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Hydrogeological Study For The Integrated Management Of Water Resources In The Manombo Sub-Basin, Southwest Coast Of Madagascar

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Abstract: Seen the daily insufficiency concerning drinking water, an underground water prospecting campaign has been achieved in the Farming Township of Manombo since 2009 in order to nourish in water the local population. Seven drillings, implanted with the rotary methods on the mud in 2010, distribute along the coastline of the Southwest of Madagascar. Hydrogeology of the area inshore sandstone of the Big Island where the problem of availability in quantity of water and in water of quality be inherent in again. These results allowed us to give some propositions and recommendations permitting to facilitate the management integrated of the drinking water of Manombo of which the setting in work will be made in collaboration with the different entities and local populations concerned.

Key words: prospection, hydrogeology, pumping, hydrochemistry, drinking water, integrated management.

Résumé : Vue l'insuffisance quotidienne en matière d'eau potable, des campagnes de prospections hydrologique et hydrogéologique ont été réalisées dans le bassin versant de Manombo -Ranozaza englobant les Communes Rurales d'Ankililoaka et de Manombo, Sud-ouest de Madagascar depuis des années en vue de la gestion intégrée des ressources en eau en particulier l'alimentation en eau potable. Sept forages répartis le long du littoral sont implantés avec les méthodes rotary sur la boue en 2010. Ils ont fait l'objet d'essais par pompage et d'analyses hydrochimiques. Cette dernière campagne apporte des nouvelles connaissances sur l'hydrogéologie de cette zone côtière gréso-sableuse de la Grande Ile où le problème de disponibilité en quantité d'eau et en eau de qualité réside encore.

Les résultats ont permis de donner quelques propositions et recommandations permettant de faciliter la gestion intégrée de l'eau potable de Manombo dont la mise en œuvre sera faite en collaboration avec les différentes entités et populations locales concernées.

Mots-clés : prospections, hydrogéologie, pompage, hydrochimie, eau potable, gestion intégrée, ressource

INTRODUCTION

Water management remains an expressive challenge for developing countries, including Madagascar. The Malagasy population faces unequal access to freshwater, with the southern part of the island particularly affected by critical water scarcity due to its semi-arid climate. Currently, the rural commune of south Manombo, located in the Toliara II District of the Atsimo-Andrefana Region, is still classified among areas struggling to achieve the Millennium Development Goals (MDGs) and the National Water, Sanitation, and Hygiene Policy (PNEAH), which aims to increase the water supply rate to 50% by 2025.

Despite various studies and initiatives (Arthaud et al., 1990; 1991; HUMADA, 2009) undertaken by national and international organizations, the Franco-Malagasy association HUMADA has been leading a project since 2009 to provide freshwater to all villages in the commune by drilling wells and boreholes along the Manombo coastline. This project has revealed the presence of mineralized groundwater, indicated by the hard, brackish, and saline water, as well as drinkable water of acceptable quality for human consumption. Nevertheless, the water issue persists, as the demand for water continues to grow.

This situation highlights the need for a thorough understanding of the hydrogeology of the area, the implementation of appropriate groundwater exploitation methods, and the establishment of integrated water resource management (IWRM). This article presents the hydrogeological characteristics of the coastal aquifer system in the Manombo-Ranozaza watershed in southwest Madagascar, studies the adaptive practical employed by villagers to address water issues in their daily lives, and proposes an appropriate management strategy for the situation.

I. CONTEXT OF THE STUDY AREA

1. Geographic Situation

The Manombo-Ranozaza watershed is located in the Atsimo-Andrefana Region, within the Toliara II District. In addition to the coastal basin, it encompasses the rural communes of Ankililoaka to the northeast and Manombo-sud to the west along the coastline. The latter is situated 35 km north of the city of Toliara and extends for a length of 105 km. It is bordered to the north by the township of Befandefa and to the south by Belalanda.

The main villages in the commune line the coastline, including: Fiherenamasay, Tsifota, Tsiadamba, Tampolo, Ankaramifoka, Salary-sud, and Salary-nord (see Figure 1). These are fishing villages inhabited by the Vezo community.

