

Perspective of the Wastewater Evacuation Network and the Treatment Plant of the Diamniadio Urban Pole

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Abstract In Senegal, urban expansion and overpopulation, especially in the capital Dakar, have caused increased problems in terms of housing. To alleviate this scourge, the government of Senegal has decided to create new towns through the Diamniadio Urban Pole and that of Lac Rose to resolve the housing problem but also a set of economic activities. The ambition is to make these Clusters new urban centralities based on social and functional diversity, creating wealth and jobs. The objective of this article is to study the feasibility of the wastewater evacuation network and the treatment plant of the Diamniadio Urban Pole. The approach undertaken initially involves bibliographic research, followed by data collection from project stakeholders, then with the use of Excel software for determining flow rates, calculating and verifying the operating conditions. self-cleaning. Thus, we have achieved a wastewater treatment system with pipes whose sections vary from 250mm to 1000mm. For the operation of the STEP we obtained a pretreatment comprising a screen of 3 m² of surface, a desander of 4.5 m² of surface, a degreaser of 190.71m² of surface, a primary decanter of 4768 m³ of volume, a treatment biological comprising an aeration basin of 101,002 m³ and a clarifier of 4,768 m³.

Keywords: sanitation, sizing, wastewater, treatment plant, flow rates, Pôle Urbain Diamniadio

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1. Introduction

The Urban Pole in Diamniadio helps decongest Dakar and cope with a cumulative deficit of 150,000 housing units plus 20,000 other requests per year. With an area of 1,644 ha, this Pole is located about thirty kilometers east of Dakar.

It is within this framework that the new dynamic of territorial planning materialized by motorway and airport infrastructure projects towards areas of virgin urban areas and low demographic density takes place.

Demographic growth is accompanied by the development of human activities (industry, agriculture, domestic activities) with the consequence of greater production of polluting discharges which in particular degrade water quality. If wastewater is not systematically treated before being released into the natural environment, it risks deteriorating the environment which would then no longer be able to provide enough water, thereby increasing the risk of shortages. This is why wastewater sanitation is absolutely essential to preserve natural resources. The wastewater discharged every day contains organic matter, chemical residues and billions of germs. So many elements at risk for health and the environment. To avoid

diseases and pollution, a good sanitation system is essential.

Thus, to benefit from a good living environment, the liquid sanitation system must be well integrated into an adequate urban development framework taking into account the different aspects of rainwater and wastewater management.

The main objective of this article is to establish a defense project against all pollution in the city.

2. Materials and Methods

2.1. Data Acquisition

Pôle Urbain de Diamniadio is a new town which covers a gross area of 2,000 ha, or a net area of 1,644 hectares of which a priority zone extends over 700 ha [1]. Within the perimeter of the urban center of Diamniadio, it is planned to accommodate nearly 350,000 inhabitants. Within five years, Diamniadio should have at least 40,000 houses and apartments to accommodate 150,000 inhabitants and meet one of the priority objectives of the Emerging Senegal Plan: to compensate as quickly as possible for the enormous housing deficit in Dakar, which amounted to more than 150,000 units at the end of 2015 and is

increasing by 20,000 homes per year [2].

It is located southeast of Dakar in the Dakar-Thies-Mbour triangle. It is limited to the West by the agglomeration of Dakar (Rufisque and Bargny), to the East by Diass, Sébikotane, to the North by the Niayes pole (between Sangalkam and Notto Gouye Diama) and to the South by the Atlantic Ocean (Figure 1)



Figure 1. Carte de localisation de Diamniadio [2]

Referring to the geological map (Figure 2) we see that the study area is located in the Lutetian which is a stage of the Eocene (Cenozoic era) more precisely in the part of Bargny which is made up of alternations of marl-limestone with silicified phosphate beds and marl with planktonic foraminiferal bone debris (Figure 2).

