

ECOLOGICAL STUDIES OF THREE WEST ALGERIAN RIVERS: THE HABRA RESERVOIR AND THE MACTAA CANAL**Muhammad S. Al-Asadi^a;
R. Antoine^b****and****P. Randerson^b;
K. Benson-Evans^b***^aMarine Science Centre, University of Basrah, Iraq**^bSchool of Biosciences, Cardiff University, Cardiff CF10 3TL, Wales, UK***ABSTRACT**

Limnological studies of Habra Watershed were carried out on aquatic bodies of the coastal north-west Algeria. The Habra-Sigg (Habra Watershed) forms a large basin in which two sampling sites were chosen, the Mactaa Canal, a canal with connections to the sea and the Habra Reservoir. Samples were taken monthly for two years (1986-1988). Air temperatures were ranged from 14°C to 31°C and water temperatures from 10°C to 30°C. Fluctuations at Mactaa Canal were more than those of Habra Reservoir regarding hydrogen ion concentration (6.8-8.1), oxygen percentage saturation (54-125), biological oxygen demand (0.8-11.8mg l⁻¹), total residue (3.39-25.3 mg l⁻¹), volatile matter (1.03-16.95 mg l⁻¹), chloride (1.35-10.40g l⁻¹), ammonium-nitrogen (5.2-26.3 µg l⁻¹) and silicate-silicon (1.8-5.1mg l⁻¹), whereas fluctuations were similar for current velocity (CV), water turbidity (50-95mg l⁻¹), electrical conductivity (2.6-10.22mScm⁻²), dissolved oxygen (4.8-11.8 mg l⁻¹), suspended solids (20.4-84.5mg l⁻¹), dissolved organic matter (3.53-21.76 PV(4h)mg l⁻¹), fixed total residue (2.65-12.49 mg l⁻¹), nitrite-nitrogen (0.07-1.03 mg l⁻¹), nitrate-nitrogen (3.1-8.6 mg l⁻¹) and phosphate-phosphorus (1.1-7.2mg l⁻¹). Magnesium hardness at Habra Reservoir (1.70 mg l⁻¹ as CaCO₃) and at Mactaa Canal (1.57 mg l⁻¹ as CaCO₃). Calcium hardness and total hardness values were similar at both sites (0.7 and 2.4 mg l⁻¹ as CaCO₃ respectively).

INTRODUCTION

An initial study was carried out to determine limnological conditions at the three main watersheds in western Algeria, which occupy the cultivated lowlands near the Mediterranean Sea, and which had not been studied previously. Very few studies have been carried out on Algerian water bodies (Gagneur and Kara, 2001). This paper deals with the Habra

Watershed (Habra Reservoir and its tributary, the Mactaa Canal). To the east of Habra Watershed is the Cheliff Watershed (the Cheliff River and its tributary, the Mina River), and to the west is the Tafna Watershed (the Tafna River and its tributary, the Remshy River), for more details of the project please see first part of this study (Al-Asadi, *et al.* 2006) of this issue.

STUDY AREA

Algeria is one of the second largest countries in the continent of Africa, having an area of 2,381,745 km². Most of the area is desert (Great Western Desert), but the Mediterranean coastal belt of the north (12%), is formed of tells and plains, and extends from the Tassala Mountains in the west to the Dhahra Mountains in the east. This area (around 1.6 million ha) is irrigated by three main water sources; the River Cheliff, the Mactaa (Habra) Reservoir and River Tafna (Ayoun, 1985).

Habra Watershed and the sites

The Habra Watershed is a Habra Reservoir basin which is a saline geological depression on the plain of Habra-Sigg, the lower part (surface area 1988 km²), is used as a reservoir. The plain of Sigg is delimited in the west by a lower reservoir, and by Habra to the east. In a north-south direction the basin passes through the canal of Mactaa and borders the Gulf of Arizew.

Station 1, Mactaa Canal: A uniform water channel of 5-6 metres width and 3-4 metres depth. The site is open with no large trees, but some *Tamarix*, *Acacia* and *Atriplex* were recorded. There is little tidal incursion into the canal from the sea. This station is only 5 km from Arizew Gulf (Oran Willaya), and is less than 80 m above sea level.

