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Research Article

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Abiotic factors of Thermal water: daily physicochemical indicators of the therapeutic quality of the new SPA of Moulay Yacoub Fes (Morocco).

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Abstract

The objective of this work is to evaluate the physicochemical quality of the thermal water, in the traditional pool of men, located in the urban community MoulayYacoub.

Thirteen physico-chemical parameters were monitored (temperature, pH, conductivity, Turbidity, Nitrites, Nitrates, Ammonium, Orthophosphates, Sulfates, chlorides and Hardnesses; total, calcium and magnesium) in a week on a daily basis for a period of three months ranging from March to May.

The results of the physico-chemical study show the good quality of this water. In return, the quality of the pool water has been poor to unfavorable especially during periods of high attendance which shows the potential risk run by spa guests.

Keywords: Thermalism, water, physicochemical quality, urban commune MoulayYacoub.

Introduction

The virtues of hydrotherapy have been known since ancient Greco-Roman times. Water sources have always been linked to the miraculous and beneficial properties of the Earth, and the use of natural hot and cold mineral water was an art of healing and living (Melillo, 1995). The thermal or thermo-mineral waters provide a privileged place in the cure of several diseases, these waters are characterized by their biological purity, the stability of their chemical composition and their therapeutic properties brought out by generations of clinicians. The ingestion of mineral water has effects on the metabolism of carbohydrates, lipids, minerals and dermo-cosmetics show real interest. The improvement of the health of the patients who make a spa treatment is manifested in osteoarticular, venous, gynecological, ENT, skin psoriasis, generalized anxiety disorder ... etc. (Roquesand*al*., 2009).

Morocco has a rich and varied thermal heritage in the various regions of the country: 117 thermal springs, of which 29 are listed, the waters are analyzed and pathologies determined (Benaabidate, 2000). Starting from this water privilege, spas in Morocco are

established and used for therapeutic purposes, they are indicated for chronic diseases, as an accompaniment to a conventional treatment or in prevention of complications of certain diseases(Bouraada and *al.*, 2019b). However, the qualitative situation of the waters is far from satisfactory. Even though surface waters are the most threatened by human activities, which diminishes the potential of good-quality water resources (El addoulianda*l*., 2009b), groundwater, which is often geologically protected, is also exposed to agricultural pollution. , industrial and / or urban (El addoulianda*l*., 2009a). A threat that can deteriorate the quality of the hot spring supposed to be beneficial at first. The situation becomes even more critical in the event of poor hygienic control in thermal establishments with the presence of patients with weakened immune systems, which constitutes a significant health risk. Indeed, work by Khayliand*al*., (2011) and Salameand*al*., (2013) have shown the presence of *Pseudomonas aeruginosa*, and other contaminating microorganisms, which could constitute a serious health risk affecting the health of spa guests.

I - Presentation of the region of study

The spa town of MoulayYacoub is located 25 km north-west of the city of Fes. It is part of the province of MoulayYacoub in the region Fes-Meknes. This province extends over a territory of 1700 Km². It is bounded by the province of Taounate, on the east and south-east by the prefecture of Fes (Bouraada et *al*., 2018a), on the south by the provinces of Sefrou and Elhajeb and on the west by the prefecture of Meknes and the province of SidiKacemESSAFI Mariam and *al*., 2019). This SPA is among the first establishment in Morocco that offers its visitors all the comforts to make the most of modern equipment.

The other SPA are operated in an artisanal way and mainly by a local and regional population (Bouraada and *al*., 2019c).

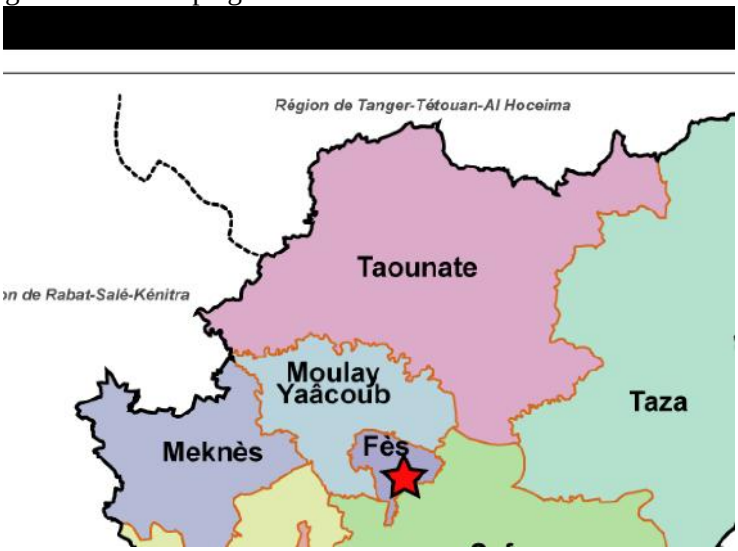

Figure 1: Location of the study station

Each thermal water has a specific curative identity, consequently, the cures at home have no interest and requires the displacement of the patient to achieve its treatment in situ to fully benefit from the virtues of this water (Traissac et *al*.,2006).

