Modeling Transport in Porous Solute Unsaturated: Risk of Contamination of Groundwater in the Area of Niayes (Senegal)

Mamadou Lamine DIALLO[1], [1]El Hadji Bamba DIAW , [1]Alassane DIENE, [1]Paul DEMBA, [1]Moustapha NDIAYE, [1]Ablaye DIALLO and [2]Grégoire SISSOKO
[1] Ecole Polytechnique of Thies, EPT, Thies, Senegal
[2]University Cheikh Anta Diop of Dakar, Senegal)

Summary:
In Senegal, the Niayes is an agricultural area where market garden producers use a lot of products such as fertilizers and pesticides. With irrigation, assuming a vertical flow, infiltration can cause with it chemicals that can reach the water in the water table, which is used for drinking by people in the area and other domestic activities.
In this article, it is to assess the risk of contamination of the water straight to the use of chemicals in the Niayes.
To do this, the software HYDRUS-1D allows us to model and visualize the spread and flow component concentration considered pollutant from the soil surface to a specified depth, and to report links which may exist between certain depth and soil parameters. The substance will be considered non-radioactive, with a particular concentration. To the ground, it is necessary to consider the hydrodynamic characteristics in the various study sites.
We have helped to specify the vulnerability of some soils of the area by fertilizers such as urea and NPK 46% mainly used in different doses. Nitrates are hardly retained in soils (behavior of a tracer with little ion exchange) and therefore easily reach groundwater. So they move with the irrigation water along the profile.
We have chosen in the simulations the amount of fertilizer recommended by the Regional Agricultural Thies Center. The drainage time as placing a substance to reach the water is not the same for different soils. But with the intensification, the layer of the Niayes is exposed to obvious contamination. Introducing parameters such as the distribution coefficient or rate constant of degradation in NPK, we obtained a significant reduction of the final concentration.
Keywords*: groundwater-contamination-fertilizers-concentration-distribution coefficient-constant of degradation-modeling.*

INTRODUCTION

The Niayes is an agricultural region that stretches from Dakar to Saint Louis with a length of 80 km by 20 km wide. It includes nearly 80% of the vegetable and horticultural production in Senegal. Because of the need to meet the needs of local and foreign market, farmers engage in an intensification of agricultural production policy. This requires the use of certain substances such as fertilizers, raw for watering plants pesticides or sewage. The study area consists of six predominantly sandy sites. When considering a vertical flow, water infiltration can cause with it chemicals that can reach groundwater **[1]**.

Also, the water from the groundwater is used for agriculture and for drinking by people and animals. This contamination has serious effects on human health, the environment and livestock **[2]**. The groundwater quality depends on our ability to assess the risk of transfer of pollutants depending on the choices of land management that are made **[3]**. The objective of this study is not to quantify the pollution as such or include areas already polluted, but rather to assess the risk of contamination of groundwater consecutive use of chemicals. This is all the more reason that these pesticides, the fertilizers and the wastewater may eventually constitute force pollutants accumulate in the soil **[4-5]**.

The approach used in this work is to study first the unsaturated porous media and then saturated environment. These two areas are the key element of the soil and act as a filter for groundwater **[6]**. Indeed, according to the thickness of the unsaturated zone, the pollutant can reach the water or not. Rock or element containing groundwater can affect the potability of it **[7]**. Then, we present different models of solute transport used previously. And models **[8]** allow us to access experimental values, particularly difficult to measure, and are therefore a suitable tool for the study and prediction of water transport in the unsaturated part both in economic and technically. A final study will assess the risk of groundwater contamination from a chemical.

To do this, the software HYDRUS-1D **[8]** allow us to see the spread of flow component concentration considered pollutant from the soil surface to a specified depth, and to report as links that may exist between the depth and some soil parameters. The substance will be considered non-radioactive, with a particular concentration. For soil it is necessary to consider inter alia, the content and residual water saturation, bulk density, saturated hydraulic conductivity.

I. PRESENTATION OF THE STUDY AREA

1.1. Location

Located on the northern coastline of Senegal (Figure 1), the Niayes is characterized by favorable physical conditions (climate, soil, hydrogeology), which are the support of agricultural activities (horticulture, poultry and dairy). The long coastline of 180 km by twenty wide, produces more than 80% of vegetable crops in the country, contains 1% of cattle, 3% of small ruminants and a very important part of the poultry industry.

The narrowness of this environment, shared housing and agriculture reflects a whole strategy of intensification of agricultural systems at both small than large producers.

The Niayes is also characterized by its particular vulnerability in its geology, plant resources, especially water resources. The latter being located at very shallow depths, sometimes flush, is used both for agriculture and for drinking. The porous nature of the substrate that covers (Quaternary sands) translates all its vulnerability towards all forms of pollution of groundwater from agricultural sources, but also domestic.

Niayes are thus inter-dune troughs more or less flooded, permanent or semi-permanent located in depressions between red dunes (North Mboro) or internal depressions between dunes and coastal dunes (South Mboro). They are traces of small rivers formed during regressions intersecting the dunes and the sea then invaded. Communications have gradually disappeared with the formation of the coastal strip. We note the main Niayes between Mboro and Loumpoul with particularly Niayes of Mboro, lake Tamna and Mekhe which are the greatest.

