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Quantitative analysis of mineral matter by atomic absorption spectrometry of two water sources in Fokontany Irodo of North-East Madagascar

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SUMMARY:

The quantitative analysis of six (06) mineral elements (Ca, Mg, Cr, Zn, Cu, Fe) in the water samples of the Fokontany of Irodo (E_1 (water of Tegnan'Irodo) and E_2 (water of Bemagaro)) allowed us to confirm to meet the drinking water standards established by the World Health Organization in 2006 (*), the drinkability of water malagasy.et of the European Union. The results of the laboratory analyses confirmed that the average value of mineral concentrations in the E_2 water samples was lower than that of the E_1 water samples. Notably, the highest calcium concentration was visualized in E_1 at 13.6 mg. L^{-1} and 12.8 mg. L-1 for magnesium. Iron concentrations were the least visualized in both water sources but in low amounts detected in E_1 at 5.10-2 mg. L^{-1} versus E_2 (0.82 mg. L^{-1}). Local residents of Irodo can drink both water sources, but the recommended daily water is Tegnan'Irodo water because of its very high concentrations of calcium and magnesium.

Keyword: mineral elements, water source, Fokontany Irodo

I. INTRODUCTION

A population of 4.5 billion and represents 60% of the world's population, of which 115 countries including Madagascar benefit from the project to support access for all to sustainably managed water and sanitation services, and to eradicate open defecation by 2030 (**WHO, 2019**).

According to **Frappie (2003), AAE (2018),** water is the most widespread mineral substance on the surface of the globe, which constitutes the hydrosphere. Its volume is estimated at 1,360 million km^3 worldwide. It is constantly needed, not only for agriculture and industry, but above all for the population for

reasons of hygiene and public health. Even if the water we use for drinking or washing seems clear and pure, it should always be analyzed (**Skoog *and all*., 2015; WHO, 2019**).

Atomic absorption spectrometry is an analytical technique for quantifying chemical elements in solution. Each element has a specific number of electrons associated with its nucleus. The normal and most stable orbital configuration of electrons is called the base state.When energy is supplied to an atom, the latter absorbs it and adopts an electronic configuration called the excitation state (**Dinert (1972)**; **Belarra *and all*., 2002; L'vov (2005); Maurice (2015), Andriamaherina (2021)**.

In Madagascar during the last eleven years (2011 to 2021), this analysis technique is highly developed in the physico-chemical field for researchers, applied to the biotope environment (water, soil, and rock), biocenosis (animals, plants), industrial products (food, cosmetics).

Attached are some partial examples of the results of Malagasy researchers listed. **Andrianjarany (2011)** made the physico-chemical study of aqueous extracts of green clays for use in cosmetology. **Be (2013)**, to be analyzed on trace elements and mineral elements in vanilla pods of the SAVA Region using total reflection X-ray fluorescence techniques of atomic absorption and ion chromatography. **Vangay (2014)** to work on a physico-chemical study of the viticultural soil in four localities of Madagascar. In 2017 and 2018; Nadia (2017), to study on the development and validation of a method for the determination of lead in plant matrices by atomic absorption spectrometry; **Razafindrabe (2018)** performed an analysis of lake waters using spectrometic techniques. **Andriamahenina (2021)** to explain the development of software by validation of analytical method and application on lead analysis by atomic absorption spectrometry.

This topic concerns the quantitative analysis of mineral matter by atomic absorption spectrometry of two sources of water consumed by the population in Fokontany Irodo, Rural Commune of Ankarongana, DIANA Region, Province of Antsiranana, Madagascar. So far no author has yet carried out a quantitative analysis of the water in this Fokontany.

The objective of this study is to determine the determination of various mineral elements in water extracts using Atomic Absorption Spectrometry (AAS). These mineral elements are: Calcium, Magnesium, Iron, Copper, Chromium and finally Zinc.

In order to carry out this study, the materials and methods will be explained in the second part. After the results and the discussion will be included in the third part. We will conclude with the conclusion.

II. MATERIALS AND METHODS

II.1 Materials used in the laboratory

During the quantitative analysis of mineral material in the laboratory, the materials are Varian Spectre AA 240 (Z and F) atomic absorption spectrometers, a printer, an office computer, a thermostat and water samples (E_1 and E_2) (**Photo 1**).



