



STEADY AND SPATIOTEMPORAL MONITORING OF WATER QUALITY FEEDING AREA SOUTHWEST OF GREAT CASABLANCA, MOROCCO

Science

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| Fatine AKOH | Geoscience laboratory, Ain Chock's Sciences faculty, Hassan II University Casablanca Morocco |
| Mohamed TAHIRI | Geoscience laboratory, Ain Chock's Sciences faculty, Hassan II University Casablanca Morocco |
| Salah SOUABI | Water and Environment Engineering laboratory Mohammedia's Sciences & Technics faculty, Hassan II University Casablanca Morocco |

ABSTRACT

In Morocco, where the semi-arid climate is dominant, the supply of industrial and drinking water is provided primarily by surface water. Morocco has currently 118 multi-purpose dams. If the construction of these works was a necessity to ensure the water essential to our country in all seasons, it is impartial to control and protect the quality of running water.

- Most dam reservoir used are threatened by eutrophication due to increased terrigenous and anthropogenic pollutants, coming from an over-fertilization of water by phosphorus and nitrogen nutrients and accelerated by the uncontrolled development of microalgae aging. It is also noted that the daily practices of citizens concerning all human activities (agriculture, agro-industries, hydropower, etc.), have significantly contributed to the deterioration of water quality despite its treatment in several plants. Therefore, the treated water provides a legacy of bitter tastes and by the consumer.
- The present work exhibits result of water quality watershed Oum Erbia used to supply drinking water to the whole terraced area connecting the city of Khenifra to the one of Azemmour. The area south west of Great Casablanca (metropolis of the kingdom with about 4 million inhabitants) supplied 50% of its water needs by sourcing Dam Sidi Said Maachou located, last anchor points of the watershed before the spill in the Atlantic Ocean.
- The results were performed in a spatiotemporal scale and helped to establish a history of monitoring water quality during the 2009-2011 cycles; the study also presents the development of quality according to the seasonal rhythmicity and rainfall. It also gives an overview of the watershed stewardship concept.

KEYWORDS

Crude surface water quality, Oum Erbia hydraulic basin, spatiotemporal monitoring, Greater Casablanca, Drinking water quality, Morocco.

I. INTRODUCTION

A. Watershed Oum Erbia

The watershed Oum Erbia includes (Fig. 1) the basin of the Oum Erbia (average surface 35,000 km²) is a rich source of renewable water resources with more than 3,600 M m³/an, constituting a quarter of Morocco resources (25%). They are mostly surface water (90%).

The Oum Erbia river, a length of 550 km, has its origin in the Middle Atlas with 1,800 m above sea level, through the chain of the Middle Atlas, the Tadla plain and the coastal plateau and flows into the ocean Atlantic about 16 km from the city of El Jadida.

The watershed of Oum Erbia has lived for a cycle's afflux of populations that grow around the river, with all the possible activities enabling them to ensure an acceptable quality of life. Moreover, the basin of the Oum Erbia is the pond which concentrates the largest water demand of Morocco (4.25 billion m³, or 35% of the total water demand of Morocco).

The particularity of this watershed will negatively impact the water resources and the environment. The continual change in the industry, agriculture has increased and even modernized (overuse of fertilizers and soil); towns and cities, became more and more populated. These three areas are key factors responsible for the degradation of the quality of freshwater and environmental watershed of Oum Erbia.

B. Urban Planning

The area of the river basin of Oum Erbia represents 5.1% of the total area of the country and offers 65 urban and 254 rural communes in 12 provinces, this is one of the most populated basins of Morocco with about 5 million inhabitants (2004). This population is predominantly rural, even if the share of urbanization rate is 39%, which is the lowest in Morocco (the national average is around 55%).

The main urban areas and towns sit on the course of the river and will run the risk of all known wastewater (domestic, urban, agricultural, industrial, livestock, etc.).

The total population of the basin is approaching 5 million, of which

61% are rural, the density is about 100 inhabitants per km² with a concentration in the center and in the surrounding areas of rivers and springs (2.4 million).