Some of these "Niayes" with fresh groundwater, led to the installation of vegetable crops with high use of labor, and nearly 60% of the daily activity is devoted to manual watering on sandy soils.

Groundwater surfaces in depressions along the massive dune, causing the formation of temporary or permanent marsh called Niayes that give special character to this region. They are indeed green areas where seasonal crops are grown. Niayes are powered by the water and therefore their flooding is related to the flow and groundwater recharge system. The piezometric groundwater sands of Niayes is characterized by a very pronounced piezometric dome in south-central sector, that collapses to the isopieze zero towards the north. The water flows to the ocean with a slope of 0.5% at the edge of the sea and to the groundwater of east Lutetian calcareous.

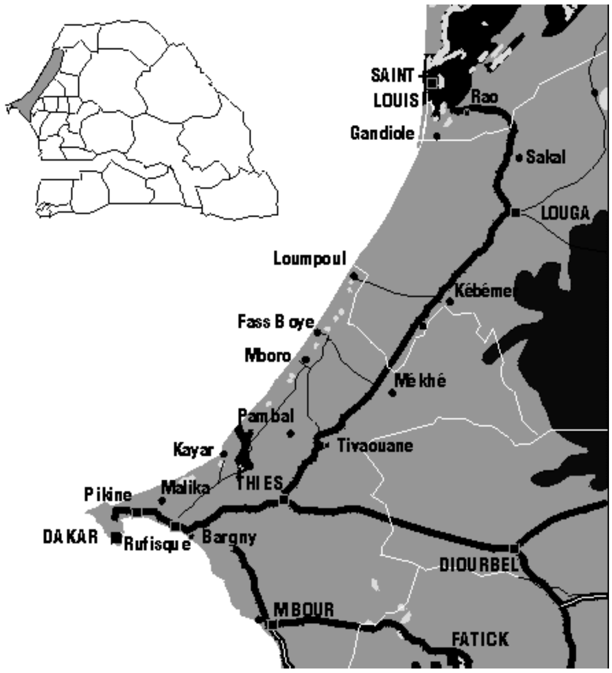

Figure 1: Area of Niayes

1.2. The soils of the Niayes

The geomorphology of the area of Niayes is characterized by the coat of Quaternary sands covering the oldest geological formations.

Schematically, and starting from the coast, we can successively observe:

- Coastal dunes of bright sand, a width of 200 to 300 m but extends further in places and threatens inland areas;
- Dunes more or less fixed, interspersed with depressions more or less humid;
- Red sands constituting ferruginous soils at the bottom of the slope;
- Peat soils located in the low points of depression and having a surface layer composed of decaying organic matter, highly acidic and relatively high salinity;

• Vertisols, limited to Sébikotane area, characterized by a high content of montmorillonite.

This device has an area of 270.000 ha, covering ancient valleys that intermediate depressions partially leave short; it is the "Niayes" who gave their name to the natural area.
The dominant soils are sandy texture varying types Dior, Dior Deck Deck with a decreasing degree of leaching and clay content of organic and inorganic materials generally low. There are:
• Soil "dior" sandy, yellow-brown, not leached ferruginous, located at the top of the dunes; they are permeable but poorly structured deep soils because their clay content is almost zero;
• Soil "deck-dior" clay, brown on the sides. They consist of a mixture of clay and sand, and are located downslope. They are seasonally marshy and can be quite rich in minerals with shallow depth;
• Soil "deck" made of slightly argillaceous and hydromorphic black soil. Their organic matter content is variable rather low in the inter-dune and stronger in large poorly drained depressions.
The soil data used in this article come from a study carried out in the framework of support for the project of peasant entrepreneurship Niayes Senegal (PEAP). Several parameters have been studied, but we just consider those necessary for this study.

II. MATERIALS AND METHODS

2.1. Physical and hydrodynamic characteristics of soils

Table 1 presents data from the ground to be used as input parameters in the Hydrus-1D software for carrying out numerical simulations. In different soils we notice that we have a structure in sandy character. Parameters such as the density (ρ), the residual water content (θ_r), the content of saturation water (θ_s), the shape factor of the soil retention curve (α) and the saturated hydraulic conductivity (Ks) are those used in the Van Genuchten model for sand. Tortuosity (τ), the hydrodynamic dispersion coefficient (D) and the rate constant for degradation (μ) are those of the convection-dispersion equation in one dimension. The longitudinal dispersivity of a soil is soil capacity for passing therethrough by a chemical compound in the longitudinal direction.

