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Process of creation of natural temporary pools in Morocco, and physicochemical characteristics of some pools of them

Sara Sassa[1], Hafsa Ouattar[2], Rachida Fegrouche[3], Mostafa Slim[4], Mohamed Fadli[5*]

[1, 2, 4, 5] Laboratory of Nutrition, Health and Environment, Department of Biology, Faculty of Sciences, University IbnTofail, Kenitra, Morocco

[3] Laboratory of Biodiversity, Ecology and Genome, Rabat, Faculty of sciences, Rue Ibn BP 1014, Australia

Abstract

In the Mediterranean region, temporary pools are accumulations often formed annually, by water inputs of precipitation. The biotopes of these pools can be of artificial origin, by creation voluntarily or involuntarily of the Man, or natural.

Moreover, whatever the evolution of the characteristics of the waters of the temporary pools does not differ in very remarkable ways, the geologic nature of the parent rock and the pedagogy of the sediment influence these characteristics. Thus, the present work, by an observation and an analysis of the geological context and biotope of the biotopes of the temporary pools in the richest geographical zones of temporary natural pools. The results showed that in Morocco, different types of natural pond formation process differ according to the geological nature of the support. The latter may be clayey, sandy, calcareous or dolomitic, basaltic or granitic. However, the tendency of these processes is effected by water erosion, erosion, chemical, and the result is the same: progressive enrichment of the biotope by the clay.

From the point of view of physico-chemical characterization of temporary pools, the results showed the evaluation of physicochemical parameters characterizing the water showed that, in the region studied, the values of these parameters are influenced by the factor "season". In fact, the majority of the parameters showed low values at the beginning of impoundment of the pond and high values towards the end of this impoundment. Similarly, during the flooded phase of the pond, the evolution of the values of certain parameters such as the pH, the rate of oxygenation of the water, the rate of the organic matter is influenced by the quantity of the excrements of the pond. livestock using the pond as a source of food or watering place.

Keywords: temporary pools, processus training, Physical chemistry, Morocco

1. Introduction

Mediterranean temporary pools are a priority habitat for fauna and flora in Europe and North Africa. These are ecosystems occupying, in the Mediterranean region, periodically flooded biotopes composed of low vegetation, geophytic and xerophytic vegetation and biocoenosis [1]. These are wetlands, called "Daya" in Morocco. By their fauna and flora they constitute an important trophic link in the ecological network of their surrounding geographical environment [2]. Animal and plant biodiversity is often very high [3] and many species have adapted to ecological conditions, especially their temporality, to be characteristic species of these environments, anostraceous crustaceans are a good example [4, 5].

Similarly, the detention of Mediterranean temporary pools is often linked to Mediterranean climatic conditions, particularly the period, quantity and seasonal variability of rainfall [3].

From a morphological point of view, as reported by Fadli (1987) [6], the biotopes of these pools are depressions of variable area and depth, flooded from the end of autumn to the end of spring by the water. Oligotrophic freshwater (sometimes mesotrophic) and very dry at the end of spring. The origin of these basins is not always the same and the physico-chemical conditions, which vary from one basin to another, have common characteristics.

In this work, we are interested in the diversity of these origins in Morocco and in giving an insight into the evolution of the physicochemical characteristics of certain pools of the Mamora forest located in the north-west of the country.

2. Material and Method

2.1 Methodology of the determination of the main types of natural temporary

Pools of Morocco

The principle of determining the natural origin of natural temporary pools is the analysis of the geological, pedological and geomorphological contexts of different biotopes of temporary pools that are located in the geographical areas of Morocco which are the richest in temporary pools.

2.2 Methodology of physicochemical study

2.2.1 Studied sites

Four temporary pools in the Mamora Forest have been prospected. In each site we carried out physicochemical analyzes of the water, determined the structure and the evolution of the abundance of the species. The study was carried out during the impoundment during the 2016/2017 years and the number of water sampling stations analyzed per studied site depends on the heterogeneity of this station.

