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# Evaporation and annual evolution of chloride concentrations in the water of a shallow Sahelian lake: Lake of Guiers (Senegal)

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## Introduction

Lake Guiers is the only lake in Senegal. Located 50 km from the Atlantic coast (latitude 15°10′ N; longitude 16°08′ W), it is a narrow cavity 50 km long and 7 km wide, situated at 2 m b.s.l. (Fig. 1). The lake constitutes an important fresh water reserve and is connected to the lower Senegal River in a straight line by the Taoué canal. A system of sluice gates allows control of water exchange between the lake and the river.

The configuration of the lake changes considerably through time and space, under the effects of the river inflows, losses through evaporation and pumping. In its average state, the lake has a depth of 1.5 m, an area of 225 $km^2$ and a volume of 350 millions $m^3$.

*The climate* is sahelian and the data recorded by the Richard Toll station (north of the lake) show:
- an annual rainy season (July–September) with an average rainfall of 215 mm (1976–1991);
- an annual average air temperature of 27.6 °C with a minimum of 22 °C in January and a maximum of 30.3 °C in June;
- a low relative humidity (at 40 %), a maximum deficit in the vapor tension in March, April and May and a minimum during the rainy season;
- an average windspeed at 2.4 m/s.



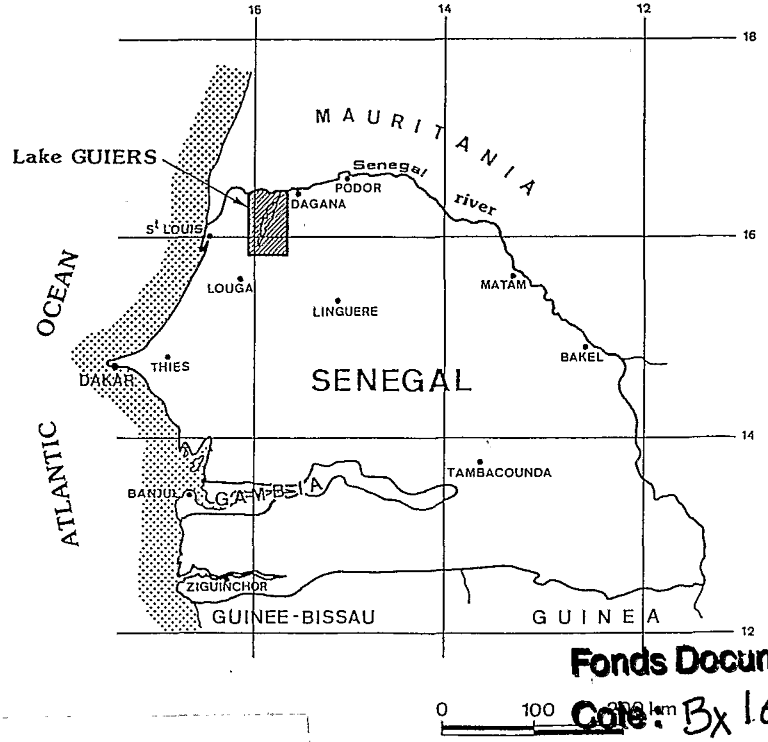




Fig. 1. Lake Guiers in West Africa.