Station 2, Habra Reservoir: On the Mactaa Canal near the Habra reservoir, it has similar characteristics to Station 1. It is mainly an open area but with more shade from *Tamarix* trees. This station is 10 Km from Mohammadia Town (Mascra Willaya) and the reservoir (surface area 1988 km²) and with

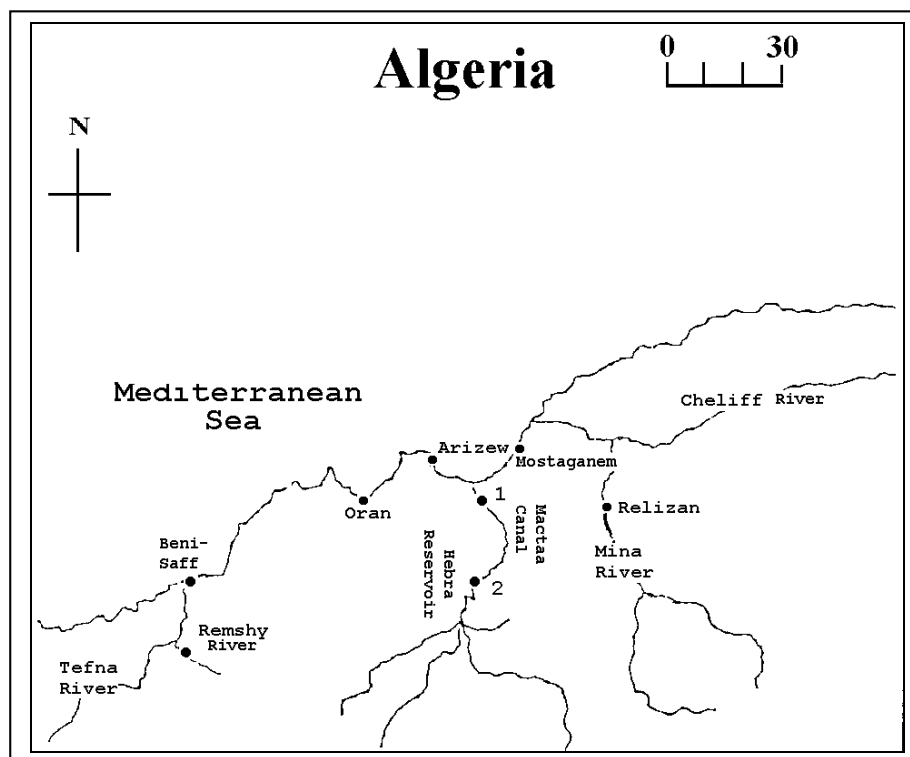


Figure 1: Map of the study area, Station 1(Mactaa Canal) and Station 2 (Habra Reservoir).

the Mactaa Canal. The sampling site is 25km from the Mactaa Canal sampling site (Station 1). The site is more than 90 m above sea level.

Climatic Conditions: Algeria is characterised by hot summers and cool winters (Gagneur & Kara, 2001). The temperature ranges from 11.6°C in winter (January) to 32.7°C in summer (August). The rainfall, ranging from 5.8 mm in November and December to less than 0.1 in July and August, the winds are usually north-western or south-western (Mejrab, 1988).

MATERIALS AND METHODS

Surface water samples were collected at bimonthly intervals between June 1986 and March 1988. Determinations were made of air and water temperatures, current velocity (CV), light intensity (LI), water turbidity (WT), electrical conductivity (EC), pH, dissolved oxygen (DO), oxygen percentage saturation (OPS), biological oxygen demand (BOD), suspended solids (SS), dissolved organic matter (DOM), dissolved CO₂, HCO₃ and total alkalinity, total residue (TR), fixed total residue (FTR), volatile matter

(VM), total- calcium- and magnesium-hardness, chloride, nitrite-nitrogen ($\text{NO}_2\text{-N}$), nitrate-nitrogen ($\text{NO}_3\text{-N}$), ammonium-nitrogen ($\text{NH}_4\text{-N}$), phosphate-phosphorus ($\text{PO}_4\text{-P}$), silicate-silicon ($\text{SiO}_3\text{-Si}$) (Al-Asadi *et al.*, 2006).

RESULTS

The water temperature at both stations was less than that of the air temperature. Minimum air was recorded at both Stations (14°C) in January 1987 and maximum one (31°C) in September 1987. The maximum water temperature was recorded at both stations (30°C) in July, while the minimum was recorded (10°C) at Station 1 in January 1987 (Figures 2).

Current velocity (CV) ranged between 11 cm s^{-1} to 13.5 cm s^{-1} . Light intensity (LI) values showed similar variation and ranged from 2.7 W m^{-2} in March 1988 to 50.1 W m^{-2} in October 1986. Turbidity was the same at the two Stations, with the highest value in March 1988 (95 mg l^{-1}) and lowest value in September 1987 (50 mg l^{-1}). Seasonal fluctuations of electrical conductivity (EC) at Mactaa (Station 1) were greater than at Habra (Station 2) and ranged from 2.6 S cm^{-1} in July 1987 to 10.22 S cm^{-1} in May 1987 (Figure 2).