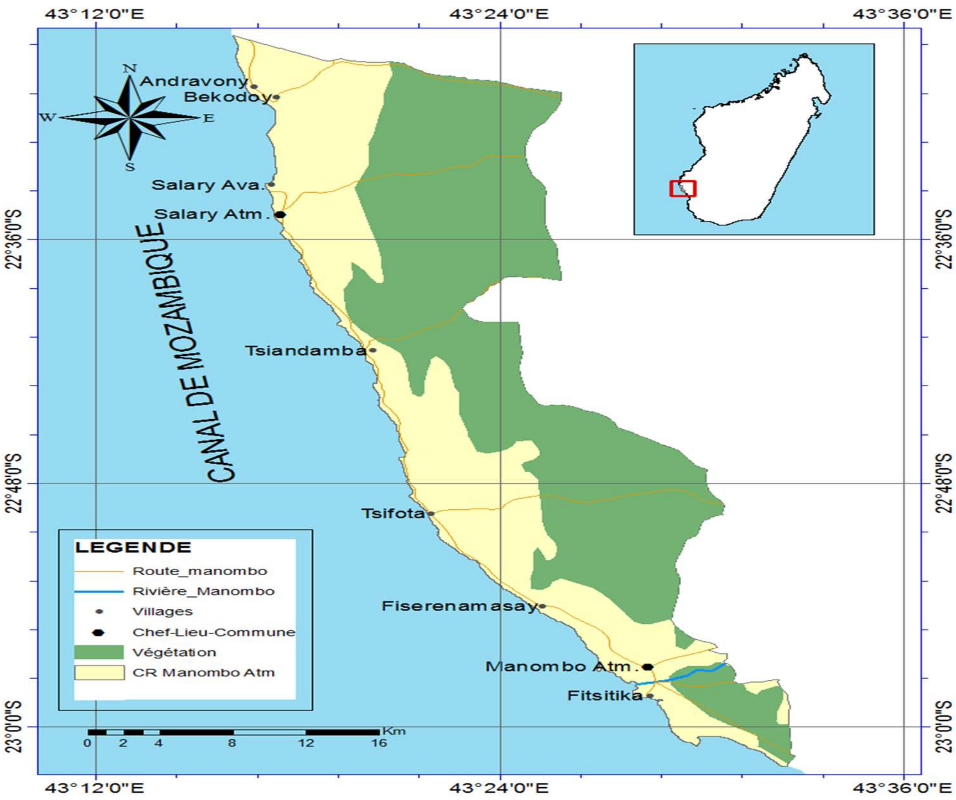

Figure 1: study area

2. Climatic Context

2.1 Temperature

In general, the study area experiences temperatures with low variations (the annual range is between 7° and 10°). The annual averages typically range between 23°C and 25°C. However, these values can drop below 20°C during the cool season, especially in July.

2.2 rainfall

The southwest region, including the rural municipality of Manombo, experiences a semi-arid climate that results in low precipitation. The values recorded from the two meteorological observation stations in Toliara and Morombe are below 460 mm. This precipitation can exceed this value within the Toliara II district. Rainfall gradually increases towards the northeast (from 300 mm to 600 mm) as one moves inland. The distribution of rainfall throughout the year follows a bi-seasonal pattern, with a « wet » season from December to February. The rainy season lasts an average of three months along the coastal strip, from December to February, with maximum precipitation occurring in January.

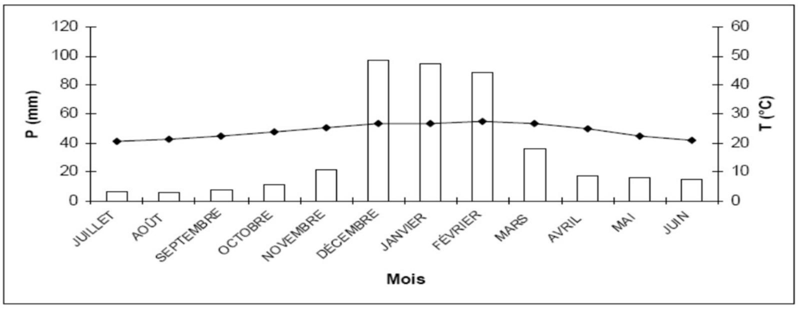

Figure 2 : Ombrothermic Diagram of the Study Area
(Source: Toliara Weather Station)

3. Hydrological and Hydrogeological Contexts

a. **Hydrology**

The Manombo River is the only hydrographic network running through the area. It originates from the Eocene Mahafaly karst plateau and drains a watershed with a surface area of 2,090 km². The river flows through the village of Manombo in an east-west direction. During flood season (December to mid-March), it divides the village of Manombo into the neighborhoods of Fitsitike and Tsihake. There are risks of flooding due to overflow, threatening these villages and disrupting economic activities in the region (agriculture, transport, tourism, etc.) during this period. The characteristic flows of the Manombo River are (UNDP, 2007):

- Maximum flood flow: 4 m³/s;
- Absolute low flow: 2.3 m³/s;
- Average monthly flow: 2.5 m³/s.

The area is also noted for the presence of saline lakes, with the main ones being Fiherenamasay at an altitude of 4.5 m, located 100 m east of borehole FSAY1, Ramangoa (see Figure 4), and Salary in the Mikea forest, located 1 km north of borehole SLD1, noted for its evaporite salt at the end of the dry season, referred to as « siratany » by local residents.

b. **Hydrogeology**

The study area is coastal. The presence of a seawater-freshwater aquifer system (Castany, 1998) cannot be ruled out. The contact between seawater and freshwater causes the aquifer layers to be brackish to saline, which the local population extracts via wells for their water needs (human consumption and livestock). In other locations, there are some shallower freshwater aquifer reservoirs (shallow water table) with low flow rates exploited by villagers. This phenomenon may be due to the presence of an impermeable formation or the freshwater-saltwater interface separating the contact between saline water and infiltrating water.

Moving away from the coast towards the east, three types of karst aquifers are encountered beneath the limestone cover:

- Eocene limestone with a free water table,
- Sandy sandstone or porous limestone (Cretaceous) with a free or semi-confined water table,
- Quaternary sand with a free water table.
  These aquifers can be directly exploited using wells and drillings.

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4. Geological and Pedological Contexts

a. **Geology**

The coastal area is primarily composed of limestones, marls, marly sandstones, and middle to upper Eocene sandstones. A large part of the area is covered by Quaternary sedimentary formations of various types (sands, silts, and clays), which are evidence of fluvial and/or aeolian sediment loads. Sandy shells and dunes cover sandy limestones, grés limestone, and Eocene dolomites. These latter formations constitute the most probable water reservoir zone. Marine deposits are dominant in the southern part of the area, while continental deposits predominate in the north. In the coastal plain, basalts from Cenozoic volcanism are present within the Eocene series (see Figure 3).