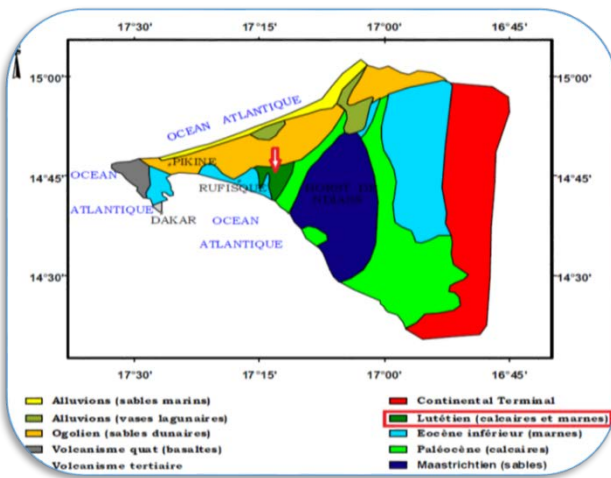


Figure 2. Geology of the area [3]

Hydrologically, the Diamniadio-Sébikotane area does not have a permanent watercourse. However, there are some temporary backwaters constituting outlets towards the sea during the winter. Water from the plateaus in the surrounding areas often causes flooding.

At the perimeter of the urban center, three lakes are identified whose regime depends on rainfall, particularly runoff coming from the mountainous regions around the project site. [4]

The water potential of the area has, like that of the country, been greatly reduced in recent decades. The average annual rainfall between 1960 and 2015 is 146 mm. The reduction in rainfall, following cyclical droughts, has a major impact on plant cover and the recharge of the water table. On an agroecological level, it results in a degradation of vegetation and a reduction in agricultural

production [5].

The system chosen concerns a separate network where wastewater can be transported to the treatment stations independently of rainwater which is a source of overload because it drains higher flow rates.

In the case of wastewater sanitation, the collective system will be applied and composed of conventional sewer. Given the planimetry of the site to house the Diamniadio Urban Pole, as well as the general development plan (infrastructure, roads, etc.), three (3) different variants of wastewater evacuation networks and related works have could be defined, such as pumping stations and sewage treatment plants.

The proper functioning of the sanitation network makes it possible to improve the living and housing conditions of populations, to limit the development of water-related diseases and to protect the environment from discharges resulting from human activity [6].

2.2. Data Processing and Analysis

The flow of wastewater is evaluated on the basis of overall water consumption, the urban area and the industrial sector, recorded on the day of highest consumption.

The water consumed by populations is then discharged in a polluted state. Wastewater treatment consists of collecting and treating this water in order to counter any risk of ecological imbalance, contamination of groundwater or surface water for consumption and diseases in homes.

The population of Diamniadio is supplied by the main drinking water pipe called Alimentation du Lac de Guiers numero1 known as ALG1. This pipeline crosses the project area to serve the inhabitants of the Dakar region [7].

The consumptions are as follows:

- economical and medium-standard housing: 80 l/inhabitant/d;
- luxury accommodation: 100 l/inhabitant/d;
- hospital: 400 l/bed/d;
- internal student: 80 l/student/day;
- external student: 40 l/student/day;
- educational establishment (school, middle school and high school): 9 l/student/day;
- hotel: 400 l/bed/d;
- neighborhood mosque: 10 l/person/d;
- large Friday mosque: 20 l/person/day;
- church: 10 l/person/day;
- health center: 400 l/person/day; poste de sante: 400 l/personnes/j ;
- police: 100 l/person/d;
- firefighters: 100 l/person/d;
- industry: 100 m3/ha/day.

Thus, after analyzing the planimetry of the site based on the contour curves and the general development plan, three (3) different variants of wastewater evacuation networks and related works could be defined, such as the pumping stations and sewage treatment plants. This study made it possible to choose the type of network and the type of system for the station which best suits the study area. This choice is also made on the basis of a multi-criteria study [8]. The variants are described below:

- variant 1: This route consists of collecting and

evacuating domestic wastewater and industrial wastewater in two separate networks to the same treatment plant;

- variant 2: This second variant will collect domestic and industrial wastewater in a single network to a single treatment plant;
- variant 3: The latter will consist of collecting and evacuating domestic and industrial wastewater in two separate networks to separate treatment plants.

