THE MECHANISMS OF WATER AND SOLUTE TRANSPORT IN THE UNSATURATED ZONE OF THE THIAROYE AQUIFER AND IMPACT OF POOR SANITATION ON THE GROUNDWATER QUALITY

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INTRODUCTION

- groundwater is highly mineralized and has predominantly Ca–Cl facies
  (Chouai S. 1996; Tandia A. 1997; Cisse Faye. 2001);

- groundwater is contaminated by anthropogenic effluents: solutes (e.g. nitrates, trace metals), pesticides, and microbiological pathogens
  (Tandia A. 1997; Cisse Faye. 2001; Ndiaye et al. 2006);

- geochemical & isotopic tools used to trace pollution to sanitation
  (Re et al., 2010; Diedhiou et al. 2012);

- elevated concentrations of Hg, Cd and Ni are a risk to human health
  (Essouli O.F. 2005; Pouye A. 2013);

RESEARCH QUESTION

What are the processes by which effluent from septic tanks migrate in the unsaturated zone?

OBJECTIVES:

The main goal of this thesis is the quantitative and qualitative assessment of sources, types, migration and natural attenuation processes of the various pollutants from the surface, through the unsaturated zone media down to the water table in selected sites; .

OBJECTIVES:

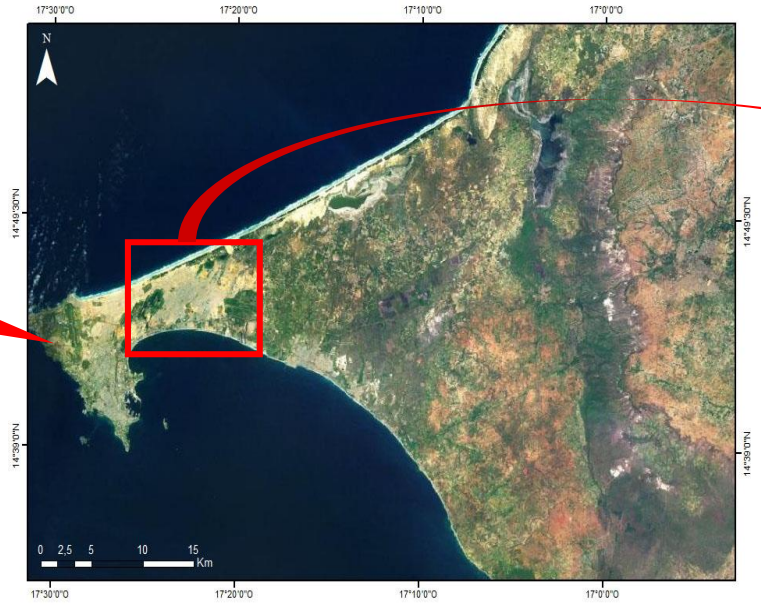
The main specifical goals are :

- Identify the different point sources and types of pollutants;
- Determinate the hydraulic properties of the unsaturated zone;
- Assess the different factors affecting the migration process in the unsaturated zone for nitrogen compounds and other pollutants such as Trace metals or emerging pollutants;
- model the transport of N solutes (NO_3^-, NH_4^+) in the unsaturated zone using transport models (HYDRUS 1-D or COMSOL Multiphysics)

