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# Characterization of water and sediment quality of Oued Laya (Sousse/Tunisia)

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## Abstract
In Tunisia, the economic, industrial and agricultural development represents a potential threat to the quality of water resources by the lack of control of effluent discharge into the natural environment. Furthermore, the national policy for the management and protection of natural environment quality is not sufficiently advanced. Indeed, there is no Tunisian standard for monitoring the quality of water and sediments of rivers. Our paper aims to provide an inventory of water and sediment quality of Oued Laya located in the zone of Akouda in Sousse region (Tunisia) which proved to be a major nuisance for the residents. Six waters and two sediment samples were collected for analysis.Water analyzes are focused on some physico-chemical parameters, ammonium, phosphorus content and heavy metals. For the sediments, the analyses concerned heavy metals and Polycyclic Aromatic Hydrocarbons (PAH). Furthermore, in the absence of Tunisian standard, the French system SEQ-Eau was used to assess the quality of water and sediment of Oued Laya for the biology aptitude. For water, results show, generally, a high organic and oxydible matter, and a contamination by phosphorus content which justifies the eutrophication of the river by the presence of algae. Some heavy metals (cadmium, copper, chromium, nickel, tin, selenium, manganese, iron) were quantified but their concentrations were below the accepted standard used in this study. We can also note the absence of mercury, arsenic, zinc and antimony in all analyzed water samples. For sediments, analyzes show their contamination by heavy metals and PAHs. According to the French standard, poor quality can be attributed to Oued Laya sediments.

*Key words:* heavy metals, Oued Laya, PAHs, sediment, water.

## 1. Introduction
Sewage treatment plants are receiving wastewater from different origins (domestic, industrial, storm, etc.) and types (organic, inorganic, etc.) [1]. The commonly used standard treatment can't allow the elimination of all polluting agents present in wastewater [2]. Especially, the persistent organic pollutants (POPs), constituted by chemical compounds of a highly diverse origin [3], is characterized by its high production and consumption entailing its continuous presence in the environment [4]. The treated effluent is typically discharged to a receiving water environment (river, lake, estuary, etc.) [5].
The absence of tertiary treatment and the poor treatment performance of the Waste Water Treatment Plant (WWTP), caused either by the bad state of the equipment or the under sizing of the WWTP, lead to a poor quality of the treated water [6]. This later represents a threat for the environment, mainly water resources taking into account the leakage between aquifers and rivers [7]. This environmental problem becomes more severe in the absence or the non application of legislation.
In Tunisia, one of the objectives of the national policy concerns the integrated water management and protection of water resources against pollution [8]. Several studies have focused on pollution of surface water mainly by heavy metals [9, 10 and 11]. These studies show that industrial activity [12] is responsible for the contamination of water and sediments with heavy metals, mainly by the discharge of effluents in nature [13]. In this context, our paper aims to assess the water and sediment quality of a stretch of Oued Laya located in the zone of Akouda in Sousse region (Tunisia).

## 2. Material and Methods

*2.1. Study area*

The site of the study is a stretch of Oued Laya located in the east central of Tunisia and belongs to Sousse region (Figure 1). The stretch of the Oued is crossing an agricultural area in the zone of Akouda. The choice of the study area is justified by the presence of potential pollution sources considerd to be a major nuisance for the residents, farmers and Mediteranean Sea (outlet). Indeed, the site received (at the upstream) the discharge of the Wastwater treatment plant of Kalaa Sghira, and (at the downstream) the industrial effluent. In addition, it is an anarchic dumping of various types of solids, plastic, household, etc.