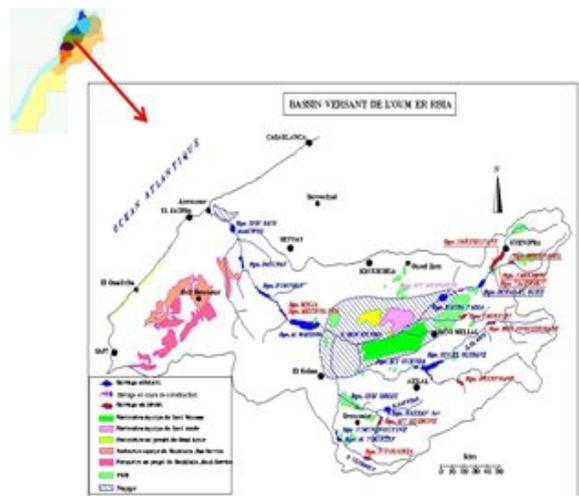


Figure.1 Hydrographic Basin of the Oum Erbia (www.abhoer.ma)

The results presented by the satellite images (Fig. 2) reflect degradation of vegetative cover for 19 years between 1987 and 2010 in the same month. This change, resulted by the economic and demographic development, should also generate increased pollutant emissions accompanied by some adverse effects on the natural environment, which leads to a significant and progressive deterioration of the quality of surface and underground water. Thus, the water resources are being increasingly exposed to pollution in its various forms (Table I).

The total flow by the collected wastewater systems of all centers of the

area of the Agency currently stands at 40 million m³ per year with an estimation of the annual amount of pollution emitted by these centers at 32,051 tons and 66,281 tons of BOD and COD. We must note that more than four cities and 12 villages produce sewage which directly flows into the rivers (khenifra, Kasba Tadla, Souk Es-sebt, and Ouled Zidouh). In Beni Mellal, the flow is a tributary 35 Km far from the river. Unfortunately, Oum Erbia is the principal collector of wastewater from neighboring centers.

The following images (Fig. 3) show the type of pollution brought by the population located around the Oum Erbia in the town of Kasba Tadla. This city has a population of approximately 41,783 inhabitants and has several specific activities (workshops mechanical, paint shops, washing vehicles, Laundromats, and laundries), which makes it difficult to eliminate persistent pollution and adds to the pollution domestic wastewater.

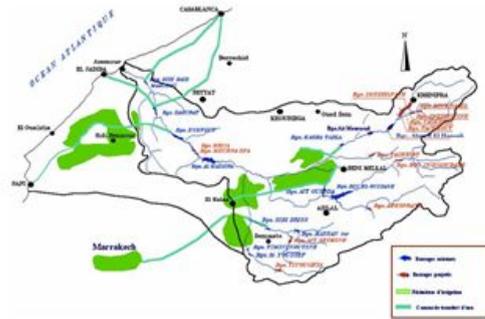


Figure.4 Location of the agricultural plains of the watershed the Oum Erbia (www.abhoer.ma)

The Agricultural demand amounts to nearly 4 billion m³. It's at the forefront of Morocco with 32% of the total agricultural demand (Ministry of Agriculture). Agriculture contributes to the pollution of water due to the irrational use of fertilizers and pesticides that farmers use for increasing their productivity.

The following satellite image shows one of the main agricultural plains and urban concentrated on both sides of the Oum Erbia approaching the city of Beni Mellal.

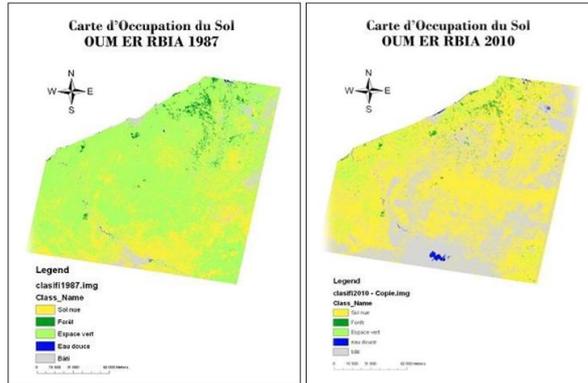


Figure.2 Map of comparative land between 1987 & 2010

TABLE 1 POLLUTANT LOAD OF THE LOCAL POPULATION

| Total Population | BOD Biological Oxygen Demand (t /an) | COD Chemical Oxygen Demand (t /an) | OM Organic Matter (t /an) | SSM Suspended Solid Matter (t /an) | NKT (Organic Nitrogen and Ammonia) (t /an) | Total Phosphorus (t /an) |
|------------------|--------------------------------------|------------------------------------|---------------------------|------------------------------------|--|--------------------------|
| 2 397 669 | 32 051 | 66 281 | 43 461 | 43 393 | 8 751 | 1 750 |

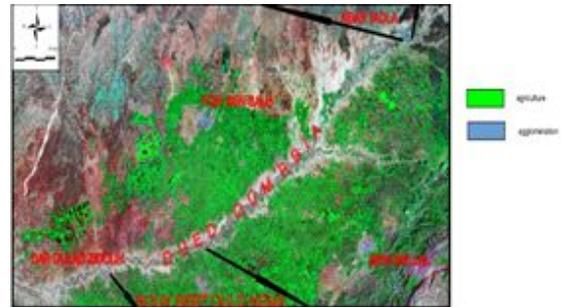


Figure.5 Main activities and agriculture (www.abhoer.ma)

The amount of nitrogen leached into the groundwater or run-off to rivers is estimated at 10%. So about 3500 tons of nitrates from fertilizers, reach the Kasba Tadla by the water table. Also, pollution from pesticides is approximately 2.2 tons per year.