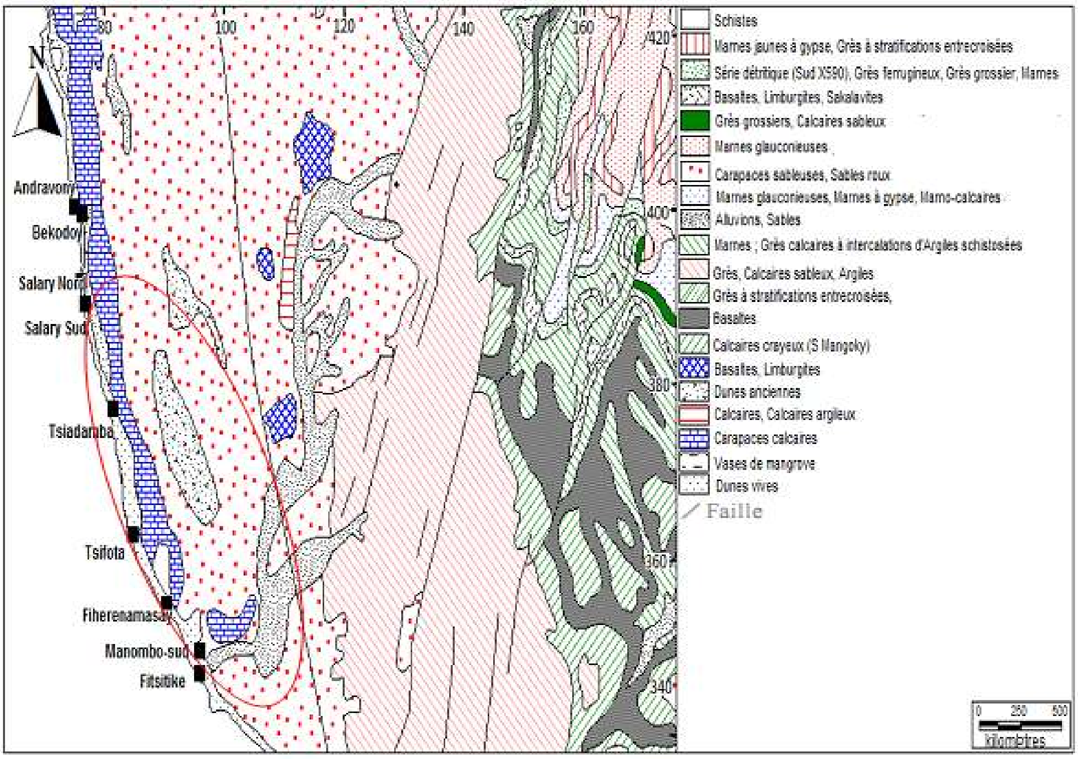

Figure 3: Geological Context of the Study Area

b.Tectonics

The area is bounded to the east by the Toliara fault, which is discordant with the one observable to the west of the Belomotra-Vineta Plateau (see Figure 3). A slightly discordant fault to the Toliara fault controls the upstream flow of the Manombo River. It develops in parallel directions N-S to NNO-SSE due to a more recent tectonic phase (Arthaud et al., 1993). Thus, this fault affects the entire area of the Mikea forest. Further east, the Eocene volcano-sedimentary formation is characterized by brittle tectonics in a NE-SW direction.

c.Pedology

The study area consists of sandy red soils classified as « clay-sandy cover »(Sourdat, 1972; Salomon, 1980). These are not true « red sands, » which fall under tropical ferruginous soils, but rather « pseudo-Mediterranean decalcified soils » that are highly permeable, with low water retention, very sandy and coarse texture, and clay and silt content below 10%.

II.METHODOLOGICAL APPROACHES

The evaluation, monitoring, and characteristics of available resources are conducted at water points deemed representative of the area. These points include wells and beholes. The field measurement of hydrodynamics characteristics is also used to accure a good result.

1. Description of the Groundwater Resource Monitoring Network

a.Monitoring at Traditional Wells

The inventory of water points in the area allows for the selection of fourteen (14) wells. Some physico-chemical and bacteriological tests have been carried out to characterize the existing aquifer system and its functioning, as well as the quality of the groundwater.

2. Monitoring at Boreholes

Drilling works extend along the coast in the rural municipality of Manombo. Seven (7) boreholes have been installed, four (4) for supplying drinking water to the municipality (HUMADA, 2009) and three (3) private boreholes. These boreholes are distributed across various villages: two (2) in Fiherenamasay (3.5 km from the village), two (2) in Salary-Sud in the Mikea forest, one (1) in Ankaramifoka in the Mikea forest, and two (2) 4 km from Tampolo. Some foreigners also have boreholes on their property.

The mud drilling technique was used for these water points. However, in the presence of hard formations like compact limestones, the compressed air drilling method was adopted. The analysis of cuttings allows for the establishment of drilling logs to determine the structure and geometry of the aquifer system.

These boreholes underwent blowouts and short-duration pumping tests, as well as long-duration pumping to characterize the existing aquifer system and its functioning. Hydrochemical and bacteriological measurements were taken for the physico-chemistry of the waters. Long-duration pump tests were executed after short-duration tests, using the maximum flows obtained for each borehole. All boreholes were pumped for over 24 hours, and drawdown measurements were taken regularly.

Existing Wells in the Study Area

Village	well	depth (m)	latitude	longitude	Débits	CE (uS/cm)	taste
Salary Nord	Puits N°1	7	S 22°33'27.7''	E 43°17'54.2''	2m^3/j	4680	brackish
	Puits N°2	2	S 22°32'45.0''	E 43°17'23.6''	0,5m^3/j	1250	Mild
	PuitsN° 3	3	S 22°33'47.4''	E 43°17'25.0''	1,2 m^3/j	3540	less brackish
Salary Sud	Puits N°1	2	S 22°34'49.1''	E 43°17'24.7''	1,2m^3/j	4320	less brackish
	PuitsN° 2	1,5	S 22°33'34.9''	E 43°17'30.5''	0,8m^3/j	3500	less brackish
Tsadamba	Puits n°1	2,5	S 22°41'53.0''	E 43°20'06.5''	2,5m^3/j	4570	brackish
	Puits N°2	1	S 22°41'53.0''	E 43°20'05.6''	1,6m^3/j	1380	Mild
	Puits N°3	1,5	S 22°41'26.6''	E 43°19'59.5''	2,2m^3/j	2800	Mild