Table 1: Parameters of the soil at different sites

Sites / Data	Ndoye	Gabar	Sao Peulh	Fass Boye	Mboro	Touba Ndiaye
Average Ks (cm/h)	**19.1**	**127.0**	**17.5**	**124.9**	**23.2**	**75.2**
Porosity %	**46**	**39**	**66**	**27**	**49**	**64**
Apparent density	**1.42**	**1.62**	**0.90**	**1.92**	**1.34**	**0.96**
Depth (cm)	**160**	**190**	**200**	**170**	**200**	**140**
Dispersivity λ_L [L]	**10**					
α	**0.145**					
θ_s	**0.43**					
θ_r	**0.045**					
n	**2.68**					

a. Presentation of the pollutant: the reasons for choosing

The substance in this part is nitrogen. It is a molecule present in the majority of chemical fertilizer as a percentage and is involved in plant growth. A fertilizer is any natural or synthetic substance that is added to the soil to provide nutrients for plants including nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O).
In the Niayes, several fertilizers are used but we will only consider two only because of their dominance. This is urea 46-0-0 and NPK 10-10-20.
The nitrogen molecule (N_2) is substantially present in the air, but in the water and the soil, it is in the form of nitrates (NO_3^-) and nitrite (NO_2^-). All these substances belong to the nitrogen cycle.

i. The nitrogen cycle

The nitrogen cycle is very complex and leads to the production of nitrates or nitrites.

$$\underbrace{2N_2(g)}_{Nitrogengas} + \underbrace{3(CH_2O)}_{organicmaterial} + \underbrace{3H_2O}_{water} + \underbrace{4H^+}_{hydrogen} \rightarrow \underbrace{NH_4^+}_{ammonium} + \underbrace{3CO_2}_{carbondioxide}$$

Soils where the pH is high, the ammonium is transformed into gaseous ammonia.

$$\underbrace{NH_4^+}_{ammonium} + \underbrace{OH^-}_{hydroxyl} \rightarrow \underbrace{NH_3(g)}_{ammonia} + \underbrace{H_2O}_{water}$$

Nitrification transforms products fixation $\left(NH_4^+, NH_3\right)$ in NO_x (NO_2^- and NO_3^- are), nitrites and nitrates. This is an oxidation reaction that is catalyzed by enzyme linked to bacteria in soil and water. The chain reaction is of type:

$$\underbrace{NH_4^+}_{ammonium} \leftrightarrow \underbrace{NO_2^-}_{nitrite} \leftrightarrow \underbrace{NO_3^-}_{nitrate}$$

Either:

$$\underbrace{2NH_4^+}_{ammonium} + \underbrace{3O_2}_{oxygen} \rightarrow \underbrace{2NO_2^-}_{nitrite} + \underbrace{2H_2O}_{water} + \underbrace{4H^+}_{hydrogen}$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^-$$

Ammonia nitrogen is essentially a transitional form; it is the first soil transformation of organic nitrogen. The presence of water can lead to the formation of nitrates or nitrites through ammonium. Nitrates, very soluble in water, are driven by leaching into the depths. They follow the water as it moves and can go down to a speed that depends on the physical condition of the soil and the amount of infiltrated water. They can also, if they have not migrated too deep, flow up into the soil profile by capillary, in dry period.

Thus, nitrates are considered as tracers. A good tracer moves at the speed of the water without interaction with the environment with little or ion exchange **[8]**. In this study, we consider the urea as a tracer because, with less cation, it does not react with the environment. Cation exchange in the case of NPK will be greater.

ii. Effects of nitrates on health

We know that nitrates and nitrites have several negative effects on health when the application is excessive. Among these effects we can mention:

- Reactions with hemoglobin in the blood, causing a decrease in transport capacity of oxygen (nitrite);
- Decrease in the functioning of the thyroid gland (nitrate);
- Lack of vitamin A (nitrate);
- Production of nitrosamines, which are known as one of the most common causes of cancer (nitrates and nitrites) **[10]**.

2.2.3. Quantification of nitrogen

According to information at the regional agricultural center in Thies, registered standards authorized in the Niayes are 100 kg/ha for urea and 150 kg/ha for NPK 10-10-20. We will reduce this amount per square meter to calculate the number of moles. The concentration is the number of moles per amount of volume; we consider a liter of solution. For urea: 46% N_2 which gives us a mass of 4.6 g/m^2, the molar concentration will then be 0.160 mol/l/m^2 or 160 mmol/l/m^2. For NPK 10-10-20: 10% N_2 which gives us a mass of 1.5 g/m^2, the molar concentration will be 0.107 mol/l/m^2 or 107 mmol/l/m^2.These concentration values are input to the simulation model data.

III. Modeling of pollutant transport in the study area

During solute transport, there is a displacement of the concentration front of the surface to the depths. To study this phenomenon we use a numerical simulation model called Hydrus-1D.

3.1. Presentation of software Hydrus-1D [9].

Hydrus-1D is a computer simulation of water transfers and pollutants in unsaturated porous media based on the finite element method in terms of temporal and spatial discretization (higher order approximation in time and space). It is developed by the look-Agrucultural Service of the U.S. Department of Agriculture (USDA), in Riverside, California, in collaboration with the International Ground Water Modeling Center (IGWMC). Version 4.0 is used to simulate inter alia, the flow of water, solute transport and heat transfer in one dimension in a water-saturated environment variably. The simulations can be conducted in homogeneous as in heterogeneous media environment and can integrate the transport of several solutes. The software contains a generator of finite element mesh for the spatial discretization of the domain model. It runs in a Microsoft Windows environment with an interactive interface for parameter input and presentation of results. The hydrodynamic parameters of inputs to the soil are those of Van Genuchten model.