The test results show no standard element of Nitrogen rate (Nitrate and ammonium), Selenium and Arsenic (Work in progress).

B. Industry

The principal sources of industrial pollution are in the lap of the Beni Amir and Beni Moussa. Canneries, mills and dairy plant have an impact on increasing rates of nitrates and organic matter. Mining and food industries are also quite numerous. It is possible that industrial demand related to the growth plans an increase by 2030 of major companies in the area, such as COP (Cherifian Office of Phosphate). Nevertheless, it is possible to control the impact of this growth on the deficit by finding suitable unconventional solutions. Indeed, the industries in the area are highly polluting. The degradation of groundwater (especially the aquifer of Tadla) could increase as well as sections of the Oum Erbia (between downstream rejection at Kasba Tadla and the downstream discharge at Dar Ouled Zidouh) that are most strongly affected by the combined effect of industrial waste.

Sampling points are then identified and located on maps developed using GIS. These points are selected based on the information that can provide the input and output of cities, near agricultural areas, industrial and road traffic, around geological training, etc. The water samples are put in polyethylene bottles pre-rinsed with distilled water and with water samples then they are transported in the cooler at 4°C to be processed in the laboratory within a few hours sampling.

In this article, we will communicate the results of analysis of the mass of water collected at the entrances of dams Boulaouane (S1) Daourat (S2), Sidi Said Maachou (S3) and Sidi Said Maachou output (S4).

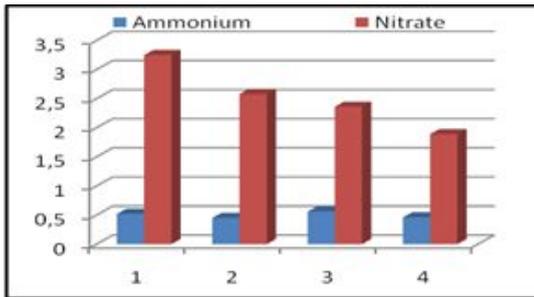


Figure.3 Waste from street market, solid waste deposits near the river, wastewater sewage flowing into the river

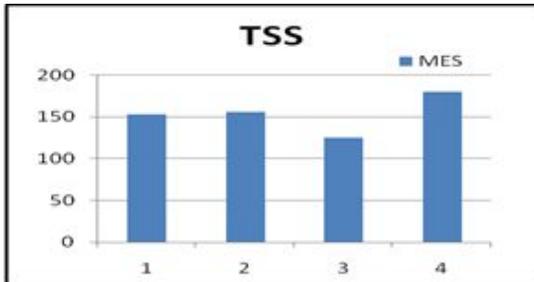
I. WATERFRONT ACTIVITIES

A. Agriculture

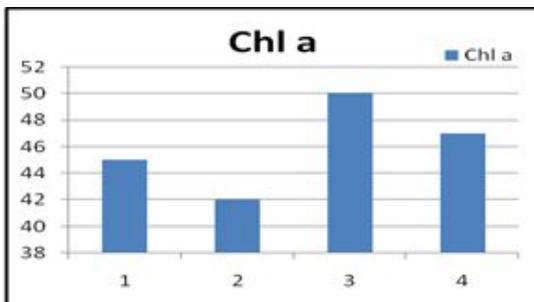
The Oum Erbia watershed is one of the main agricultural regions in Morocco; not only with its higher surface (over 27% of the irrigated agricultural area of Morocco is 493,600 ha) but also regarding consumption per hectare where it considered as the highest in Morocco (Fig. 4)



The ammonia and nitrate concentration mg/L



Total Suspended Solid mg/L



chlorophyll (a) mg/L

Figure 8. Physicochemical parameters measured in the Oum Erbia

The results are related to the four sampling points S1, S2, S3, and S4 cited above. These are part of a study spread over the cycle from January to October and revealed the following findings:

- The dissolved oxygen ranges from 5 mg/L to 11 mg/L. This parameter reflects an excellent quality of the majority of water on the entire journey.
- The total phosphorus varies from a value of 0.2 mg/L to 13 mg/L. This parameter involves all forms of phosphorus, dissolved or particulate and reactive or unreactive. We can see that the Minima is in the basic range of the average concentration registered elsewhere while the maxima are outside of norms. Total phosphorus varies considerably over time and is particularly sensitive to flow. Figure 8 shows soluble reactive orthophosphate which is usually equivalent to orthophosphate. The limiting nutrient in fresh water dams and streams is typically phosphorus.
- The ammonia concentration is 0.1 mg/L to 300 mg/L. This parameter describes a toxic form of nitrogen, formed when organic matter breaks down in water. It indicates the influence of human activity. Nitrate is the major inorganic form of nitrogen. Nitrate and nitrite are often combined because analytic methods usually don't distinguish between these two forms of nitrogen. Nitrate is not always directly introduced into the environment. The main sources can be fertilizers, organic nitrogen in soil and manure, wastewater, detergents, etc.. Watershed with a high percentage of tile-drained agricultural land often has high level of nitrate. In this case, the nitrate concentration is less than 3.5 mg/L. Nitrate concentrations in streams are highly dependent on season, with much higher value in spring than in summer or fall which is mainly the result of tile drains.
- Now see the water hardness. It is around 130 to 150 mg (Ca) / L (i.e., from 30 to 37 ° F), which allows to classify it as hard water

due to the geological nature of the sediment, which is the river bed.

- Total Suspended Solids (TSS) expressed as MES in figure 8 quantifies all particles suspended and dissolved in water. Suspended material include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances, which are typically in size range of 0.004 mm to 1.0 mm. Nonpoint sources of suspended solids includes soil erosion from agricultural and construction sites. According to the Michigan Department of Environmental Quality, this kind of water containing more than 150 mg/L is at the limits of cloudy and dirty water. The average concentration is in fact between 125 and 172 mg/L.

Determining the water quality requires the positioning of each element measured on an evaluation grid of threshold limits for each parameter and to recognize the degree of water pollution.

In this study, we adopted SEQ WATER (System evaluation quality) which permits us to distinguish four levels: Very good (blue), acceptable (red), Medium (green), and bad (purple color). The application of this rubric was achieved by test results obtained. The classification of water quality according to:

- The physicochemical parameters obtained the value of the of the sampling sites is as follows:

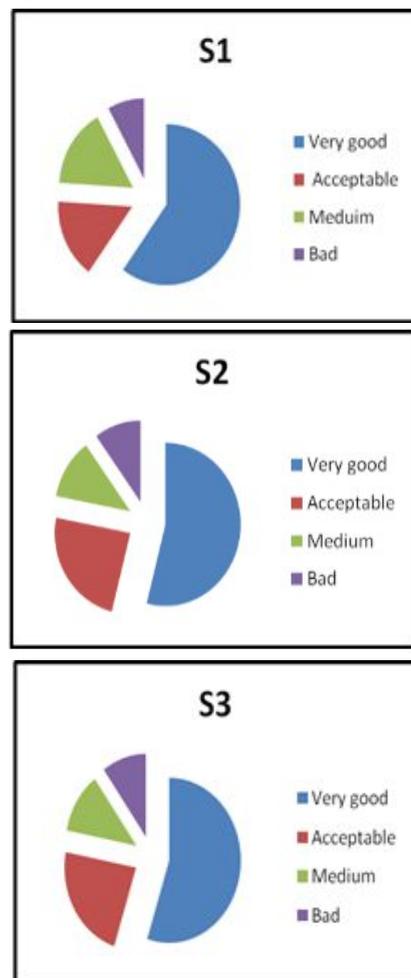


Figure 9. Classification of water quality collected according to the physicochemical parameters.

B. Standardized Global Biological Index: SGBI

Standardized Global Biological Index: SGBI is a standardized method used in applied ecology to determine the biological quality of a water court. It's somehow equilibrium between physical, chemical and biological integrities.

The SGBI is the French (IBGN: Indice Biotique Général Normalisé) standard method for assessing the biological quality of rivers (NF T90-350 - *AFNOR, 1992, revised 2004). It allows you to assign a rating of

environment quality, which includes both influences of physicochemical water quality and morphological and hydraulic characteristics of the stream. This method evaluates the overall ability of a community to house beings considering both the diversity of benthic macroinvertebrates and representativeness of habitats present on the station. This index is the most widely used in France.

