



(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



## Impact Factor: 8.699

## Volume 14, Issue 5, May 2025

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405020|

## Evaluation of the Physical Quality of Well Water in the District of Ambilobe and JIRAMA Water of Antsiranana-I, D.I.A.N.A Region, Madagascar

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**ABSTRACT**: There are many problems related to drinking water, but the most well-known are pollution and depletion of drinking water. The study of the physical parameters contained in well water in the district of AMBILOBE and tap water JIRAMA of ANTSIRANANA I remains a relevant research topic related to water consumption in Madagascar, as well as its quality. The DIANA region is one of them. Very few people have benefited from drinking water, which is necessary to assess their potential impact on public health. This study aims to assess the quantity of physical parameters contained in well water in some DIANA regions, more precisely in the district of AMBILOBE and ANTSIRANANA-I. The analysis was carried out by ion chromatography at the INSTN-Madagascar laboratory. Well water and tap water samples were taken at different sites, including the district of AMBILOBE and water JIRAMA of ANTSIRANANA I. Several categories of physical parameters were identified in the samples: pH, temperature, conductivity, dissolved oxygen, turbidity, and ions (fluoride, chloride, nitrate, and sulfate). Concentrations varied significantly depending on the water sampling points. This study highlights that the pH values of the samples are outside the imposed standards, and the turbidity of the MATIAKOHO well water is well above the standards imposed by the competent authorities. This highlights the importance of vigilance by consumers and regulatory authorities.

KEYWORDS: Well water, Tap water, Physical parameters, and Ion chromatography.

## I. INTRODUCTION

In African countries, access to improved water sources is less than 50% [10]. As part of the African country, Madagascar is close to 30 to 35 % in terms of access to drinking water. The Malagasy population is still faced with a low rate of access to drinking water [12]. For this, the Malagasy State has adopted for several years the policy of supply and conveyance of drinking water for the population, especially for rural areas which do not have access to water from JIRAMA [10]. It is seen through the ramifications of numerous projects which affect water management [1]. In this case, the study of water quality is necessary to ensure its potability [7]. Only about 10% of the population of the ANTSIRANANA agglomeration have a private connection to the drinking water network, the rest mainly draws from the various public standpipes installed in all districts of the city [9]. A large part of the population therefore uses wells to meet their daily water needs [11]. The main problem related to water consumption in Madagascar concerns both its quality and its quantity [8]. Then comes the importance of rational management of water resources in all regions of the island [6]. Very few people have benefited from drinking water [5]. The DIANA region is one of them.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025

## |DOI: 10.15680/IJIRSET.2025.1405020|

## **II. METHODOLOGY**

## 1. STUDY SETTING

Our study took place at the National Institute of Nuclear Science and Technology (INSTN-Madagascar), University of ANTANANARIVO ANKATSO. Samples will be collected in two districts of the DIANA region: ANTSIRANANA I district and AMBILOBE district. The analytical results must be comparable to the standards established by the Malagasy Ministry of Public Health and the World Health Organization.



Fig 1: Potential sampling map

## 2. SAMPLING AND DATA COLLECTION

## 2.1 Sampling Equipment

The following equipment was used during the sampling phase:

- Digital camera (Canon EOS 750D) to document the samples,
- GPS receiver (Garmin eTrex 30x) to record the geographic coordinates of the sampling points,
- Containers: Plastic containers (virgin crystalline bottles) were used.
- Powder-free nitrile gloves for sample handling,
- Labels and permanent markers for sample identification.

## 2.2 Sampling Strategy

The sampling strategy plays an important role in the conduct of a given research project. We chose probabilistic methods. This probabilistic method aims to collect samples that are as representative as possible of the study population. Water will be sampled from 10 sites in November 2024.

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025

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Sampling locations	Depth (in meters)
MATIAKOHO	14 m
ANORONALA	15 m
ANJARIDAINA	5 m
AMBATOBE	10 m
AMBAKIRANO CENTRE	10 m
AMPASINDAVA	15 m
MANTALIMARO	16 m
EPP BETSIAKA	5 m
CEG BETSIAKA	6 m
DIEGO-SUAREZ	Tap water

Table 1: Well Depth (in meters)

2.3 Instrumentation and spectrometric analysis



(a)



(b)

Fig. 2. 2100A Turbidimeter (a) HANNA Multiparameter (b)

Samples in bottles, tightly closed to prevent contamination or leakage. The time between collection and laboratory analysis to avoid potential sample deterioration is 72 hours.