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	Puits N°4	4	S 22°41'26.0''	E 43°20'03.2''	1,5m^3/j	9110	Salty
Ankaramifoka	Puits N°1	5	S 22°38'04.4''	E 43°18'24.0''	2,2m^3/j	12140	Salty
Ankazoberavina	Puits N°1	0,70	S 22°36'40.1''	E 43°18'07.0''	0,5m^3/j	1180	Mild
Tsifota	Puits N°1	3	S 22°49'28.0''	E 43°22'01.6''	2,8m^3/j	8330	Salty
	Puits N°5	1	S 22°49'21.2''	E 43°22'57.5''	1,2m^3/j	1800	Mild
Fiherenama-say	Puits N°1	1	S 22°54'02.2''	E 43°26'10.6''	0,8m^3/j	1110	Mild

Characteristics of Boreholes

Drillings	depth	*Altitude*	*Latitude*	*Longitude*	flow rates	*C.E*
FSAY1	25m	21m	S22°53'13,66"	E043°28'2,10"	12m^3/h	***1098uS/cm***
FSAY2	25m	21m	S22°53'15,8''	E043°26'71,0''	18m^3/h	***1080 uS/cm***
ANKFK	42.44	20m	S22° 38' 13.9''	E043° 20' 56.4''		***9000 uS/cm***
SLD1	29m	22m	S 22° 35' 38.0	E 043°20' 47.1''	7,5m^3/h	**3500µS/cm**
SLD2	29m	22m	S 22°35'35.9''	E 043° 20'54.5''	7,5m^3/h	***3605uS/cm***
TPL1	26,2m	20m	S 22°39'01,3"	E 043°21'11,7"	6m3/h	***4105 uS/cm***
TPL2	29,4m	20m	S 22°39'00,2"	E 043°21'15,1"	12m3/h	***3 505 uS/cm***

III. RESULTS AND INTERPRETATIONS

1. Geological and Structural Characteristics

The boreholes (see Figure 4) indicate that the area is composed, from west to east, of surface and subsurface formations made up of red sands, fine to coarse-grained sands, and limestones. The logs from the boreholes provide a hydrological cross-section or the structure of the aquifer system in the area (see Figure 4). The system exhibits a faulted structure. Various layers of permeable formations are observed, including sands, sandstones, and fractured limestones. The most promising aquifer layer is the sandstone. There is no impermeable layer, and not all boreholes are complete.

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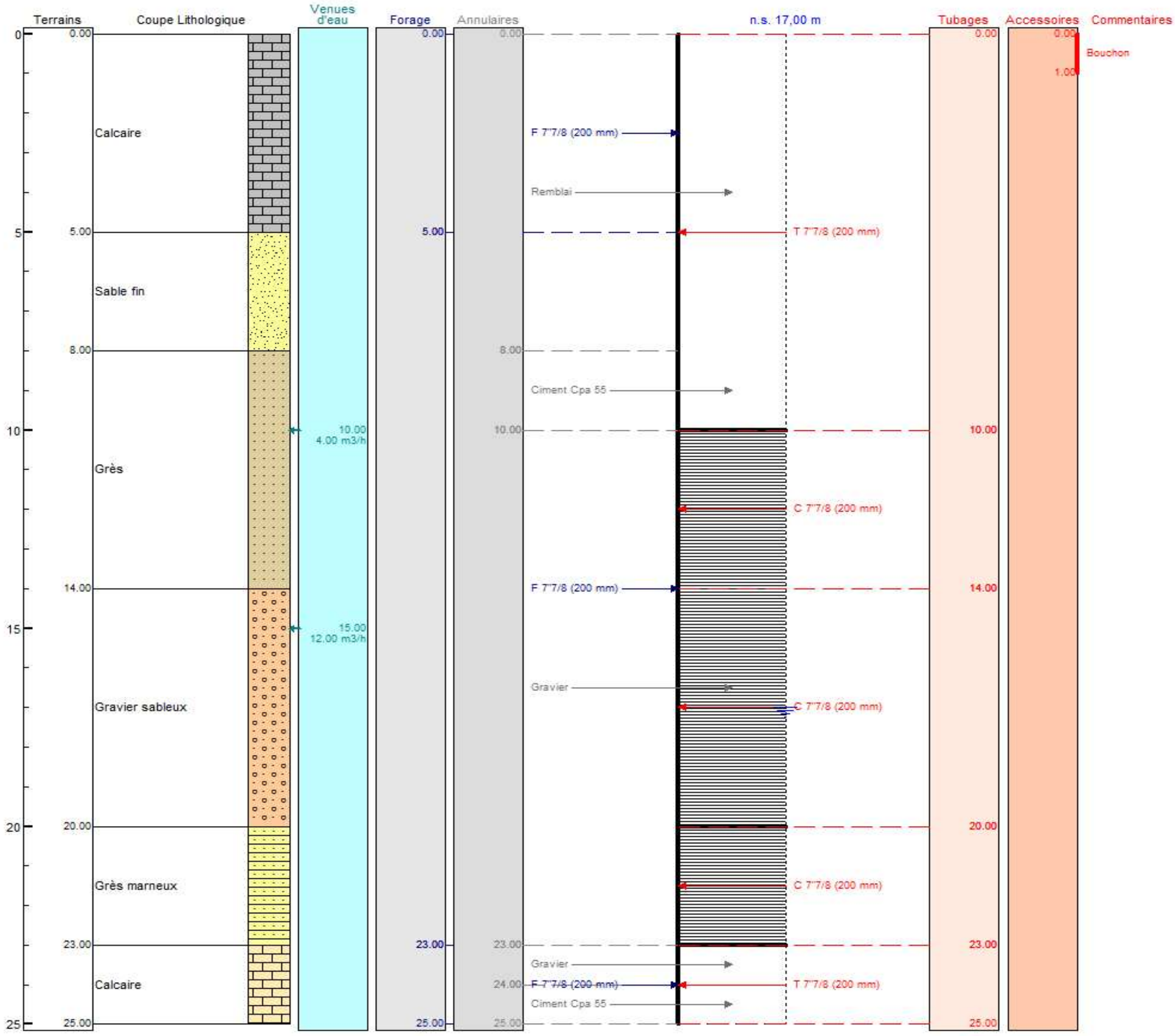

Figure 4: Example Borehole Logs

2. Characteristics of Groundwater in the Manombo Coastal Area

Regarding recharge, the shallow aquifer in the southwest coastal region of Madagascar has only about five months of replenishment per year, and rainfall is infrequent. The annual precipitation is critically low, leading to very low discharge rates from several wells throughout the year. From late April to October, there is almost no rainfall, causing an important drop in the piezometric levels of some wells.