In the Oum Erbia watershed, the measurements were made on several portions of the stream of the river. It starts from the town of Khenifra who is head of the river and ends at Daourat dam that supplies 50% of the Great Casablanca water needs.

The following classification shows the water quality of the Oum Erbia according to the results obtained through the standardized global biological index (SGBI).

TABLE 2 REFERENCES TO DIFFERENT SAMPLES OF THE HYDRAULIC BASIN STUDIED

| Sample references | Indicator group | Sum Taxa | Value SGBI | Quality |
|---|-----------------|----------|------------|------------|
| upstream of the city Khenifra | 7 | 42 | 18 | Very good |
| downstream of the city Khenifra | 6 | 27 | 13 | Medium |
| contact point urban waste-water river | 2 | 2 | 2 | Bad |
| downstream of the city Kasba Tadla | 4 | 14 | 8 | Acceptable |
| upstream of the city Béni-Mellal | 7 | 29 | 15 | Medium |
| downstream of the city Béni-Mellal | 3 | 32 | 11 | Acceptable |
| upstream of the city Souk Es-sebt | 7 | 40 | 17 | Very good |
| upstream of the city El Brouj | 7 | 32 | 15 | Medium |
| downstream of the city El Brouj | 5 | 30 | 13 | Medium |
| downstream of the city Machraa Ben Abou | 5 | 23 | 11 | Acceptable |
| Downstream of the city Daourat | 6 | 34 | 15 | Medium |

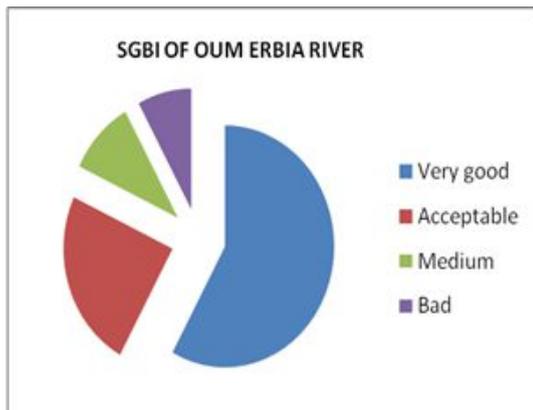


Figure 10. Classification of water quality collected according to standardized global biological index.

On the whole Oum Erbia, we found that:

- The City of Kasba Tadla recorded high levels of pollution due to direct discharges to the river, where the poor water quality downstream was detected.
- A Poor water quality also characterizes the upstream part of the city of Khenifra related to untreated rejecting of this agglomeration.
- Some recovery of water quality through self-purification was observed on the section between the two towns mentioned above.
- The section between Ouled Zidouh downstream of Kasba Tadla knows improvement to a level of acceptable quality due to the good oxygenation during flowing.
- The accidental existence of Selenium and Arsenic (worrying

values were detected) and mainly due to agricultural activities, overexploitation of land and the intensive use of persistent organic compounds (POPs) constituting the family of fungicides, insecticides, and biocides.

- In general, the downstream part of the essential effluent Oum Erbia has a poor water quality.
- The degradation of groundwater (the aquifer of Tadla) could increase as well as sections of the Oum Erbia (between downstream Kasba Tadla -discharge and downstream discharge of Dar Ouled Zidouh) that are most strongly affected by the combined effect of industrial waste (sweets) and domestic.

IV. CONCLUSIONS

River Oum Erbia hosted for years populations increasingly growing to around rivers. Some agglomerations quickly turned into villages and big cities whose water needs are many and varied. More than four-fifths of them do not have stations sewage treatment, and most of them discharged directly into the rivers while other agricultural and industrial activities, combined with deposits in some cities have accumulated urban waste on the edges. All these parameters have reduced the quality of fresh waters of the river and accumulated various pollutions.

The assessment and analysis of turbidity, physicochemical parameters, toxic, nutrients, and IBGN show that the quality of water supplied to the Grand Casablanca still overall good and acceptable. Note traces of Arsenic and Selenium which remain a concern and should be even more depth to meet the doubts and identify the source of these toxic elements.

The spatial and temporal study of the different potential pollution on the water quality of the source Oum Erbia well as the organoleptic characteristics of the water feeding the Grand Casablanca is necessary to set the priority action plans aimed at the preservation of vital natural resource for the region.

ACKNOWLEDGEMENTS

We would like to express our deepest appreciation to "Lyonnaise des eaux" who financed this work research and to hydric basins of Oum Erbia agency for all complementary information and authorization.

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