Use of waste water in urban agriculture in the Dakar area, Senegal: an interdisciplinary study towards sustainability

Swiss National Science Foundation, Research Partnerships with Developing Countries, Joint Research Project No 207021-109689/1. From 1.10.2005 to 31.9.2008.

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Abstract :

This project aims to assess two widespread practices used in irrigated agriculture in developing countries: the use of untreated or poorly treated wastewater or mixtures of wastewater with groundwater water in order to supply for the lack of fresh water (during the dry seasons) and the massive use of often prohibited pesticides. The area to be studied is the costal area of Dakar, whose urban agriculture provides more than 60% of the vegetable production for the 2.3 million inhabitants living there. A group of university researchers, NGOs and local authorities, instead of prohibiting this practice of known high health and environmental risks, but of a high potential to guarantee a certain level of livelihood, collaborates to find optimal, sustainable practices and alleviate poverty among the rapidly growing urban population. By studying the current agronomic practices, testing low cost extensive wastewater treatment methods and by studying in detail the current interaction between water contaminants (micro-organisms, macro-and micro-pollutants), farm products, soils and groundwater, a complete environmental and socio-economic assessment is planned. The used approach will necessarily be interdisciplinary, based on environmental and socio-economic research methods, involving 2 Ph.D. students, several master students and the scientific and technical specialists of their host institutions. The final results will be presented as a Geographical Information System (GIS), including different layers showing not only scientific maps of soil types, ground water level, micro-contaminant degrees of pollution, but also socio-economical data as farmer income, farming practices, identified diseases, etc. This powerful tool will facilitate communication between researchers, stakeholders and local policy makers and will allow an integration of urban agriculture in urban development politics. Besides, it could be easily and regularly updated. Furthermore, GIS will allow authorities to regulate and communicate a sustainable use of wastewater and pesticides in the various local situations and thereby help to alleviate poverty.

The main objective is to contribute to increase sustainability of urban agriculture in Dakar area. There are six specific objectives, and for each one, scientists from University of Dakar (UCAD), University of Lausanne, the NGO Enda-Tiers-Monde, the national institute of agronomic research (ISRA), the hygiene service from Ministry of Health and the Centre de Suivi Ecologique (CSE) are implied:

1. Assess and improve quality of farm products
2. Assess health risks and improve (waste)water quality used for irrigation

3. Assess environmental impacts of wastewater contaminants and pesticides for the soil and groundwater resources
4. Investigate salt intrusion in the ground water and improve ground water exploitation
5. Optimize crop productivity and increase farmers income
6. Facilitate communication on UA between farmers, distributors, consumers, researchers and policy makers

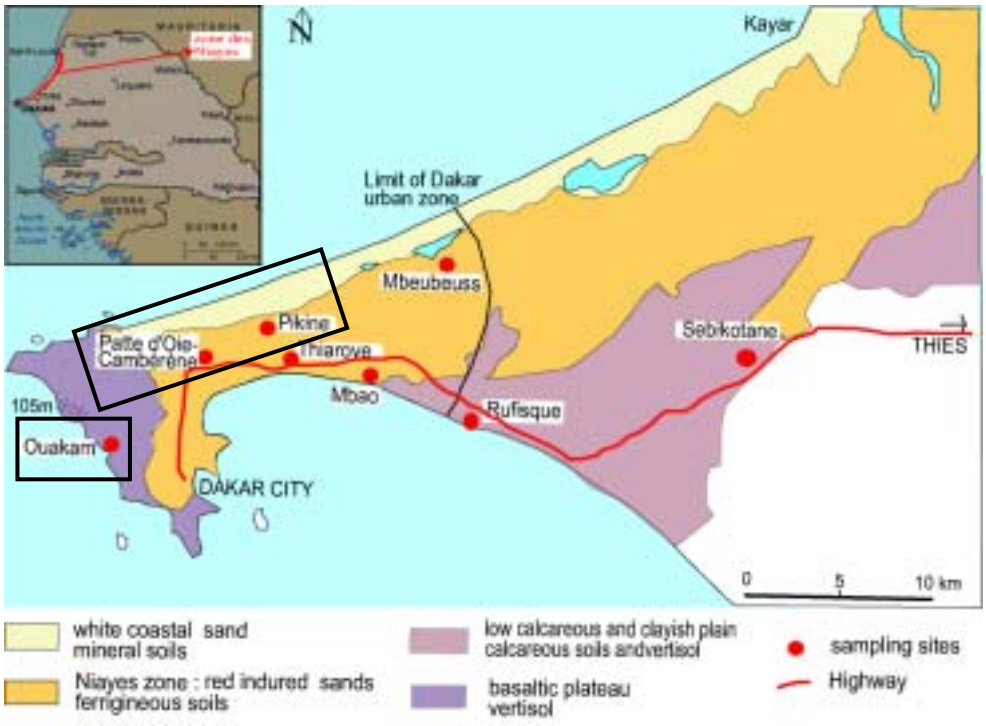

Fig. 1 : Soil map of the Dakar area, showing the three main study sites, Patte d'Oie-Cambérène, Pikine and Ouakam.

