

---

## Water, Health and Agriculture in Africa

Proceedings of the COPED-GID Forum, held in the Académie des Sciences,  
Paris, 12-13 May 2011 Actes du Forum COPED – GID qui s’est tenu à  
l’Académie des Sciences, à Paris les 12 et 13 mai 2011

*Eau, santé, agriculture en Afrique*

*Agua, salud y agricultura en África*

---



**Publisher**

Institut Veolia Environnement

**Electronic version**

URL: <http://factsreports.revues.org/1370>

ISSN: 1867-8521

**Electronic reference**

« Water, Health and Agriculture in Africa », *Field Actions Science Reports* [Online], Meeting Reports,  
Online since 11 April 2012, connection on 30 September 2016. URL : [http://  
factsreports.revues.org/1370](http://factsreports.revues.org/1370)

---

The text is a facsimile of the print edition.

Creative Commons Attribution 3.0 License

**“Water, Health and Agriculture in Africa”****Proceedings of the COPED-GID Forum, held in the  
Académie des Sciences, Paris, 12-13 May 2011**

A major Franco-African forum entitled “Water, Health and Agriculture in Africa”, was held at the Paris Académie des Sciences on May 12 and 13, 2011, under the aegis of the Committee for Developing Countries (COPE1) and the Delegation for International Relations (DRI), and in liaison with the Interacademic Group for Development (GID2).

Since its creation in 1996, COPED has principally striven to reinforce scientific and technical links with French-speaking Africa. Forums have been organized, focusing either on fundamental global issues of research, education or training, or on specific questions concerning health, agriculture, nutrition, epidemiology, demography, or energy and mining resources. This Forum, the 11<sup>th</sup> Forum, brought together French academics and researchers, as well as several members of the Paris Académie des Sciences and from African Academies. In this sense, the meeting follows in the tradition of earlier COPED forums.

The African participants—academics, research center directors, and academy members—outlined the current situation with regard to water resources, and how they are managed, in their respective countries. In parallel to these inventories, French and African researchers reported on a range of different approaches, including cutting-edge methodologies for water purification and sanitation, risk prevention, new paradigms on the reuse of wastewater, and local experiences and experiments.

**Introductions**

Opening the Forum, Professor Guy Laval (Académie des Sciences, Vice-President, Delegate for International Relations) began by underlining the adjoining and complementary objectives of the two institutions, with the GID being more focused on the countries bordering the Mediterranean, and COPED being more focused on purely scientific and technical questions, and on the specific problems of Sub-Saharan Africa.

Professor François Gros (Honorary Permanent Secretary, Founding President of COPED) placed in context the latest COPED Forum, which highlights a topic frequently discussed by international bodies, but which is of increasing concern, even in France: access to water resources. The most urgent question is without doubt that of sanitation, a pressing requirement if we are to prevent so many children from dying from diarrhea and parasitic diseases. Advances in water monitoring and purification will be one of the Forum’s central themes. Another important area will be the relationship between water and agriculture, an aspect that is not on the agenda of the Parmenides Conference.

It should be noted that the Forum is organized as a prelude to the 4th GID Parmenides Conference, to be held in Rabat

in November 2011. Parmenides IV will address more specifically the sanitary and societal consequences of the urbanization of the coastal areas of the Mediterranean rim, and of the desertification of rural areas—phenomena with profound implications for access to water.

Professor François Gros paid homage to the essential contribution made by Professor Michel Delseny to the organization of the Forum, and offered sincere thanks to the “partners” who made it possible to convene the forum: Doctor Robert Parienti, and Professor Philippe Kourilsky, both of them loyal supporters of COPED.

Doctor Robert Parienti (Secretary General of FIRAS—Fondation Internationale pour le Rayonnement de l’Académie des Sciences), expressing his gratitude to François Gros for his work, added that FIRAS was pleased to participate once again.

Professor Philippe Kourilsky (Professor at the Collège de France), after paying homage to François Gros, pointed to the convergence between COPED’s action and the fight against poverty. A chair in “Knowledge and Poverty” has recently been created at the Collège de France, aimed at mobilizing different forms of knowledge—while also promoting “know-how”—in order to address the major challenges facing the planet, which notably include access to water.

Professor André Capron underlined the highly positive interaction between COPEL and the GID in preparing the Forum, which is intended to be complementary to Parmenides IV. The origin and achievements of the GID are recalled in his speech (see below).

## A Resources, needs, constraints and challenges

*Mustapha Besbès (Emeritus Professor of the Ecole Nationale d'Ingénieurs in Tunis, foreign associate of the Académie des Sciences): "Water security in North Africa: the priority issues"*

For some twenty years now, experts have been announcing serious water shortages, first for around 2000, then for later timelines. As a scientist, Prof. Besbès examines the validity of these predictions, and undertakes an analysis—if anything, quite an optimistic one—of the data.

The fact that the date of this “catastrophe foretold” has been put back is probably not unconnected to the two following phenomena: (i) the regular decrease in estimates of demographic growth around most of the world, and (ii) the observation that progress has generally been made in local water management as peoples have become emancipated.

Water security can be defined as “sustainable access to adequate quantities of water of acceptable quality”.

To measure levels of water security calls for reliable quantitative indicators. The most widely-used indicator evaluates resources relative to population (1700 cubic meters of water per inhabitant per year to be “water secure”, with less than 1000 being defined as chronic scarcity, and less than 500 as structural scarcity).

This universal and easy-to-use indicator suffers from two major drawbacks: (i) it is linked to demography (which changes), (ii) it implies a logic of food self-sufficiency; but very few countries are self-sufficient in food, and the total flows of “virtual” water—i.e. the quantity of water used to produce food—are vast.

Prof. Besbès proposes that this indicator should be supplemented by a vulnerability index, corresponding to the resource consumption rate.

I. In the first part of his exposé, taking North Africa as his example, Prof. Besbès lists the main parameters that come into play in water management.