The hydrogen ion concentration (pH) values fluctuated little at either station (6.8 - 8.1) but were mostly higher at Mactaa Canal than at Habra Reservoir.

Irregular variations of DO values occurred during the study period, ranging between 4.8 and 11.8 mg l^{-1} . OPS showed similar variation (Figure 3). BOD values ranged between 0.8 mg l^{-1} in November 1987 to 11.8 mg l^{-1} in May 1987 at Mactaa Canal Station. Average values of BOD at Mactaa were higher than at Habra. SS showed similar variations at the two Stations (20 to 80 mg l^{-1}) (Figure 3).

Values of DOM varied between 3.53 mg l^{-1} at Station2 in October 1986 and 21.76 mg l^{-1} at Station1 in March 1987 (Figure3).

TR and FTR values showed a generally seasonal trend with maximum values (25.3 mg l^{-1} in July 1987 and 14.88 mg l^{-1} in May 1987 respectively and minimum values 3.39 mg l^{-1} in March 1987 and 2.65 mg l^{-1} in November 1987 respectively (Figure 4). In the case of VM, the highest value was recorded at Station 1 (16.95 mg l^{-1}) in June1986, after which values were generally low except for Mactaa in the later months of 1987, while the lowest value was recorded 1.03 mg l^{-1} in January 1987. Average values were slightly less in the reservoir than in the canal for TR and VM, but more for FTR.