Domestic wastewater will be transported to the STEP located in the site predefined by the National Sanitation Office of Senegal (ONAS), while industrial water will be discharged into the STEP built in the industrial zone near the largest lake located in Southwest [9].

For each variant, the primary, secondary, tertiary networks, pressure pipes, lifting stations (STAP), load-break manholes, inspection manholes and treatment stations (STEP) have been marked on the route.

The comparison criteria for deciding between the variants are as follows:

- impacts on public health;
- sociocultural and urban impacts;
- impacts on the environment;
- technical feasibility;
- consideration of sustainable development;
- construction costs;
- operation and maintenance costs.

Based on these results, variant 2 was chosen. Domestic wastewater and that of industries are collected and transported in the same network to a single treatment plant, but manufacturers will have to carry out in situ pretreatment of their effluents before their discharge into the collection network [10].

Determining the discharged flows constitutes a fundamental step in the study of the sanitation of an area. This evaluation is to be correlated with the quantity of water consumed by the populations which is defined in the Drinking Water Supply (AEP) section, and the latter is calculated for a period of 15 years in the case of this project. The rejection coefficient, applied to water consumption, is generally equal to 80% [11].

3. Results and Discussions

The daily peak flow is determined by the formula:

$$Q_{PJ1} = C_J \times T_r \quad (1)$$

- Q_{PJ} : daily peak flow
- C_J : average daily consumption (m³/d)
- T_r : rejection rate which is 80%

$$Q_{PJ1} = 29942,56 \times 0,8 = 23954,0464 \text{ m}^3 / \text{d}$$

For the flow of industrial wastewater, we have allocated a specific volume of 100 m³/ha/d, following the indications of APROSI and the requirements of French Technical Instruction No. 70. The calculation of the quantity of wastewater produced by an industry is obtained by multiplying the specific volume by the area of the site [12].

The sum of the average flow rates is:

$$Q_{PJ2} = 19848 \text{ m}^3 / \text{d}$$

The average hourly flow Q_{mh} is determined by dividing the daily peak flow by the number of hours of network operation per day, taken equal to 24 hours in this article.

$$Q_{mh} = \frac{Q_{PJ}}{24h} \quad (2)$$

Therefore:

• Domestic wastewater flows

$$Q_{mh1} = \frac{Q_{PJ1}}{24h} = \frac{23954,0464}{24h} = 998,085 \text{ m}^3/\text{h} = 277,25 \text{ l/s}$$

The average hourly flow rate obtained is 998.085 m³/h, or 277.25 l/s.

• Débit d'eaux usées industrielles

$$Q_{mh1} = \frac{Q_{PJ1}}{24h} = \frac{19848}{24h} = 827 \text{ m}^3/\text{h} = 229,72 \text{ l/s}$$

The average hourly flow rate obtained is 827 m³/h, or 229.72 l/s.

• Peak flow

It should also be taken into account that at certain times of the day, water consumption may be higher than that corresponding to the average flow. We then apply a coefficient called peak coefficient noted (p). This flow rate is called maximum flow rate [13]. The hourly peak flow Q_p is calculated by:

$$Q_p = p \times Q_{mh}$$

With:

Q_p : hourly peak flow

p : hourly peak coefficient

• Domestic wastewater flows

In general, the coefficient p is calculated by the following formula proposed in technical instruction INT 77-284

$$p = a + \frac{b}{\sqrt{Q_{mh}}} \quad (4)$$

With Q_{mh} expressed in liters per second (l/s) and the values of a and b are respectively equal to 1,5 et 2,5.

$$p = 1,5 + \frac{2,5}{\sqrt{277,25}} = 1,65$$

$$Q_{p1} = 1,65 \times 277,25 = 457,5 \text{ l/s} = 39\,527,62 \text{ m}^3/\text{d}$$

We can remember that the daily volume of domestic wastewater is:

$$Q_{p1} = 39\,527,62 \text{ m}^3/\text{d}.$$

• Industrial wastewater flow

We will take $p = 3$

$$Q_{p2} = 3 \times 229,72 = 689,17 \text{ l/s} = 59\,544 \text{ m}^3/\text{d}$$

The details of all these calculations can be found in the table in appendix no. 2.