The wealth of underground water: generic water resources are made up of two sources of supply: rainfall, or “green water”, with a water cycle dominated by evapo-transpiration in arid countries (90% of the water returns into the atmosphere); and groundwater (or “blue water”) which makes up 99% of the freshwater resource in Tunisia. A map of Tunisia’s aquifers reveals its wealth—two thirds of the country’s surface area is water-bearing: roughly one hectare per inhabitant. This heritage must be preserved; in many parts of the world, the relative aquifer surface area is much lower (0.4 hectares per capita in France).

The deterioration of water resources: the intense exploitation of groundwater inevitably means that water tables fall, leading to changes in the geochemical equilibrium and

salinity of groundwater. Overexploitation of aquifers is common throughout North Africa. Prof. Besbès cites some examples: the coastal aquifer of Tripoli in Libya, where pumping has caused the water level in wells to fall by 80 meters in 30 years, with salt water seeping into the water table; catastrophic predictions for the future led to the construction of the “Great Artificial River” which carries fresh water from the aquifers of the Sahara to the coast; in Morocco, the water tables of Souss and Fez have also fallen alarmingly; in Algeria, the reserves of the Hodna water table are totally exhausted; in Tunisia, while it would take 10,000 years, at the current rate, to completely drain the aquifers of the south, in the center and north of the country, it would only take 800 years.

The relationship between water security and food security: the virtual water balance. Agriculture depends on two types of water resources: on the one hand, surface and ground water (increasingly exploited to meet the demand for drinking water and from industry: 20% of total water extraction is estimated to be for agriculture), and on the other, rainwater, which makes it possible to grow highly water-dependent crops, but which is subject to the vagaries of the climate. A third component of this water balance is the import and export of “virtual” water, equivalent to the quantity of water used to produce traded foodstuffs.

In Tunisia, the balance is currently negative, and a sharp increase in the productivity of rain-fed agriculture is needed, implying new development strategies.

II. The next section of Prof. Besbès’ exposé centers on the major challenges that must be met if we are to improve the region’s water security:

- Improving the level of food security by optimizing exchanges of virtual water (e.g. the virtual green water of rain-fed olive groves, the blue water used to grow dates, which are mainly exported, representing a quantity of water lost for Tunisia);
- Improving the water balance through better knowledge of additional hydraulic resources (green water reservoirs, underground storage, wastewater reclamation), and through clearer understanding of decision processes concerning water, made possible by computer modeling, and by greater involvement of scientific research;
- Controlling and reducing over-exploitation, the dilemma being to preserve the water table without impeding economic development;
- Developing awareness of these issues among farmers, as ignorance of the effects absolves everyone of any responsibility for the way the system works (example of community-based cognitive management in India, teaching people about aquifers and water balances);
- The final challenge is the modernization of water governance: we must promote institutional reforms designed to create synergies between the state and the users. There are few experiments of this kind in the world. We need more government, more local

democracy, more knowledge, and better supervision of the farming community through training programs. It is proposed that a water law be introduced.

*Vincent Dabilgou (COBATY International, Brussels, former Minister for Housing and Town Planning of Burkina Faso): "Water issues and urbanization in Africa".*

After paying homage to COPED, and welcoming the presence in the Forum of several members of COBATY International, Mr. Dabilgou stressed that Africa is confronted with a twofold constraint, acting concomitantly: the continent is undergoing a historic period of demographic and territorial change.

At the beginning of the 1990s, two thirds of its population lived in rural areas, but according to forecasts, Africa will have 750 million town-dwellers in 2030, and more than 1,200 million by 2050. Its urban population alone will exceed the entire urban and rural population of Western countries. Two thirds of this population growth will be absorbed by medium-sized towns, sometimes accompanied by worsening inequalities and the disruption of the social fabric, due to the failure of urban planning. There are many challenges, but one of the most decisive remains that of water.

At the same time, Africa is bearing the full brunt of the initial effects of climate change: when there is no rain, the rivers and wells dry up, causing famine; when there is too much, the urban water infrastructure is destroyed, causing flooding, landslides, and the loss of goods, to which is added a deterioration in conditions of hygiene and in the environment, favoring the spread of diseases such as cholera and malaria.

Mr. Dabilgou described the recurrent failure of urban development plans and guidelines, due to the difficulty of land management, to the specific topology of the inhabited environment, and to movements of population within urban areas.

Some 97% of the world's water resources are in saltwater. Africa has 13% of the world's population, and 9% of its water resources. The greatest demand comes from agriculture, and is set to rise by 30% in the coming years.

Africa's vulnerability to water issues depends on local plant cover, but also on the way farmers use the soil, and on phenomena such as deforestation and bushfires.

The climate, with its torrential rains, can cause catastrophic flooding (800 dead in Algeria in 2001; 24,000 houses destroyed in Burkina in 2009; the unforeseen overflows of the dams on the Niger river in 1999, responsible for a thousand deaths). The other distinctive climate characteristic is the long dry season (7 to 8 months). In all, more than 20 African countries are confronted with water scarcities.

### What is to be done?

There are still a few core structures left over from colonization, but these sanitation works are now showing their age, while town centers are being abandoned in favor of new districts. Towns and cities are growing without any overall development plan. Water and sanitation infrastructures are expensive. We are forced to do the planning and development work for outlying urban areas as the need arises.

The total surface area of agricultural land, meanwhile, is diminishing. We must therefore:

- clarify the role of local government, at the institutional and financial levels, while transferring the corresponding resources, and identify international funding sources;
- limit the impact of urbanization on the water cycle through measures to prevent flooding: building local rain patterns into the design of structures, making water management a structural, landscaping factor in town planning; turning natural constraints into positive urban features (buffer zones between river banks and the urban fabric, agricultural urban developments with market gardens along riverbanks, pools, aquariums, etc.) and taking account of local hygiene and sanitation practices;
- with regard to drinking water, repair leaking pipes (50% of losses in South Africa) and defective taps; monitor pollution of land adjacent to clean water resources; ensure that all privately-owned wells and bore-holes are declared; remove household waste.