II- Material and Method

We conducted the collection of thermal water at different levels of the basin and at the source.

The samples were sampled at the source (P1) at the pool level (P2) and at the level of the evacuation point (P3).

The samples are collected from the various points selected in the men's pool in 1-liter flasks, their transport to the LRDEHM Laboratory(Regional Laboratory for Epidemiology and Hygiene in the Middle of Fes), is done by means of a cooler whose temperature is between + 5 and - 3 ° C. For the temperature, conductivity and pH, these parameters may change over time are measured in situ and the others are established in the laboratory.

III- Results and Discussion

Temperature (T°C)

Temperature plays a very important role in the solubility of salts and especially gases, it conditions the dissociation equilibria. The temperature, expressed in degrees Celsius (° C).

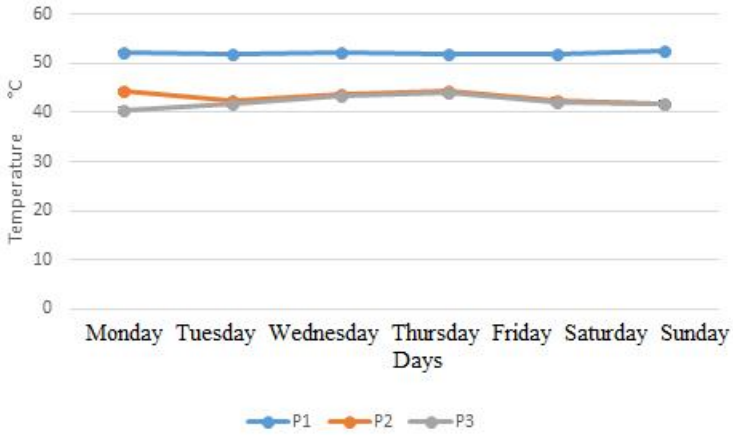

Figure 1: average daily variation in temperature in ° C

The average daily temperature variations at the MoulayYacoub men's traditional swimming pool show stability throughout the week for the three sampling points. For the variation of the temperature as a function of the different sampling points, the lowest mean value is that found at point P3 (42.25 ° C), followed by a slight difference of 1 ° C from point P2 (43.16 ° C) and finally, the point whose temperature is the highest; P1 pool source with a temperature of 51.1 ° C. This high temperature at the source, qualifies this water to be hyperthermal water. On the other hand, this gradient of temperature decrease from P1 to P3 is undoubtedly due to the dissipation of heat by contact with the air and bathers.

pH

The pH (Hydrogen potential) measures the concentration of H + ions in the water. It thus reflects the balance between acid and base on a scale of 0 to 14. This parameter characterizes a large number of physico-chemical equilibrium and depends on multiple factors, including the origin of water.

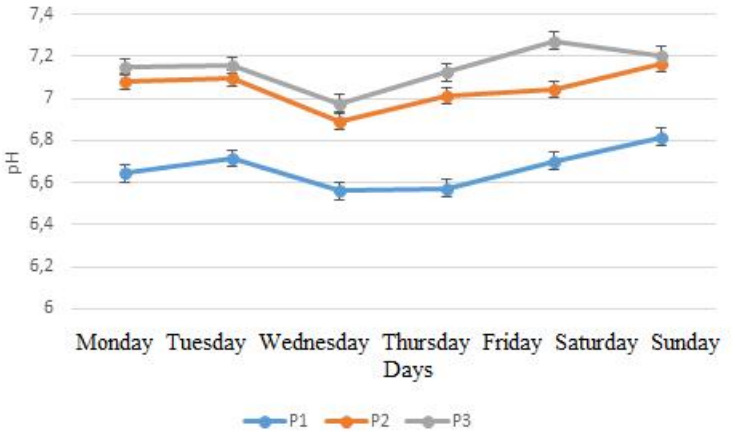

Figure 3: Average daily variation in pH

The pH noted does not show a significant variation of the three points during the week, except for two days on Wednesday and Friday when there is a small simultaneous decrease in the pH of the three points. For the average variation of the pH between the three points we notice a small increase which revolves around the neutrality from point P1 (pool source) whose pH leans weakly towards the acidity with a value of 6.66 approximately equivalent to that found by Benmakhlouf (2001), up to point P2 and then P3 which are more or less neutral. This increase may be due to the effect of bathers.