Fig. 2 : Situation of the two major study sites within the urban area of Dakar : within the urban area of Dakar.

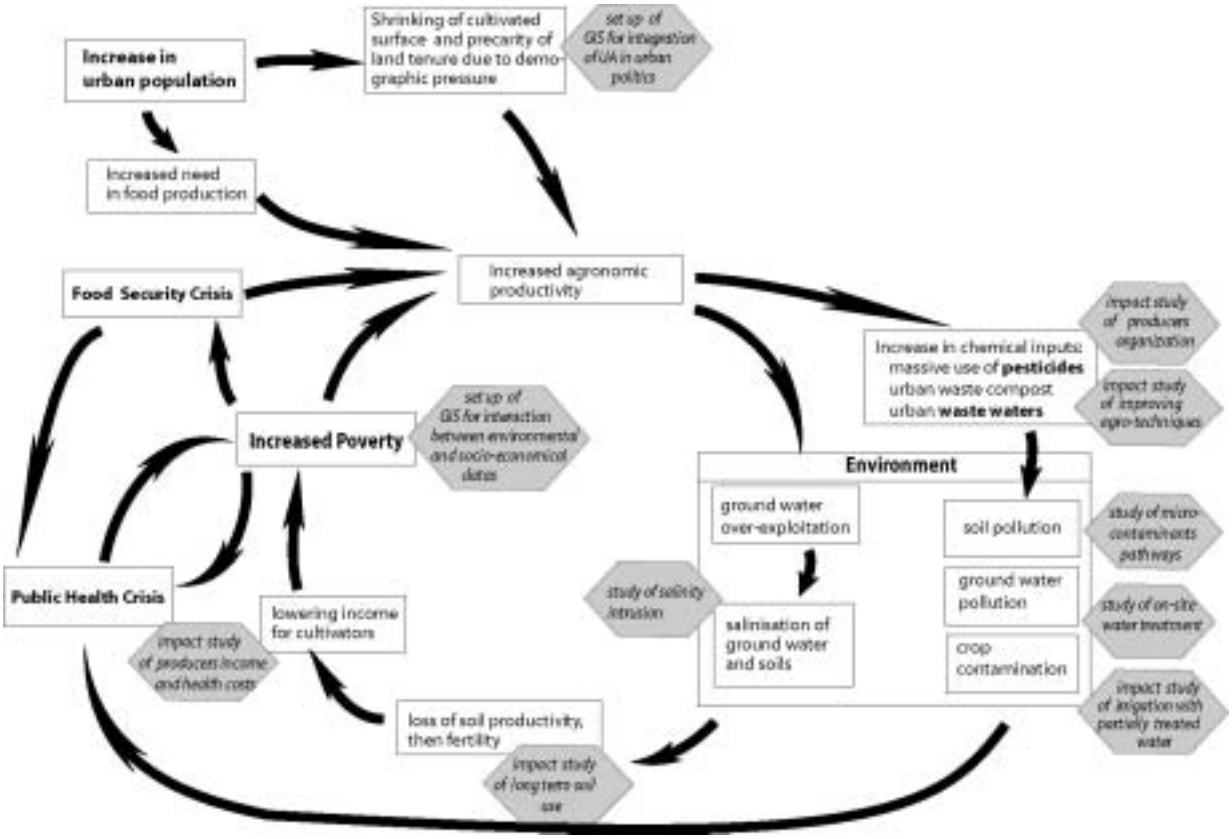

Fig 4 : Conceptual model of urban agriculture in Dakar area and studies proposed (polygons) to minimize impacts to environment and health.