We can conclude from this table that the daily volume of industrial wastewater is:

$$Q_{p2} = 59\,544 \text{ m}^3/\text{d}.$$

• Total wastewater flow

Which gives us a total flow of

$$Q_T = Q_{p1} + Q_{p2} = 99\,071,62 \text{ m}^3/\text{d}. \text{ (Table 1.)}$$

Table 1. Details of peak flow calculations

Designation	Area busy	Average flow(Q _{mh})				Peak Coefficient (p)	Peak flow: Q _p			
Units	Hectares	m ³ /d	m ³ /s	m ³ /h	l/s	-	m ³ /s	l/s	m ³ /h	m ³ /d
Domestics	1802	23954,05	0,28	998,09	277,25	1,65	0,46	457,50	1646,98	39527,62
Industrial	198	19848,00	0,23	827,00	229,72	3,00	0,69	6889,17	2481,00	59544,00
TOTAL	2000	43802,05	0,51	1825,09	506,97	2,26	1,15	1146,66	4127,98	99071,62

Table 2. Summary of flow rates

Average flow(Q _{mh})	Peak Coefficient (p)	Peak flow: Q _p	Infiltration flow(Q _{inf})	Equipment flow (Q _{equip})			
m ³ /d	m ³ /d	m ³ /d	m ³ /d	m ³ /d	m ³ /d	m ³ /s	l/s
43802,05	2,26	99071,62	9907,16	5448,94	114427,72	1,32	1324,39

• Infiltration flow Q_{inf}

Given the proximity of the water table outcropping in the depressions, an infiltration flow Q_{inf} will be taken into consideration. The latter is taken at 10% of the hourly peak flow [2].

$$Q_{inf} = 0,1 \times Q_T \quad (5)$$

$$Q_{inf} = 0,1 \times 99071,62 = 9907,16 \text{ m}^3 / d$$

• Equipment flow Q_{equip}

The equipment flow rate is taken equal to 5% of the sum of the hourly peak flow rate and the infiltration flow rate [2].

$$Q_{equip} = 0,05 \times (Q_{ph} + Q_{inf}) \quad (6)$$

$$Q_{equip} = 0,05 \times (99071,62 + 9907,16) = 5448,94 \text{ m}^3 / d$$

• Sizing flow Q_{dim}

The design flow of the pumping station is the sum of the peak, infiltration and equipment flow rates. The results obtained are recorded below (Table 2)

$$Q_{dim} = Q_{ph} + Q_{inf} + Q_{equip} \quad (7)$$

$$Q_{dim} = 99071,62 + 9907,16 + 5448,94 = 114\,427,72 \text{ m}^3 /$$

4. Conclusion

This article is part of the dynamic of preserving health and respecting natural balances [14]. The means implemented must result in particular in safe and reliable sanitation networks, and treatment plants capable of dealing with a wide diversity of flows. It deals with the techniques used for the collection, evacuation and treatment of water, and provides the hypotheses for creating the corresponding networks and structures. The calculation methods applied to comply with the regulations in force are widely described. An important

part is also given to the management and operation of STEPs.

Through the modernity of the solutions it presents and its global approach to sanitation, this article provides a global vision of the sanitation of the Diamniadio Urban Pole.

The problem of solid waste management (household waste, industrial waste, manure) and adequate water evacuation are all evils which still plague the lives of populations. The urgent need to finally have a better living environment deserves, from the authorities, all the attention required to definitively resolve this problem.

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