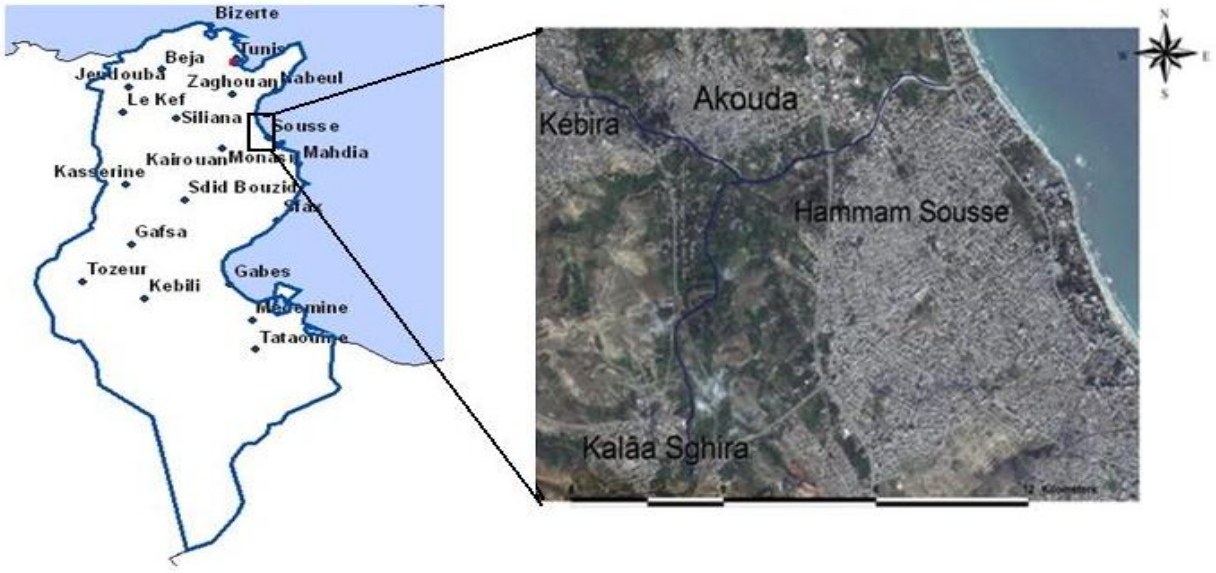


**Figure 1.** Location of the study area

The length of the segment is of 5.3 km, the average altitude varies between 10 and 80 m NGT (Tunisian level datum). The hydrographic network of the Oued Laya basin is characterized by temporary watercourses. The origin of Oued Laya consists on the defining the plains endorheic of low steppes of Sahel hills, flowing towards Wadi El Hammam and finally the Mediterranean Sea (Figure 1).

The climate in the region is semi-arid. The average yearly rainfall is about 320 mm. Generally, 50% of annual precipitation occurs during the autumn. The annual average temperatures are generally moderate with an average of 18.6°C. The variation of monthly average temperatures shows that the hottest month is August with an average of 26.3°C and the coldest month is January with an average of 11.2°C, a temperature range of 15.1°C.

In the study area, water courses flow over loose rock. These are alluvium, clay and sand or a mixture of them [14]. The medium and coarse texture gives a high soil permeability and infiltration which increases the vulnerability of groundwater resources. The practiced cultures int the study area are trees cultivation and vegetable crops.

*2.2. Wastewater treatment plant of Kalaa Sghira*

The WWTP of Kalaa Sghira was established in 1993 with a processing capacity of 1450 $m^3$/day. It provided services to 20,000 people. The discharge is released directly to the natural environment Oued Laya after the treatment with the channel oxidation system. The monitoring of the quality of treated wastewater is made by the laboratory of the «*Office National d'Assainissemnt*» (ONAS / National Sanitation utility) to verify compliance with the Tunisian standard NT 106.002. According to the annual report analysis of treated water in 2012, WWTP of Kalaa Sghira generally does not respect the standard NT 106.002 for release to the environment (Oued Laya).

*2.3. Monitoring*

To determine the impact of point source pollution on the environment, it is advisable to position a control point in the upstream of the discharge pollutant (source of pollution) and a sampling point downstream the source. Six sampling points over the course of Oued Laya were chosen to characterise water and sediment pollution of the study area. The figure 2 shows the location of these sampling points and the potential sources of pollution in the strech of the Oued. For sediment, one sample was taken at P2 and, average sample (P3-4) was prepared from the sediment sample collected at P3 and P4. The monitoring campain was performed during May 2013.