2.4 Standards by competent entities for drinking water

Standards have been established, which notably set the maximum levels not to be exceeded for a certain number of harmful substances likely to be present in water.

Table 2. Standards by Competent Entities [4] [2]	Table 2: Standards by 0	Competent Entities	[4]	[2]
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Entities	Temperature (°C)	Turbidity (NTU)	рН	Conductivity (µS/cm)	Fluoride (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)
Madagascar	< 25	< 5	6,5 à 9	< 3000	≤1,5	≤ 250	≤ 50	≤ 250
WHO	< 25	< 5	6,5 à 8,5	180 à 1000				

## **III. EXPERIMENTAL RESULTS**

Ten (10) samples were taken from different locations, such as the Antsiranana I district (North University of ANTSIRANANA I) and the AMBILOBE district (MATIAKOHO, ANORONALA, ANJARIDAINA, AMBATOBE, AMBAKIRANO CENTRE, AMPASINDAVA, MANTALIMARO, EPP BETSIAKA, CEG BETSIAKA), more specifically in the DIANA region. The results of these analyses show that they contain several elements such as fluoride, chloride, nitrate, sulfate, and physical parameters (Temperature, Turbidity, pH, Conductivity, and Dissolved Oxygen).

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405020|

3.1 Ion Chromatography analysis results

Table 3 shows the average water concentrations.

Collection site	Fluoride (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)
Diego-Suarez (UNA)	$0,053\pm0,01$	$6{,}39\pm0{,}39$	$0{,}54\pm0{,}01$	$2,\!06\pm0,\!02$
MATIAKOHO		$107,\!48 \pm 12,\!69$	$235{,}48\pm 6{,}67$	$23{,}22\pm0{,}87$
ANORONALA	$0,111 \pm 0,02$	$157,85 \pm 2,37$	$110,93 \pm 7,96$	$23,\!47\pm3,\!68$
ANJARIDAINA	$0,\!101 \pm 0,\!01$	$159,\!29 \pm 4,\!41$	$179,88 \pm 3,70$	$2,\!17\pm0,\!07$
AMBATOBE	$2,201 \pm 0,36$	$54,\!19\pm0,\!77$	$105,54 \pm 0,99$	87,91 ± 1,78
AMBAKIRANO CENTRE	$0,\!224\pm0,\!09$	$186,82 \pm 2,45$	$268,00 \pm 3,01$	$61,\!52\pm3,\!33$
AMPASINDAVA	$0,\!115 \pm 0,\!02$	$43,85 \pm 1,06$	$76,\!34\pm9,\!33$	$49,61 \pm 2,50$
MANTALIMARO	$0,\!128\pm0,\!08$	$166,78 \pm 8,88$	$35,75 \pm 1,68$	$335,\!68 \pm 10,\!49$
EPP BETSIAKA	$0,\!236 \pm 0,\!07$	$21,\!20 \pm 0,\!09$	$0,\!91 \pm 0,\!17$	$61,93 \pm 6,01$
CEG BETSIAKA	$0,\!049 \pm 0,\!01$	$13,51 \pm 0,87$	$13,\!79\pm0,\!03$	$9,76 \pm 2,73$

## Table 3: Ion Chromatography Analysis of Water Concentration (n=5).

The measured nitrate concentration is between  $0.54 \pm 0.01 \text{ mg/L}$  to  $268.00 \pm 3.01 \text{ mg/L}$ ; the standards by the competent entities require that the limit concentration is 50 mg/L. The chloride content found is between  $6.39 \pm 0.39$  to  $186.82 \pm 2.45 \text{ mg/L}$ , the concentration required for drinking water is 250 mg/L by Malagasy State. The measured Fluoride concentration is between  $0.049 \pm 0.01 \text{ mg/L}$  to  $2.201 \pm 0.36 \text{ mg/L}$ ; the standards by the competent entities require that the limit concentration is 1.5 mg/L. The sulfate concentration found ranged from  $2.06 \pm 0.02 \text{ mg/L}$  to  $335.68 \pm 10.49 \text{ mg/L}$ . The required concentration for drinking water is 250 mg/L, which is acceptable for human consumption.

3.2 Analysis results for physical parameters

Table 4 shows the physical parameters of the waters studied.

Table 4: Physical Parameters (n=5) of the Waters Studied.