These very practical "sustainable urbanization" measures concern most African towns and cities that have watercourses, dams, rivers, wetlands or marshes on their territory.

We need to invent a form of urban planning that gives water its proper place, protecting it where it exists, and creating it in times of drought. We cannot simply transpose the development model of Western towns and cities. It is with this in mind that COBATY International implements exemplary urbanization programs in Africa, helping the architectural community to fully integrate water issues. It is of primary importance to promote the education of children, and to have debates with mothers and children, and with local authorities. We need to sensitize policy-makers so that they bring in the necessary legislation and allocate competences in the field of water management.

*André Capron (Member of the Académie des Sciences, President of the GID): "Water and sanitation: health risks and challenges in the Mediterranean".*

The GID was born out of the desire to bring together a large number of national Academies to address the problems of our time. A network of 19 Academies has progressively been built up, most of them located around the Mediterranean rim. Five scientific exchange programs have been set up in emerging countries, the 4<sup>th</sup> of which is the Parmenides Conference, to be held in Rabat on November 22 to 24, 2011.

1. Firstly, Prof. Capron wished to share with the Forum, prior to publication, the memorandum on water and sanitation, which he coordinated, and which has been approved by the Academies of the G8 and the emerging countries.

This report, submitted to the G8 at Deauville in June 2011, notes the worrying convergence of three phenomena: diminishing water resources, exploding demographics, and a changing climate. And yet water quality, and water treatment, have received very little attention to date. The United Nations, on July 28, 2010, instated access to clean water as a human right.

The declared goal is to reduce by half the number of people without access to clean water by 2015.

Substantial progress has been made on access to water, as one billion people have gained access. But there is still no significant progress on sanitation. Twenty percent of the world's population still practices open defecation (300 million tons a year, which contaminate water supplies).

The reason is that dealing with the sanitation problem (building latrines, for example) is not attractive; most of the progress made has concerned the "happy few" rather than the poor. And where latrines have been built, they often go unused because they are culturally inappropriate, and are not supported by education. And as regards young children carrying germs or parasites, there has been no appropriate treatment.

The report stresses the many pathologies transmitted by water: microbial or viral diseases (cholera, diarrhea, hepatitis, dengue) or parasitic illnesses (bilharzia, malaria, etc.). Water is a major source of morbidity and mortality: 50% of hospitalizations are linked to water-borne diseases. The report also underlines problems of chemical pollution of water in Africa itself, due to industry and agriculture (micropollutants, hormones, antibiotics).

The socio-economic implications are significant: 443 million school absences per year; one billion women and girls who have to cover long distances to fetch drinking water. Hence the need for a public health policy that puts sanitation problems at the top of the priority list, focusing on decentralization (community-based action) and on the role of women.

In Europe, extended to the USSR and part of the Mediterranean, where 30% of the population lives in rural areas, 120 million people do not have access to drinking water and basic sanitation. Diarrhea is the second-largest cause of infantile mortality (39,000 deaths a year among children under 5). Fully 25% of rural houses have no facilities.

In the Mediterranean zone, 47 million people have access neither to drinking water nor sanitation. Twenty-seven percent of households lack basic hygiene facilities. The situation is made worse by the rural exodus and a 60% increase in urbanization. The number of tourists, meanwhile, will rise from the current 250 million to 400 million by 2020.

2. As part of the initiatives led by the GID to create the Mediterranean Scientific Area, the 4<sup>th</sup> Parmenides Conference, entitled "Water and Sanitation: Health Challenges in the Mediterranean Region" will be devoted to analyzing the relationships between health and water resources. Looking at major health risks of microbial or chemical origin, and analyzing monitoring and sanitation strategies, the conference will postulate that supplying clean water is not enough: the integrated management of water resources must be supplemented with equipment and health education. The topic of sanitation equipment must be made a key component of public health policy in developing and emerging countries, with its own socio-cultural and educational dimension, in which women have a major role to play.

The cost of sanitation, as André Capron points out, is not astronomical: 12 billion dollars a year over 10 years would be enough. A Korean experiment shows that investment

in this area is profitable: for an investment of 1 billion in sanitation, the return to the economy as a whole is worth 7 billion.

## B Technologies and innovations in sanitation

*Emmanuel Trouvé (Director of the Wastewater R&D program, Veolia Environnement Research & Innovation): "General introduction to sanitation problems and technologies".*

Thanks to the efforts made to apply the results of research in the field, significant innovations are under way in the management of wastewater. Mr. Trouvé reminded us that by 2030, 40% of the world's population will live in water-stressed areas, and that it costs half as much to recover and recycle wastewater as it does to desalinate seawater.

In the 19<sup>th</sup> century, the first great objective was to protect urban populations, by putting mechanisms in place to avoid direct contact with used water, and to limit the spread of infectious agents.

Then, in the 20<sup>th</sup> century, the second great objective was to protect receiving environments through the centralized treatment of major pollution flows, starting with the simplest (carbon, followed by nitrogen and phosphorus), and extending the collection and containment of all effluents starting with the most hazardous (industrial effluents).

In the 21<sup>st</sup> century, where the third great objective is to protect resources for future generations, the innovation is to see wastewater as a recyclable resource. This is a paradigm shift. The idea is to recover the resources contained in wastewater, and to press for sustainable wastewater management. In Europe, a good third of all wastewater is not collected.

In addition to producing clean water, the goal is therefore to derive useful by-products, and to reduce the energy cost of decontamination: from "recycled green carbon" we can generate energy (the energy balance of generation plants becoming positive), manufacture green materials (biopolymers) and produce mineral ingredients, making the benefits obtained accessible to everyone, depending on the context.

Emmanuel Trouvé illustrated the major effort that is made to integrate the contributions of science into sustainable management.

