The seasonality of water quality in the drainage basin of a tropical river (R. Jong in Sierra Leone)

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ABSTRACT

The physico-chemical quality of water at each of 18 selected sites in the drainage basin of the River Jong in Sierra Leone has been studied. Fourteen variables were monitored at monthly intervals over a one-year period. Several exceptionally low conductivity values (lowest = 3.8 μS cm-1) were recorded for surface-water sources during a monomodal wet season; all of these sources then dried up at some stage of the dry season. However, variations observed in water quality during the drying process, and in samples taken from shallow pools dug in dried source-beds, provided some explanations for water quality variations which occurred in the main river channel. Less pronounced seasonal variations occurred in ground-water quality.

KEY WORDS : Hydrochemistry — drainage basin — Seasonal changes — River Jong — Africa.

RÉSUMÉ

VARIATIONS SAISONNIÈRES DE LA QUALITÉ DE L'EAU DANS LE BASSIN D'UNE RIVIÈRE TROPICALE (R. JONG EN SIERRA LEONE)

La qualité physico-chimique de l'eau a été examinée dans chacun des 18 sites sélectionnés dans le bassin de la R. Jong en Sierra Leone. Quatorze variables ont été contrôlées mensuellement sur une période d'un an. Plusieurs valeurs exceptionnellement basses de la conductivité (la plus basse = 3.8 μS cm-1) furent enregistrées pour les sources d'eau de surface durant une saison des pluies; toutes ces sources se sont taries complètement à un moment ou un autre de la saison sèche. Cependant, les variations de la qualité de l'eau observées durant le tarissement et sur les échantillons pris dans les trous peu profonds creusés dans les lits asséchés des sources, fournissent un début d'explication aux variations de la qualité qui se rencontrent dans le lit principal de la rivière. Des variations saisonnières moins prononcées se rencontrent dans la qualité de l'eau phréatique.

MOTS-CLÉS : Physicochimie des eaux — Bassin versant — Variations saisonnières — Rivière Jong — Afrique.

Tropical rivers display, on average, a lower total dissolved chemical content than temperate rivers (LIVINGSTONE, 1963), which often fluctuates considerably through seasonal changes. More detailed information on the hydrochemical properties of [illegible] recently within the Onchocerciasis Control Programme (OCP) area of West Africa, e.g. MOLINIER (1976) and ILTIS & LÉVÊQUE (1982).

Sierra Leone is a West African country (at present outside the OCP area) where there is an extreme seasonal variation in rainfall; an intense monomodal wet season, when an abundant network of surface-water sources exists is followed by a sharply- [illegible] the interior of the country. However, the River Jong is the only one which has been studied in any detail. CHAYTOR (1969) first reported some hydro-

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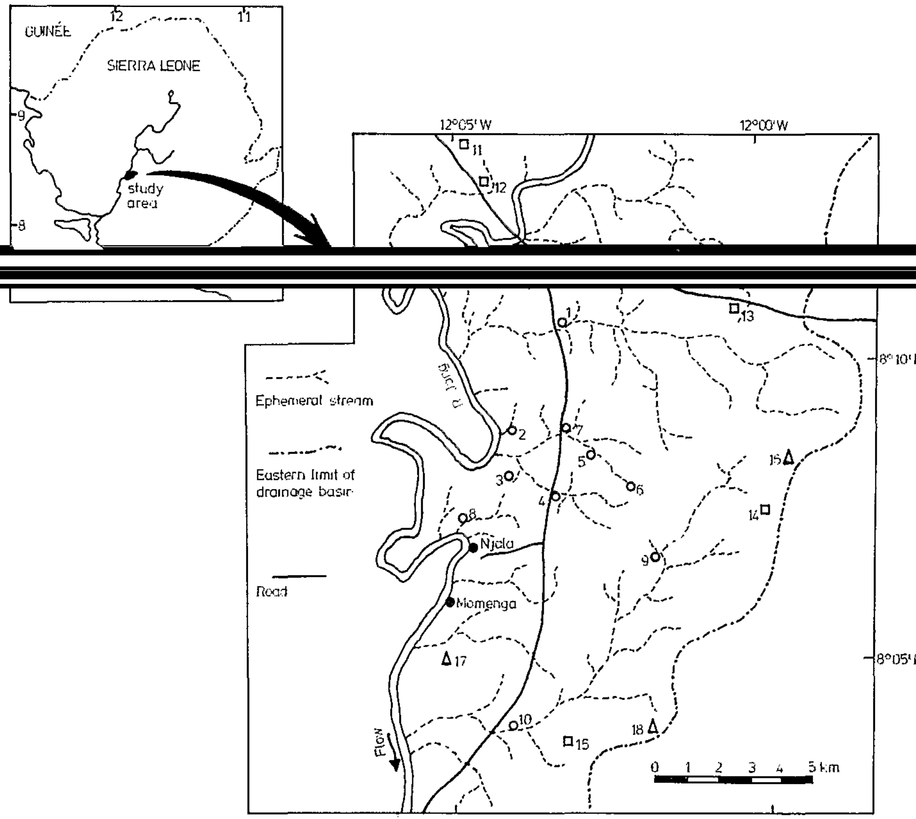