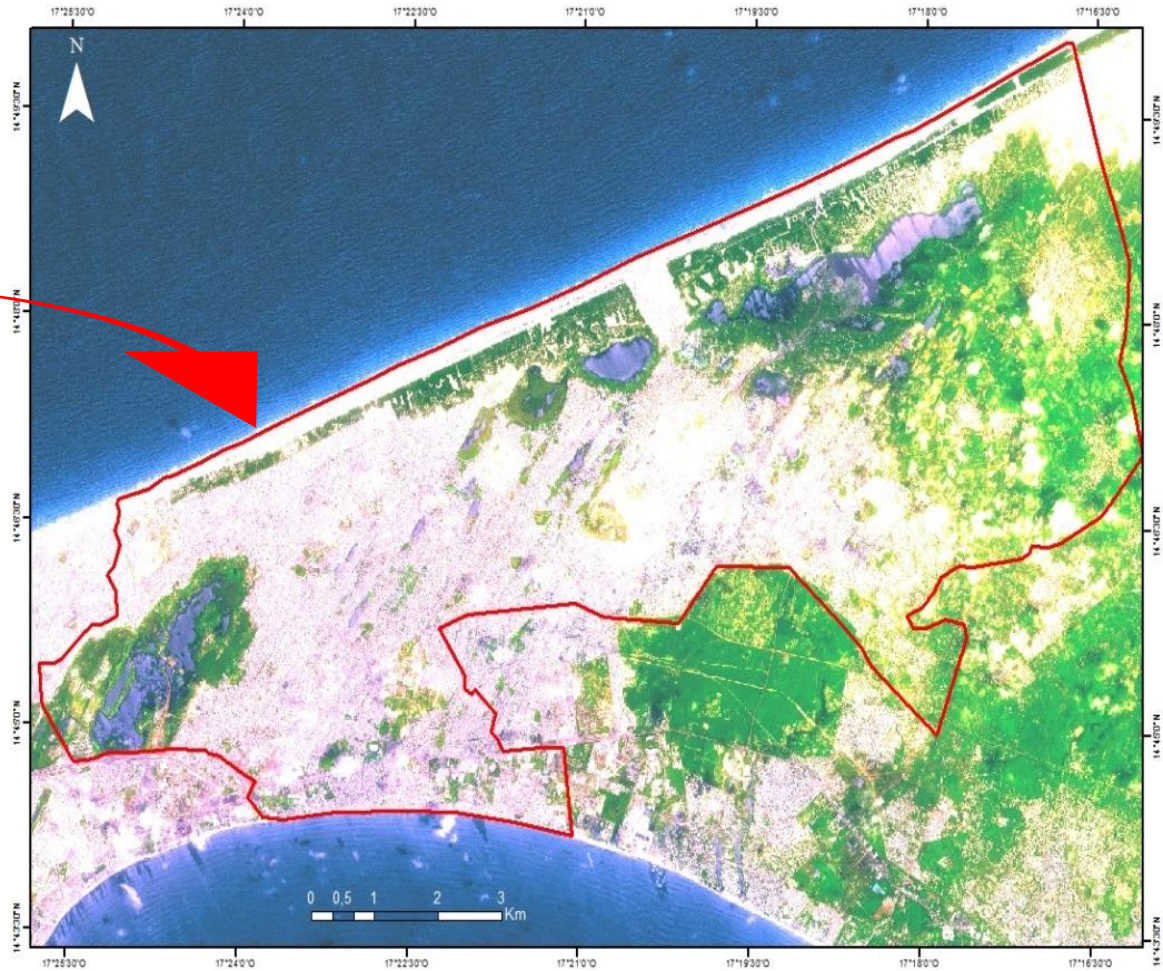
PRESENTATION OF THE STUDY AREA:

The study area is the suburban zone of Dakar region. It is located between longitudes **17 ° 18 ' and 17 ° 28' West** and latitudes **14 ° 25 'and 15 ° 05' North**.

Cape verde peninsula (Arcmap 10)