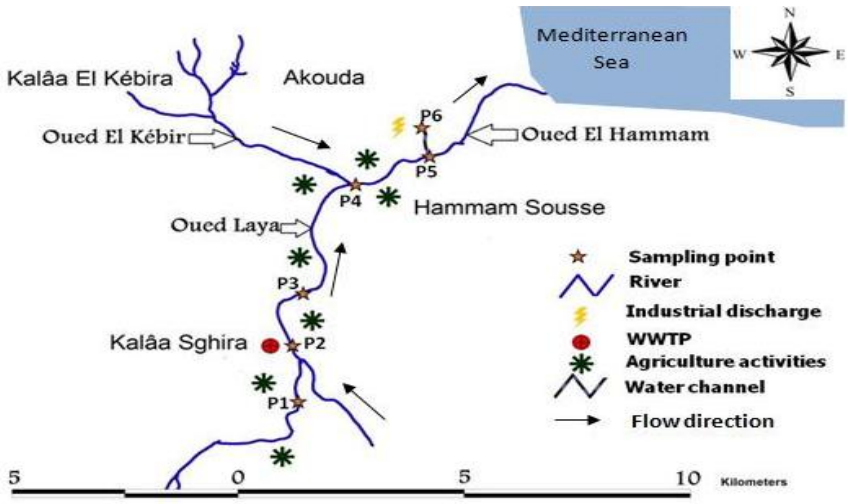


**Figure 2.** Situation of the sampling point and the potential sources of pollution

In the absence of Tunisian standard for quality control of surface water, the «*Système d'Evaluation de la Qualité des Eaux*» (SEQ-Eau − Water Quality Evaluation System) introduced in France in 1992 was used for biology aptitude. Furthermore, concentrations were compared to the Tunisian standard NT106.03 for the reuse of the treated wastewater for agricultural purposes. The analysis of the component was accomplished in the Tunis International Center for Environmental Technologies according to the following analytical program (Table 1).

**Table 1.** Analytical standards of compounds in water and sediment matrix

| Matrix | Parameters | Methods | Reference |
|---|---|---|---|
| Water | $CO_3^{2-}$, $HCO_3^-$ | Titration | NF EN 9963-1 |
| | P, $PO_4^{3-}$ | Colorimeter | NF EN 1189 |
| | $NH_4^+$ | IC | NF EN 10304-1 |
| | Cu, Zn, Pb, Ni, Cr, Cd | ICP | NF EN 11885 |
| | As | AAS | FD T 90-112 |
| | Hg | AAS | NF EN 1483 |
| Sediments | Cu, Zn, Pb, Ni, Cr, Cd | ICP | NF EN 11885 |
| | As | ICP | FD T 90-112 |
| | Hg | ICP | NF EN 1483 |
| | HAP | CPG-MS | EPA 610 |

## 3. Results and discussion

*3.1. Results of surface water analysis*

The analysis results are summarized in the table 2. It shows high concentrations in the organic and oxidisable matter ($DBO_5$, DCO and $NH_4^+$) at the majority of points and essentially immediately downstream of the discharge of the WWTP (P2) and that of the industry (P6). Theses concentrations leads to a high consumption of $O_2$ present in water and are not consistent with the Tunisian standard NT 106.03 for reusing this water for irrigation. The decrease of concentrations observed at P4 and P5 may be explained by the dilution caused by Oued El Kebir effluent.

Regarding phosphorous and ammonium content, the water quality is generally poor for biology and good for the proliferation of algae which was observed along the studied stretch of Oued Laya. For heavy metals, the measured concentrations show a good agreement with a good quality for biology except for the cadmium at P3 (16 µg/l). We note also that As, Hg, Zn and Sb were not quantified at all sampling points. In addition, selenium (Se) concentration at P3 (54 µg/l) is greater than the Tunisian standard NT106.03 and therefore is not consistent for irrigation. Indeed, the presence of various types of solid waste was observed near P3 and can affect the quality of surface water.