For instance, "biodesign" seeks to reproduce the natural ("black box") situation in wastewater treatment plants, through the use of agitation and the introduction of microorganisms to digest organic matter. The next step is to constitute a reservoir of biocatalysts by attaching microorganisms to membrane supports, which makes for a more favorable energy transaction. The 3<sup>rd</sup> step is then to open up the black box, to find out which species are present, and which outcomes are favored by different techniques. The reservoir of biocatalysts is extraordinary, and demonstrates remarkable adaptability. The biological systems involved are highly complex, poorly understood, and often unstable. Metagenomics will help us to understand them better.

Research should enable us to gradually improve the carbon balance of wastewater treatment plants, the goal being to achieve an energy self-sufficient facility.

Another line of research concerns how to detect the impacts of newly discovered pollutants on the environment and on human health, how to measure them while treating the water, and when best to eliminate them during the sanitation process.

In conclusion, in the management of wastewater, it is important to use a range of approaches so as to be better able to cope with complexity and degrees of uncertainty. One major aspect is to take account of people's reactions: are people ready to drink recycled water, to use it to wash their vegetables or water their gardens, and to drink from recycled recipients? Should the recycled water be redirected to irrigation, to industrial uses, or to the water table?

Another important point is the reality on the ground: priority must be given to at-source control in order to keep costs down. Systems must be put in place to aid and assist the application of new techniques. According to Emmanuel Trouvé, the problem is not so much the resources as the orientations: we need to break away from our traditional frames of reference.

*Yves Lévi (University of Paris Sud, Académie des Technologies and Académie Nationale de Pharmacie): "Micropollutants: environmental and health risks".*

Water resources, in particular those intended for human consumption, are contaminated by a wide range of pollutants, themselves linked to human activities: pesticides, fertilizers, antiparasitic agents and liquid manure from agriculture; metals, metalloids, mineral and organic substances, and nanoparticles from industry; as well as detergents, cosmetics, medicines, solvents... The list goes on.

At the other end of the chain, we are confronted with a complex techno-politico-economic matrix involving the consumer, farmers with their problems of yields and revenues, industrial players with their shareholders and work forces, and, of course, local politicians.

With the refinement of techniques (analytical chemistry, genomics, proteomics)—which are not cheap—we are now finding pollutants everywhere, and we often seem to be in a race to find the smallest possible trace element. And yet, we are not able to analyze everything; there are new pollutants, and there are artifacts, false positives, and potential interactions between pollutants and methods of disinfection.

### Consumers are worried

And so the policy-makers turn to the health agencies:

- (i) to try to analyze the water-related component of the biological disturbances observed. These may, for example, be serious endocrine disruptions (sexual malformations, hormone-dependent cancers) where the suspected cause is products such as pesticides, hydrocarbons, and heavy metals (all of which are known for their toxicity). Pharmacological tests on fish have revealed endocrine disruptions after estrogens were released into a lake. But the effect is dose-dependent, and has yet to be extrapolated to humans;

- (ii) to evaluate the level of risk on the basis of field data, to decide what is and what is not tolerable (standards often vary between countries), and to try and replace certain products in use by others that are less genotoxic. To do so, we need to develop the epidemiology of the risk. With this goal in mind, a 20-year cohort study of 20,000 children is under way, into which water has been introduced as a parameter.

To conclude his exposé, Prof. Lévi argued in favor of investing much further upstream, with risk assessments based on field data. Thus, the Micropollutants Plan (2010-2013) aims to reduce emissions at source and improve knowledge about the status of watercourses. Major new challenges are emerging, forcing us to assess the environmental and health risks arising, in particular, from combinations of organic micropollutants.

To reduce the effects of endocrine disruption or residues of medicinal products calls for management actions that are costly to society, and which must be built up by developing multidisciplinary research in toxicology, eco-toxicology, analytical chemistry and process engineering, whose findings will help to guide management decisions.

The protection of resources, and the restoration to sound ecological status of watercourses, as set out in the European framework directive on water, develops partnerships between the actors involved in order to optimize the management of agricultural inputs, waste, irrigation and wastewater recycling.

In conclusion, Prof. Lévi added that he had not said much about Africa and developing countries, of which he has little knowledge. He considers that the risk of microbiological pollution is currently the priority there, but that the levels of chemical pollution are already significant. A scientific understanding of the situation will be of benefit to everyone.

*Alain Grasmick (Professor at Polytech Montpellier-Université Montpellier 2; European Membrane Institute) UNESCO SIMEV Chair: "Membrane processes and urban water purification: technological innovations and paradigm shifts".*

Global water needs (140 l/day/person in Europe vs. 10 l/day/person in poor countries), in particular for agriculture (80%), are not set to diminish in the years ahead. Faced with this very real health problem, membrane processes have been developed with the aim of reclaiming high quality water, according to the adage: "the most valuable component of wastewater is the water itself". These methods began to be developed for water treatment in the 1970s, notably for desalination by reverse osmosis.

In addition to the familiar conventional processes (decantation, ion exchange, distillation, adsorption, absorption), Prof. Grasmick briefly outlined the characteristics of the membranes used: successive filters, depending on the size of the particles one wants to retain, and selectivity of membranes depending on their physical properties, but also on the expected quality in use.

The filtration surfaces use a variety of fibers (polymers, ceramics, etc.). The filter membranes have thicknesses of between 0.2 and 0.3 mm. Their selectivity is the result of

different pore sizes and electrostatic repulsion properties. They are extremely reliable.

The progress achieved in controlling the selectivity and integrity of industrial membranes means that their use can be extended to the treatment of urban and industrial wastewater.

The processes are adapted to the components present in the wastewater (organic matter, organic nitrogen, phosphates, germs, micro-pollutants); bacterial bio-reagents coupled with membranes are used to produce various chemical reactions of degradation and clarification, then to eliminate germ contamination by passing the water through the membranes. These processes are perfectly mastered and can handle up to 20 m<sup>3</sup>/hr.

The quality of the water treated means that it can very often be directly reused near the site of consumption (in the case of small structures with a short distribution circuit, the cost of a collection network being 4-5 times that of a treatment plant) for irrigation, washing surfaces, and buildings. In Singapore, for example, 2% of the drinking water is produced from sewer water by reverse osmosis.