Conductivity

Conductivity measures the ability of the water to conduct the current between two electrodes. Most of the dissolved materials in the water are in the form of electrically charged ions. The measurement of the conductivity makes it possible to estimate the quantity of dissolved salts in the water.

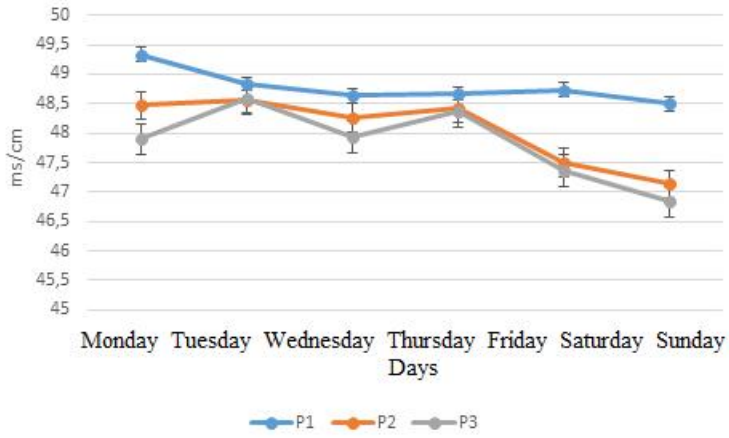

Figure 5: Average daily change in conductivity in ms / cm

The conductivity measurement revealed high values, whose variation for the P1 point is more or less stable during the week except for a small increase at the beginning, but for the other points we notice a small variation in the magnitude that is more apparent at the end of the week where there is a big decrease. The difference in conductivity between the three sampling points is small but detectable since there is a decrease from the source point P1 with 48.78 ms / cm to 47.83 ms / cm for P3. Since the electrical conductivity of natural waters is directly related to the formations of the geological lands traversed (Alayat, 2007), the discovery of mineralized high-mineralized metamorphic to metamorphic high-grade metamorphic metric extrusions justifies the high values found in this water (Lakhdar, 2007).

N.B: For these three parameters, temperature, conductivity and pH, they are measured in situ.

Turbidity

The measurement of turbidity makes it possible to specify the visual information on the water. Turbidity is the presence of particles suspended in water (organic debris, clays, microscopic organisms, etc.). The inconvenience caused by turbidity among users is relative because some populations are accustomed to consume water more or less cloudy and do not appreciate the qualities of a very clear water. However, high turbidity may allow microorganisms to attach to suspended particles.

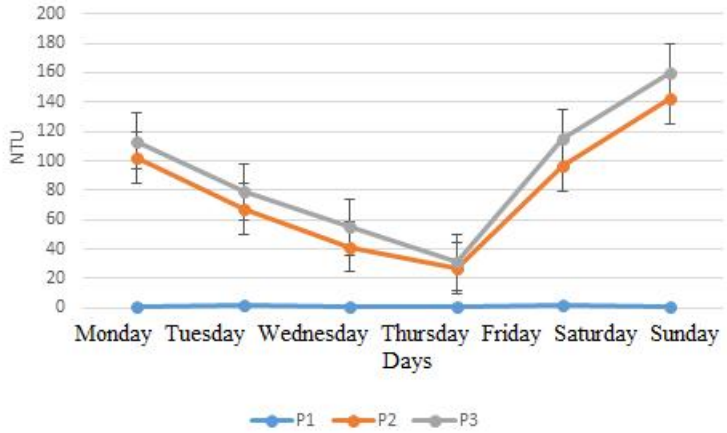

Figure 7:Average daily change in turbidity in NTU

Turbidity at the source is constant during the week, but for points P1 and P2 it is very large and suffered a remarkable fall in the middle of the week, which is more apparent for Friday (day of reopening after maintenance) and then raises to form a V by increasing on Saturday to reach a maximum value on Sunday, which can be explained by the high attendance in those days.