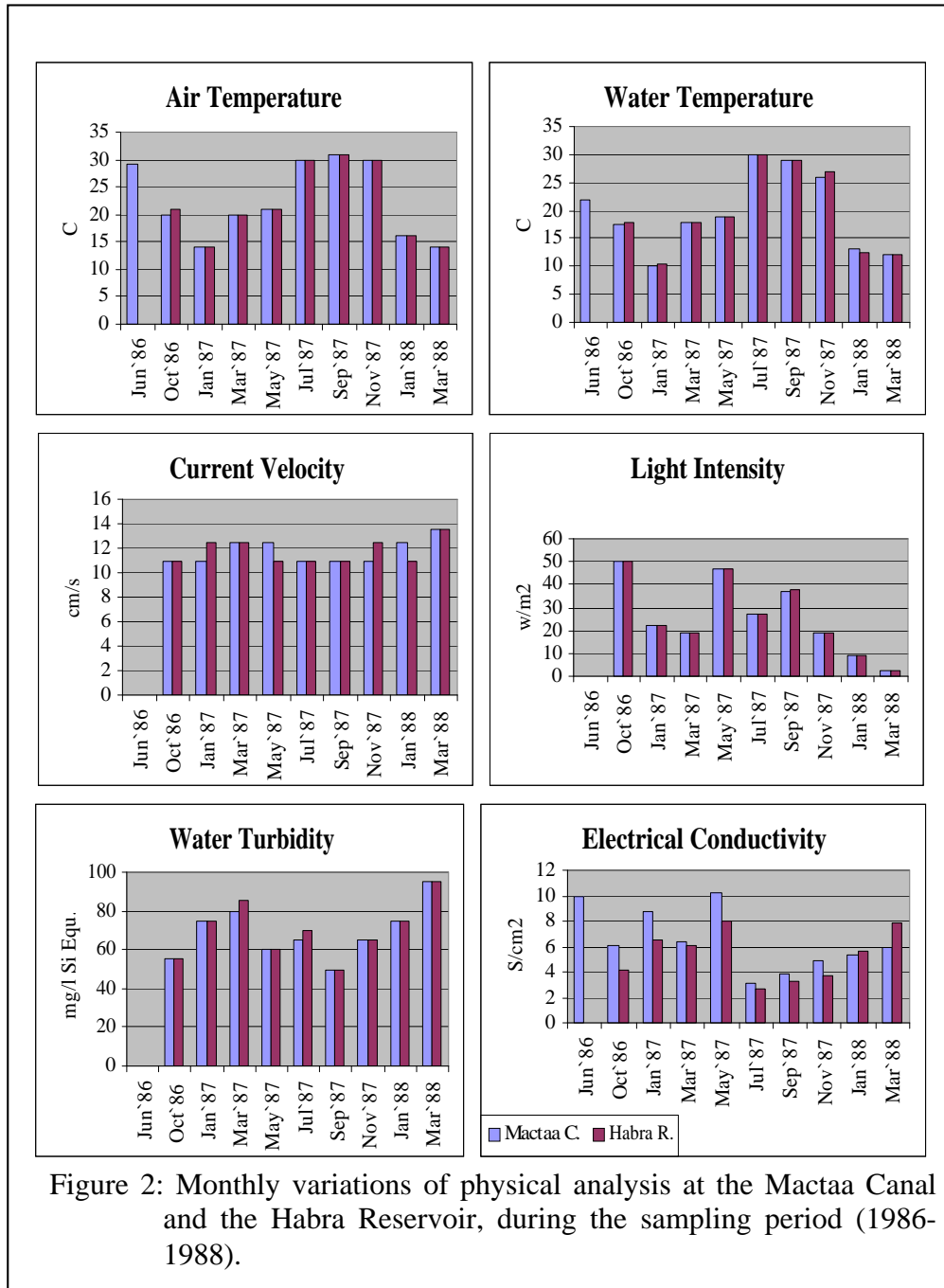
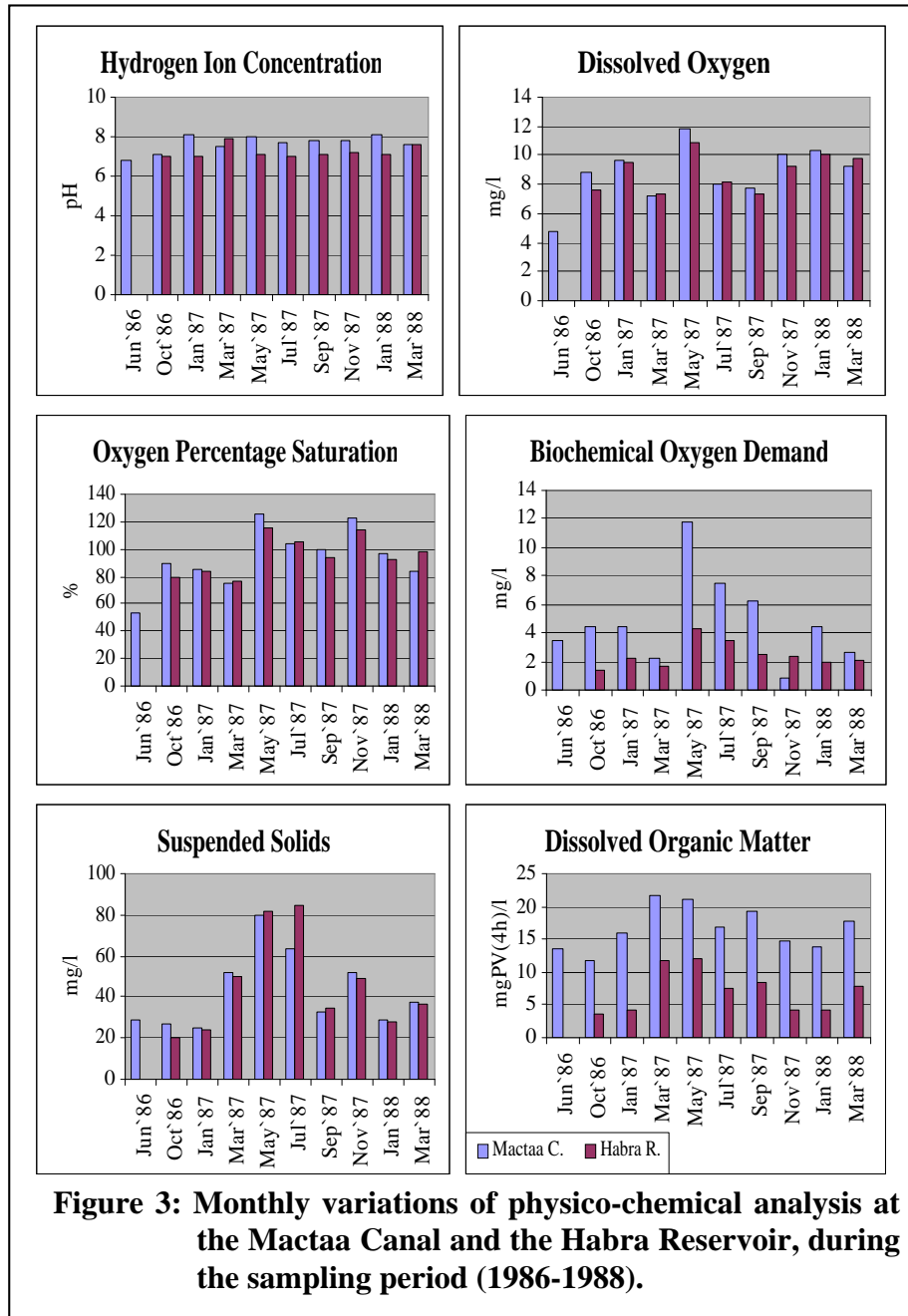


Figure 2: Monthly variations of physical analysis at the Mactaa Canal and the Habra Reservoir, during the sampling period (1986-1988).