### A new paradigm

But far more than this, instead of destroying the molecules found in wastewater, we can recover them: this is the case with organic carbon, a potentially energy-producing compound; we can also reclaim the phosphate, which—according to a German study—could cover up to 30% of our fertilizer needs.

In conclusion: research and development work—in membrane materials chemistry, in biotechnology, in process engineering—has given rise to new methods of purification. We have mastered the processes, they are easy to access and to maintain, and they are affordable. In industrial settings we already recycle 90-100% of water. Urban sanitation networks are set to become veritable energy production and nutrient recovery plants.

*Dorothee Benoit Browaeys (Vivagora, Paris):  
“Nanotechnology risks and opportunities for the water and energy sectors of developing countries”*

The non-profit organization Vivagora is engaged in the democratic debate about the new dangers created by new technologies. The French Development Agency commissioned Vivagora, along with the Groupe de recherche et d'échanges technologiques (GRET), to conduct a study of the risks and opportunities represented by nanotechnologies for developing countries. (More than 1000 nanoproducts are currently on the market—see references below).

Vivagora focused particularly on the implications for the water sector. Two fields of application were studied: the rapid detection of contaminants using portable biosensors (detection of arsenic by nanofibers, toxins by paper nanosensors, etc.), and the purification of water (filtration of impurities by carbon nanofibers, chemical dissolution or extraction of pollutants, destruction of bacteria by nanoparticles of silver...).

The risks inherent in these technical solutions need to be monitored; the nanoparticles have unprecedented properties: penetration, ability to bypass biological barriers, enhanced reactivity, but also the inflammatory and carcinogenic effect

of carbon nanotubes when inhaled, etc. Consequently, the European Environmental Bureau (EEB) has expressed reserves about the use of water filtration / decontamination mechanisms that involve nanotechnologies.

Regulation needs to be introduced (pre-market risk assessments, specific labeling, traceability). It is essential to bring in the actors of innovation and the users concerned by these developments very far upstream (information, technological horizon-scanning, consultation workshops as part of the international management of chemicals, the information portal <http://nano.acen-cacen.org>; see references).

Developing countries are significant potential markets for these technologies. North-South scientific partnerships (exchanges, internships, training courses) will play a key part in adapting nanotechnological processes to local realities and in favoring their adoption, and the transfer of skills, through long-term support. In particular, we will need to evaluate the cost / risk / benefit ratios of these new technologies relative to more traditional methods.

*Christian Ruby (CNRS /University of Lorraine):  
“Purifying anoxic wastewater with green rusts:  
application to phosphates and nitrates”*

After purification, and degradation of the organic matter, the nitrate and phosphate content of wastewater and intensive agriculture runoff remains relatively high (more than 50 mg/l and 20mg/l respectively). The Rhizostep process, developed by SAUR, uses reed plantations for water purification; it cannot, however, eliminate nitrates and phosphates, whence the idea, presented by Christian Ruby and supported by France's National Research Agency, of a complementary process designed to improve their elimination. It is deployed in series, after purification, and leverages the synergy between the reduction of nitrates by the Fe<sup>2+</sup> cations of Green Rust (more specifically Fougérite, a naturally occurring mineral from the forest of Fougères—formula Fe<sup>++</sup>4,Fe<sup>+++</sup>4(OH)12CO<sub>3</sub>,3H<sub>2</sub>O—which can also be obtained by chemical synthesis) and the action of iron-reducing bacteria that regenerate the reactive compound.

The core of the process is to manufacture the precursor, deposit it on an appropriate medium, transform it into green rust, and then determine the chemical kinetics of denitrification. It generates no pollution and consumes only minimal energy. The materials used are inexpensive.

At the end of the process, the nitrates are reduced to N<sub>2</sub> (the concomitant formation of NH<sub>4</sub><sup>+</sup> is limited in neutral environments); the phosphates are effectively trapped. This pilot study, on reagents of one liter, yielded encouraging results, and larger-scale trials are planned. The process, effective for the elimination of phosphates, and for small installations, needs to be improved for the elimination of nitrates.

*Sophie Courtois (Suez-Environnement, Paris):  
“Detection of cytotoxic cyanobacteria in lake water”*

The increased proliferation, over the last ten or so years, of cyanobacteria (blue-green algae) in bodies of water on every continent has led to regulation and to strong demand for tools

to measure and monitor water quality. The implications are health-related (toxins, odors, anoxia), as well as economic and environmental. Of the 1,500 known species of cyanobacteria, 200 are toxic (for the liver, the nervous system, or the skin).

However, the biomass and abundance indicators currently used for this kind of monitoring do not reflect the full toxic potential in cases of proliferation. The World Health Organization (WHO) therefore recommends tracking the toxin content, an analysis performed in specialist laboratories and which is consequently expensive.

The Proliphyc project focuses on an automatic “real-time surveillance buoy” to monitor the proliferation of all bacterial strains, whether or not they produce toxins.

The “MicroCytos” project seeks to develop and validate a complete automated and miniaturized system which assesses in situ the proportion of toxic cyanobacteria relative to the total cyanobacteria: the sample is concentrated on magnetic beads, the DNA is extracted and purified (4 or 5 cells per ml is enough to begin with) then the proportion of toxigenic cyanobacteria (microcystins, anatoxins and cylindrospermopsins) is evaluated and quantified, using qPCR (quantitative polymerase chain reaction). The entire process, which takes about 2 hours, can be done in real time during periods of proliferation. (The same mechanism can be used to detect other types of bacteria.)

One year on, the model has been validated, including its miniaturization aspect. This new, field-ready instrument, with its key ability to provide a quantitative measurement of toxic potential—and to do so quickly—can be used for monitoring “high risk” watercourses and lakes, and providing an instant warning to the public.