The variation between the different sampling points is very striking with a large difference between the source point P1 with 1.29 NTU clear water (<5 NTU) and the other points P2 and P3 whose high respective values are 79.48 and 92.36 NTU which represents a cloudy water (> 50NTU). This shows the contamination due to the external contributions of swimmers.

Nitrites NO2-

Nitrites are at the source of a low and constant content throughout the week. On the other hand this content increases at the level of the other points and varies considerably during the week by increasing at the beginning, then decreasing after, on Friday by taking lower values and then increasing again on Saturdays to reach maximum values on Sunday. which may be due to thermo-tolerant bacteria in relation to contamination due to the high rate of weekend use, such as E. coli whose enzyme reductase allows the use of nitrate NO3- as acceptor of electrons during anaerobic respiration transforming it into nitrite NO2- (Blasco et al., 1990).

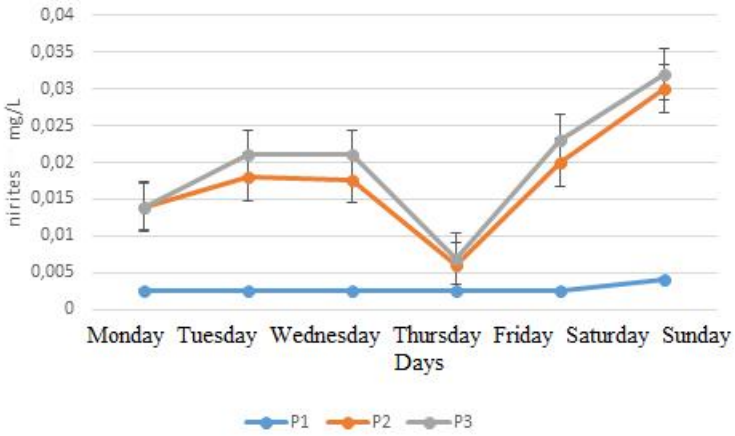

Figure 9:Average daily variation of nitrites in mg/L

Nitrates (NO3-)

Measuring nitrates makes it possible to detect their presence in groundwater, which may be due to fertilizers, septic systems, storage of fertilizers or diffusion systems (Rodier et al., 2009). For nitrates their daily frequency varies relatively, with lower contents for P1 but with a high rate for P2 and P3 which are close and varying in the same direction decreasing slightly on Friday and increasing on Saturday and Sunday.

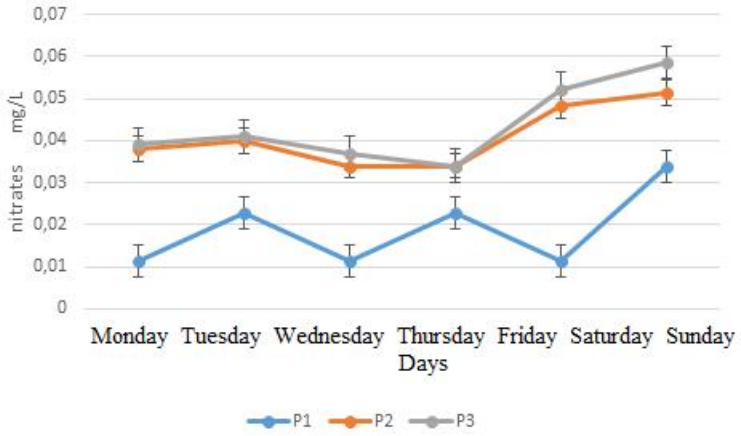

Figure 10:Average daily variation of nitrates in mg/L

Ammonium (NH4 +)

Ammonium is the main chemical indicator of direct pollution (decomposition of organic matter and urea) (Rodier et *al.*, 2009). The average ammonium content is very low and constant all week at the source P1. But for the other points their content varies in the same pace by decreasing after Monday to low values on Friday, then reaching maximum values on Sunday, which again bears witness to the contamination at the end of the week.