- **Dayet Sidi Amira:** It is located about 15 km east of Rabat near the forest house of Sidi Amira. It is a bowl with almost flat bottom. The impoundment is temporary and 4 to 5 months. Vegetation, both aquatic and terrestrial, begins to appear as soon as impoundment begins, and the flora consists of herbaceous formations of hygrophilous species, a characeae (*Chara canescens*) and other filamentous algae (*Spiroger sp*). The border vegetation consists of phanerogams including *Ranunculus aquatilis* and *Glyceria fluitans.*
- **Dayet Eddis:** It is a temporary water accumulation located in the western part of the Mamora forest, with an area of approximately 8800 m2 and a depth of up to 60 cm. It is fed by precipitation, runoff and ground water when it swells as a result of heavy rainfall. The aquatic vegetation consists mainly of *Panicum repens*, *Ranunculus aquatilis*, *Lemna gibba* and filamentous algae.
- **Dayet Zdegh:** It is a semi-permanent pond of 2 hectares of surface which is located 7 km east of the city of Kenitra. The depth of the water can reach one meter and the aquatic vegetation is rich in filamentous algae and *Ranunculus aquatilis.*
- **Daya Twila:** It is an elongated, semi-permanent pond of about one hectare of surface and is located 7 km east of the town of Salé. The depth of the water can reach one meter and the aquatic vegetation is rich in filamentous algae and *Ranunculus aquatilis.*

2.3 Methods of sampling water

According to the dates reported in Table 1, we measured in situ water temperature (Tp), electrical conductivity (Cd), dissolved oxygen (Od) and pH with devices. of land. The other variables were analyzed at the Laboratory level Kenitra Faculty of Sciences (Morocco). The assays are either volumetric or spectroscopic according to the analytical methods proposed by Rodier (2009) [7]. These variables are Nitrites (Nit), Orthophosphates (OPh), Total Alkalimetric Title (TAC), the content Calcium (Ca), Magnesium content (Mg), Hydrometric Title (TH) and Chloride content (Cl).

3. Results and Discussion

3.1 Training mechanisms for the main types of natural temporary pools in Morocco

These mechanisms differ according to the type of the source rock or the geological formation that supports the pond:

3.1.1 Mares on clay or marly geological formation

This is the most common type of dayas formation: Due to the impermeability of the clay, as a result of heavy rainfall and if the relief allows it, accumulations of water are trapped in the open here and the. Runoff plays a major role in feeding these types of water collections. But their volume is generally insufficient to allow them to persist throughout the year. Indeed, as reported by Wagner (2013) [8] the clay soil has a slow permeability resulting in a very large capacity of water retention. Because soil particles are small and narrow together, water takes a lot of time to move through the clay soil than it does with other types of soil. Note that the high temperatures of summer evaporate almost all dayas, leaving in their place a particular vegetation.

On marly soil, because of the percentage of clay that these soils contain, the processes of the formation of the biotopes of the temporary pools occur in much the same way as on clay soil.

In addition, temporary ponds on clay or marly geological support are common in the Gharb plain, the coastal meseta and the Middle Atlas.

3.1.2 Pool on siliceous sand

The wind is an essential erosion agent especially when it blows very hard in a discovered area. It erodes by deflation and corrosion and accumulates in dunes or other forms the grains it carries.

In temperate countries, such as Morocco, these forms are rapidly fixed by vegetation. Some of them may present wind-eroded summits that swirl hollow depressions where dayas can then settle.

Then, if the water table is relatively deep and cannot play any role in feeding these types of dayas. On the contrary, runoff, leaching and creping play a key role in the formation of these types of water collections. Generally the sand is not in the pure state, it contains impurities, in particular fine elements and in particular clay. The runoff, no one in an absolute desert, is very active in northern Morocco despite the scarcity of rainy days, it occurs in heavy rain and a significant portion of the precipitation flows on the surface. This runoff is all the more aggressive because the vegetation cover is not continuous and the land is not consistent. The slopes are violently attacked by the sudden rains (one of the characteristics of the rains of the Mediterranean climate). The fine elements and bottom impurities are transported by runoff and oblique leaching to the bottom of the depression, resulting in a washing of the tops of the slopes and an enrichment of clay elements of the bowl. A less permeable layer is thus formed which can withstand for a certain period of time a mass of precipitation and runoff water.