In summary, the recharge of the aquifer accessed by the drillings occurs through the infiltration of surface waters, particularly from the Amboboka and Manombo rivers. This is enhanced annually by effective rainfall infiltration during the wet season, along with intercommunication between the existing aquifers in the area.

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3. Hydrodynamic Characterization

The borehole logs (Figure 4) indicate that the aquifer system in the Manombo sub-basin is a free aquifer, with the most promising water-bearing layer being the sandy sandstone. The piezometric map (Figure 7) reveals that the groundwater level in the Manombo coastal area is shallow, varying between 3 and 15 meters in depth.

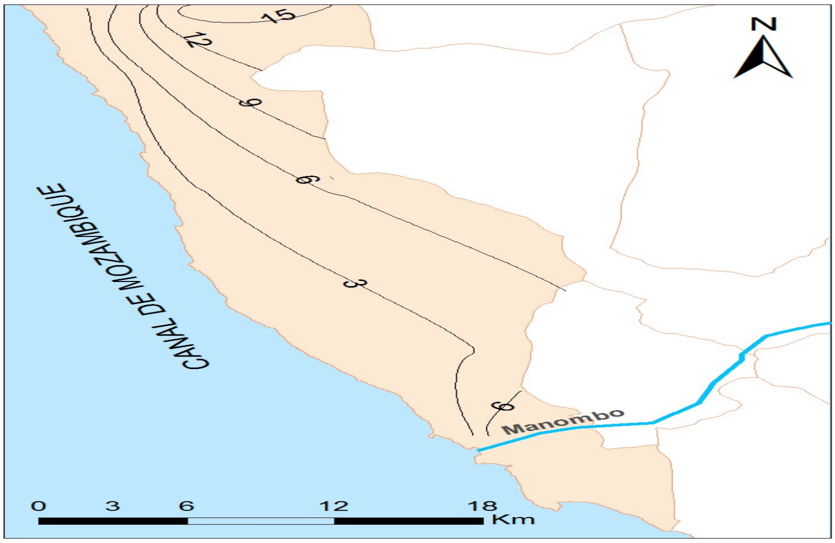

Figure 5: Piezometric Map of the Study Area

This aquifer system and the water table are characterized by several hydrodynamic parameters, including head losses, transmissivity, storage coefficient, drawdowns, extraction rates, and groundwater flow. Some of these parameters are derived from pumping tests.

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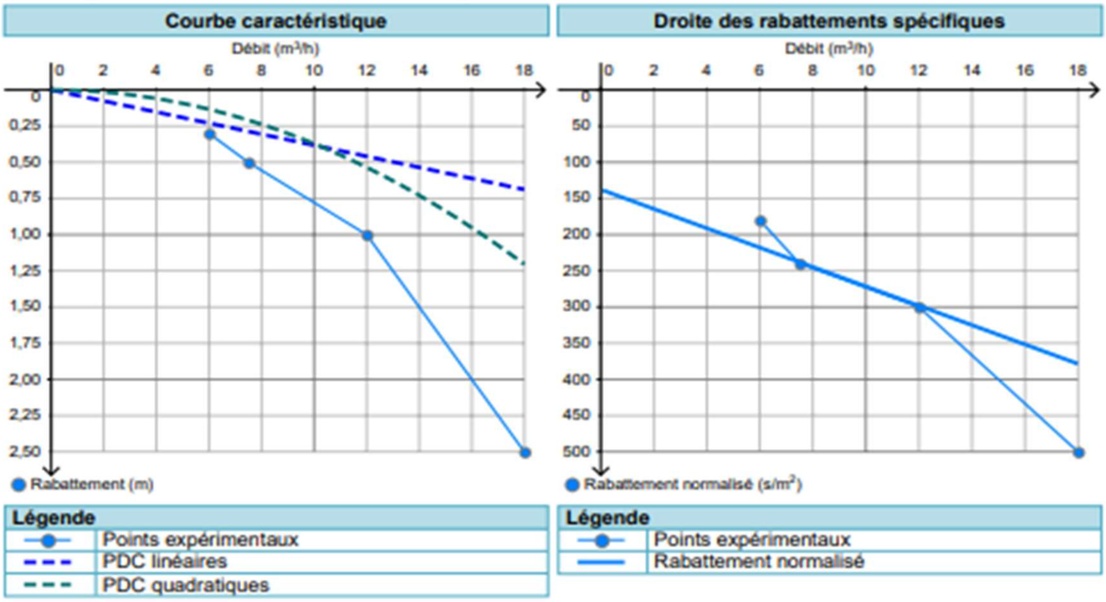
a. Multi-step pumping test

Site	Littoral nord de Toliara	Aquifère capté	Alluvions
Date	12/10/2011	Epaisseur de l'aquifère	8 m
Projet	AEP littoral Manombo	Type d'ouvrage	Puits
Client	Maherisoa	Type de pompage	Paliers de débits non enchainés
Société	REVA		