~~FIG. 1. — Sierra Leone: study area indicating sampling points in the drainage basin of the river Jong~~
Sierra Leone : zone d'étude, présentant les points d'échantillonnage dans le bassin de la rivière Jong
○ 1-10 : streams, *ruisseaux*; □ 11-15 : swamps, *marais*; △ 16-18 : spring pools, *sources*; ● : R. Jong (*d'après* WRIGHT, 1982)

logical and hydrochemical observations on this river, covering the period 1967-1969. WRIGHT (1982) later described the marked seasonality of the river. In the latter report the physico-chemical variables examined were considered to be either intrinsic or extrinsic with respect to the river, according to whether or not they fluctuated in a significant relationship to the river depth. Fluctuations of the extrinsic variables were tentatively ascribed to seasonal events in the drainage basin.

As reported here, the water quality of selected sources in the drainage basin of the R. Jong is described, providing a more complete picture of the seasonality of this tropical river.

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In July 1979, 18 sampling points in the drainage basin of the R. Jong were selected (Fig. 1). Selection was not random, but based on proximity to Njala, where the quality of water in the main river channel has been reported previously (CHAYTOR, 1969 ; WRIGHT, 1982). Fifteen of the points represented surface-water sources (streams and swamps) and three, ground-water sources (springs).

From August 1979 to July 1980 each sampling point was visited monthly. The approximate surface flow (if applicable) of the water source was recorded and four samples were taken: one for dissolved oxygen analysis, one for dissolved iron analysis, one (in a polyethylene container) for Na^+, K^+, silicate-Si and conductivity determinations, and the last (in a glass container) for the remaining determinations — colour, turbidity, pH, permanganate values, free CO_2, HCO_3^-, Ca^{2+} and Mg^{2+}. The methods used have already been described (WRIGHT, [illegible] the dry season. However, many of the water sources represented by these points were artificially deepened by the inhabitants of local settlements (who then used water from the shallow pools created for domestic purposes); wherever this occurred close to the initial sampling point, samples continued [illegible]

Meteorological data for the study period were obtained from the government meteorological station situated at Njala.

RESULTS

Monthly rainfall and temperature variations (see WRIGHT, 1982) were normal for this part of West Africa (OJO, 1977). Whilst temperature fluctuated little from an average value of 27° C, monthly rainfall declined sharply from approx. 500 mm in September to near zero between December and March, then rose again to the 500 mm level by July.