Wind erosion, the main physical factor of agricultural land depletion [9], leads to severe environmental degradation through soil depletion and the displacement of high volumes of particles by wind. Indeed, according to Larue (2000) [10], runoff erosion results from the detachment and transport of particles under the combined action of rain and runoff. The latter occurs when the intensity of precipitation exceeds the infiltration and the retention capacity of the soil surface. Diffuse runoff is surface run-off from pellicle or unstable fillets which, by lateral erosion, exports fine particles

If the sand layer is thin in places and rests on a waterproof floor. So, during the rainy season, the water table can outcrop locally. The water of the water accelerates the alteration of the substrate, especially that of impurities in the sand. The water lens will be a trap for fixing clay and fine elements transported by the wind, which will clog the originally permeable substrate. Runoff also participates by leaching the small watershed that surrounds the outcrop of the water table, which enriches the fine substrate of this small depression. Then, from year to year, the same phenomenon is repeated to such an extent that the neoformed layer of clay becomes sufficiently important to prevent direct communication between the rainwater and that of the groundwater. Arrived at this stage, called maturity, this type of daya continues its evolution by horizontal extension. This extension is theoretically unlimited. The water supply of the pool is mainly by rainwater and the quantity is generally insufficient to ensure their annual permanence.

In addition, temporary pools on siliceous sand are very common on the Mamora forest.

3.1.3 Mare on limestone or marly geological formation

In areas with a calcareous substratum, water, agent of alteration of the rocks [11], the alteration processes can be physical or mechanical or chemical. However, in temperate regions the chemical processes play a preponderant role in the weathering of the rock. It is about alteration and dissolution by the waters more or less charged with carbon dioxide able to create in places laps or depression accumulating the water of precipitation thus constituting a birth of temporary pond.

Limestones are homogeneous rocks. Erosion by dissolution can give a karstic relief, but any limestone relief is not karst: the forms of dissolution can be absent to give way to other forms of erosion.

The water penetrates easily in the limestones and with the carbon dioxide of the atmosphere dissolves lime carbonates ($CaCO_3$). Only insoluble impurities remain on site. The double carbonates of magnesium and calcium (dolomite) are poorly soluble and therefore resist in places. The dissolution is made at very uneven local velocities, giving various forms such as plateaux cut or not by valleys, lapies, closed depressions of various shapes and sizes and often lined by dissolving clay from impurities from the limestone. The clay layer can thicken enough to prevent vertical infiltration of water into the rock. Then, the dissolution attacks especially the edge of the depression to give it an extension rather horizontal than vertical. The precipitation and runoff water accumulates temporarily in these depressions to give dayas on calcareous grounds.

In the Rif, dayas are scarce. The presence of non-karstic limestone and the instability of the terrain prevent the accumulation of precipitation and runoff water. On the contrary, water favors landslides.

Finally, on calcareous ground some depressions which are at the origin of dayas could be due to tectonic phenomena.

3.1.4 Mare on basalt ground

Various small peaks of the Middle Atlas are ancient volcanoes (Jbel Hebri, Jbel Mi Chliffen,...). Once hardened, the volcanic effusions of the liquid flows gave a more or less porous rock: the basalt. This possible porosity of the rock facilitates its alteration, the water penetrated into the voids and attacks certain minerals. Erosion also benefits from resistance inequalities between hard lava, slag that is relatively weak and non-volcanic rocks that coat or support lava. The volcanic flow first sees its irregularities destroy by alteration, bursting and dwindling. Thus, as it gets older, the rougher casting becomes united and quite impervious.

According to Molnereau (1977) [12], in the phenomenon of alteration of basalt the alteration of basaltic materials in an organic and humid environment in a temperate climate is carried out essentially under the influence of water-soluble organic acids. Then there is the formation of an amorphous, highly polymerized, humin-forming organo-mineral complex, which coats the leaflets and occupies the interfoliary spaces of the swelling organo-mineral intergrade present in andosols. Consequently, the humus plays, during clay-genesis, successively the role of an aggressive agent, selective, protective and conservative, according to its degree of saturation and polymerization.

Likewise, the impermeability of old basaltic flows, the irregularity of the relief, the erosion which favors the formation of a soil having certain proportion of clay in the soil, and finally the runoff allow the accumulation of precipitation waters. on some depression of the relief

3.1.5 Mare on granitic ground

This type of pond is common in the Zaer areas. And Central Plateau. In these areas, granitic outcrops facilitate the formation of dayas by enriching the environment with weathering clays of black micas and feldspaths. In fact, over time, the granite rocks break up by erosion to release minerals that in turn recombine, recrystallize from the elements in solution to form new minerals called secondary minerals. The main secondary minerals found in soils are: clays. According to Pajon-Perrault (2008) [13] Generally, a fracture of any origin of the rock puts the water contact water of a large number of crystalline faces. In the case of granite two phenomena can occur total hydrolysis (the mineral is destroyed in smaller possible compounds (hydroxides, ions)) or partial hydrolysis: the degradation is partial and directly gives silicate compounds (clays).