*Jean Louis Oliver (Secretary General of the Académie de l'Eau, Paris): “Desalination processes”*

Mr. Oliver began by underlining the fall in aquifer levels and the over-exploitation of these non-renewable resources. The geographical disparity of water resources leads to specific problems of water transfer, which come within the remit of regional development policies.

We are forced to draw on unconventional water resources, after taking the essential health precautions. This is the case with desalination processes, which were briefly presented here, insisting on certain undesirable side effects such as the high energy cost, and the environmental impact of salt releases on maritime species.

Mr. Oliver then presented the activities of the Académie de l'Eau and the UISF—the International Union of Engineers and Scientists using the French Language—an NGO based at UNESCO and headed by Professor Elie Absi.

In recent years, the UISF and the Académie de l'Eau have launched a major program of activities, under the patronage of UNESCO and oriented toward Africa and the Mediterranean basin, involving a series of conferences on scientific, technical and economic topics of common interest concerning sustainable development.

The program consists of a cycle of annual gatherings focusing on the countries of North Africa. The first was held, successfully, in Tunis in December 2010.

The second gathering, to be held in Rabat on November 25, 2011, includes a colloquium entitled “Water, Regional Planning and Sustainable Development”, a major issue currently facing every North African country.

This colloquium will follow on from the one organized on November 23 and 24, also in Rabat, by the Interacademic Group for Development (GID) on the topic “Water and Sanitation: Health Challenges in the Mediterranean Region”.

As a multi-disciplinary, cross-sector and prospective think tank and advocacy body for all aspects of water use and resource management, in France and around the world, the Académie de l'Eau is closely associated with all of these public interest projects.

*Nathalie Dörfliger (BRGM, Orléans)  
“Innovative new approaches for monitoring coastal aquifers: Application to the detection of saltwater intrusions”.*

In coastal areas that have a significant demographic inflow in the “high season”, the risk of saltwater seeping into coastal aquifers is a serious problem. In the absence of adequate surveillance and management, this phenomenon can have major environmental and economic consequences.

Mrs. Dörfliger presented a new method for monitoring saltwater intrusions in coastal aquifers in the Roussillon region of France. The Plain of Roussillon is a representative example of complex sedimentary coastal aquifers, for which it is difficult to establish a clear picture, due to their heterogeneity (saltwater wedges under the dunes, saltwater contamination from drainage, from leaking wells, etc.).

The standard method of direct ad-hoc salinity measurements is useful for identifying groundwater resources in the coastal environment, but not for anticipating risks. If we want to set up management and warning systems, the only way is through a systemic approach based on knowledge of the geometry and functioning of coastal aquifers, and using data acquisition.

The Grain d'él project sets out to develop and validate new approaches, and to do so on different scales:

- i. at the regional scale, using aerial geophysical data over an area of 40 km x 10 km (simultaneous recording of magnetic field, spectral radiometry and electromagnetism) acquired as part of the European EUFAR project in 2008. This airborne method, already used for mineral exploration and in volcanology, is new in geophysics for studying salinity;
- ii. at the local scale, with the acquisition of continuous hydro-geophysical data from drilling, and hydro-geochemical data (including on isotopes).

The joint use of these different approaches is a real innovation in terms of integrated instrumentation systems; it will help to shed light on the complex geometry of these aquifers, and on their hydrodynamics, with the ultimate aim of developing a monitoring and warning system for saltwater intrusions.



Stanislas Dusko Ehrlich (INRA, Jouy en Josas):  
 “The metagenomics of intestinal flora”

Prof. Ehrlich wound up the technical and technological part of the forum by illustrating the impressive advances made by metagenomics.

Metagenomics characterizes, through shotgun sequencing of DNA extracted randomly from an ecosystem, all the genes and genomes of the microbes found in ecological niches, and monitors the frequencies and dynamics of these complex microbial communities, more than 80% of which have never previously been cultured. An ongoing cross-disciplinary project (the MetaHIT Consortium) unites the expertise—from the clinical field to IT—of 12 European institutions and one from China; its focus is the human gut, “the forgotten organ”, which plays a key role in our health through its interactions with the external environment.

One of the first results from this work has revealed the complexity of intestinal microbial communities; their numbers far exceed both the number of cells in our own bodies (by a factor of 10) and the number of genes in our own genome code (3.3 million intestinal microbe genes have been identified—150 times the human genome—and each individual has a repertoire of some 500,000). Moreover, these studies have shown the similarity of these microbe populations in more than 150 individuals in Europe (Denmark and Spain), North America (United States) and Asia (Japan). The intestinal microbial communities of other human populations, notably from Africa, are yet to be characterized.

A second discovery is that individuals can be classed into three groups (or enterotypes) on the basis of their microbial communities, which extend beyond differences in age, geography or state of health. The reasons for the existence of these 3 enterotypes remain to be elucidated.

This differentiation opens up numerous perspectives, which are the object of research by the MetaHIT Consortium: the search for correlations between human gut microbial genes and chronic human illness, vulnerability or resistance to disease (“quantitative metagenomic pipeline, a powerful microscope”), a French project (MICRO Obes Project) in the field of nutrition and human health. For example, obese individuals are distinguished from others by enterotypes that are less diversified than for the non-obese. Thirty-three bacterial metasppecies are correlated with a predisposition to obesity, and factoring in the enterotype improves risk prediction by 85%, whereas factoring in diabetes markers improves it by just 8%.

Although this was not the object of Prof. Ehrlich’s speech, it is clear that the metagenomic approach is a very powerful tool for understanding the microbial populations of wastewater or contaminated water. Prof. Ehrlich underlined the power of these methods of analysis: the sequencing capacity is increased by a factor of  $10^9$  with a considerable reduction in cost, far in excess of the growth capacity of computer processors.

Once again, we need to retain the references, for the sake of uniformity

- Qin J, Li R, ... MetaHIT Consortium, Bork P, Ehrlich SD, Wang J. (2010) A human gut microbial gene

catalogue established by metagenomic sequencing. *Nature*. 464(7285): 59-65.

