wastewater discharged to a 1,000 m^3/day/capita-equivalent wastewater treatment plant, where the water undergoes biological treatment using activated sludge.

Types	Subscriber numbers	%
Households	5385	72
Administration	169	2
Retail	402	5
Industry	703	9



Graph 3: Number of subscribers connected to wastewater network

All wastewater from the town of Hassi-Messaoud is collected via three main collectors. All the water conveyed to the El Haïcha station (ST 2) is then discharged to the other 200-housing discharge station (ST3), which in turn discharges all the water from the three collectors to the temporary Toumïat. All wastewater from the town of Hassi-Messaoud is collected by three main collectors. All the water is first conveyed to the ST2 treatment station at El Haïcha, then pumped to another lifting station (ST3) located near the 200 housing units (table n°1. This last station in turn discharges all the water from the three collectors to the temporary Toumïat slough. There are seven stations, three of which are for lifting and four for pumping water.

Table 1 : Characteristics of discharge stations

Pumping stations			
1850 housing units (Larbi Tebessi)	El Haïcha	200 homes	Toumïat
abandoned	3 discharge pumps with a capacity of 58.3 l/s 	This is the main station, with three pumps. Its current capacity is 113 l/s. 	With four pumps. two at 80 l/s each and two at 70 l/s each. this station is currently only operating with a 70 l/s pump. 

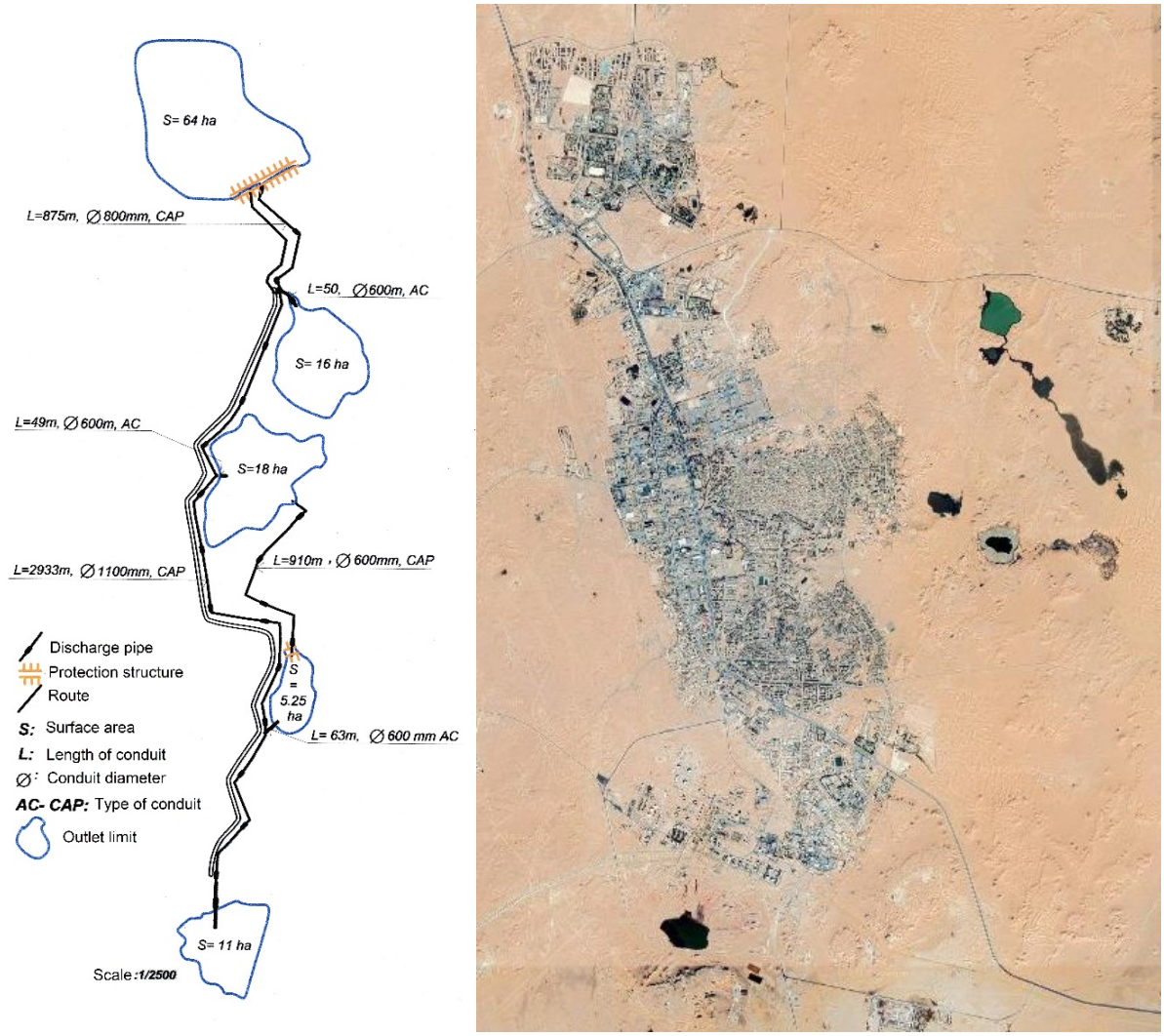
Sewage Outfalls: A Major Environmental Problem.