3.2 Physicochemical characteristics of waters

The Table 1 groups the values of the physico-chemical parameters estimated in the biotopes surveyed.

Table 1: Values of the studied physicochemical parameters

Pools	Dates	Tp	pH	Cd	Mo	O_2	Cl-	Alc	Ca++	Mg++	DT	Nitrat	Nitrit
Dayet Zdagh	15/11/2015	13.8	7.5	402	4.2	2.9	127	66	74	24	98	1.6	0.019
	18/01/2016	15.4	7.3	425	3.6	3.6	134	87	72	25	97	1.8	0.018
	16/03/2016	22	7.4	534	5.7	4.4	189	69	85	21	101	1.9	0.021
	15/04/2016	24.2	7.7	802	6.6	4.4	235	78	94	25	119	2.04	0.021
	29/05/2016	27.7	7.9	1006	7.3	2.2	321	102	105	26	131	2.09	0.024
Dayet Eddis	15/11/2015	14.5	7.3	221	2.3	1.4	148	81	55	21	76	1.35	0.021
	18/01/2016	17	7.3	182	2.8	2.5	165	79	63	23	86	1.42	0.011
	16/03/2016	21	7.5	239	4.1	2.6	174	81	71	25	96	1.81	0.012
	15/04/2016	24.5	7.2	602	3.8	2.3	189	78	83	26	109	1.92	0.020

	29/05/2016	28	7.7	1039	4.9	2.3	201	111	96	**27**	123	2.24	0.021
Dayet Sidi Amira	15/11/2015	14	7.5	218	4.9	4.2	138	64	56	22	78	2.23	0.018
	18/01/2016	16.7	7.4	257	5	4.2	120	66	74	25	109	2.11	0.018
	16/03/2016	225	7.6	379	5.7	4.5	145	79	85	25	110	2.05	0.017
	15/04/2016	24	7.6	581	6.6	4.5	160	97	94	25	119	2.19	0.017
	29/05/2016	26.5	7.9	992	7.8	4.7	194	92	106	27	133	2.07	0.021
Dayet Twila	15/11/2015	14.2	7.4	314	4.1	3.2	102	104	65	26	91	1.64	0.019
	18/01/2016	16.8	7.4	405	4.7	3.2	117	95	77	25	102	1.84	0.018
	16/03/2016	23	7.6	702	5.5	4.5	221	83	84	25	109	2.09	0.019
	15/04/2016	25	7.7	906	5.8	4.2	236	106	84	24	108	2.0 4	0.018
	29/05/2016	27.1	7.8	1100	4	3.8	251	92	95	26	121	2.18	0.021

3.2.1 Temperature

The temperatures noted are between 13.5° C and 27.7° C. For all the biotopes studied, the temperatures vary according to the seasons. They are low in winters, intermediate in spring or autumn and maximum in summer. It should also be noted that, in shallow, shallow water, the temperature trend is often linked to that of air [14]. In relatively deep waters, a thermocline can alter the vertical homogeneity of temperature [15]. The vegetation cover can also act as a stabilizer of the temperature of the aquatic environment. In flowing waters, the arrangement of the sampling station relative to the source (often at constant temperature) and the speed of the water greatly influences the temperature of the water.

In addition, temperature is one of the first factors that control the biology and ecology of living things. It acts on the density, the viscosity, the solubility of gases in water, in particular that of oxygen, and on chemical and biochemical reactions [16]. It also has an effect on competition interactions between species [17]. In addition, in the Mediterranean region, areas known by its climatic variations, the effect of temperature is largely predominant in the determinism of the composition of zoocenoses [18]. Similarly, in some species such as molluscs, many authors including Yoshida *et al.*, (2012) [19] reported that temperature may affect egg hatch, speed of development, speed of sexual maturity and abundance of the species. The abundance of the population is also influenced by water temperature [20].

