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Groundwater biodiversity and water quality of wells in the Southern region of Benin

Biodiversité aquatique souterraine et qualité de l'eau des puits au Sud-Bénin

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ABSTRACT

This study performed in South-Eastern Benin aims to correlate the regional subterranean aquatic fauna, still poorly unknown, with the main physico-chemical characteristics of well-water used by human populations. Two kinds of descriptors are used. Physico-chemical analyses of water and faunistic sampling were consequently performed for one year at 15 stations. Multivariate analyses show different groups of stations depending on the kind of descriptor. Thus it appears that, in the Pobè region, the water quality, very variable from one station to another, is certainly not the main determinant of the well-water fauna distribution. Among the subterranean crustaceans, species belonging to genera *Allocyclops* and *Metastenasellus* have never been described before. These results are a contribution to the knowledge of the regional biodiversity and suggest that this biodiversity can be used as an indicator for better protection of regional groundwater.

Mots clés:
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RÉSUMÉ

Cette étude, réalisée dans le Sud-Est du Bénin, a consisté à corréler la faune aquatique souterraine, encore inconnue au Bénin, avec la qualité physico-chimique de l'eau de puits utilisée par la population. Des analyses physicochimiques de l'eau et des prospections faunistiques ont été réalisées pendant un an sur 15 puits. Des analyses multivariées réalisées à partir de deux types de descripteurs ont permis de déterminer des groupes de stations qui diffèrent assez sensiblement. Il apparaît ainsi qu'à Pobè la qualité de l'eau, pourtant très variable, n'est certainement pas le seul facteur qui détermine la répartition de la faune stygobie. Parmi les Crustacés souterrains, des espèces des genres *Allocyclops* et *Metastenasellus* n'ont jusqu'ici jamais été observées. Ces résultats peuvent être utilisés à la fois pour mieux connaître la biodiversité régionale et pour justifier une protection des écosystèmes souterrains.

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1. Introduction

Water is essential to sustain life, and without it life becomes impossible. It is an indispensable commodity, which should be easily accessible, adequate in quantity, free of contamination, affordable and available throughout the year in order to sustain life [1]. Water is the basic need of life but tragically its quality is continuously deteriorating due to anthropogenic activities [2]. Groundwater is the major source of water supply and presently it is the most valuable natural resource for various human activities [3]. Its use in such a huge amount is due to the scarcity of potable surface water. Due to the presence of a protective soil cover, groundwater is considered purer and safer than surface water [4] and everywhere groundwater supply is developing and is important for everyday human life [5].

Whereas subterranean domains have long been considered as species-poor environments, worldwide analyses reveal an unexpectedly high diversity of living forms in groundwater [6–9]. Due to the size and diversity of habitats, groundwater hosts a very diverse assemblage of adapted taxa [7,10,11], with high rates of endemism and reduced dispersal abilities [12]. Studies and assessments show that, in spite of the severity of the underground environment [13], stygobitic communities present an unexpected richness. This richness, however, very variable in space (regions) and stations (within a region) could be considered as a water quality indicator [14–21].

In Africa, research on subterranean fauna has been progressing in many countries especially in North Africa [6,14,22–26]. However, very little is known about the Beninese stygofauna. To date there are no literature references available on that field from Benin, except recent research performed in the North-Eastern Benin [27]. The present study aims to explore whether a stygobitic community exists and can be related to the physico-chemical quality of well-water in the Pobè region.

2. Material and methods

2.1. Study area and sampling sites

The Pobè region is located in the South-East of Benin (Fig. 1). It covers 400 km^2 in the lower part of the Ouémé drainage basin. The climate is sub-equatorial with two dry seasons and two rainy seasons alternately occurring during a year. Rainfall ranges from 1100 to 1200 mm per year. There are two types of soils in this region, hydromorphic soils with a limestone substratum in the northern part and ferrallitic soils in the south. The bedrock is less rich in limestone in the south. The main activity of the population in this rural area is traditional agriculture.

A series of 15 dug-wells has been seasonally studied for one year. Five of them (Pb1, Pb2, Pb3, Pb4 and Pb5) were selected within the urbanized district and the ten others are distributed in the rural regions (Fig. 1). Except Pb6, Pb7, Pb8 and Pb11 which are intended for domestic purposes, the others are also used for supplying drinking water. The total depth of the wells varies from 6 m for the shallower ones to a maximum of 50 m for the deepest one. Most of the studied wells have cemented walls except Pb1, Pb7 and Pb11.

2.2. Sampling and analysis methods

Sampling was carried out from June 2012 to March 2013 during the four seasons. The water pH, temperature and conductivity were recorded at the time of water sampling using a portable multi-parameter probe (HANNA, HI 991300). Samples for chemical analysis were collected in washed polyethylene bottles. Nitrate, nitrite, ammonium, sulfate, phosphate and fluoride ion concentrations were determined by using a Hach, DR 2400 spectrophotometer. Total hardness, magnesium, calcium, chlorides, and bicarbonate concentrations were measured by titrimetric methods proposed in [28].

After water collection from each well, the fauna was collected with two types of sampling equipment:

- a plankton net or a phreatobiological net sampler [29,30];
- a baited trap made from two mineral water bottles, following the system proposed in [31].

Water filtration was performed for 30 min when the use of a phreatobiological net was impossible. A phreatobiological net sampler was drawn up from the bottom to the surface of water 10 times through the entire water column. The traps were set in contact with the bottom for a mean of 18 h. The fauna samples were fixed in 7% formalin in the field. After the sorting in the laboratory, using a stereomicroscope, individuals were preserved in 70% ethanol before being identified. Animal specimens were identified to the lowest taxonomical level possible using published and informal keys. The determinations of most of the zoological taxonomic groups were performed or checked by a specialist of each group and the number of individuals of each taxon was recorded. Copepoda were identified by F. Fiers, Oligochaeta by P. Martin, Ostracoda by P. Marmonier and Planaria by H. Harrath.

The annual mean of each physico-chemical descriptor is given in Table 1. The collected fauna, abundance and taxonomic richness were calculated and are given in Table 2. Two multivariate analyses using Principal Component Analysis (PCA) and Hierarchical Clustering of stations were performed for the two sets of descriptors. A PCA usually displays the groups of variables (or descriptors, either the physico-chemical characteristics of water, or the different aquatic taxa occurring in the wells) which are highly correlated, and contribute to the formation of the same factor represented by an axis, with positive (or negative) coordinates, such as in Figs. 2 and 4. Then, a hierarchical classification of the different objects (here the wells, and the stations) deduced from the same matrix displays a number of groups, mainly formed by the objects sharing the same set of correlated characteristics (such as in Figs. 3 and 5), visible in projection on the factorial plan of the first axes [32].