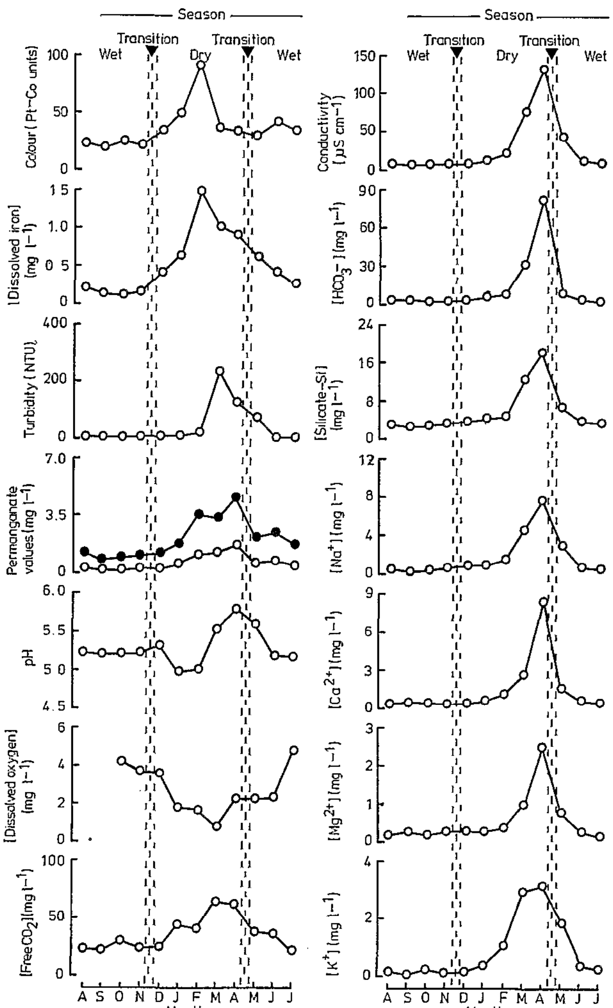

FIG. 2. — Seasonal variations in water quality of streams in the study area. (Circles represent the mean values of results from n sampling points), n = 10 for all months except January and February (n=7), March (n=5), April (n=3), May (n=4), and June (n=9).

[illegible] la zone d'étude. (Les cercles représentent les valeurs moyennes des résultats pour dix points d'échantillonnage)

Variations of water quality at the different sampling points were largely confined to the predominantly dry-season period, January to May. Average quality variations in streams (Fig. 2) were more extreme than those which were observed in the main river channel. Whereas water remained flowing in the channel throughout the year, all of the tributary streams investigated became initially stagnant (December to February) and then dried completely (March to May), except where these had been artificially deepened.

The alteration of flow in streams (Fig. 3) corresponded with marked changes in water quality. From the stable levels observed (for all the variables) between August and December, the first changes occurred in January, when the average free CO_2 concentration increased and the dissolved oxygen concentration and pH value both decreased. In February, the dissolved iron concentration and colour rose sharply, to peak figures; permanganate values also began to rise. March saw a further increase in the free CO_2 concentration, whilst the [illegible] level for the year. The dissolved iron concentration and colour then declined, as the pH value rose.

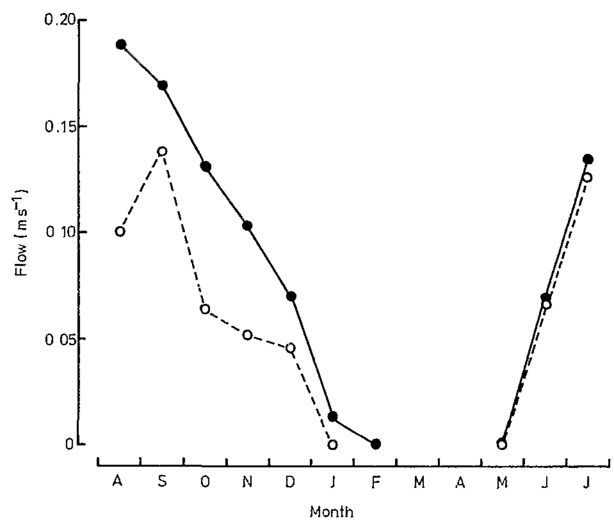

FIG. 3. — Seasonal variations in average flow of water in streams (●—●) and swamps (○ - - - ○) in the study area