3.2.2 pH

In the stations studied, the pH is neutral to alkaline. It is between 7.2 and 7.9. This alkalinity of the pH could be related to the effect of the geological nature of the lands crossed by the biotope's feed waters. Similarly, the quantities of livestock excrement that use these dayas as drinking troughs are important factors in the variation of pH.

In addition, the pH of the environment depends on the origin of the water, the petrographic nature of the source rock, the environment through which the water feeds, the temperature, the chlorophyll assimilation and the respiration of the organisms [21]. The value or the variation of the pH acts on the structure of the communities of the macroinvertebrates of aquatic environments [22] and informs on the stability and the balance established between the various forms of the carbonic acid [23]. Thus, pH can intervene to influence the ecology of animals [24].

3.2.3 Conductivity

For all the biotopes studied, the water conductivity is relatively low during the rainy season and higher during the summer season, when water evaporation becomes more intense. The results show that the conductivity varies between 221 µs / cm noted at Dayet Eddis at the beginning of impoundment and 314 µs / cm recorded at Twila pond at the beginning of impoundment, and 1039 µs / cm illustrated Eddis pond at the end of its flooded phase,

It should be noted that the conductivity measures the degree of mineralization of the water and its fall can favor the hatching of the eggs of certain invertebrates such as those of the Anostracean crustaceans [14]. Similarly, conductivity can influence egg hatch [24].

3.2.4 Dissolved organic matter (Mo)

The recorded values vary between 2.3 mg / l illustrated at the beginning of the placing of the Eddis pond at the beginning of the flooded phase and 7.8 mg / l noted in summer in the Sidi Amira daya at the flooded phase. In addition, the effect of the "season" factor is notable, in almost the biotopes studied, the highest values were recorded in summer.

It should be noted that, from a concentration threshold, the richness of organic matter in a hydrosystem reflects its degree of eutrophication. It is a form of pollution that occurs when an aquatic environment receives too much nutrients assimilated by the algae and that these proliferate.

In addition, natural organic matter is mainly derived from the decomposition of plants, animals and micro-organisms. They have a lot of impact on water quality parameters: color, odor, disinfection by-products, flavor, etc [25]. They influence the speciation and bioavailability of metals [26].

3.2.5 Dissolved oxygen (O_2)

For all biotopes, changes in oxygen levels showed relatively low values in late spring / early winter. But, this state of oxygenation gradually improves with the development of the aquatic vegetation of the environment and the good sunshine of spring and summer. However, in summer the increase in water temperature, which oxidizes the organic matter of the medium and reduces the solubility of oxygen in the hydrosystem, decreases the degree of aquatic oxygenation of the medium?

Note that in water, the concentration of dissolved oxygen depends on the pH, temperature, salinity, atmospheric pressure, chlorophyll assimilation and respiratory activity of the animals.

On the other hand, in many species the abundance of the population is influenced by the dissolved oxygen content of the environment [20]. Thus, the oxygen level influences the degree of biodiversity of a hydrosystem [27].

3.2.6 Chlorides (Cl^-)
Generally, the profile of the spatio-temporal evolution of this parameter follows that of the electrical conductivity. The noted concentrations show that generally the water is soft. In addition, for all biotopes also, under the effect of water evaporation, the highest Cl^- concentrations were noted at the end of the flooded phase while the lowest ones were recorded in winter maximum dilution of aquatic environments by rainwater.

In addition, chlorides are mostly of natural origin. The salinity of water, which is mainly related to the chloride content of the environment, influences the ecology and structure of the species' communities [27, 28]. The abundance of populations of some species itself is influenced by the salinity of the surrounding waters [20].

3.2.7 Alkalinity (Alc)
The noted water alkalinity is relatively low. In addition, for all stations the results show seasonal fluctuations and the most important values were noted in the spring.

The decrease in alkalinity during the spring could be attributed to the photosynthetic activity of the plants that develop during this season.

In addition, alkalinity evaluates bicarbonates, free ammonia and phosphates. When the pH increases, the bicarbonates are transformed into carbonates. The alkalimetric titer therefore depends on the pH equilibrium and the concentration of CO_2 in the middle water [29]. The total alkalimetric titer is the sum of the ions HCO^-_3 and CO_3^{2-}, when a water is charged with bicarbonates, carbonates, hydroxides, phosphates and silicates, it increases its alkalinity [29]. Thus, the hydrotimetric titer, or hardness of the water, is the indicator of the mineralization of water. It is mainly due to calcium and magnesium ions. It should be noted that consumption of high alkalinity water is harmful to health [30].