Pompage par palier	Débit (m³/h)	Rabattement mesuré (m)	Temps de pompage (min)	Temps de remontée (min)	Rabattement linéaire calculé (m)	Rabattement quadratique calculé (m)	Rabattement normalisé mesuré (s/m²)	Rabattement normalisé calculé (s/m²)	Écart (sim-obs) (m)
Palier 1	6	0,3	60	60	0,23	0,13	180	218	$6,31\times10^{-2}$
Palier 2	7,5	0,5	60	60	0,29	0,21	240	238	$-4,26\times10^{-3}$
Palier 3	12	1	60	60	0,46	0,54	300	298	$-6,11\times10^{-3}$
Palier 4	18	2,5	120	120	0,69	1,2	500	378	-0,608

Résultats de l'ajustement		
Coef. de pertes de charge linéaires (B)	0,0382 h/m²	**138 s/m²**
Coef. de pertes de charge quadratiques (C)	0,00372 h²/m⁵	**4,82×10⁴ s²/m⁵**
Exposant (n)	2,00	
Coefficient d'ajustement de Nash-Sutcliffe (E)	0,874 (-∞..1)	

Figure 6: Graph of Specific Drawdowns vs. Flow Rates

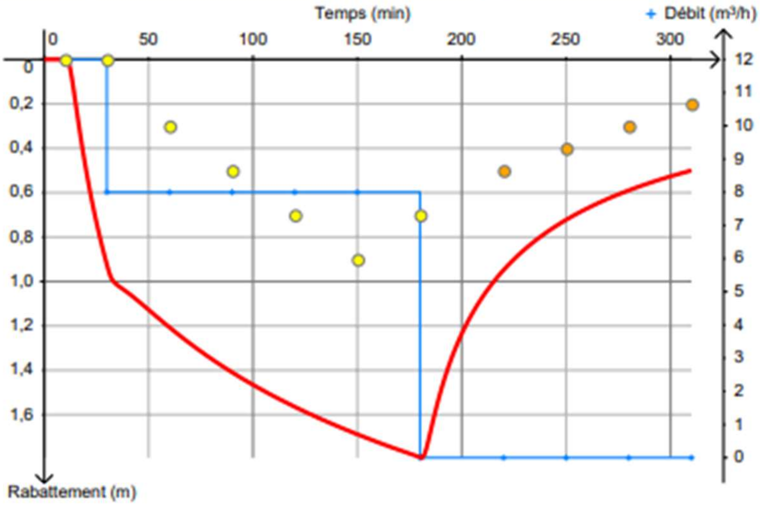
The expression for drawdown according to Jacob (1946) is $s=h+h'=BQ+CQ^2$ $s = h + h' = BQ + CQ^2$ $s=h+h'=BQ+CQ^2$, where h is the linear head loss related to laminar flow caused by the influence of the aquifer, and h′ is the quadratic head loss due to the influence of the catchment area of the structure. From the graph (Figure 6), the specific drawdown $s_s=s/Q=B+CQ$ $s_s = s/Q = B + CQ$ $s_s=s/Q=B+CQ$ provides the values of coefficients B and C with $B=0.0382$ h/m² and $C=0.00372$ h²/m⁵ Allowing to a minimum value of coefficient C corresponds minimum value of quadratic pressure loss so as result to a borehole-developed and properly sized and indicates also the effective catchment system.

b. **Long-Duration Pumping Test**

The characteristic coefficients of the aquifers, particularly transmissivity (T), storage coefficient (S), and permeability coefficient, are also determined. Transmissivity is about 3,00x10^{-4} m^2/s. Relating these values to the average thickness of the aquifer, which is about 8 m, the aquifer has a permeability coefficient is around 3,80x 10^{-5}m/s. It is very permeable, indicating a good aquifer reservoir, with its water potential depending on the extent of its recharge (Figure 4). The value of $S=5,00\times10^{-5}m^{-1}$.

The drawdowns during pumping and the residual drawdowns after pumping demonstrate the stability of the drawdown for each well (figure 7). The return of the static water level to its initial state (level before pumping or residual drawdown) was observed after 150 minutes of stopping the pumping. The pumping was conducted at a constant rate (the maximum of the submerged pump); after 180 minutes of pumping, the water level remained stable, indicating that the aquifer is significantly more powerful than the flow rate of the pump used. Thus, the yield of this well could potentially be double that of the pump we employed.

Site	FSAY1etFSAY2	Aquifère capté	Alluvion calcaire gréseux
Projet	AEP Littoral	Epaisseur de l'aquifère	8 m
Client	MAHERISOA	Type d'ouvrage	Piézomètre
Société	REVA	Rayon d'observation	30 m



Légende	
○	Rabattement mesuré
●	Remontée mesurée
—+—	Débit
—	Courbe théorique
Interprétation à l'aide de la solution	Theis, 1935
Type aquifère de la solution	Captif
Transmissivité	$3,00\times10^{-4}$ m^2/s
Perméabilité	$3,80\times10^{-5}$ m/s
Coefficient d'emmagasinement	$4,00\times10^{-4}$ (-)
Coefficient d'emmagasinement spécifique	$5,00\times10^{-5}$ m^{-1}
Coefficient d'ajustement de Nash-Sutcliffe	-5,68 (-∞..1)

Temps (min)	Rabattement mesuré (m)	Débit (m^3/h)	Temps (min)	Rabattement mesuré (m)	Débit (m^3/h)	Temps (min)	Rabattement mesuré (m)	Débit (m^3/h)
10	0	12	120	0,7	8	250	0,4	0
30	0	8	150	0,9	8	280	0,3	0
60	0,3	8	180	0,7	0	310	0,2	0
90	0,5	8	220	0,5	0			

Figure 7: Pumping test and hydrodynamics characteristics

4. Physico-Chemical Characteristics of Groundwater in the Manombo Coastal Area

The physico-chemical parameters characteristic of the waters in the Manombo sub-basin coastal area are measured in situ after pumping tests. Among these parameters, the electrical conductivity of the existing well waters oscillates between 1,110 and 12,140 µS/cm, corresponding to a salinity or mineralization of 0.6 g/L to 6.07 g/L. These values are related to the significance of marine intrusion in the area, which depends on the depth of the well and the distance from the sea.