For the solute, the parameters considered are those of the equation convection dispersion reagent solute transport or not. The entries in Hydrus-1D files are designated by four blocks represented by the letters A through M. The input files must be placed in the same directory. The program is to output 9 + (n_S-1) files with the number n_S of solutes considered at first order in the chain in the case of decomposition of a reagent solute. When the chemistry of major ions is considered, the program output is 13 files.

a. The mathematical model in Hydrus-1D

To investigate the mechanisms of solute transport in porous media saturated or unsaturated, several mathematical models are used. Whatever scheme is chosen, it is subject to the criteria of discretization in time and space.

The convection-dispersion equation in 1D, used to describe the vertical transport of a reactive solute in porous media partially saturated with water **[8]**, can be written as follows:

$$\frac{\partial\left(\phi S_w C+\rho_s(1-\phi)C_s\right)}{\partial t}=\frac{\partial}{\partial z}\left(\phi S_w D\frac{\partial C}{\partial z}\right)-\frac{\partial}{\partial z}(qC)-\mu\left(\phi S_w C+\rho_s(1-\phi)C_s\right) \quad (1)$$

C : Solute concentration [M.L^{-3}]

q : The Darcy velocity [L .T^{-1}]

ϕ : Soil porosity [-]

S_w : The degree of water saturation [-]

ρ_s : The density of the solid phase [M.M^{-1}]

μ : The constant degradation kinetics [T^{-1}]

D: The hydrodynamic dispersion coefficient [L^2 T^{-1}]

Using the effective dispersion in unsaturated media, we get:

$$\theta D=\lambda_L|q|+\theta D_m\tau \quad (2)$$

θ: [L^3 L^{-3}], the volumetric water content of the medium related to the degree of saturation by the relation:

$$\theta=\phi S_w \quad (3)$$

λ_L : Longitudinal dispersivity [L]

τ : Tortuosity

D_m : Molecular diffusion [L^2.T^{-1}]

Introducing delay factor R, depending on the water saturation in the equation (3-1), we obtain:

$$\frac{\partial(R\theta C)}{\partial t}=\frac{\partial}{\partial z}\left(\theta D\frac{\partial C}{\partial z}\right)-\frac{\partial}{\partial z}(qC)-\mu\theta RC \quad (4)$$

With $R=1+\dfrac{\rho_s(1-\phi)K_d}{\theta}$ (5)

$$R=1+\frac{\rho_b K_d}{\theta} \quad (6)$$

By asking $\rho_b=\rho_s(1-\phi)$ (7)

Kd : Distribution coefficient [L^3.M^{-1}]

ρ_b : The apparent density [M.L^{-3}]

The hydrodynamic properties are those of the equation of Mualem and Van Genuchten:

$$\begin{cases} S=\dfrac{\theta-\theta_r}{\theta_s-\theta_r}=\dfrac{1}{\left[1+(\alpha|h|)^n\right]^{1-1/n}}, h<0 \\ S=1, h\geq 0 \end{cases} \quad (8)$$

And

$$K=K_s S^{\frac{1}{2}}\left[1-\left(1-S^{\left(n/(n-1)\right)}\right)^{\left(1-\frac{1}{n}\right)}\right]^2 \quad (9)$$

With $n>0$

K_s : Conductivity at saturation [L^3.L^{-3}]

θ_s : Water content at saturation [L^3.L^{-3}]

θ_r : Residual water content [L^3.L^{-3}]

h : Pressure [L]

α : Shape factor [L^{-1}]

K : hydraulic conductivity

S: Degree of water saturation of the soil [L.T^{-1}]

n : Coefficient characteristic shape of the floor considered

IV. Results and Discussion

4.1. Presentation, analysis and commentary of the results

We will assume that leaching by rainwater or irrigation allows nitrates or nitrites to reach the water from a vertical flow. The numerical simulation with Hydrus-1D will provide a graphical representation of different mechanisms involved in the transfer of solutes to test the consistency and validity of the various assumptions made.

For the simulation data obtained, the profile is divided into several stitches and only the initial conditions and limitations will be considered:

- The initial concentration is zero at the nodes of the domain (Figure 2). At the upper limit, the concentration will be that of urea or NPK.
- The number of stitches is set in 200, which sets the same time the choice of the mesh size.
- We use the indices 1 to mean concentrations of urea C1 = 160 mmol/l and 2 for NPK C2 = 107 mmol/l.
- The urea will be considered as a tracer and NPK reactive substance, with the distribution coefficient Kd = 0.073 [L^3M^{-1}], the degradation constant is fixed at 0001 s^{-1} **[8]**.
- The simulation time is 5 hours ie 18000 s. This time is a choice and will be divided into four time intervals themselves. T1 = 0 s, T2 = 4500 s, T3 = 9000 s, T4 = 18000 s.