Total- calcium- and magnesium-hardness values were generally low, with the exception of March 1987 and 1988, when all hardness values increased 3- or 4-fold. The value of calcium hardness was ranged from (0.35 mg l⁻¹ as CaCO₃) in November 1987 at Station 2 and (1.63 mg l⁻¹ as CaCO₃) in March 1988 at Station 1. The magnesium hardness ranged (0.7 mg l⁻¹ as CaCO₃) in January 1988 at Station 1 and (4.71 mg l⁻¹ as CaCO₃) in March 1987 at Station 2. Total hardness ranged (1.08 mg l⁻¹ as CaCO₃) in January 1988 at Station 1 and (25.3 mg l⁻¹ as CaCO₃) in July 1987 (Figure4).

The chloride content varied (1350 mg l⁻¹ in June 1986) at Station 1 to (10400 mg l⁻¹ in May 1987) at Station 2 (Figure5). Values of NO₂-N were ranged (0.07 mg/l at Station 1 in July 1987 to 1.03 mg/l at Station 2 in January and minimum one), whereas NO₃-N varied relatively little (3.1 mg/l in January to 8.6 µg/l at in March 1987 at the same station 1). Values of NH₄-N were consistently higher at Mactaa than at Habra (average values 17.41 and 7.15 mg l⁻¹ respectively). Values of PO₄-P were greatest at both sites in the period May to September 1987, (7.2 mg/l in July 1987 and 1.1 in October 1986 respectively).

Values of SiO₂-Si varied with season, within a narrow range (between about 2 mg l⁻¹ in July at Station 2 and 5 mg l⁻¹ in March 1987 at Station 1) (Figure5). Values of CO₂, HCO₃ and total alkalinity (not illustrated), varied with season by a factor of 2, showing maxima in November 1987 and minima in June 1986.

DISCUSSION

The water temperatures were consistently lower at the two Stations than air temperatures. This may be due to the open nature of the sites. Seasonal fluctuations of air and water temperatures followed each other closely (Edington, 1966 and El-Sawy, 1988). The minimum water temperature of both Stations was recorded in March 1987, which coincided with the highest values of water turbidity were recorded in March 1987 and 1988. These results are similar to those of Ibanez (1998) with higher turbidity during the colder than in the warmer months, but they were in contrast to the results of Hussainy (1967), Timms (1970), Antoine & Benson-Evans (1988) and others, who suggested that turbid waters are warmer than clearer ones under the same circumstances.