In terms of borehole water, the electrical conductivity varies between 1,000 and 4,000 µS/cm, corresponding to a mineralization of 0.5 g/L to 2 g/L. Salinity also increases with depth. The water from the ANKMFK borehole is the most mineralized and saline compared to the others, as its depth (44 m) may be close to or reach the interface between fresh and saline water, or the level of a salt wedge in this area (Figure 4).

According to the analysis results, the water from the MNB borehole shows a high concentration of nitrites (71.91 mg/L). The increase in this element (NO2-) concentration is due to mineral nitrogen from animal excreta (pigs, sheep, goats, etc.), which is subsequently transformed by aerobic bacteria into nitrate and finally into nitrite through the nitrification process. The water from the MNB borehole is also rich in calcium (Ca^{2+}), sodium (Na^{+}), potassium (K^{+}), and chloride (Cl^{-}). The origin of these elements stems from the interaction or exchange with the aquifer layer and the rocks encountered during its passage and underground flow. The water facies is calcium-chloride-bicarbonate (Figure 8).

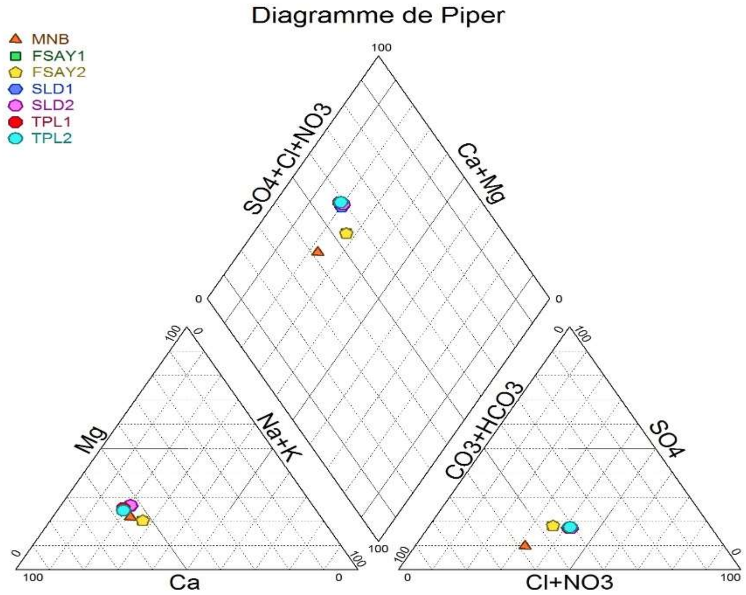


Figure 8: Piper Diagram

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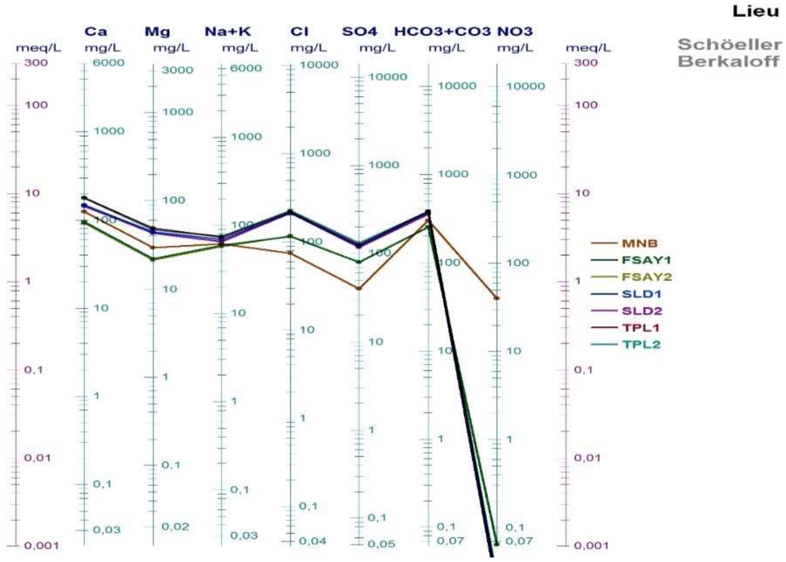

Figure 9: Schoeller-Berkaloff Diagram

The waters from the FSAY1 and FSAY2 drillings are good quality compared to others, complying with both WHO and Malagasy standards.

5. Bacteriological Characteristics

The results of bacteriological analyses indicate that the water from the MNB borehole is heavily contaminated with microorganisms (Pasteur Institute of Madagascar, 2009) such as enterococci, coliform bacteria, and viable microorganisms. The presence of these organisms suggests that the environment is aerobic, indicating that the aquifer is shallow. It also points to fecal contamination, likely originating from nearby households.

IV. DISCUSSIONS AND RECOMMENDATIONS

1. Availability of Quantity and Quality Water

The groundwater resource in the area appears to be sufficient in terms of quantity. The issue lies with the quality, particularly the high mineralization and the brackish to saline taste of the water, as well as the lack of infrastructure for the supply and distribution of drinking water. The flows from the existing supply systems are not yet proportional to the water needs of the population, both for domestic use and human consumption, as well as for the various economic activities present in the Commune. However, Fiherenamasay has potential in both quantity and quality of water captured by the FSAY1 and FSAY2 boreholes. Therefore, it is advisable to supply the villages with drinking water from these sources. Other boreholes could be utilized for the needs of other socio-economic.