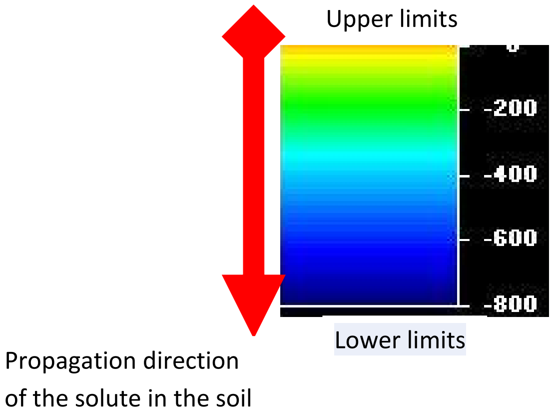

Figure 2: Example of profile after simulation

4.1.1. The boundary conditions

In our study, the boundary conditions can be imposed load conditions or imposed flow conditions. The contamination of the water is making from the surface; we will choose the imposed loads conditions. At the lower limit we consider a free drainage.

4.1.2. Initial conditions

As part of the modeling of transport in unsaturated porous media, we expressed the initial conditions in the form of pressure load. The Hydrus-1D software requires a value at each node, or common to all nodes. We chose the latter option and the assessed value is -1000 cm, which generally represents the maximum value that can be measured in a semi-arid soil with conventional equipment such as mercury sphygmomanometers.

4.1.3. Use of a solute on the same type of soil

In this section we will apply urea or NPK on the same floor. This allows us to see the effect of the tracer and NPK when introducing the constant degradation and the distribution coefficient. Imposed values for these constants are given in the table below:

	K_d [$L^3.M^{-1}$]	μ [T^{-1}]
NPK	0,073	0,001
UREA	0	0

➢ **Darou Ndoye** : In this section, the simulation with urea (Figure 3) provides for a time T2 = 4500 s a depth h1 = 69 cm and for a time 2T1 that is to say, T2 = 9000 s, we have 2h1. This shows that the material is uniform; urea is poorly retained by the soil as the final concentration is 155 mmol/l. In the case of NPK (Figure 4), the final concentration after a period of 5 h simulation is of the order of 10 mmol/l. Much of this material is retained by the soil. The time T3 and T4 are combined. The conclusion we can draw is that we must act on these two parameters to slow the progression of substance. The depth of the water is 160 cm.

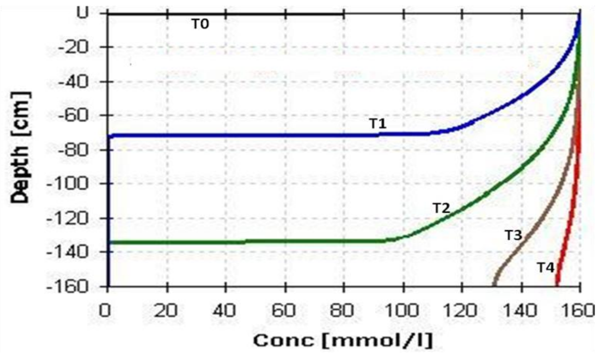

Figure 3: Simulation of Darou Ndoye with urea

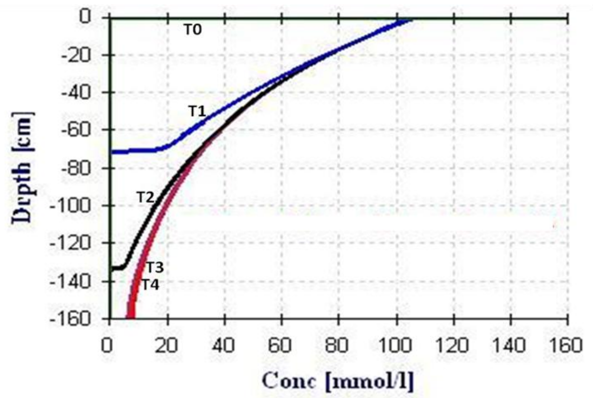

Figure 4: Simulation of Darou Ndoye with NPK

➢ **GABAR** : In this section we note that the time simulations give the same amount of product. The rate of increase of urea in the soil (Figure 5) is very important; the water is more exposed to pollution with urea. When applying NPK (Figure 6), we find a greater retention by the soil; the final concentration was 59.66 mmol/l after a simulation time of 5 h.