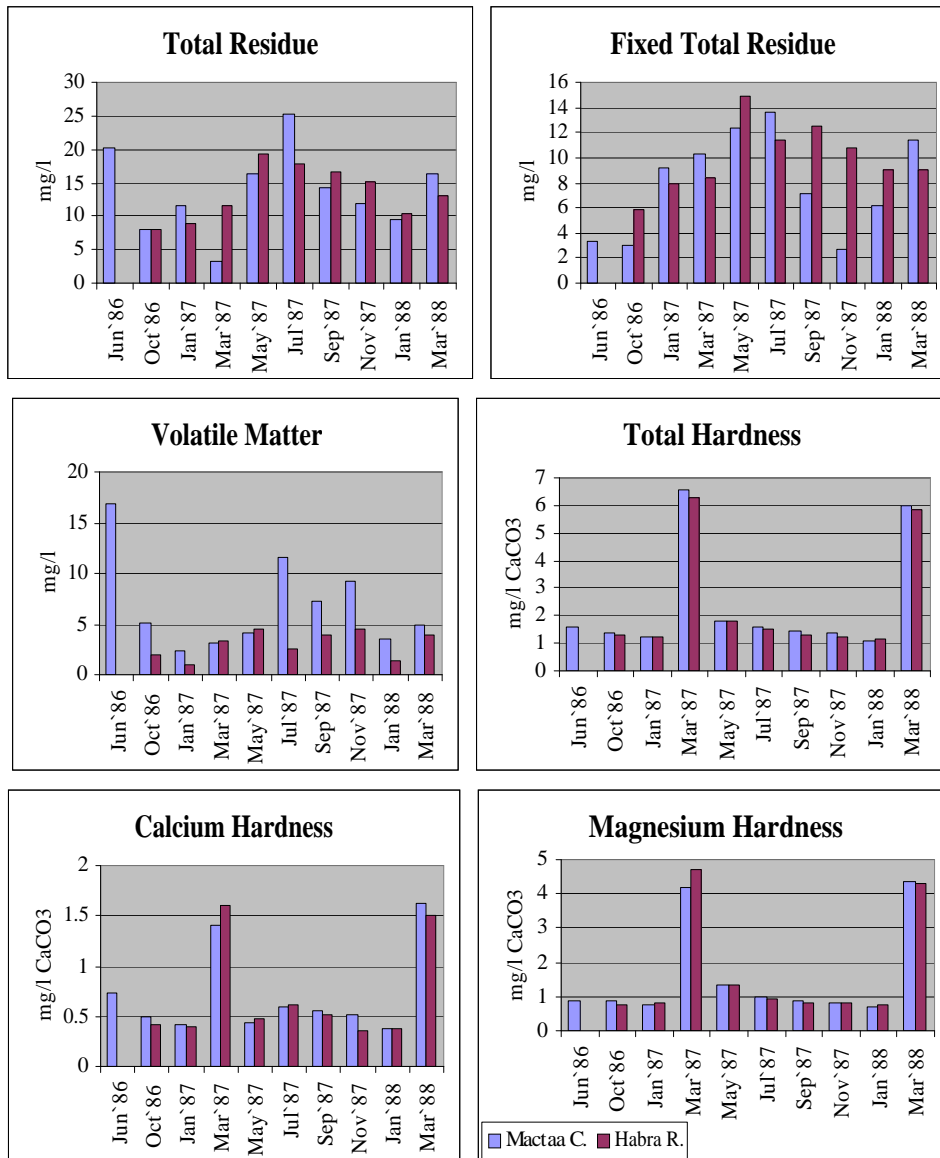


Figure 4: Monthly variations of chemical analysis at the Mactaa Canal and the Habra Reservoir, during the sampling period (1986-1988).