PhD candidate from Lausanne: Anne Gueye-Girardet
Title: Transmission of the agro-ecosystem contaminants to the soil, crop and water resources.
Beginning: 01.04.2004. End: 31.03.2008
PhD director: Hans-Rudolf Pfeifer

Tab1 1 : Specific objectives of the PhD, the related tasks and methods

Specific objectives	*Indicators*	*Tasks to be executed*	- Methods to be employed
Assess environmental impacts of wastewater contaminants and pesticides for the soil and groundwater resources	- accumulation rate of different soil types - soils: clay, organic matter and Fe-oxy/hydroxides content - porosity/permeability - waters: pH-Eh, O_2 - concentration of pesticides	- Monitoring of selected pesticides concentrations in soils, vegetables and irrigation/percolation/ground water from contrasted situations - Identification of key-parameters which govern the transfert processes of pollutants - Soil salinity assessment - UA soils mapping and GIS modeling - Mass fluxes quantification	- pesticide extraction and analyses by GC-MS and HPLC of soils, vegetables and waters - trace element in waters by ICP-MS - trace element in soils by XRF - waters: major ions by IC - C org with C-analyzer - Soils: particle size with Laser - Fe extractions - Waters: In-situ parameters: pH, Eh, alkalinity,O2, conductivity, temperature - Cross-relation among GIS layers Hormones and pharmaceuticals by HPLC - Atmospheric dusts by extractions and ICP-MS
Facilitate communication on UA between farmers, distributors, consumers, researchers and policy makers	- consideration of all stakeholders needs	- Correlation of all data in GIS - Clear representative maps with GIS - Modelisation of selected pesticides behaviour - Prediction for long term cultivation	- Set up of GIS with CSE - Forum with implicated stakeholders - Built up of user-friendly interface with CSE

Introduction:

The massive use of fertilizers and pesticides together with waste water irrigation in the urban agriculture of the Dakar area is presumed to have a strong environmental impact on soil and groundwater quality and on public health.
Two major sites, surrounded -and furthermore threatened- by the townships of *Pikine* and *Patte d'Oie*, have been investigated. Irrigation with groundwater has become difficult in *Pikine* (Fig 3) since salinity has gradually increased.

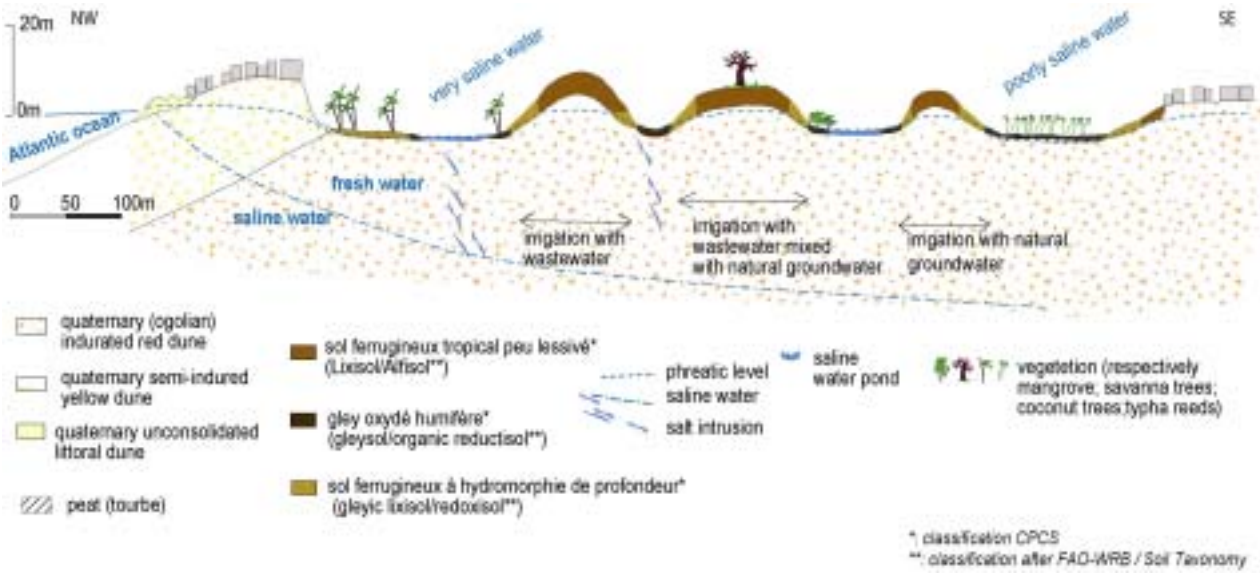

Fig 3: Cross section through the site of Pikine

Methodology:

We consider that urban agriculture can be represented as an agro-ecosystem, including inputs and outputs (Fig. 4). It is necessary to evaluate the fluxes of inputs and outputs in order to quantify accumulation rate of contaminants in soils, crops and ground water. This chemical element trasnfer point of view will help us to investigate the fate of contaminants; therefore, it is important to go beyond the size of cultivated plots and to investigate on a regional scale.