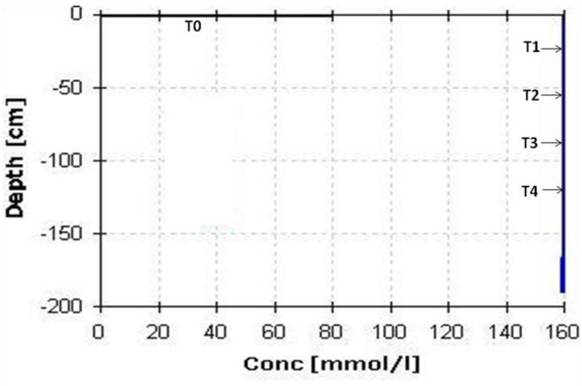

Figure 5: Simulation of GABAR with urea

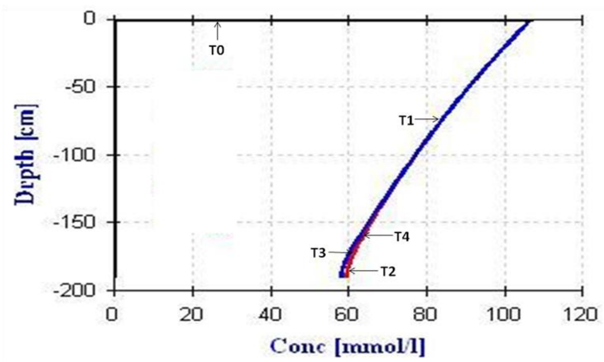

Figure 6: Simulation of GABAR with NPK

➢ **SAO PEULH**: In this area, the evolution of the tracer is identical to that of Darou NDOYE as NPK. This is due to the values of their conductivities at saturation that are equal. Both products have the same effect on these soils. After a simulation of 5 h, final concentrations are 125 mmol/l for urea (Figure 7) and 10 mmol/l for NPK (Figure 8). More time is long, less NPK reach the water. The groundwater in this area is not vulnerable to NPK when considering a time of 120 days (length of growing season in this area).

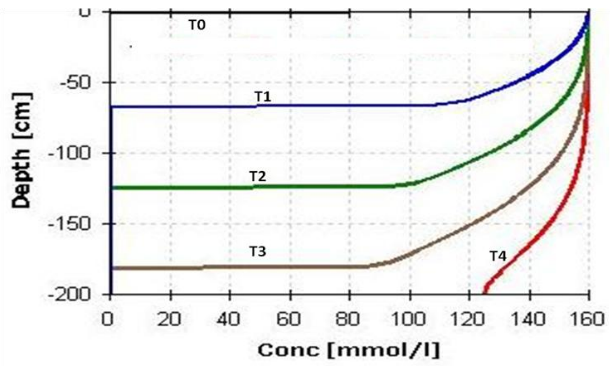

Figure 7: Simulation of SAO PEULH with urea

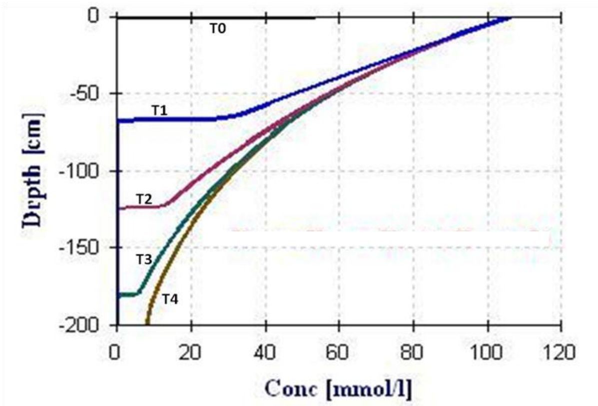

Figure 8: Simulation of SAO PEULH with NPK

➢ **FASS BOYE**: In this area, the final urea concentration was 100 mmol/l, for a simulation time of 5 h (Figure 9). There has been a significant decrease in concentration from the ground SAO where we have a final concentration of 125 mmol/l for the same simulation time. The final concentration of NPK (Figure 10) in the soil is 50 mmol/l. This soil has a low conductivity (0.00486 m/s) with porosity greater than 50%, NPK will take longer to reach the water. The progression of NPK at different times remains the same. NPK is not in use for long periods on the ground.

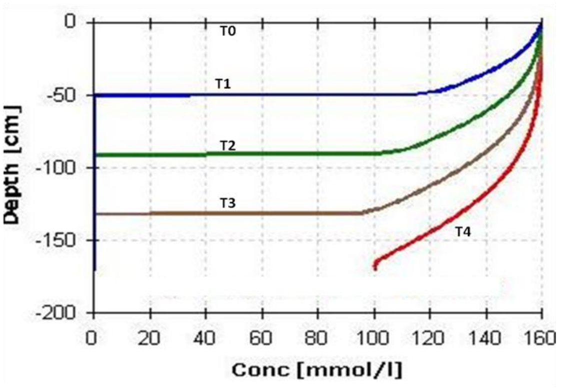

Figure 9: Simulation of FASS BOYE with urea

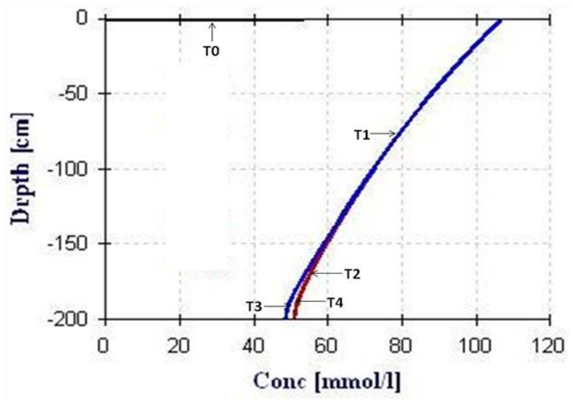

Figure 10: Simulation of FASS BOYE with NPK

➢ **TOUBA NDIAYE** : We have a rapid drainage of two substances because it fails to properly observe the different propagation times. For NPK (Figure 12), the final concentration of the various simulation time is the same (70 mmol/l). This soil is vulnerable to the two substances, but the progress of the NPK to the ground water is lower than that of urea (Figure 11).