Variations saisonnières dans le courant moyen de l'eau des ruisseaux (●—●) et marais (○ - - - ○) dans la zone d'étude

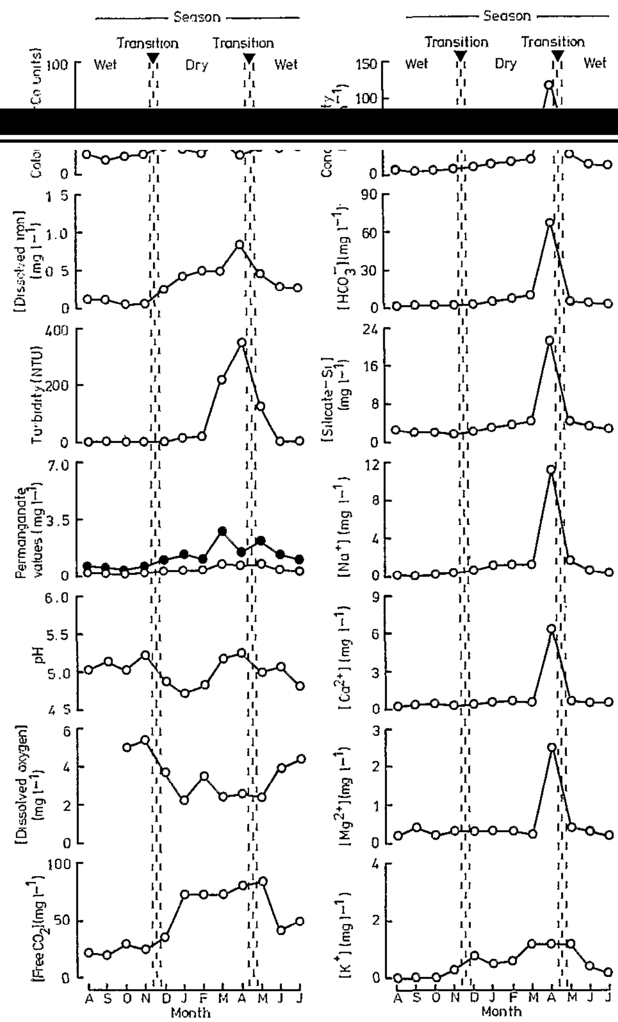

FIG. 4. — Seasonal variations in water quality of swamps in the study area. (Circles represent the mean values of results from n sampling points). n = 5 for all months except April and May, when n = 4

Variations saisonnières de la qualité de l'eau des marais dans la [redacted] *résultats pour cinq points d'échantillonnage)*