3.3 Total hardness, calcium and magnesium
The waters of the studied stations present spatio-temporal variations of the total hardness. The maximum values are noted in spring, however, the minimum values coincide with the winter period. In addition, the results further show that the profile of Magnesium Hardness is perfectly parallel to that of total hardness and that of calcium. It is also noted that magnesium levels are lower than those of calcium in all stations.

Moreover, according to Nisbet and Verneaux (1970) [21], calcium levels in natural waters, which are free of pollution, generally vary between 1 and 150 mg / l, and those of magnesium vary between 5 and 10 mg / l. However, anthropogenic activities can amplify the concentrations at the stations receiving wastewater by changing the pH and the temperature of the water.

Note that the total hardness includes dissolved quantities of Ca^{2+} and Mg^{2+} ions. Relatively high values above 50F (French degrees) indicate chemical pollution of the aquatic environment. Total hardness also influences the toxicity and bioaccumulation of heavy metals by promoting the formation of insoluble carbonates which under the competitive effect of Ca^{2+} and Mg^{2+} ions with metals reduce the incorporation of these latter organisms [29]. Similarly, water hardness can also affect larval development of some species [31].

Calcium plays a key role in cell permeability phenomena and in the constitution of skeletons and shells [29]. In a given medium, calcium carbonate additives neutralize the acidity of the biotope and avoid the presence of toxic dissolved compounds [29]. However, above a certain threshold, calcium can be harmful to health [32].

Magnesium is a chemical element of natural origin (dissolution of rocks: magnesites, basalt, clay....) Or industrial. In freshwater, concentrations of Mg^{2+} are lower than those of Ca^{2+} [29]. However, it is an indispensable element to life. It is part of the skeleton of some organisms and plays a role more or less in breathing and photosynthesis. But it can be toxic in the form of chlorides or sulphates [32].

3.4 Nitrogen products
The results show that nitrate concentrations exhibit remarkable spatio-temporal fluctuations. The values range from 1.35 mg / l to 2.24 mg / l. In most other biotopes, maximum values are noted at the end of impoundment and are due mainly to the incomplete oxidation of ammonium ions favored, especially in summer, by a decrease in dissolved oxygen concentration.

The low concentrations observed are partly due to the process of ammonification favored by the important development of plants (algae) and the incomplete decomposition of organic matter. In addition, an increase in nitrates is related to nitrification reactions from nitrogen, through nitrous nitrogen. Conversely, a decrease reflects an ammonification phenomenon.

Moreover, the presence of nitrites in water indicates the pollution of this water. They are toxic to health [33, 34] and come, either naturally from the soil, or from pollution by chemical industry, or nitrogen fertilizers [35]. They characterize active eutrophication environments [29].

Similarly, nitrates can be harmful to health [36]. Indeed, nitrate intoxication can occur through enterohepatic metabolism due to nitrate to nitrites [36] oxidizing iron atoms in ferrous iron hemoglobin (2^+) in ferric iron (3^+), rendering it unable to carry oxygen [33]. This process can lead to a general lack of oxygen in the tissues of organs and a dangerous condition called methemoglobinemia.

4. Conclusion
In Morocco, there are different types of processes for the formation of natural temporary pools. These processes differ according to the geological nature of the support of the pond biotope. But, clayey, sandy, calcareous or dolomitic, basaltic or granitic, the tendency of the process of the natural formation of the pond, is carried out by a single principle of formation: an alteration of the mother rock by water erosion, éoloienne or chemical, and whose result is the same: progressive enrichment of the biotope by the clay.

Cerning the physicochemical characterization of the pond, for all the studied biotopes the temperature varies according to the seasons. They are low in winters, intermediate in spring or autumn and maximum in summer.

The pH is neutral to alkaline and its annual evolution could be related to the geological nature of the land and the amount of livestock excrement to feed or drink. The same evolution and the factors concern the conductivity, the dissolved organic matter and the dissolved oxygen, the nitrogen products.

For chlorides, calcium and magnesium hardness, and conductivity, due to the large dillution of the medium, the values or concentrations are low at the beginning of the flooded phase. But, when the quantity of the water of the pond under the effect of the evaporation or the infiltration of waters, proressively the values of these parameters tend to become higher.

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