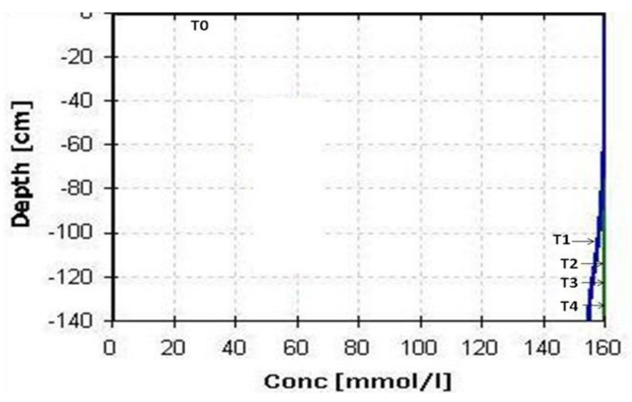

Figure 11: Simulation of TOUBA NDIAYE with urea

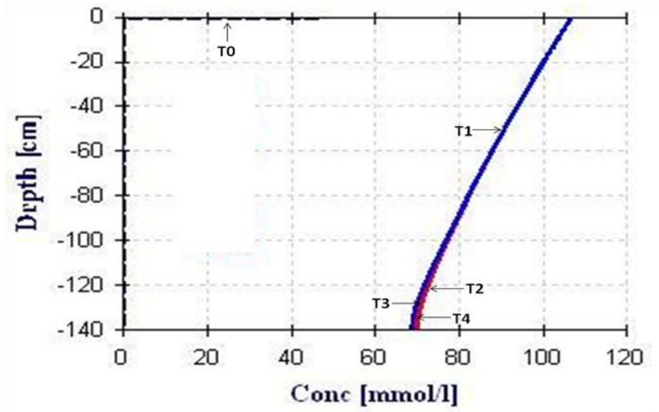

Figure 12: Simulation of TOUBA NDIAYE with NPK

➢ **MBORO** : Although urea is considered as a tracer, the final concentration is different from the initial concentration (160 mmol/l). Presumably part of the substance is retained by the soil (Figure 13). For NPK (Figure 14), we have a 90% decrease. This confirms once again the importance of acting on the delay factor in the manufacture of these fertilizers. More the degradation constant is high, the less NPK reach the water.

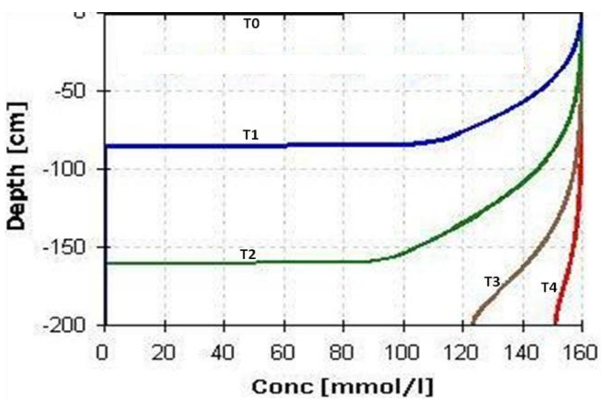

Figure 13: Simulation of MBORO with urea

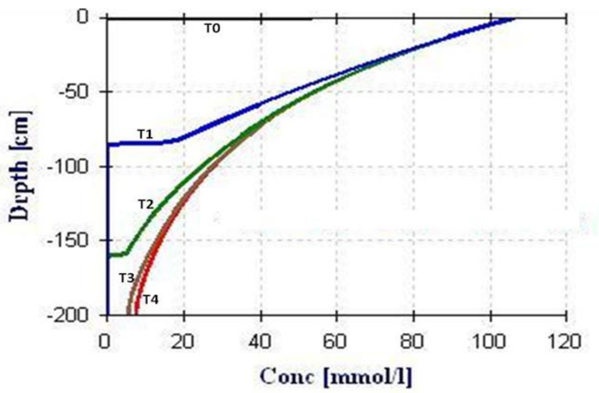

Figure14: Simulation of MBORO with NPK

In conclusion, we can say that urea is a tracer, as final concentrations remain the same as the initial concentrations, with few exceptions. The final concentration of the constant varies with NPK degradation kinetics and distribution coefficient. These data are used to calculate a retardation factor for the substance. Urea and NPK are two substances that reach the groundwater of the studied localities, but at different rate. The penetration rate of the solute is an important factor because it must take into account the duration of a crop in these areas, which is 120 days. It will then make a comparison between doses before and after cultures of the two compounds in the groundwater to quantify the contamination.

4.2. Comparative Study

In this section we try to compare the effect of the same product on different soils. We proceed as follows:

- The output of each floor is stored in a file which is NOD_INF.OUT specified. This file allows us to collect the values of the depth and concentration. During the simulation we considered a mesh of 201 nodes. It will then take deeper as the distance between two consecutive meshes will be the largest. Therefore the values of the concentrations of the other profiles will be included.
- The graphics will be made on Excel and the indices 1 and 2 represent urea and NPK. We will evaluate the results in a maximum time that is to say the time that allows us to observe the maximum drainage of the two products.
- We will try to make a comparison of urea as a tracer on different soils as well as NPK.

i. The case of urea

In this section we compare the behavior of urea, considered as a tracer on different soils (Figure 15). After five hour simulation, it is seen that in the region of GABAR initial urea concentration equals the final concentration. In this area the water is more susceptible to urea then we have less contamination regarding FASS BOYE. Here we see that when we look urea as a tracer, it will reach the water whatever the soil considered. Only final concentrations differ. This difference arises from the saturation values of hydraulic conductivity and porosity.

