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Diagnosis and Solution of the Drinking Water Supply Network of the Municipality of Diembéring

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Abstract

Diembéring, a municipality in Ziguinchor region (with 21 villages) has a considerable deficit in drinking water supply to the population. And yet the sources of supply are not lacking. In this part of the region, the quality water supply rate remains very low. This article follows a process of collection, analysis and exploitation of data (hydrogeological, geomorphological, geological) obtained at the site level. Then, an evaluation of the population compared to the horizon of 2041 is carried out, which allows the estimation of the evolution of the necessary drinking water needs. The geographical and hydraulic criteria allowed us to subdivide the system into two very distinct networks: two multi-village adduction systems (SAEMV1 and SAEMV2) composed of two water towers of 200 m^3 each for a HMT = 45 m, serving standpipes [1]. So, for [2]: • SAEMV1 (14 villages): the population is estimated at 10,400 inhabitants in 2041 and water needs are estimated at 365.849 m^3/s; • SAEMV2 (07 villages): population is estimated at 38,354 inhabitants in 2041 and drinking water needs are estimated at 1,216.537 m^3/s. As designed, this article is in line with the strategy that aims to promote access to drinking water as a means of reducing poverty [3].

Keywords

Component, Formatting, Style, Styling, Insert

1. Introduction

Ziguinchor, one of the fourteen (14) administrative regions of Senegal, is located in the intertropical zone, bordering Gambia to the North, Guinea-Bissau to the South, to the East by the region of Sédhiou and to the West by the Atlantic

Ocean. It forms the western part of Casamance, known as Lower Casamance. Thanks to its position, the region has sufficient water resources to feed the population. Diembéring, a commune in the Ziguinchor region, is an agricultural area, due to the relative generosity of rainfall (as everywhere in Lower Casamance), the abundance of arable land, the fertility of the soil and the availability of water potential [4]. The diversity of water resources offers opportunities for capturing groundwater with the use of boreholes. Despite these numerous water potentialities, the population of the commune is confronted with problems of access to drinking water. Diembéring offers the example of a municipality faced with an insufficient level of equipment and the dilapidation of existing ones to meet the growing demand for water, particularly in the tourist area of Cap Skirring, where the population continues to protest. Indeed, the water consumed has a high iron and salt content and that of the wells remains not clean because of the salinization of the soil [5].

This article aims at improving the quality of life and productivity of all the inhabitants of the municipality, by ensuring an equitable supply of water, in sufficient quantity and quality in a sustainable manner from the Multi-Village Water Supply System 1 (SAEMV1) [6].

The specific objectives are: the satisfaction of drinking water needs, the limitation of the exodus and the improvement of sanitary conditions, the reduction of poverty and the promotion of economic activities in connection with the water supply of the populations. Based on documentary research data and socio-economic surveys of villagers, we can then determine the sizing parameters [7]. The objective of this research is to definitively solve the water problem in Diembering.

2. Materials and Methods

2.1. Data Acquisition

A visit to all the localities affected by the project shows that access to drinking water is made difficult by the lack of hydraulic structures. The purpose of this visit was to:

- Meet with all the village chiefs of the localities concerned.
- Collect data on current populations and households.
- See the state of existing basic social infrastructure and drinking water supply infrastructure.2.2. Maintaining the Integrity of the Specifications.

2.1.1. Education [8]

For the 2020-2021 school year, the municipality has:

- Five (05) high schools including two (02) public (839 students) and three (03) private.
- Seven (07) CEM including five (05) public and two (02) private.
- Twenty (20) elementary schools including eighteen (18) public (3,525 students) and two (02) private (703 students).
- Nineteen (19) preschools including four (04) public (353 children) and fif-

teen (15) private (999 children).
- One (01) crèche (28 children).
- Four (04) boarding schools (150 students).
- Four Koranic schools.

2.1.2. Health and Social Action

Health infrastructure is increasing and modernizing, thus reducing the mortality rate at the commune level [9].

Most of the health infrastructures are located on the Cabrousse-Diembéring axis; the islands are less provided with them. Details are given in **Table 1**.

Table 1. Health infrastructure.

Sanitary structures	Number
Health posts	6
Maternities	6
Health huts	4 (1 functional)
Pharmacies	2
Clinical	1
Dental offices	2
Private health post	1
Sapeurs Camp (military hospital)	1

2.1.3. Tourism

Tourism is the largest source of revenue for the town, the town officially has seventeen (17) hotels (including Club Med based in Cap Skirring since 1973), nineteen (19) inns and camps, twelve (12) bars-restaurants, the majority of which are located in Cap Skirring, guest houses, four (04) travel agencies, an eco-park, etc. [10]

2.2. Drinking Water Distribution

Although it is surrounded by water, the municipality of Diembering lacks drinking water, especially on the islands. Many households use rainwater retention cisterns or get their supplies (buy) from 20-litre cans, despite the presence of SODECA (Casamançaise bottling company) with its brand of mineral water “La Casamançaise”, sold everywhere in Senegal [11].

The current state of drinking water distribution equipment is illustrated by **Figures 1-4**.

These figures show how the supply of drinking water poses many difficulties in the municipality. In addition, the situation is more critical in the islands which are faced with a dilemma [12]:

- The wells very often dry up because the depth does not exceed 4 to 5 m.
- The water table which becomes salty does not make things easier.

Figure 1. Cabrousse: existing water reservoir.

Figure 2. State of a PMH.

Figure 3. Water quality of a well in Wendaye.

Figure 4. Ourong: Water desalination system.

2.3. Data Processing and Analysis

A subdivision of the project area into sectors has been made. This subdivision meets a double criterion: geographical and hydraulic [13].