I **Photo 1**: Atomic Absorption Spectrometry Chain (**Author, 2022**)

The AA240 Z spectrometer with Zeeman spectral correction contains the following:

- a GTA120 atomizer with a graphite tube;

- and an electrothermal generator and a power box for 4 ca-thode lamps but only 2 lamps were used for zinc and chromium. Then the Neslab-Merlin M 33 thermostat is used at the same time to detect the temperature during the analysis.

II.1.2 AA240 F (Fast Sequential Absorption Spectrometer)

The AA240 F Spectrometer (Fast Sequential Absorption Spectrometer) equipped with a burner with a 4-inch slot and a power box for 4 cathode lamps (Ca, Mg, Fe and Cu).

II.2 Methods

Two different methods used during the analysis, the first of which is **F**lame **A**tomic **A**bsorption **S**pectrometry (**FAAS**) and the second is **G**raphite **F**urnace **A**tomic **A**bsorption **S**pectrometry **(GFAAS)**.

II.2.1 **FAAS**

The determination of iron, calcium, magnesium and copper is carried out using the flame atomic absorption spectrometric technique.

❖ Procedures

The sample is drawn through a nebulizer, using a capillary tube, to a flame where the metals present are reduced to their ground state. The beam of a hollow cathode lamp containing the metal to be dosed is directed towards the flame where the metal present absorbs the energy of the lamp in proportion to its concentration.

II.2.2 **GFAAS**

The determinations of chromium and zinc are made using the technique of atomic absorption spectrometry in the graphit furnace.

❖ Procedures

The sample is placed in a capsule placed on an autosampler. A drop of the sample (15µl) is deposited on a graphite tube which is gradually heated to evaporate, calcinate, volatilize and atomize the metals present in the sample. The beam of a hollow cathode lamp containing the metal to be dosed is directed through the graphite tube and the volatilized and atomized metal absorbs the energy of the lamp in proportion to its concentration.

III.RESULTS AND DISCUSSION

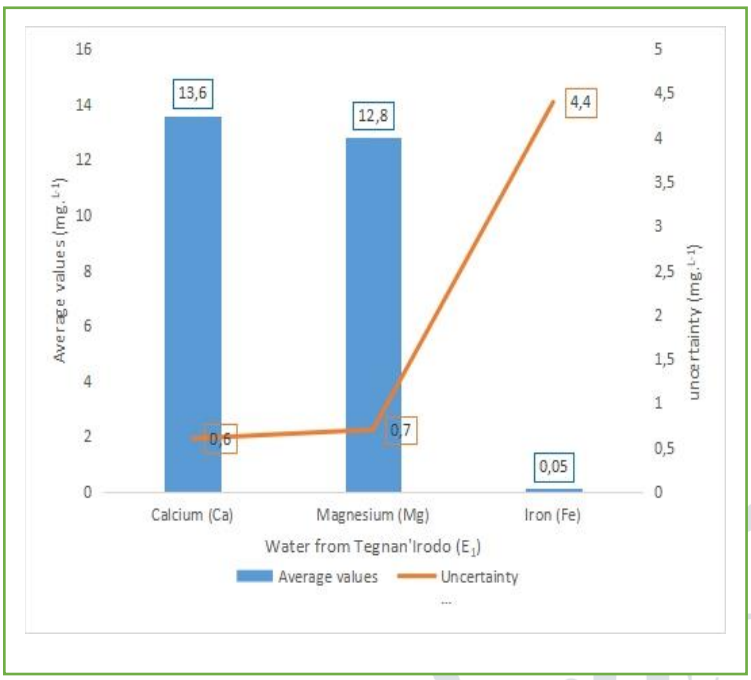
III.1 Results

The results of the quantification of the six (06) target mineral elements (Ca, Mg, Cr, Fe, Cu, Zn) in the two sources of water E_1 and E_2 are as follows:

- Referring to **Figure 1** below, numbers 1 to 2 indicate the calcium, magnesium and iron test results for water samples (E_1 and E_2). Number 1 confirms the quantification of these three mineral elements for Tegnan'Irodo spring water, and number 2 details the situation for Begaroo spring water. -Notably, the highest calcium concentration has been visualized in E_1 at 13.6 mg. L^{-1}. On the other hand, the magnesium concentration is the most dominant in E_2 with 6.9 mg. L^{-1}. Iron concentrations were the least visualized in the two water sources but in low amounts detected in the E_1 at 0.05 mg. L^{-1} versus E_2 (0.82 mg. L^{-1}).