- M. Arumugam, J. Raes, ... MetaHIT Consortium, J. Weissenbach, S.D. Ehrlich, P. Bork (2011) Enterotypes of the human gut microbiome. *Nature* (in press).

### Sanitation:

#### Ground-level experience and experiments in Africa

Doudou Ba (Permanent Secretary of the Senegal National Academy of Science and Technology): “Actions of the Senegal national academy of science and technology in the field of water and sanitation”

Professor Ba began by presenting Senegal, a sub-Saharan country of 190,000 square km with a population of 13 million. The dry season lasts 9 months. The surface water resources come mainly from the country’s three rivers: the Senegal, the Casamance and the Gambia. There is also a groundwater reserve, made up of the aquifer formations of the Senegalo-Mauritanian sedimentary basin.

The challenges facing the water sector are linked to hydrological constraints: climate variation, anthropogenic pollution, and saltwater intrusion. With the development of agriculture and livestock farming, the demands of the population, and the growth of tourism and continental fishing, the needs are enormous. As things stand, water management is very sector-specific, and often irrational, which has numerous socio-economic implications. There is little in the way of planning.

A reform of the water sector was initiated in the mid 1990s, implementing a series of programs aimed at improving the production, distribution and accessibility of drinking water and sanitation in urban and rural environments.

These programs, in particular the Water Sector Project and the Long-Term Water Sector Project (French acronyms PSE and PLT), and the Millennium Drinking Water and Sanitation Program (PEPAM), aim to ensure the financial profitability of the sector and to define strategies to conserve and protect the quality of water resources. (In its annual review, published in April 2011, PEPAM notes that the rate of access to drinking water in 2010 is 77.5% in rural areas, and 98.5% in urban areas; the rate of access to sanitation being 29.6% and 63.1% respectively, with a forecast of 40% for rural areas by 2015).

In accordance with its mission to act as an advisor to the public authorities, the Senegal National Academy of Science and Technology (ANSTS), created in 1999, became involved in these programs, organizing scientific events that brought together all of the stakeholders: public sector, private sector, civil society, and users.

To cite an example: after the catastrophic flooding of the town of Saint Louis du Senegal in 2005, meetings were organized between the different actors to raise their awareness and find new solutions to water-related catastrophes (in this case, a weir cut through to the sea seems to have been effective). Another example is the organization of the 3<sup>rd</sup> annual conference of the African Science Academy Development Initiative (ASADI) for which the

topic, proposed by the ANSTS, is Water and Health. The planning meeting served to outline the current state of access to drinking water, sanitation technologies in urban and rural areas, sanitary services, and policies for managing water-related catastrophes.

The ANSTS also chairs the national committee of UNESCO's hydrological program.

An important role, performed in conjunction with Ghana and Nigeria, is the coordination, for West and East Africa, of the water program initiated by the Network of African Science Academies (NASAC), which also involves experts from other countries of Africa that do not have academies.

*Taofick Fousseni*

*(from the NGO RACINE, Savalou, Benin):*

*"Drinking water: an experiment in Benin"*

Mr. Fousseni began with a brief presentation of RACINES (Recherches, Actions Communautaires, Initiatives pour un Nouvel Espoir), a non-governmental organization set up in Benin in 1999 by a group of young Beninois managers. It is active in the fields of health (prevention and treatment of AIDS and malaria) and of infant and primary education (creating education spaces in deprived areas of Cotonou, Bantè and Savalou).

Mr. Fousseni went on to describe his NGO's experiment in the field of water, insisting on the social mobilization aspect of the project. With 59 inhabitants per square km, and a demographic growth rate of 3.25%, Benin is 61% rural. In 2006, 50% of the rural population did not have a supply of drinking water; 10 out of 100 infrastructures were out of service. By 2009, less than a third of households had access to drinking water.

A prospective study in 2003 had revealed a priority need for drinking water in the villages of Galata and Agbon (municipality of Bantè), with 2 working water pumps in Galata (one pump for 1,200 people), and 3 pumps for 3,500 people in Agbon. With financial support from Oxfam Québec, RACINES initiated a project to install manual water pumps in these villages. The project was implemented in several stages: social mobilization around the project, with the land being made available by the beneficiary communities; geo-technical surveys; the drilling of the wells, and the management of the water.

One particularly crucial aspect was to associate the supply of water with health education for the local population: twenty months after the wells were drilled, the local management committee set up in each locality was reinforced, instating maintenance and good practice sensitization campaigns on a fortnightly basis on water-related topics. Teaching tools aimed at children are handed out during these awareness-raising actions.

Another aspect underlined by Mr. Fousseni is the introduction of a new type of leadership in the municipality of Bantè, in the course of this project, with the strong participation of young people alongside elders on the local management committees.

## C Water and agriculture

*Thierry Ruf (IRD, Montpellier):*

*"The social dynamics of irrigation: Socio-institutional innovations in irrigation management"*

In his exposé, Mr. Ruf, an agronomist and geographer by training, addressed the issues of irrigation from a socio-economic angle. These issues go beyond the development of new techniques for managing scarce water resources; they often amount to "water wars between water-rich countries", long histories of water going back centuries in rural areas around the world, with conflicts, shared responsibilities, and injustices.

Mr. Ruf began with a brief historic overview of the development of hydraulic engineering, and reviewed a number of post-WWII experiments in water governance:

- Initially, large hydraulic projects were built, with dams and irrigation, governed by powerful hydraulic authorities, and local populations were required to submit to development projects: e.g. Ecuador where, after a series of peasant revolts, a policy was constructed on the basis of local forums; or Spain, with clashes between the provinces; and one is reminded of the conflicts of interest between water managers and users in Marrakech, in an arid landscape. Elsewhere, social cohesion played its part, as on the Indonesian island of Flores, where the hydraulic system and the land ownership system share the same rights and obligations; or the Nile Delta where, with the expansion of irrigation, several models coexist, although technologies favor the rich, while the poorer peasants take what is left;
- Subsequently, it became clear that there was a need for arbitration between centralized management and local responsibilities, taking account of history (with industrialization, urbanization, and the over-exploitation of certain areas), local traditions (land rights, water rights), and geography (mountains, deltas).