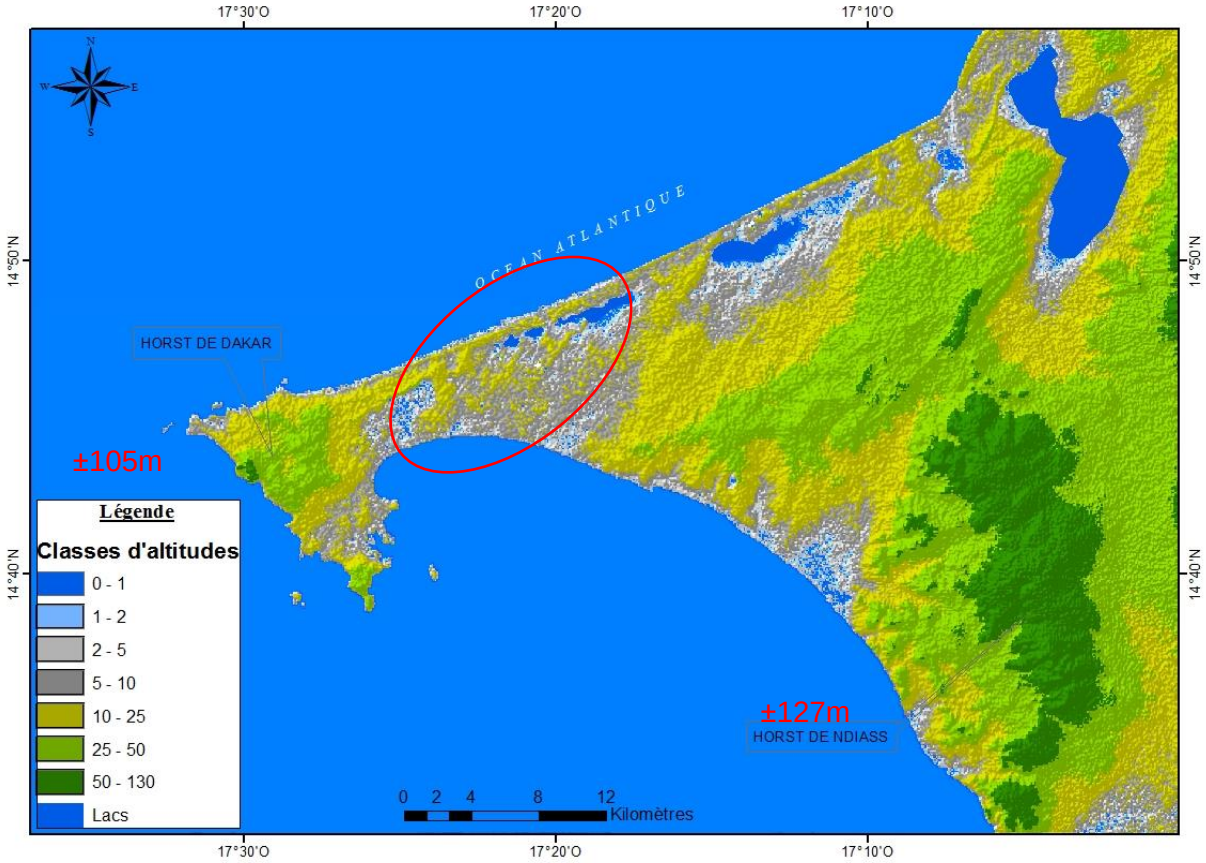


Study area (Spot 2009)