**Table 2.** Results of surface water analysis

| Parameters | Units | NT106.03 | P1 | P2 | P3 | P4 | P5 | P6 |
|---|---|---|---|---|---|---|---|---|
| **Physico-chemical** | | | | | | | | |
| TSS | mg/l | 30 | 17.94 | **92.31** | **47.00** | 8.00 | 7.50 | **435.00** |
| $DBO_5$ | | 30 | 3.85 | **51.00** | **52.13** | 8.96 | 7.02 | 22.38 |
| DCO | | 90 | **115.00** | **337.00** | **147.00** | 49.00 | 50.00 | **412.00** |
| **Phosphorous content** | | | | | | | | |
| P | mg/l | - | 1.22 | 3.77 | 3.66 | 4.04 | 2.32 | 0.36 |
| $PO_4^{3-}$ | | - | 3.73 | 11.57 | 11.22 | 12.41 | 7.13 | 1.11 |
| **Ammonium** | | | | | | | | |
| $NH_4^+$ | mg/l | - | 10.5 | 83.02 | 94.48 | 63.9 | 12.04 | 4.05 |
| **Heavy Metals** | | | | | | | | |
| As | µg/l | 100 | <lq* | <lq | <lq | <lq | <lq | <lq |
| Cd | | 10 | <lq | <lq | **16** | 4 | 7 | <lq |
| Cr | | 100 | 1 | <lq | <lq | <lq | <lq | <lq |
| Cu | | 500 | 5 | 37 | 2 | <lq | <lq | <lq |
| Ni | | 200 | <lq | <lq | <lq | 19 | 5 | <lq |
| Sn | | - | 182 | 132 | 136 | 164 | 182 | 122 |
| Hg | | 1 | <lq | <lq | <lq | <lq | <lq | <lq |
| Pb | | 1000 | <lq | 45 | <lq | <lq | 18 | <lq |
| Zn | | 5000 | <lq | <lq | <lq | <lq | <lq | <lq |
| Se | | 50 | 26 | 25 | **54** | 23 | 24 | 32 |
| Co | | 100 | 4 | <lq | <lq | <lq | <lq | 7 |
| Fe | | 5000 | 129 | 220 | 27 | 107 | 184 | 627 |
| Mn | | 500 | 266 | 60 | 63 | 139 | 121 | 138 |
| Al | | - | 6 | 6 | 12 | 22 | 95 | <lq |

* lq: quantification limit.

*3.2. Results of sediments analysis*

The analysis results are summarized in the table 3.

**Table 3.** Results of sediment analysis

| Parameters | Units | P2 | P3-4 |
|---|---|---|---|
| **Heavy Metals** | | | |
| As | mg/kg | <lq | <lq |
| Cd | | <lq | <lq |
| Cr | | 25.2 | 14.6 |
| Cu | | 139 | 5.76 |
| Ni | | 14.9 | <lq |
| Hg | | 0.63 | 0.025 |
| Pb | | 37.7 | <lq |
| Zn | | 351 | 47.8 |
| **Polycyclic Aromatic Hydrocarbons (PAH's)** | | | |
| Phenanthrene | µg/kg | 2623.61 | 36.55 |
| Anthracene | | 1765.89 | 24.60 |
| Fluoranthene | | 2724.52 | 37.96 |
| Pyrene | | 1967.70 | 27.41 |
| Benzo(a)anthracene | | 4187.68 | 58.34 |
| Perylene | | 6407.66 | 89.98 |
| Benzo(e)pyrene | | 6155.39 | 85.76 |
| Benzo(a)pyrene | | 7013.11 | 97.71 |
| Chryséne | | 7719.47 | 108.26 |
| Total PAH | mg/kg | 40.65 | 0.56 |

For heavy metals, unlike the observed concentration of surface water, the results for sediments show a significant impact at P2 essentially by Hg, Cu, Pb and Zn.

The decrease of concentration of heavy metals between P2 and P3-4 was also observed. This could be explained by the dispersion, speciation, and the adsorption of heavy metals, respectively in surface water and on sediments of Oued Laya.

The total Polycyclic Aromatic Hydrocarbons (PAH) concentration in the sediment at P2 (40.65 mg/kg) is five times more than the limit threshold (7.5 mg/kg) for the poor quality. A significant decrease of about 70 times in total PAH concentrations between P2 and P3-4 is observed. This is due to the direct discharge of WWTP in Oued Laya often without treatment. Indeed, during peak periods (seasonally, hourly, daily), the treatment plant can dump directly quantities of sewage into the river.

## Conclusion

Preservation of water resources against potential sources of pollution represents a central problem mainly in semi-arid regions. Our study was therefore focused on assessing of the water and sediment quality of a stretch of Oued Laya located in the zone of Akouda in Sousse region. The analysis results show a contamination of surface water with high phosphorous content and organic matter which justify the eutrophication observed along the Oued Laya. The quantification of the heavy metals is widely observed on sediments that on surface waters. These observations can be explained by the dispersion and speciation of heavy metals in surface water and sediment adsorption. Finally, a sediment contamination by PAHs was observed. The measured concentrations are five times higher than the limit of poor quality.

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