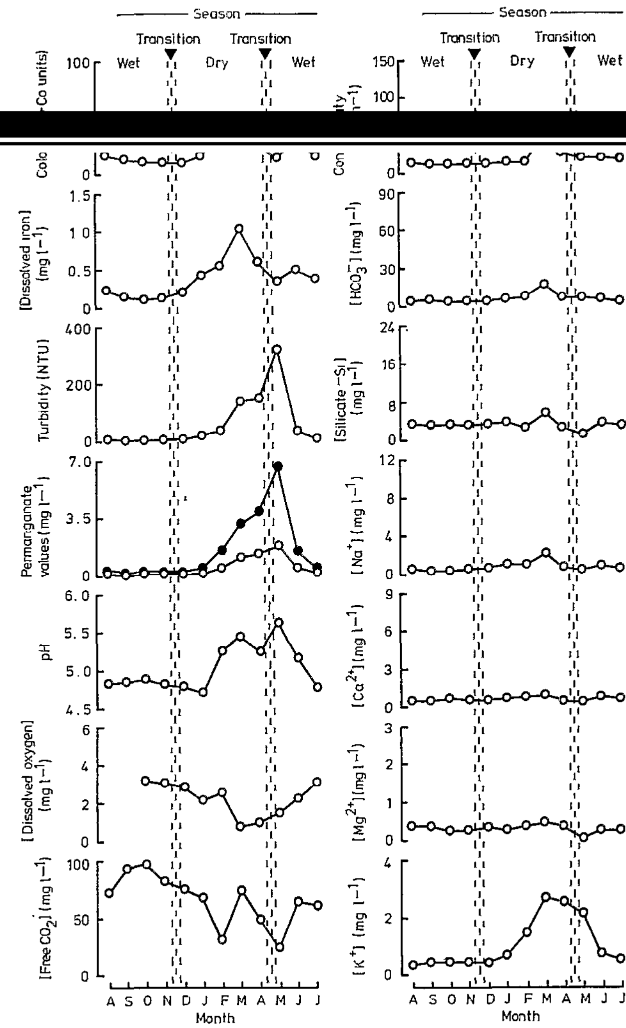

FIG. 5. — Seasonal variations in water quality of spring pools in the study area. (Circles represent the mean values of results from n sampling points). n = 3 for all months except February, March, April and May, when n = 2

Variations saisonnières de la qualité de l'eau des sources dans la [redacted] *résultats pour trois points d'échantillonnage)*

Turbidity peaked, but this was considered artificial, caused by human activity. Concentrations of the majority of the dissolved chemicals tested for (and, correspondingly, conductivity values) increased sharply in March and April, but quickly declined again in May, to reach average wet-season levels by June.

Flow and water-quality variations in swamps (Figs. 3 & 4) were broadly similar to those observed in streams. Dry-season increases for most of the dissolved chemical concentrations (and conductivity) were sharper, however, limited to the month of April. Also, the decline in pH observed upon the stagnation of swamps (December/January) did not coincide with marked increases in dissolved iron concentration and colour. Conductivity values for swamp waters were extremely low during the wet season, the lowest reading (3.8 $\mu S\ cm^{-1}$) being obtained at sampling point 11, in September 1979.

Variations in ground-water quality, as observed in spring pools (Fig. 5) were not as pronounced as for surface-water quality, although dry-season peaks

[redacted]
were consistently low and free CO_2 concentration high throughout the year. Average values for most of the dissolved chemical concentrations (and conductivity) were little higher than those for

[redacted]
in swamp pools.

The transition between dry and wet seasons was expected to coincide with a brief "flush" of materials/chemicals into the main channel of the R. Jong.

DISCUSSION

As in the main river channel (WRIGHT, 1982), there were clear seasonal patterns to the water quality of secondary sources in the drainage basin of the R. Jong near Njala.

The wet season was a period of stability, with a continual and substantial input of low-conductivity rain water to highly-weathered local soils unable to add much to the dissolved chemical load of the water. This stability was disturbed by the decline in rainfall, with streams and swamps rapidly being reduced to stagnant pools. The water quality variations which occurred at this time could not be explained entirely by the simple physical processes of evaporative concentration and drainage, but must have also been due in part to the effects of microbial respiration and an increase in the proportion of ground water in the sources.

As the dry season progressed, the divergence in the patterns of water quality variations observed between the different source types was considered a reflection of the nature of the soil material with which the water was in contact. For example, the streams studied all passed over lateritic soils, which could have contributed to the observed increase in [redacted]

were regarded as extrinsic to the R. Jong; however, except for colour, they all exhibited significant ($p < 0.05$) inverse correlations with the average flow of swamps and streams and can therefore be considered intrinsic for these sources. This confirms the re-emergence of ephemeral surface-water sources in the drainage basin of the R. Jong as the major event contributing to levels of dissolved iron, turbidity and permanganate values in the main river channel. (The fluctuation of colour must be determined by additional factors.)

Because of their extreme susceptibility to meteorological influence, the minor sources described herein (and arguably the R. Jong itself) could be considered mere "gutters" (after ROUGERIE, 1960) rather than watercourses with any greater identity. An investigation of the hydrobiology of this low-conductivity river system, which could well reveal such an identity, is now needed.

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[redacted]

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