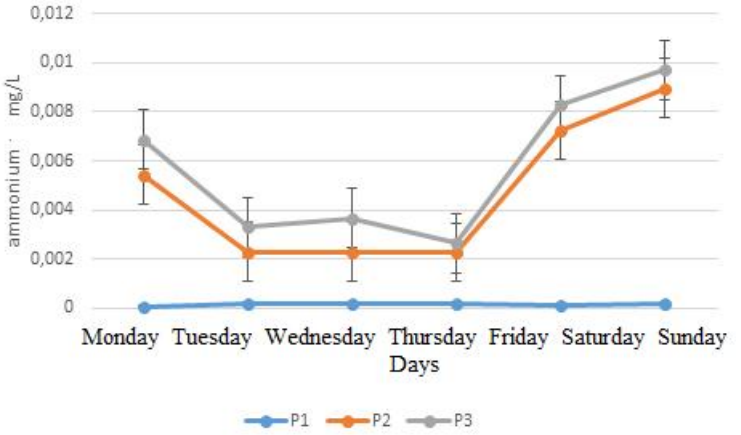

Figure 11: Average daily variation of ammonium in mg/L

Sulphates

The average sulphate content is stable for P1 during the week. However for the other points of the pool they vary considerably in the same pace as the contents of the previous substances with the lowest values recorded in the middle of the week, especially on Friday. However, its values remain very low compared to the maximum acceptable value in drinking water 250 mg / L (Rodier et *al.*, 1996) and that found by (Benmakhlouf, 2001) (38.4 mg / L).

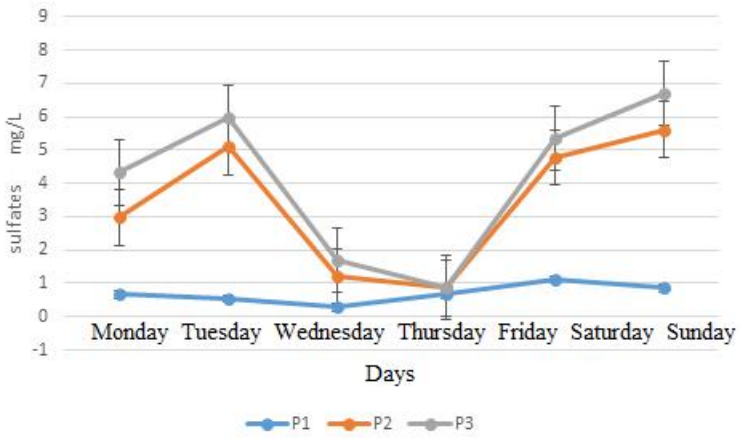

Figure 12: Average daily sulphate variation in mg/L

Orthophosphates

The presence of phosphorus in natural waters comes mainly from the use of detergents as well as the drainage of fertilized farmland. In general, phosphorus is not toxic to humans. Same principle for P1 which is weak and constant during the week in opposition to P2 and P3 which vary according to the gaits of the preceding curves thus showing the effect of frequentation. However, the maximum value at Sunday of 0.021 mg / L remains lower than the value of 0.5 mg / L above which its represents a pollution index (Rodier et *al.*, 1996).

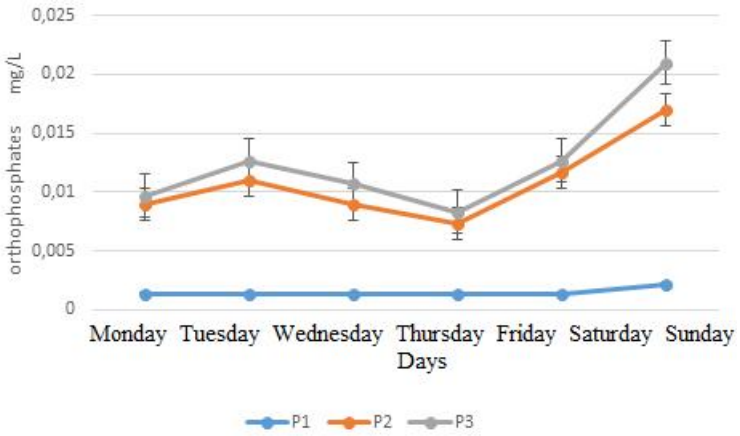

Figure 13: Mean daily variation of orthophosphate

The total hardness of the water

The total hardness of a water is the total concentration of calcium, magnesium ions and other bivalent and trivalent cations in this water. The calcium hardness of a water is the concentration of calcium ions in this water (Rodier et al., 1996). The total and more or less constant hardness during the week with variations between 66 and 73 mmol/L for P1 and lower values for P2 from 60 to 66 mmol/L and lower for P3 from 53 to 60 mmol/L . which may be due to the decrease in temperature which in turn decreases the content of dissolved salts which will tend to precipitate.