2.Population Adaptation to Water Issues

Given that the population living along the Manombo coast is predominantly from the « Vezo »ethnic group, a nomadic sea people who have established their villages near the sea since ancient times, they have developed strategies to cope with daily shortages of drinking water. Women wash their dishes in the sea and use it for bathing. Freshwater is only used for cooking and drinking. Brackish water, which produces lather with soap, is used for laundry.

According to a survey conducted among various households, they have adopted this adaptation system to address the water problem, particularly to manage their finances, as this area faces significantly higher water prices compared to other regions that have more privileges.

3.Discussion on Integrated Water Resource Management in the Manombo municipality

Integrated Water Resource Management (IWRM) is still far from being implemented in the Manombo Commune. This article provides information about the available water resources in the area, which are among the strategic elements for the effective implementation of this management method. It is essential to ensure that both surface (rivers) and groundwater resources, including shallow aquifers accessible through wells and boreholes, are managed properly to guarantee the sustainability of the drinking water supply service (DWSS) and to meet the demands of other water-using sectors.As recommendations, the provision of drinking water for the Manombo coast relies on the following proposals:

- Subject to securing sufficient funding, the two boreholes in Fiherenamasay (FSAY1, FSAY2) could be utilized to supply water to all villages along the coast up to Salary.
- Additional boreholes could be established more than 4 km from the sea, followed by the implementation of water supply systems (including drillings, water reservoirs, and piping) for each village.
- The establishment of water treatment stations using a desalination system is also feasible for areas where the water is predominantly brackish to saline.
- Exploiting the Manombo River by setting up appropriate pumping and treatment stations is another solution for villages highly affected by salinity issues.
- Some villages could consider using rainwater harvesting systems, which are already widely used in the Grand South of Madagascar, to meet their needs during certain times of the year.
- The joint application of all these mentioned proposals can satisfy the water needs of various economic sectors, ensuring that the population of the Manombo coast can live harmoniously in the future.

However, an operational management structure should be established to ensure that the resources exploited and the water supply systems put in place are sustainable.

CONCLUSION AND RECOMMENDATIONS

The establishment of water points in the rural Commune of south-Manombo, which was previously based on empirical or traditional knowledge, should now rely on this study grounded in multidisciplinary scientific observations. With these methods, none of the seven boreholes drilled in the coastal villages of the Commune are dry; six are positive, and one is presumed negative due to the salinity of the water.

Quantitatively, with proper management, the flow from each borehole is sufficient to meet the drinking water needs of the beneficiary villages (exceeding 7 m^3/h). However, the water quality of the six positive drillings varies from one point to another, particularly regarding electrical conductivity. This value changes with the depth of the borehole, the terrain profile, and the distance from the sea. The interface or saline wedge ranges from 15 to 25 meters deep. The most favorable point for drillings installation is located beyond the sandstone and limestone cap, approximately 4 kilometers northeast of the sea (a bit further from the coast).

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Annex page

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Réf. Commande :
N/réf. : EAU-3594-14/12/2009-1
V/réf. :

Antananarivo, le 18 décembre 2009

RAPPORT D'ESSAIS

Examen demandé par :
HUMADA
Chez Honoré NOMERY
TULEAR

Désignation du produit : EAU NAPPE non traitée prélevée à 5h

Date du Prélèvement : 14/12/2009
Lieu de prélèvement : MANOMBO SVA TULEAR II
Arrivée au laboratoire : 14/12/2009
Nombre échantillons : 1
Date des manipulations : 16/12/2009
Technicien : 03
Prél. effectué par : HUMADA
Temp. de réception : 4,6 °C
Conditionnement : Flacon stérile

N° d'échant.	**3594-1**	**Unités**	**Critères (m)**	**Méthodes**
V/Réf. Echant.	EAU NAPPE			
*Microorganismes revivifiables à 22 C	**>3.10^2**	ufc/ml	<100	NF EN ISO 6222
*Microorganismes revivifiables à 37 C	**1,9 .10^2**	ufc/ml	<20	NF EN ISO 6222
*Bactéries Coliformes	**4,3 .10^1**	ufc/100ml	0	NF T 90-413
*Escherichia coli	<3	ufc/100ml	0	NF T 90-413
Entérocoques Intestinaux	**9,3 .10^1**	ufc/100ml	0	NF T 90-411
*Spores de micro-organismes ASR	**1,7 .10^1**	ufc/100ml	0	NF EN 26461-2
Vibrio	A	/100ml	Absence	Protocole CNR Paris
Interprétation	**NC**			

Interprétation selon Circulaire DGS/SD7 A n° 633 du 30/12/2003 relative à l'application des articles R. 1321-1 et suivant du code de la santé publique concernant les eaux destinées à la consommation humaine, à l'exclusion des eaux minérales naturelles.

C : Conforme - **NC** : Non Conforme - **A** : Absence **p** : présence (1 à 3 ufc) - # nombre estimé
ASR : Anaérobies sulfito-réducteurs

CONCLUSION : L'échantillon d'eau analysé est non conforme aux critères bactériologiques de potabilité.

Destinataires : - -

« Compte rendu sans signature adressé par courrier électronique »

- Les résultats ne se rapportent qu'aux échantillons soumis à l'analyse et ceux-ci ne peuvent être étendus à un lot
- L'accréditation par le Cofrac atteste de la compétence du laboratoire pour les seuls essais couverts par l'accréditation qui sont identifiés par le symbole *
- Les zones apparaissant en gris ne sont pas couvertes par l'accréditation
- Les résultats des dénombrements sont donnés avec une probabilité de 95%. L'intervalle de confiance est déterminé conformément à la norme NF EN ISO 8199 (T90-400) Janvier 2008 et peut être communiqué au client sur simple demande.
- La reproduction de ce rapport d'essai n'est autorisée que sous sa forme intégrale

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K PO2/02	06	06/07/09

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