➢ Hence E_1 has a higher concentration of mineral elements compared to E_2, but iron concentration is more dominant in E_2. Compared to the two samples (E_1 and E_2), Tegnan'Irodo water contained more calcium and magnesium than Begagavo water. These two mineral elements are very useful for the functioning of the human body. On the other hand, it contains less iron than the other, which is useful for the growth of plants and animals. These three elements are therefore beneficial to the health of all living beings and to the growth of plants.

➢ About uncertainty, iron marks the high level of uncertainty with respect to the three target elements is 57.3 mg. L^{-1} in E_2 is 4.4 mg. L^{-1} in E_1. For calcium and magnesium, the value of the detected uncertainty is less than 1 mg. L^{-1} in E_1 and E_2.



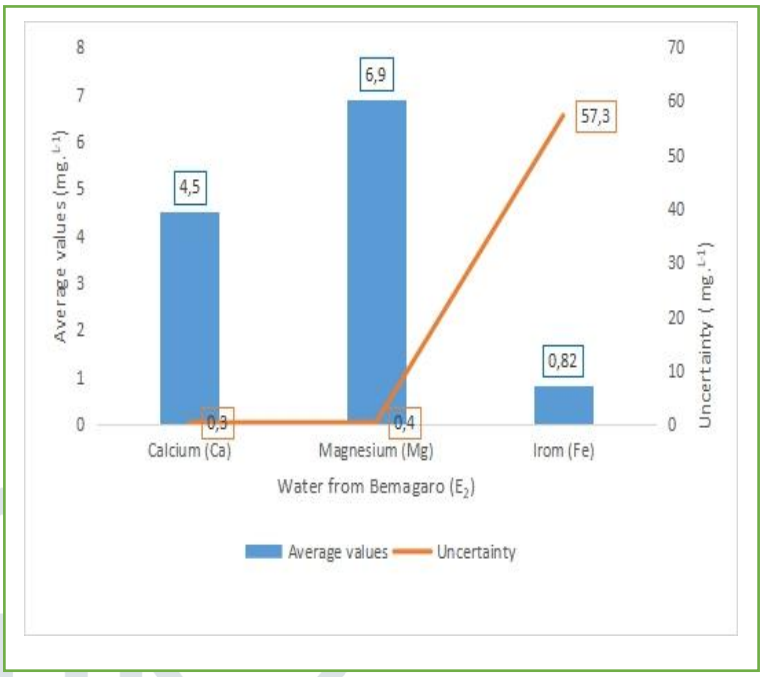


Figure 1: Analysis results of the two samples (E_1 and E_2) on calcium, magnesium and iron

- The same concentrations of chromium, copper and zinc are less than 5.10-3 mg. L^{-1}, 10-2 mg. L^{-1} and 3.10-3 mg. L^{-1}. It can be said that these three elements can be detected in the minor state in both cases for both samples (E_1 and E_2).

- For the villagers of the Rural Commune of Ankarongana, the preference is to consume the water of Tengan'Irodo than the water of Bemagaro, given the dissimilarity of the concentration results they contain and the beneficial contributions on biodiversity.

III.2 Discussion

Table 1: comparison of E_2 results with WHO (2006) (*) drinking water standards (*), Malagasy water and the European Union in 2020.

		Water from Tegnan'Irodo						
Parameter	Unity	Valeurs moyennes	Average values WHO limit values on drinking water	Observation	Malagasy water drinking water standard	Observation	European drinking water standard (OJEU, 2020)	Observation
Calcium (Ca)	$mg.L^{-1}$	13,6 ± 0.6	VNF		200	Satisfying	VNF	
Magnesium (Mg	$mg.L^{-1}$	12,8 ± 0.7	VNF		50	Satisfying	VNF	
Chrome (Cr)	$mg.L^{-1}$	$< 5.10^{-3}$	0,05	Satisfying	5.10^{-2}	Satisfying	5.10^{-1}	Satisfying
Iron (Fe)	$mg.L^{-1}$	0,05 ± 4.4	VNF		5.10^{-1}	Satisfying	2.10^{-1}	Satisfying
Copper(Cu)	$mg.L^{-1}$	$< 10^{-2}$	2	Satisfying	1	Satisfying	2	Satisfying
Zinc (Zn)	$mg.L^{-1}$	$< 3.10^{-3}$	3	Satisfying	5	Satisfying	VNF	

Table 2: comparison of E_2 results with WHO (2006) (*) drinking water standards (*), Malagasy water and the European Union in 2020.