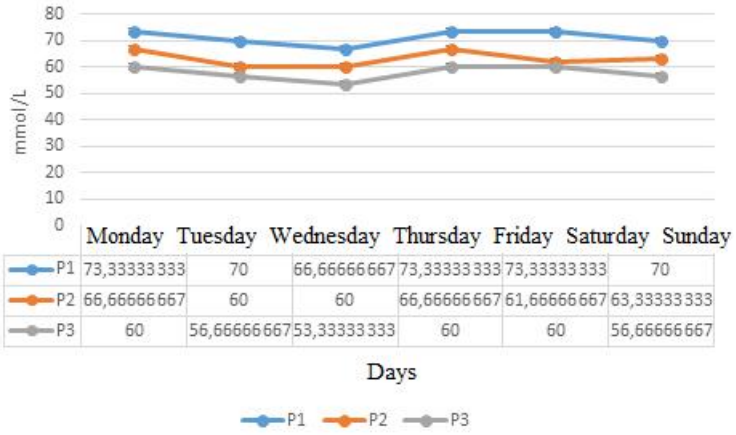

Figure 14:Average daily variation of total hardness in mmol/L

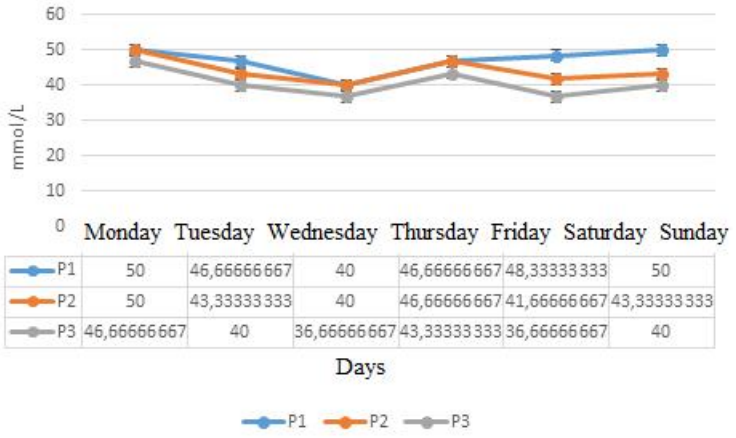

Figure 15: Average daily change in calcium hardness in mmol/L

The calcium hardness is still high for P1 throughout the week with values between 46 and 50 mmol / L which means between 1844 and 2000 mg / L of Ca2 + showing a great mineralization of this water that would be forbidden to people suffering from 'hypertension. For P2 and P3 the values are relatively lower and can also be explained by the decrease in temperature.

Chlorides

The chlorides are determined in neutral medium by a titrated solution of silver nitrate in the presence of potassium chromate. The chloride content generally shows high values ranging from 18908 to 19735 mg / L which is close to what was recorded by El Morabiti (2000) 18815mg / L, which bears witness to the reputation of MoulayYaâcoub water. to be a seawater with high salinity not consumable. However, for the other sampling points the levels increase more and especially at the end of the week, which can be explained by the sweat rate added in the pool water alongside other products used by the high number of visitors. weekend.

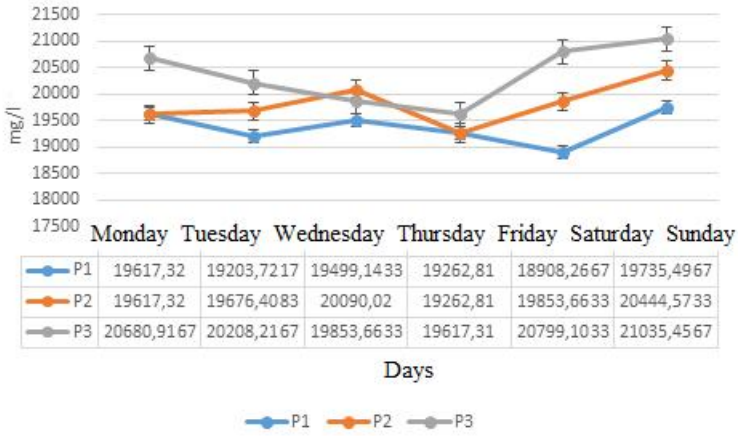

Figure 16 : Average daily variation of chloride in mg/L

Conclusion

According to these results, the physicochemical composition shows that this natural mineral water is rich in mineral elements which explains its beneficial healing properties, with nutrient values based on nitrogen (nitrite, nitrates and ammoniums).) and phosphorus (orthophosphate) and similarly for sulphates which do not exceed the maximum allowable values. However this water is particularly forbidden to people with hypertension because of the high degree of dissolved salts (chlorides, etc ...).

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