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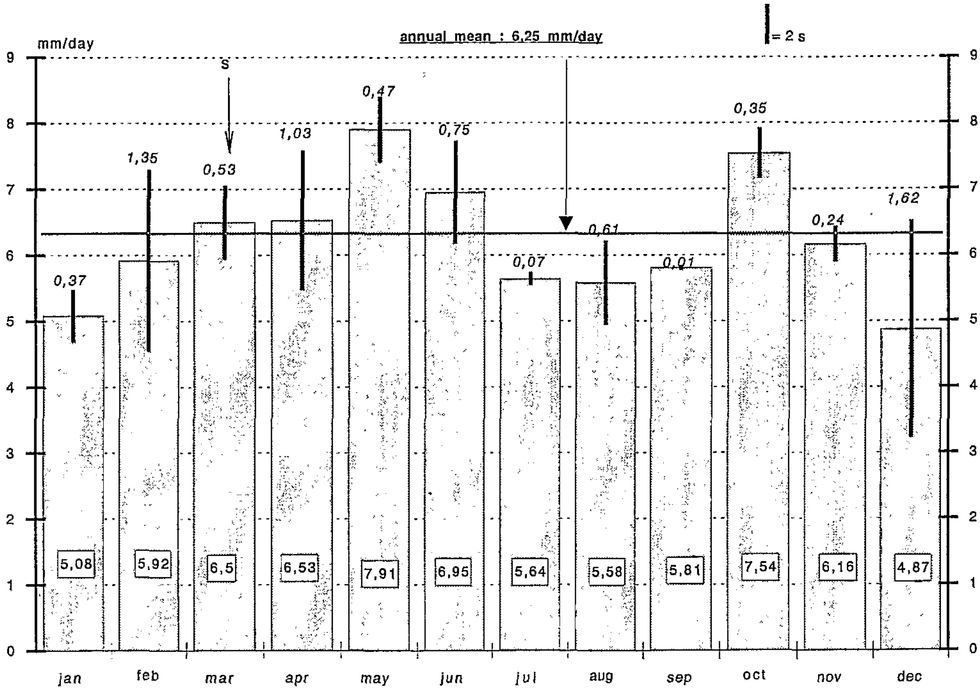


Fig. 2. Average monthly evaporation (mm · $d^{-1}$) and standard deviation (s): 1976–1991.

*Guier's hydrology* was studied over the period 1976 to 1991 (COGELS et al. 1990), and is regulated by two major periods of the year:

- a *filling period* between August and October, with inflow from the Senegal river to the lake;
- a nine month *isolation period* without convergence between lake and river. The lake's water level decreases due to evaporation and the pumping out of water.

## The lake's evaporation, methodology

The lack of data on the climate hinders direct calculation of lake's evaporation by the Penman's equation. The first stage of work was to ascertain the water balance of Guiers with maximum precision to determine the unknown quantity of the budget: evaporation. The monthly hydrological results were calculated over the 16-year period, from 1976 to 1991. All of the quantifiable parameters were measured directly, i.e. the volumes pumped (irrigation and drinkable water production) and released (by drains from irrigated cultures) and the pluviometric input. The surface and volume of the lake were calculated from the water level.

The evaporation is calculated separately during the two periods of the hydrological year:

- during the isolation period, evaporation is the only unknown parameter of the water balance and can be directly deduced.
- during the filling period (August and September) the lack of limnimetric equipment on the Taoué canal hinders to quantify the river's inflow; two parameters, evaporation and river's inflow, are simultaneously the unknown terms of the water balance. Lake's evaporation in August and September is then estimated with reference to "Class A tank".

## Results

On average, evaporation represents 80 % of the annual water losses from the lake, various pumpings 15 to 18 % and infiltrations 1.5 %. 85 % of the water supply come from the river Senegal, 8 % from the pluviometry and 6 to 7 % from the drains of the irrigated areas.

*Fig. 2 shows* the average monthly evaporation (192 months) calculated by dividing monthly evaporated volumes (from water balances) by the average surface areas of Lake Guiers at the same month. The evaporation follows a regular cycle, each year repeated, with a minimum in Decem-