		Water from Bemagaro						
Parameter	Unity	Valeurs moyennes	Average values WHO limit values on drinking water	Observation	Malagasy water drinking water standard	Observation	European drinking water standard (OJEU, 2020)	Observation
Calcium (Ca)	$mg.L^{-1}$	4,5 ± 0.3	VNF		200	Satisfying		
Magnesium (Mg	$mg.L^{-1}$	6,9 ± 0.4	VNF		50	Satisfying		
Chrome (Cr)	$mg.L^{-1}$	$< 5.10^{-3}$	0,05	Satisfying	5.10^{-2}	Satisfying		Satisfying
Iron (Fe)	$mg.L^{-1}$	0,82 ± 57.3	VNF	Satisfying	5.10^{-1}	Satisfying		Satisfying
Copper(Cu)	$mg.L^{-1}$	$< 10^{-2}$	2	Satisfying	1	Satisfying		Satisfying
Zinc (Zn)	$mg.L^{-1}$	$< 3.10^{-3}$	3		5	Satisfying		

If we refer to **tables 1 and 2** above, compared to the values set by the WHO (2006) (*), the water potability standards of Madagascar and Europe, the results of studies state that:

- In E_1, whose concentration found for Zn < at 3.10^{-3} is much lower than 3 mg. L^{-1} and 1 mg. L^{-1}; Cr < at 5.10^{-3} is well below 5.10^{-2}mg. L^{-1} and 50 mg. L^{-1}; Cu < at 10^{-2} is well below 2; Fe is 5.10^{-2} much lower VNF and 5.10^{-2} mg. L^{-1}; Mg is 12.8 with VNF and 50; It's 13.6 with VNF and 200.
- Regarding E_2, whose concentration found for Cr < at 5.10^{-3} is well below 5.10^{-2} mg. L^{-1} and 50 mg. L^{-1}; Fe is 0.82 much lower VNF and 5.10^{-2} mg. L^{-1}; Cu < at 10^{-2} is well below 2; Zn < at 3.10^{-3} is well below 3 mg. L^{-1} and 1 mg. L^{-1}; Mg is 6.9 with VNF and 50; It's 4.5 with VNF and 200.

Then, the two water samples check the drinking water potability standards set by the WHO (2006) (*), Malagasy water potability standards and the European Union.

On the other hand, if we refer to the study carried out by **Razafitsiferana (2007)** on the physico-chemical analysis of the water of Lake Ampombilava de Nosy bé, stated that the two lakes studied (Lake Ampombilava (east coast) and Lake Ampombilava (northeast coast)) whose calcium concentrations are 31.4 mg. L^{-1} and 30.2 mg. L^{-1} for these two lakes and for Iron concentrations are 38 mg. L^{-1} and 37.2 mg. L^{-1}. Compared to the calcium and iron concentrations identified in this study, there is a decrease in concentration compared to the current study by **Razafitsiferana (2007**). This decrease could indicate that the concentration of these mineral elements varies according to the target environment to be studied. Regarding the concentration of chromium according to **(OJEU, 2020),** the parametric value for chromium currently remains at 50 µg. L^{-1}. From 12 January 2036, this value will change to 25 µg/l.

IV. CONCLUSION

The six mineral elements detected in the two water sources (E_1 and E_2) of the Fokontany Irodo follow the drinking water potability standards set by WHO, 2006 (*), Malagasy water potability standards and European Union for the elements calcium, magnesium, chromium, zinc and copper. On the other hand,

given the different concentrations obtained, compared with studies carried out previously by different authors, the concentrations obtained show that the water sampled contains a small quantity of useful elements for men. Then in terms of agriculture and health, the E_1 sample (Tegnan'Irodo water) is recommended to be used in the Rural Commune of Ankarongana for the living beings who use it.

V. ACKNOWLEDGMENTS

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