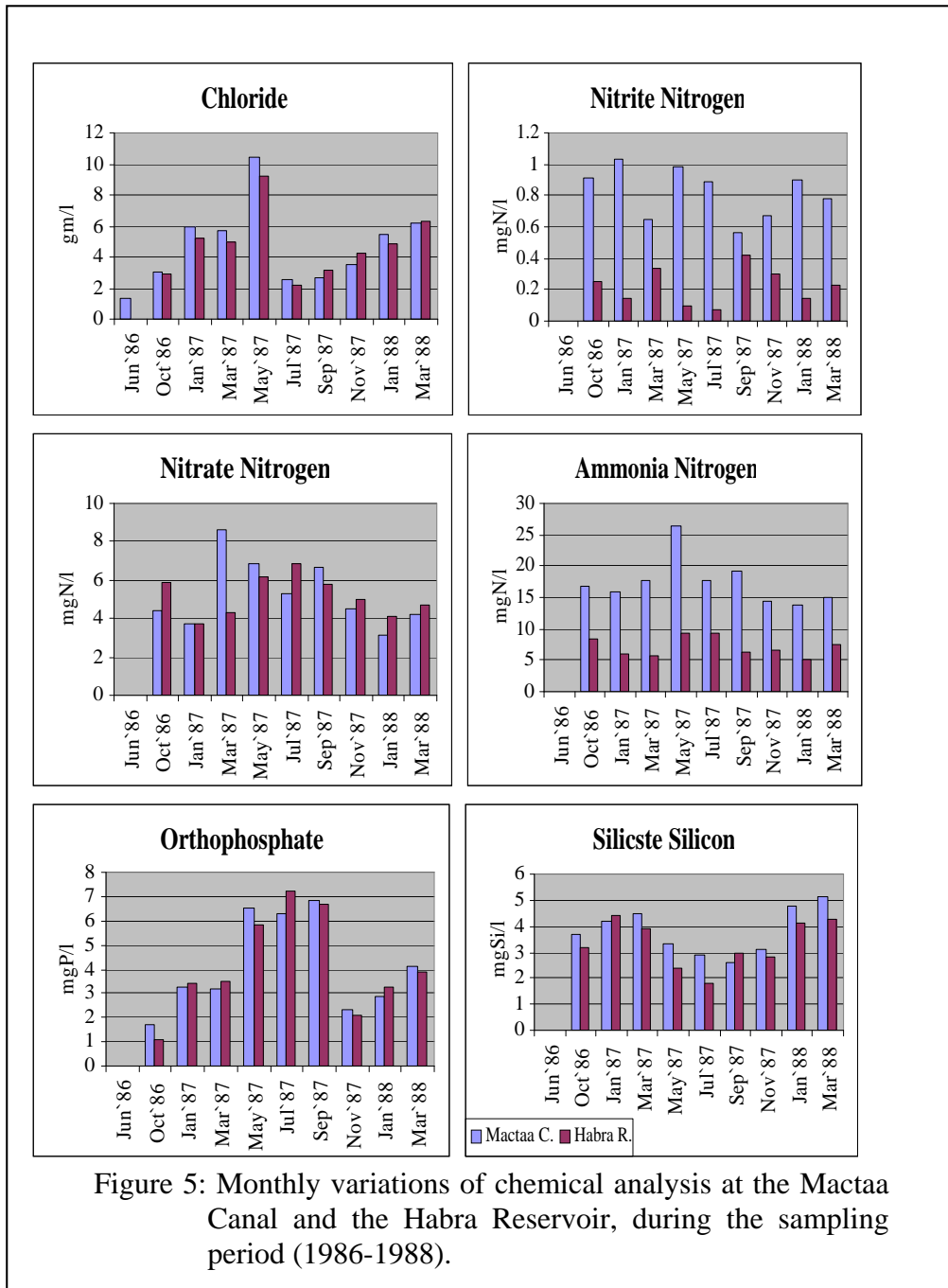


Figure 5: Monthly variations of chemical analysis at the Mactaa Canal and the Habra Reservoir, during the sampling period (1986-1988).

Current velocity varied little with season in these slow-flowing water bodies. At Habra Reservoir, there was an inverse relationship between dissolved oxygen and the previous parameters (air and water temperatures, water velocity, water turbidity and light intensity).

In this study of the Habra watershed, conductivity was, in general, very high, compared with the other two watersheds, the Cheliff and Tafna (Al-Asadi, 1991). This may be due to the fact that the study area lying in a saline area. The conductivity at Mactaa was a little higher than upstream in the Habra reservoir, which may be due to rock weathering (Kimbadi *et al.* 1999).

The pH values of the water samples were more alkaline and fluctuated more at the Mactaa than at the Habra, during the investigation period. These values were within the range of pH 6.8-8.1, which would be expected for natural inland waters (Sarker *et al.* 1980; Antoine & Al-Saadi, 1982; Esho 1983). There was no clear seasonal trend, and less variation at the Habra site, during the sampling period. This may be due to complicated reactions between the minerals and the phytoplankton (Antoine & Al-Saadi, 1982; Antoine, 1983).

Irregular variations of both DO and OPS occurred during the sampling period at both Stations. This was not the case in the Habra and Mactaa water bodies, where current velocity varied little throughout the year. This is in contrast with observations made by Saad & Antoine (1978, 1983); Saad & Abbas (1985); and Esho & Benson-Evans (1984) in the Rivers Tigris (Iraq), the Rossetta Branch of the Nile (Egypt) and Ely (Wales, U.K), respectively, where water flows were highly variable throughout the year. DO show an inverse relationship with DOM, BOD, SS and chloride.

High BOD values were, in general, observed in the warmer months and low ones during the colder months. These fluctuations were greater at Habra than at Mactaa. Average values of BOD were higher at Mactaa canal than at Habra Reservoir, may be due to accumulation of organic matter downstream.

Fluctuations of SS are often due to local conditions such as wind action, rainfall, and inflow. Esho (1983) and Saad & Abbas, (1985) recorded similar results on other rivers. SS values were high in warm months at the two Stations, and this may be due to the increase in biomass in contrast to Hynes' (1970) results, which showed that most streams and rivers are normally clear at low water. They become turbid during floods when suspended matter and nutrients may be carried in. Highly variable values for DOM were observed, probably due to local factors such as changes in biomass, surface runoff, wind action and pollution, which tend to produce

such local variations (Saad & Antoine, 1980, 1983). The maximum values could have been due to allochthonous (Liaw & MacCrimmon, 1977), and autochthonous sources (Fogg, 1958; Nalewajko, 1962), or even due to autolytic processes especially in March. In this respect, Weinmann (1970) stated that low molecular weight organic substances such as amino acids, monomeric sugars and organic acids can enter directly into the water, e.g., as excretion from the plankton. An important role is probably played by heterotrophic microorganisms in the enzymatic hydrolysis of high molecular organic compounds (Hoppe 1986).

There was a seasonal trend of TR, FTR and VM at the two Stations, increasing in values during the warmer months and decreasing during the colder months. Saad & Abbas (1984) found similar results on the Rosetta branch of the River Nile, Egypt. Higher average values of TR and VM were recorded at the Mactaa Canal than at the Habra Reservoir, while the relationship was reversed in the case of FTR.