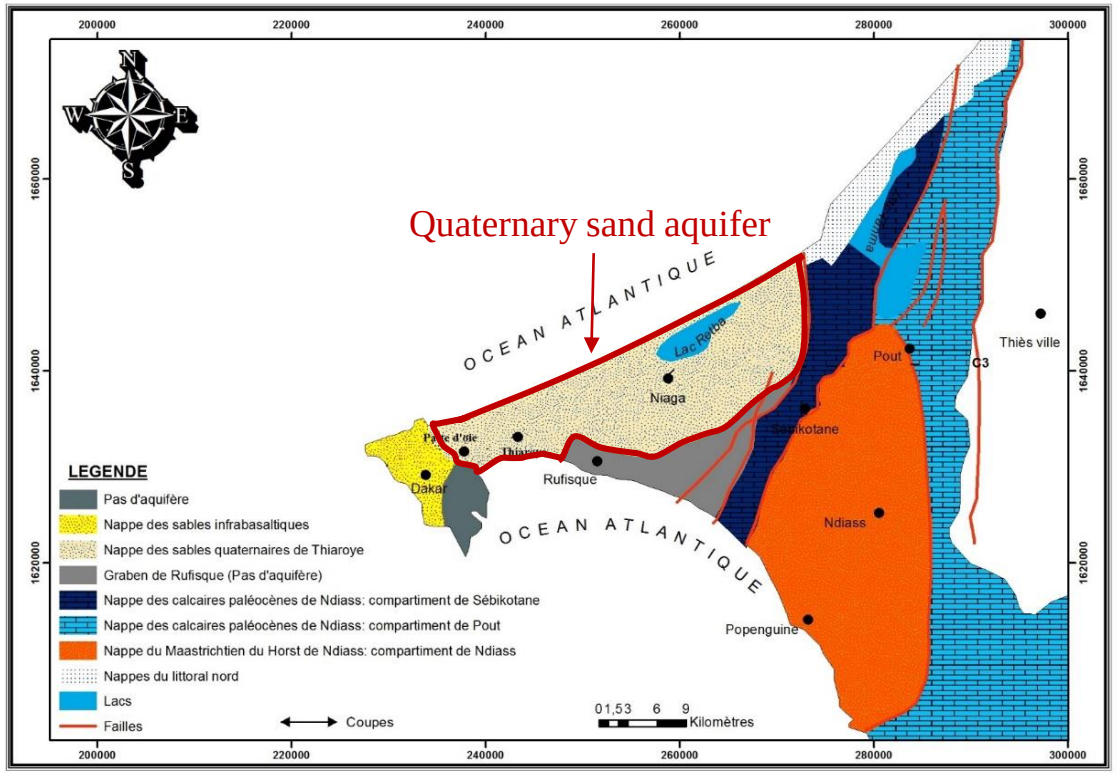
PRESENTATION OF THE STUDY AREA:

❖ Geomorphology:



Elevations of the Cape verde peninsula (SRTM-USGS / NASA)

❖ Hydrogeology:



Aquifer systems of the Cape verde peninsula

METHODOLOGY

Objective 1: Identification of different point sources and types of pollutants

Field and digital mapping:

Land use

On-site sanitation facilities

Aquifer caracteristics

Delimitation of study area

Monitoring well network:

Water level monitoring

In-situ parameters measurements

Water Sampling

Identification of points sources and types of pollutants

Solutes

Faecal indicators

Microbiological species

Isotopic ratios ($^{15}N/^{14}N$, $^{11}B/^{10}B$)

Trace metals (As, Cd, B)

Emerging pollutants (Pharmaceuticals products)

METHODOLOGY

Objective 2: Determination of hydraulic properties of the unsaturated zone

Study of physical properties of unsaturated zone

Unsaturated zone tickness

Soil matrix caracterization

Hydrodynamic parameters of Unsaturated zone

Study of the chemical properties of interstital water:

Leaching experiments

Pollutant vertical profiles

water-rock interaction

Retention of solute in the matrix

Adsorption

Ion exchange reactions between water and the matrix

Solubilization/Precipitation reaction

Microbiologic reactions

METHODOLOGY

Objective 3: Assessment of the different factors affecting the migration process in the unsaturated zone for nitrogen compounds;