- Geographic in that localities sharing the same system are geographically close;
- Hydraulic in the sense that the localities located in the same system are supplied by the same source of drinking water and the same storage reservoir (water tower) and that the topographical conditions are favorable (do not require intermediate recovery);

Consequently, the type of network adapting to this situation is therefore a Multi-Village Water Supply (AEMV). [14]

2.3.1. Estimated Population at the Project Horizon

The estimation method used is geometric growth due to the young and growing population. The growth rate is proportional to the population.

$$Pn = P_0 (1+\tau) n \tag{1}$$

with:

P: Future population by 2040 (Hbt)

P_0: Current population (Hbt)

n: Number of years separating the reference year at the considered horizon

τ: Average annual population growth rate in (%)

The growth rate of the municipality is 2.66% (**Table 2**).

Table 2. SAEMV1. Population estimates at the project horizon.

System	Localities	Population in 2013 (hbt)	2021	2041
SAEMV1	Karabane	614	757	1247
	Ehidje	120	148	244
	Ourong	475	586	965
	Cachouane	367	453	746
	Sifoca	117	144	238
	Wendaye	344	424	699
	Gnikine	179	221	364
	Kaout	398	491	809
	Etama	344	424	699
	Etoune	305	376	620
	Haloudia	528	651	1073
	Niéné	132	163	268
	Houdiabousse	544	671	1105
	Kaengha	651	803	1323

2.3.2. Estimation of Water Needs over the Project Horizon

It was done on the basis of the population at the project horizon, taking into account domestic and social needs.

The specific consumption per inhabitant is estimated at 27 litres/day

$$Q\_domestique = C\_s * Pop \quad (2)$$

Table 3 illustrates the estimate of domestic needs over the project horizon.

Table 3. Estimated domestic needs at the project horizon.

Localities	Pop. in 2041(hbt)	Domestic needs (l/s)
Carabane	1247	33,669
Ehidje	244	6588
Ourong	965	26,055
Cachouane	746	20,142
Sifoca	238	6426
Wendaye	699	18,873
Gnikine	364	9828
Kaout	809	21,843
Etama	699	18,873
Etoune	620	16,740
Haloudia	1073	28,971
Niéné	268	7236
Houdiabousse	1105	29,835
Kaengha	1323	35,721

The distribution network is sized on the basis of the hourly peak flow given by Equation (3).

$$Qph = (Djm * Cps * Cpj)/(\eta r * 24) * Cph \quad (3)$$

Thus, the design flow values at the project horizon are given in Table 4 [15].

Table 4. Values of design flow according to localities.

Localities	Qdim (m^3/h)
Karabane	8,594
Ehidje	0,934
Ourong	3,111
Kachouane	2,502
Siffoca	0,730
Wendaye	2,385
Nikine	1,149
Kaout	2,935
Etama	2,182
Etoune	2,080
Haloudia	3,240
Niéné	0,920
Houdiabousse	3,903
Kaengha	0,317

The design flows in each section are assessed on the basis of the hourly peak flows at the service points.

Thus, the specific throughput, en-route services and nodes are given by Equations (4)-(6).

$$Q_s = \frac{Q_p}{\sum Li} \tag{4}$$

Q_p: Hourly peak flow Qph (l/s)

Li: Line length (m)

Q_s: 0,003321617 l/s.m

$$Q_r = Q_s * Lij \tag{5}$$

$$Q_i = \sum\left(\frac{Q_{ri}}{2}\right) \tag{6}$$

The calculation of the diameters of the pipes will be done by setting an acceptable speed of 1 m/s (in the water distribution pipes, 0.6 < V < 2.5 m/s), the diameters are obtained by the formula next:

$$Dth = \sqrt{\frac{4*Q}{\pi * V}} \tag{7}$$

Dth: theoretical diameter (en m)

Q: section flow rate (en m^3/s)

V: speed fixed at 1 m/s

Knowing the normalized diameters of each section, the real flow velocities are obtained by Equation (8):

$$V = \frac{4*Q}{\pi * D^2} \tag{8}$$

V: real speed (en m/s)

Q: section flow rate (en m^3/s)

D: nominal diameter (en m)

The formula of Hazen-William which makes it possible to describe the turbulent flows of water with a relative precision is the formula adopted for the calculation of the losses of linear loads (Equation (9)).

$$\Delta HL = \frac{10.675 * Q^{1.852}}{{C_{HW}}^{1.852} * D^{4.87}} \tag{9}$$

Singular head losses are due to sudden changes in the flow at singularities and are illustrated by Equation (10).

$$\Delta HL = K * \frac{V^2}{2g} = K\left(\frac{8*Q^2}{g*\pi^2 * D^4}\right) \tag{10}$$

K: the head loss coefficient specific to each singularity

V: average speed

For water distribution pipes, the singular head losses represent 5 to 10% of the linear head losses.

$$\Delta Hs = 10\% \Delta HL \quad (11)$$

2.4. Tank Capacity

The tank volume can be determined using three (3) methods, namely the table method, the simplified method and the graphical method. The simplified method which estimates the storage capacity between 25% and 50% of the peak daily consumption with an average of 33% gives:

$$V_{reservoir} = Cpj * Djm * 33\% + firereserve$$
$$V_{reservoir} = 182803 \text{ m}^3 \quad (12)$$

By referring to the usual volumes of water towers in Senegal, we obtain water towers of 200 m^3.

3. Conclusions

This article mainly deals with multi-village drinking water supply 1 (SAEMV1). The need to improve the drinking water supply facilities in the 14 localities of the municipality of Diembéring served by SAEMV1 has become urgent, due to the dilapidated state of the drinking water supply network.

This article will improve the physical infrastructure, thanks to the extension of the existing facilities and the quality of the services that will contribute to improving the health and well-being of the populations and to reviving economic activities in the area.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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