Recharge estimation of two unconfined aquifers near Abidjan (Ivory Coast).

C. Marlin[1], M.S. Oga[2], L. Dever[1]

[1] *Laboratoire d'Hydrologie et de Géochimie isotopique, Université de Paris-Sud, Orsay, France*

[2] *Ecole Polytechique, Yamoussoucro, Côte d'Ivoire*

This study presents and discusses results of both chemical (major ions) and isotopic (^{18}O, ^{2}H, ^{3}H, ^{13}C, ^{14}C) analyses performed on ground, rain and surface water samples from the Grand Abidjan region in Southern Ivory Coast. This area constitutes the central part of a coastal sedimentary basin which covers a surface of ca.16,000 km^2 between the latitudes of 5°00 and 5°30 N and the longitudes of 3°00 and 6°00 W. The water supply of investigated region is mainly tributary of underground resources and of the Continental Terminal (CT) and the Quaternary (Q) aquifers, made of clay and sandy formations. The potentiometric data obtained for these unconfined aquifers indicate a general lowering of the water-table due to the recent intensive pumpings of groundwater.

Groundwater from CT displays low values of pH (3.5-5.4) and mineralization (E.C. between 20 and 55 $\mu S.cm^{-1}$). Water from the Quarternary aquifer also shows low pH value (3.8-6.6) and relatively low mineralization (140-225 $\mu S.cm^{-1}$). In the same area, groundwaters from both the cristalline bed-rock and Maestrichtien aquifers, sampled only in 4 locations, are more mineralized, ranging from 165 to 280 $\mu S.cm^{-1}$ for the former and being 395 $\mu S.cm^{-1}$ for the later.

The major ions of groundwater (CT and Q) are Cl^- and Na^+, but locally, the chemistry of groundwater can be dominated by HCO_3^-, K^+ or Ca^{2+}. The chemistry of solutions mainly derives from the atmospheric input and the acid weathering of silicate minerals (albite, anorthite, microcline being present in the groundwater-bearing formations). In coastal area, the increase of mineralization is related to lagoon water intrusion (brackish water coming the dilution of sea-water). However, this intrusion is quantitatively low, up to 4 %. The high concentrations of NO_3^- (up to 70 $mg.L^{-1}$) of some groundwaters are due to anthrogenic pollution in urban areas.

The comparison of heavy isotope contents in both precipitation and groundwater suggests that the recharge occurs all over the year. However, the contents of ^{18}O and ^{2}H in groundwater are significatively higher than that of the mean annual rainfall (weighted by rainfall amount), The annual precipitations are mainly represented by main rainy season (70 % of the total rainfall amount) which are depleted in ^{18}O and ^{2}H with respect to other small rainy seasons. This suggests that the recharge of the unconfined aquifers studied does not occur by total infiltration of water from the main rainy season. Two hypothesis can be given : (i) the rainfall of the small rainy season also participates to the recharge of the aquifers, and/or (ii) the infiltration towards the water-tables occurs at the beginning of the rainy events which are supposed to be

enriched in heavy isotopes according to an amount effect. During heavy rainy events, the saturation in water of soils could lead to the impermeabilization of surficial layers and to important rainoff.

The homogeneization in space of ^{18}O and ^{2}H contents of groundwater ($\delta^{18}O$ between -3.4 and -2.4 ‰, and, $\delta^{2}H$ between -13.7 and -6.2 ‰) results from a good mixing between waters of different recharge episodes within the aquifer ; this observation is consistent with the porous matrix of the aquifer. In a diagramme, $\delta^{2}H$ *vs* $\delta^{18}O$, all groundwaters are located along the world meteoric line, indicating that the recharge to water-table occurs rapidly through the unsaturated zone without any evaporation phase during infiltration.

The total dissolved inorganic carbon is shown to come from the biogenic CO_2 dissolution since all groundwaters are in isotopic equilibrium under open conditions with biogenic CO_2 generated either by the forest cover in the region of Abidjan (average $d^{13}C$ of -25.0 ‰) or arbustive savanna in the region of Dhabou (average $\delta^{13}C$ of -11.6 ‰). The high ^{14}C activities (92-115 pmC) and the ^{3}H contents (2.0-8.4 T.U.) of groundwater are indicative of recent recharge. The modelling of ^{14}C activities and ^{3}H contents according to a model of well-mixing reservoir give similar results of annual renewal rates for both studied aquifers, between 0.3 to 2 %. This corresponds to mean residence times between 1700 and some tens years. These short residence times, estimated by two independant time tracers, are consistent with low mineralization of groundwater.