Groundwater observatory

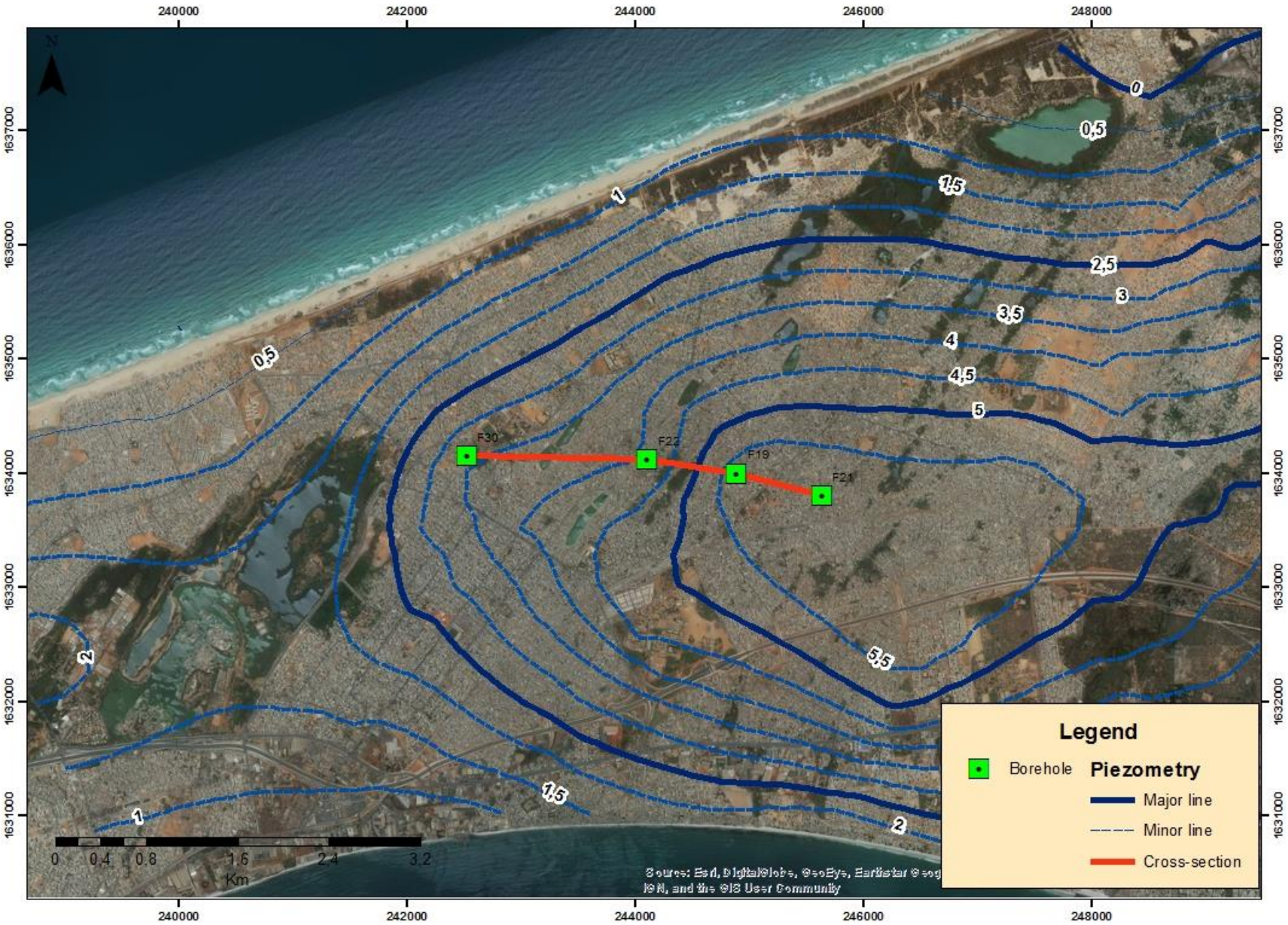
What are the different factors affecting the migration process in the unsaturated zone for nitrogen compounds?

What are the different parameters influencing the vertical hydraulic gradient?

How can we quantify the recharge?