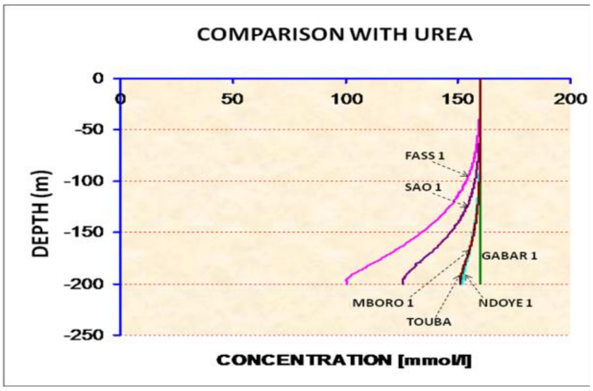

Figure 15: Comparison of urea on different soils

ii. The case of NPK

By introducing the constant degradation and the distribution coefficient in the NPK, we see a significant decrease in the final concentration of the different soils in relation to the case of urea (Figure 16). It is 59.66 mmol/l for GABAR, after a five-hour simulation. The infiltration of NPK in NDOYE and MBORO remains the same for the same value of final concentration of 8.34 mmol/l. Their saturated hydraulic conductivities have similar values, as well as their porosity. In Touba Ndiaye, the final concentration of NPK is 70.009 mmol/l and 51.1 mmol/l for FASS. This comparison shows the importance of the introduction of the degradation constant and distribution coefficient in these products. These parameters significantly affect the rate of progression of NPK in the soil.

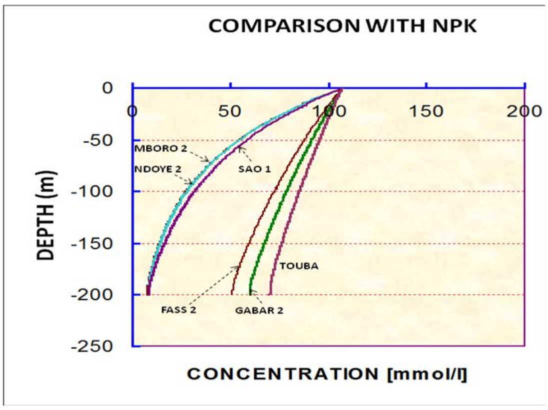

Figure 16: Comparison of NPK on different soils

iii. Comparison of final concentrations

This time, we see the effect of urea and NPK on these soils (Figure 17). The final concentrations in the case of NPK decreased compared to the values of urea. In the case of GABAR, we have a final concentration of zero for the NPK and 100% for urea.

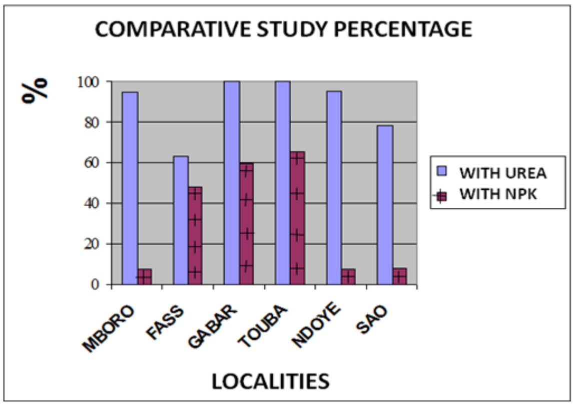

Figure 17: Comparison of the final solute concentrations after simulation

V. Conclusion

In this study, we have contributed to highlighting the vulnerability of some soils of the Niayes by fertilizers such as urea and NPK 46% mainly used in different doses. Nitrates are hardly retained in soils (behavior of a tracer with little ion exchange), and therefore easily reach groundwater. So they move with the irrigation water along the profile of infiltration. The intensity of nitrate leaching in the Niayes can be caused by several factors such as: the coarse texture of the soil, the types and amount of irrigation (leaching potential is higher in surface irrigation than under drip irrigation drop) and finally the form, dose and timing of the contribution of the fertilizer (a delay or advance of the times needs of culture, promote leaching).

We have chosen in the simulations with Hydrus-1D, the amount of fertilizer recommended by the Regional Agricultural Thies center. The study showed that the drainage time it takes for a substance to reach the water is not the same for different soils. But with the intensification, the layer of the Niayes is exposed to obvious contamination. For proper monitoring of the water quality of the Niayes groundwater, it will take samples before and after a crop.

Introducing parameters such as the distribution coefficient or rate constant of degradation in NPK, we obtained a significant reduction of the final concentration. We note as well that urea is more polluting the groundwater as NPK.

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