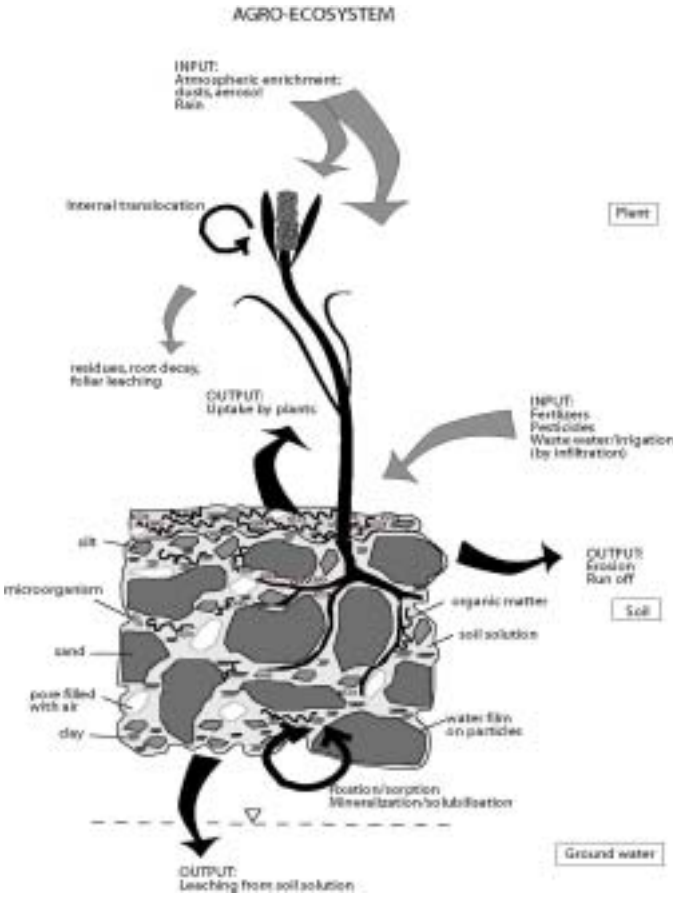

Fig 4: agro-ecosystem

First results:
Using the FAO-WRB soil classification, our results show that lixisols are the dominant soil type and occur on the top of dunes until mid-slope. The transition from mid-slope to foot slope are characterised by gleyic lixisols, and depressions are represented by gleysols. The latter are either oxidized and poorly organic, or totally reduced and strongly organic and but represent only few % of the cultivated sites. Soil analyses indicate that pH in the top layer horizon is strongly dependant on irrigation water and fertilizer type. Not cultivated lixisol had a neutral to acid pH, while cultivated soils tend to be strongly basic in the top layer, except soils fertilized with acid peanut residue. Lixiviation inside the soil profile may also be increased by the high quantity of irrigation (> 10 liters/m2/day).
The individual inquiries demonstrated that agricultural practices are extremely heterogeneous, but there is clear evidence that fertilizers and pesticide application are much higher than national recommendation levels (ISRA, CDH[1]). 15 pesticides have been regularly encountered (40% organophosphorous, 20% carbamates and 13% organochlorined) and 12 of them –the most used- are prohibited for market gardening according to CSP/CILSS[2].
In summary, the Dakar urban agroecosystem is characterised by an excess in contaminant inputs, which not only causes damage to natural resources, but also increases the production costs. Further studies to understand pathways of other microcontaminants and to predict exposure risks are running.

PhD candidate from Dakar: Mamadou Lamine Ndiaye
Title: Health risks related to the origin of irrigation water
Beginning: 01.04.2006. End: 31.03. 2009
PhD director: Raffaele Peduzzi, UNIGE. Co-director: Seydou Niang, UCAD

This part of the project deals with the characterization of the different types of water used for irrigation and will study low-cost wastewater treatment methods that fit to the context where wastewater is used. A follow-up of the efficiency of the proposed methods for the removal of pathogenic organisms as well as excess nutrients, suspended solids and organic matter will be conducted.
For the all selected sites, water used for irrigation will be characterized. For this purpose, samples will be taken after random selection of different kind of water irrigation. On each site, four period of sampling and analyzing will be done each year: during the rainy season, during the hot and humid season, during the hot and dry season and during the fresh season. The parameters followed will be in the water: suspended solids, BOD5, COD, NO3, NH4, NK, total P, PO4, fecal coliforms, pathogenic germs such as *salmonella, vibrio cholera, shigella* or *staphylococcus* and parasites. Level of contamination will also be followed up in crops and analysis will concern fecal coliforms, and parasites. DNA-based microbiological methods will also be used when necessary (Ndiaye, 2005). Further assessment of faecal coliforms and parasites transport in soils will be studied by laboratory experiments with soils columns irrigated with waste or treated water.

[1] ISRA : institut sénégalais de recherches agronomiques ; CDH : centre de développement de l'horticulture
[2] CSP/CILSS : comité sahélien des pesticides ; CILSS : comité inter états de lutte contre la sécheresse au Sahel