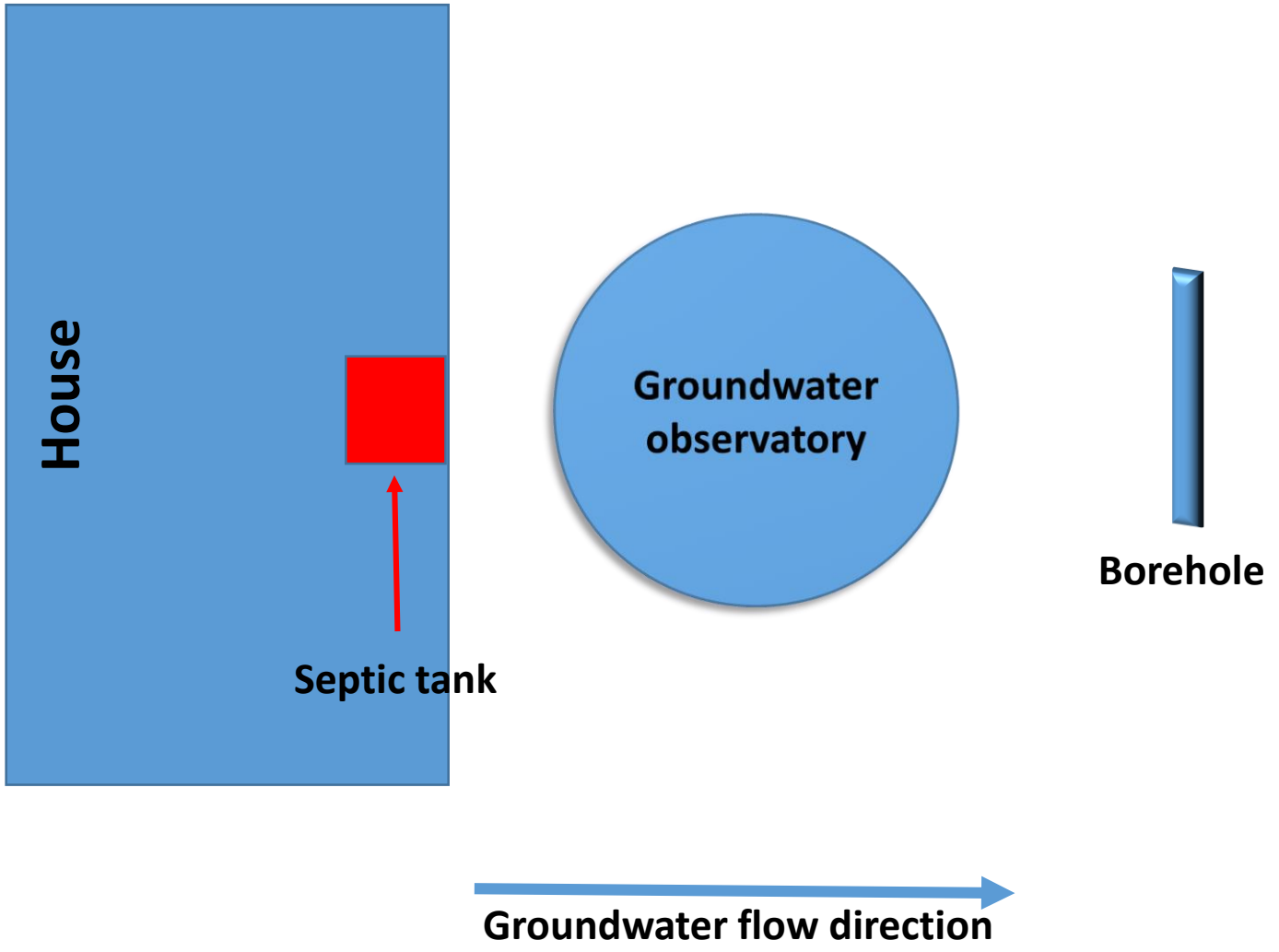
METHODOLOGY

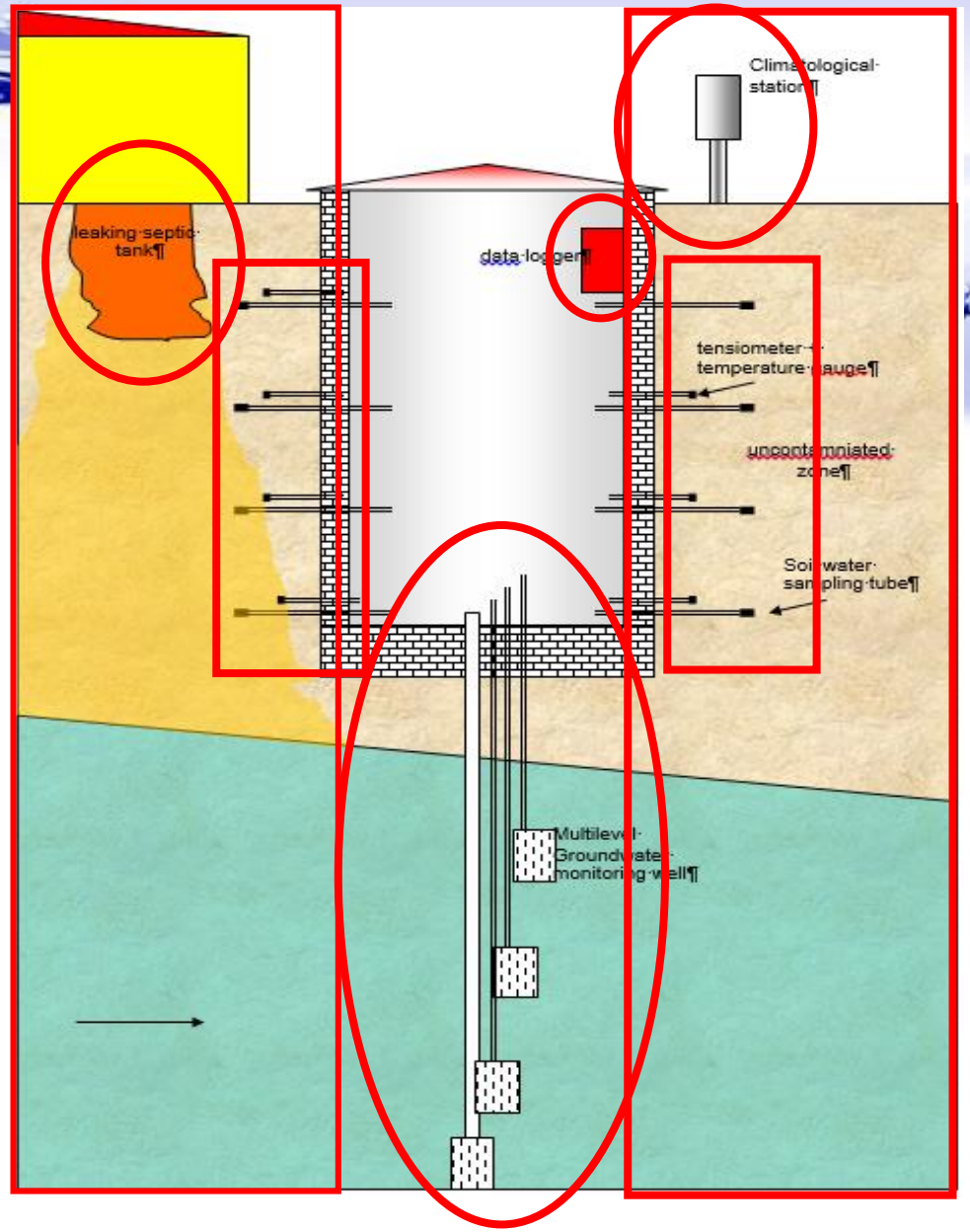
Groundwater observatory : Location



METHODOLOGY

Groundwater observatory: Site design





Plan of the research observatory (aerial view)

METHODOLOGY

Objective 4: Modelling of the transport of sanitation related pollutants in the unsaturated zone using transport models;

Choice of modelling tool

Hydrus code

Comsol multiphisics code

Validation of modelling tool

Lysimeter test

or

Laboratory test

Modelling/simulation

1D and 2D modelling

Simulation on a spatio-temporal scale

CONCLUSION

- hydrodynamic, hydrochemical and microbiological characteristics of the unsaturated zone overlying the Thiaroye aquifer to be assessed;
- detection and quantification of pollutant concentrations from septic tanks to be made;
- model of flow and pollutant transport in the unsaturated zone to be developed;
- processes and interaction governing the transport of pollutants from septic tanks in the unsaturated zone to be assessed;
- impact of pollutants (Nitrogen compounds, As, Cd, B, Faecal indicators) on water quality to be assessed;
- strategies for water resource protection to be outlined.

Thank you for your kind attention