Higher values of total hardness and magnesium hardness were recorded at Habra Reservoir (St.2) than at Mactaa Canal. This contrasted with Antoine & Benson-Evans (1988), who showed a marked downstream increase in total hardness during their studies on the River Wye, Wales, UK. They attributed this to the accumulation of calcium and magnesium carbonate from the catchments area. Higher chloride contents were recorded at the Mactaa than at the Habra and this coincided with phytoplankton numbers, and dissolved oxygen.

Ammonia, nitrite and nitrate were higher at Mactaa Canal than at Habra Reservoir and these were never limiting to the growth of algae (Al-Asadi 1991). Jarvinen *et al.* (1999) found that increasing the amount of ammonia-N had no effect on primary productivity also Karjalainen *et al.* (1998) stated that the available nitrogen did not increase chlorophyll a concentration in any experiments compared with the controls. There was no clear decline in amounts of nitrogen sources during the study period. Antoine & Benson-Evans (1985a, 1985b, 1988) reported a similar temporal fluctuation in the River Wye, Wales, UK. Relatively higher nitrogen values were observed at Mactaa than at Habra.

There was no clear marked downstream increase of PO₄-P values in this study. This may be due to there being no clear input from land drainage and urban runoff at the Habra Station. Jarvinen *et al.* (1999) found that increasing amounts of PO₄-P could slightly increase the primary productivity. Higher averages of SiO₂-Si were recorded at Mactaa Canal, than at the Habra Reservoir. A downstream increase was noted in most rivers in other countries.

Generally there was a strong correlation between CO₂, HCO₃ and total alkalinity, and all followed the same trend. Average values of CO₂ at Habra Reservoir were higher than downstream at the Mactaa Canal. Norris *et al.* (1980) observed significant temporal variation in free CO₂ concentrations during their studies on the south Esk River in Australia and concluded that it is normally controlled by physical factors. Bicarbonate and total alkalinity had positive relations with calcium hardness, magnesium hardness and total hardness.

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دراسات بيئية لثلاثة أنهار غرب الجزائر: خزان الهبرة وقناة مقطع

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الخلاصة

هذه الدراسة الثانية وهي جزء من برنامج دراسي بيئي لساحل شمال غرب الجزائر (شمال افريقيا). جمعت عينات شهرية خلال سنتين (1986-1987) حيث تم تعيين محطتين في منطقة الهبرة-سيك. المحطة الاولى هي قناة مقطع وهي قناة تربط حوض الهبرة (منخفض جيولوجي) بالبحر وهي قريبة من مدينة مستغانم. اما المحطة الثانية فهي من احدى الروافد القريبة من هذا المنخفض. درجات الحرارة (الهواء والماء) للمحطتين متماثلة حيث كانت الصغرى في شهر كانون الثاني والعظمى خلال اشهر تموز - ايلول. وجد ان هناك تباين في القراءات في قناة المقطع اكثر منه في منخفض الهبرة بالنسبة الى الاس الهيدروجيني (pH)، نسبة التشبع الاوكسجيني (OPS)، متطلب الاوكسجين الحيوي (BOD)، المادة المتخلفة الكلية (TR)، المادة المتطايرة (VM)، الكلور، نتروجين الامونيا (NH₄-N)، والسلكون (SiO₃-Si). بينما تقاربت القراءات بين المحطتين بالنسبة الى سرعة الجريان (CV)، وعكورة الماء (WT)، التوصيل الكهربائي (EC)، الاوكسجين الذائب (DO)، المواد العالقة (SS)، المادة العضوية الذائبة (DOM)، المادة المتخلفة الكلية الثابتة (FTR)، نتروجين النتريت والنتريت (NO₂-N, NO₃-N)، الفوسفات (PO₄-P) والقلوية الكلية. ان قيم المادة المتخلفة الكاملة والثابتة (TR & FTR) والطيارة (VM) في الصيف أكثر مما هو الشتاء ولا توجد فروقات واضحة عند المقارنة في كلا المحطتين. بينما سجلت معدلات قيم العسرة الكلية وعسرة المغنسيوم لمنخفض الهبرة اكثر منها لقناة المقطع اما قيم عسرة الكالسيوم فهي متساوية في المحطتين موضع الدراسة. سجلت قيم عالية لكل من التوصيل الكهربائي والنايتروجين والكلور في هذه المحطتين مقارنة بالدراسة السابقة لنهر شلف ورافده واللاحقة لنهر تافنة ورافده (ضمن برنامج الدراسة البيئية للمنطقة). هناك عدم انتظام للتغيرات الموسمية في كلا المحطتين لبعض العوامل المدروسة مثل الاس الهيدروجيني والتوصيل الكهربائي والاكسجين المذاب ونسبة الاوكسجين المشبع.

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