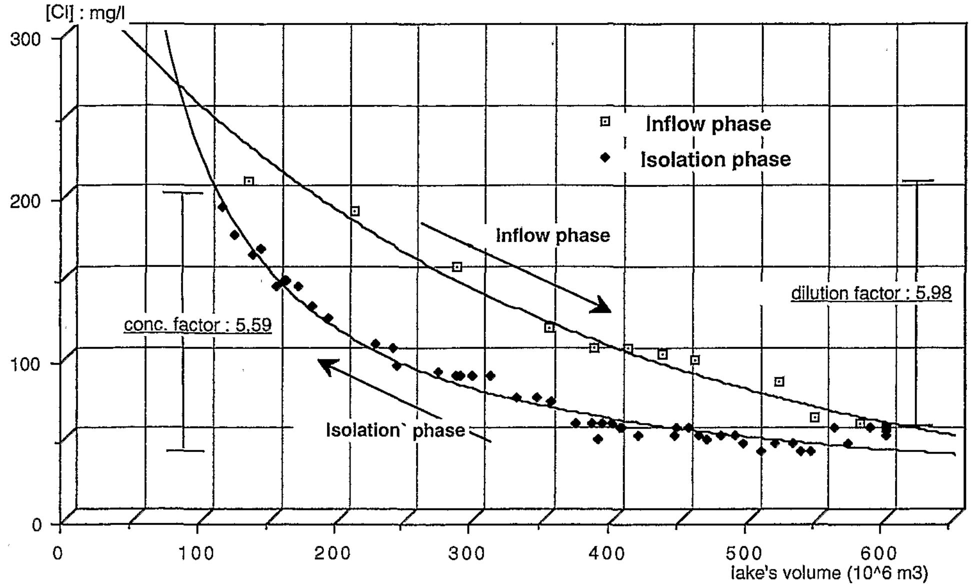


Fig. 3. The evolution of the dissolved chlorides during the hydrological year of reference 1985–86.

ber, and a progressive rise up to May. As the rainy season approaches it gradually diminishes until September. The end of the rainy season is well characterized by a secondary maximum in October. The average of the total annual evaporation is 2.27 m (6.25 mm/day) with a standard deviation of 0.11 m (5 %) and some extremes calculated figures of 2.14 m in 1979 and 2.58 m in 1983.

The data recorded for Guier's Lake are similar to those measured from other sahelian lakes: Lake Bam (Pouyaud 1986) and the sahelian pound of Oursi in Burkina Faso (Chevallier et al. 1985), and Lake Chad (Gac 1980). The annual cycle is comparable with a simple seasonal decline due to the difference in longitude.

## Evaporation and the annual change in water quality

The alternation of the 2 periods of the hydrological year induces an annual cycle in the water quality with:

- a phase of *mineralisation* (9 to 10 months) during the isolation period, due not only to the evaporation but also to the salted water released in the lake by the drainage system from salted soils of the irrigated areas.
- a phase of *dilution* (2 to 3 months) by the river inflow during the filling period.

The hydrological year 1985–86 can be considered as example to demonstrate the phenomenon repeated every year with more or less intensity according to the evaporation and the annual evolution of the lake's volume. This hydrological year of reference begins July 29, 1985 with the filling phase until September 23rd. The isolation period follows, and lasts until July 21, 1986.

Dissolved chlorides are analysed weekly at the NGnith station (on the west bank). This station can be considered as representative of the average quality of lake's water (Cogels et al. 1992). Fig. 3 shows the importance of the annual variations of dissolved chlorides.

During the lake's filling phase, the water dilution rate is 6.0, almost identical to that recorded during the isolation period (5.6). From one year to another, the figures vary in accordance with the importance of the water balance's parameters and with the evolution of the lake's volume during the 2 periods. The exact role of the evaporation in the annual process of mineralisation cannot be quantified directly since the salted drainage waters contribute equally to it. However it can be estimated monthly by dividing the volume evaporated by the mean volume of the lake during the same month. For the year 1985–86, and during the isolation period, the concentration rate of the water as a result of evaporation's influence was thus 3.85.

From 1976 to 1991, the average annual concentration rate of dissolved chloride was near 4.2 during the isolation period of the lake. During this period, evaporation induces an average concentration rate of 3.6, as 85 % of the total.

## Conclusions

In sahelian region the total annual evaporation of a lake

*Sphaenoclea zeylanica.* The consequences on the lake's hydrology, hydrobiology and public health could be very harmful.

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