Sampling site	pН	Temperature	Conductivity	Dissolved Oxygen	Turbidity
Diego-Suarez (UNA)	6,70	10,52°C	164 µS/cm	61,9 %	1 NTU
MATIAKOHO	5,71	11,23°C	726 µS/cm	50,7 %	8 NTU
ANORONALA	5,23	11,08°C	785 µS/cm	53,4 %	1 NTU
ANJARIDAINA	5,51	11,07°C	803 µS/cm	56,2 %	1 NTU
AMBATOBE	6,13	10,37°C	774 µS/cm	59,1 %	1 NTU
AMBAKIRANO CENTRE	6,22	10,92°C	1127 µS/cm	57,3 %	1 NTU
AMPASINDAVA	6,24	12,56°C	488 µS/cm	56,1 %	0 NTU
MANTALIMARO	6,15	11,15°C	1202 µS/cm	58,0 %	2 NTU
EPP BETSIAKA	6,46	12,11°C	390 µS/cm	57,2 %	3 NTU
CEG BETSIAKA	6,36	12,42°C	145 µS/cm	58,6 %	1 NTU

According to the analysis, we found the temperature is between  $10.52^{\circ}$ C and  $12.42^{\circ}$ C. The conductivity, in turn, its higher value at MANTALIMARO including 1202  $\mu$ S/cm and the lower content at CEG BETSIAKA including 145





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025

## |DOI: 10.15680/IJIRSET.2025.1405020|

 $\mu$ S/cm. The turbidity value of MATIAKOHO is 8 NTU, this value is much higher or other sampling point. The pH value found can be considered as unsatisfactory.

## **IV. DISCUSSIONS**

These results reveal that the water contains fluoride, chloride, nitrate, sulfate, and physical parameters such as pH, temperature, dissolved oxygen, and turbidity.

## - Case of Fluoride and Chloride

The fluoride concentration from AMBATOBE is  $2.201 \pm 0.36$  mg/L; the limit concentration is less than 1.5 mg/L, meaning the water is polluted. The chloride concentrations found are lower than the concentration required for drinking water in the Malagasy state, which is 250 mg/L; it is acceptable for human consumption.

#### - Nitrate and Sulfate Cases

The nitrate concentrations from DIEGO SUAREZ ( $0.54 \pm 0.01 \text{ mg/L}$ ), MANTALIMARO ( $35.75 \pm 1.68 \text{ mg/L}$ ), EPP BETSIAKA ( $0.91 \pm 0.17 \text{ mg/L}$ ), and CEG BETSIAKA ( $13.79 \pm 0.01 \text{ mg/L}$ ) are below the concentration limit of 50 mg/L, so the water is not polluted; however, the other sampling points have levels above the standards imposed by the competent authorities. The measured sulfate levels are all below the standards, which require the concentration limit to be less than 250 mg/L; therefore, it is acceptable for water intended for human consumption; except for water from MANTALIMARO, which has a concentration of  $335.68 \pm 10.49 \text{ mg/L}$ .

## - pH and Temperature

The pH values found at all sampling points are below 7; the water can be considered acidic, unsatisfactory for drinking water. According to the temperature values observed at all sampling points, which are below 25°C, the value is acceptable for drinking water.

## - Dissolved Oxygen and Turbidity

The dissolved oxygen levels are below the drinking water standard, requiring a limit value; the organic matter levels in the sample are acceptable for drinking water. The values found for turbidity, the water is clear, as they are below 5 NTU at all sampling sites; except for water from MATIAKOHO, which has a limit of 8 NTU.

#### - Conductivity Case

The conductivity of AMBAKIRANO Centre, which is 1127  $\mu$ S/cm, and of MANTALIMARO, which has a value of 1202  $\mu$ S/cm, are outside the range of the standard required for drinking water, respectively between 180 and 1000  $\mu$ S/cm, according to the World Health Organization.

## V. CONCLUSION

The former province of ANTSIRANANA suffers from a water shortage that is evident in the neighborhoods and its outskirts where it is developing. In fact, this provision is at the origin of the increase in population and the expansion of the city. The physical parameters of the analyzed water are poor for water intended for human consumption according to the standards required by the Malagasy State and the World Health Organization (WHO). These results underline the crucial importance of rigorous monitoring of metal contaminants in well water, particularly those intended for regular consumption. They also call for a better understanding of the sources of contamination and the implementation of effective hygienic measures to protect the health of regular users.

## ACKNOWLEDGMENT

I express my sincere thanks to Dr. Augustin RAZAFINDRAPATA and Mr. Georgial RAVOMANANA, particularly for their efforts, and a special thanks to the entire laboratory team for their spirit of solidarity and sharing.

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

## Volume 14, Issue 5, May 2025

## |DOI: 10.15680/IJIRSET.2025.1405020|

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