The nearest outfalls, located 1,500 m from the urban core (next to Toumïat), forms a large lake with a surface area of 62 hectares and a capacity of 1,860,000 m^3 of polluted water, with a water level three meters high (table n°2). As a result, these polluted waters provide an ideal breeding ground for mosquitoes and rats, and risk damaging the environment, including public health. To keep the dangers away from this outlet, the city authorities have created four other basins far from the city. However, the risk of groundwater contamination remains, due to the untreated discharge of this wastewater into the natural environment. The

southern production center, without prior treatment, discharges its industrial wastewater into a nearby slough (map n°3).

Table 2: The characteristics of the basins

Basins	Area		Water volumes		Water level (m)
	hectare	%	m^3	%	
Basin 1	62	*55.23*	1.860.000	*29.94*	3
Basin 2	16	*14.25*	1.120.000	*18.02*	7
Basin 3	18	*16.04*	1.980.000	*31.87*	11
Basin 4	5.25	*04.68*	262.500	*04.23*	5
Basin 5	11	*09.80*	990.000	*15.94*	9
Totals	*112.25*	100	*6.212.500*	100	/
Source : ONA Hassi-Messaoud 2020.					



Map 3: The quagmires

Wastewater: No Water Purification.

Due to a galloping population and difficulties in controlling urban growth, the A.D.E. estimates the volume of water discharged by the city at 75% of the volume consumed. This considerable volume is discharged untreated into the environment, due to the absence of a wastewater treatment plant. It should be

remembered that the amended Water Code stipulates that “all agglomerations with more than 100,000 inhabitants must have wastewater treatment processes and systems in place. For example, Hassi-Messaoud, with a population not expected to exceed 65,000 in 2020, is not supposed to have a wastewater treatment plant, despite the critical state of its environment and the worrying effects of an oil industry on a fragile ecosystem. Hassi-Messaoud, with its specific characteristics and satisfactory financial situation compared to other Algerian towns, needs as a priority to set up a wastewater treatment system. Over 67% of households surveyed consider wastewater to be a source of environmental and health problems.

The Hassi-Messaoud region, centered on the oil industry, suffers from the harmful effects of various industrial activities, particularly through sludge and flaring. Lack of domestic wastewater treatment in the urban core, industrial effluent discharges laden with toxic substances and often discharged into the environment (sludge), and leaks from petroleum product storage tanks are among the main causes of urban water pollution. The severity of this pollution depends on population density, industrial practices and the presence or absence of wastewater recovery and treatment systems.

A Highly Polluting Oil Industry.

The location of industrial units within the city limits actively contributes to environmental degradation. As petrochemical plants, they generate wastewater discharges from production centers, including cooling and cleaning water, among other things. The pace of industrialization in the Hassi-Messaoud region has led to a considerable increase in wastewater discharges into the environment. The current wastewater evacuation network has shortcomings that encourage the phenomenon of water rising to the surface. The outfall where this wastewater is discharged is largely saturated, posing a serious threat to the ecological environment and the natural balance in terms of groundwater supply, as well as to the ecosystem as a whole. This means that the current pace of industrialization must necessarily lead to regulatory measures and actions aimed at maintaining the ecological balance and avoiding the risk of destroying the natural environment. Inadequate equipment for deep wells (Albien) can lead to serious and irreversible situations, particularly in areas with saline horizons. Casing can corrode, leading to water leaks which, as they rise, become loaded with salts and can degrade the quality of the water in the Terminal Complex aquifer.

Sloughs and Mud.

Analyses carried out by the Mud Logging laboratory in Hassi-Messaoud on the slough located south of the production center revealed a high concentration of toxic elements and significant pollution in the slough's waters.

Sludge can therefore be classified as a hazardous industrial waste in the Hassi-Messaoud region, requiring immediate treatment to prevent the pollution it generates and its impact on the environment (soil and groundwater contamination). Drilling mud generally requires a two-phase physico-chemical system (liquid phase and solid phase). Consequently, the return of sludge from oily water treatment to nature without prior treatment constitutes an environmental risk. In the ecosystem of our desert region, surface water is non-existent, which gives groundwater great importance, as it represents the sole source of water supply for all development activities in the region.

Conclusions.

The town of Hassi-Messaoud has significant water and oil resources, essential for its economic and social development. However, pollution is on the rise, contaminating the water table and threatening the environment, exacerbated by the discharge of 6,212,500 m³ of untreated wastewater into the environment. The city faces challenges in wastewater treatment and management due to the growth of a polluting oil industry. In Algeria, the protection of water resources is often neglected in favor of the search for new exploitation sites. It is crucial to prioritize water and environmental protection to ensure sustainable development.

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