Next, Mr. Ruf outlined the ISIIMM program (Institutional and Social Innovations in Irrigation, Mediterranean Management: <http://www.isiimm.agropolis.org/>) in which he is active. This European water management and governance project brings together 6 Mediterranean countries: Egypt, Morocco, Lebanon, Spain, Italy and France. Although these countries are home to varied rural societies, they find themselves facing a similar set of injustices, and a set of irrigation rules has been proposed:

- i. the recognition of local historical issues (the contribution made by different, sometimes competing, civilizations);
- ii. a concrete ground-level description of water territories;
- iii. due consideration of social disparities and solidarity networks;
- iv. better consultation with local associations.

In conclusion, Mr. Ruf underlined the plurality of situations on the ground, which calls for a plurality of management

modes. The hydraulic economy requires large-scale cooperation: a state capable of looking beyond local contradictions, of defending downtrodden communities, and of building a compromise between the responsibilities of the administration and those of local people.

*Jean-Yves Jamin (CIRAD Montpellier): “The impact of rice cultivation on the management of water resources”.*

Mr. Jamin reminded us that agriculture consumes 70% of the planet’s fresh water, and that irrigation concerns 18% of cultivated land and provides 40% of the world’s food. The challenges are many: feeding cities, coping with drought or with unpredictable rainfall, reducing poverty, or attracting investors for irrigation development projects.

Although the productivity per hectare of irrigated agriculture is higher, and more regular, than that of rain-fed agriculture, irrigation also involves greater constraints: steep investments, large operating and maintenance costs, intensive crop systems that are heavily dependent on upstream (agricultural supply) and downstream (market) segments, and often compulsory collective management, the allocation of the water having to be negotiated with other users.

Mr. Jamin illustrated ongoing developments and new issues in irrigation, using examples of irrigated rice cultivation, in particular the example of the Office du Niger in Mali.

The Office du Niger, designed as part of the vision of French West Africa in the colonial period, was a project on a regional scale, the river being “trans-national”.

The water is diverted by a dam, without pumping, and the irrigation works by gravity; the energy cost is very low, and the estimated developable potential is of 2 million hectares, of which 90,000 are currently developed. Alongside peasant farmers with 3 to 30 hectares (sometimes of borderline viability) major international investors (Libyan, Chinese) have obtained concessions in the order of 200,000 hectares in order to grow rice (50%), sugar cane, biofuel crops, etc.

What are the limiting factors? Only a small number of hectares are actually cultivated. Social unrest is surfacing against the investors. And while, according to the contracts, the quantity of water is supposed to be unlimited, in the dry season the water becomes a limiting factor, and the issue of water management for irrigation outside the rainy season is a source of tension. Moreover, priority is given to the hydro-electric dams upstream. There is also a conflict between irrigation and the supply of drinking water.

But the most limiting factor of all is the high cost of developing the land, for the government of Mali, for the peasant farmers, and for the investors, both large and small (four to five thousand Euros per hectare).

*Didier Simon (French Development Agency, Paris): “A rural development project in the Guinea forest region: rice/fish farming”.*

### Outcome of a rural development project

Didier Simon presented an original experiment in rice/fish farming, performed with limited resources in a poor and very

isolated part of the Guinea Forest Region some 800 km from Conakry. The project—modeled on a pilot experiment initially conducted in Côte d’Ivoire—sought to improve the food security of the local populations and to foster autonomy.

The key points of the project are as follows:

- The development of lowlands to produce fish and rice is funded by farmers groups, supported by expatriate volunteers and local facilitators. The technical assistance and training expenses are covered by a 1.8 million euro grant from the French Development Agency;
- The lowlands are transformed into rice/fish ponds, through the construction of a dam, dykes, and 2 types of pond: a service pond, which is kept full of water to raise the fry, and a production pond, which is used alternatively for fish production (3 species: tilapia, arowana (*Heterotis niloticus*), catfish) and, in drier periods, for rice cultivation, which benefits from the enrichment of the soil by the residues from the fish-farming operation. The labor is family-based, which keeps costs down, and the labor costs of rice-growing are, anyway, lower;
- The farmers groups play an essential role in ensuring the autonomy and long-term viability of rice/fish farming by advising and training new candidates;
- The results are positive, with 370 rice/fish-farmers and 650 ponds developed at the end of the project; rice yields are improving; the return on investment comes through after two years, which gives people the hope of “escaping the poverty trap”. There is a clear impact on health, thanks to better food security (1/3 of the fresh fish are eaten on-farm), an improvement in child nutrition (thanks to these animal proteins), a reduction in cases of malaria and bilharzia (eradicated by the arowanas, which eat the larvae). On the environmental side, the impacts are also positive, notably through the restoration of soil fertility and the beneficial effects of ponds on the natural environment.

Despite the recent political upheavals, a project to extend this approach to other parts of Guinea, and to other African countries (Liberia, Côte d’Ivoire) is in the pipeline. The goal is to raise the number of rice/fish farmers from 300 to 1500 over 5 years.

*Robin Duponnois (Research Director at France’s Research Institute for Development (IRD), Joint International Laboratory, Microbial and Plant Biotechnologies, IRD, Montpellier, Rabat, Dakar): “The great green wall of Africa: origins and implementation”*

One of the key strategies for combating the desertification of arid or semi-arid land is reforestation, a method that prevents soil erosion and facilitates water penetration.

Mr. Duponnois began by citing some examples of experiments with green dams or green belts—in Algeria in the 1970s, the great green wall of China, green belts around Niamey, in Mauritania, in Mali, around Dakar, and Ouagadougou—and described their frequent failures (due to inappropriate tree

species, or authoritarian implementation without regard to the socio-economic environment of local populations).

The African Union (NEPAD Environment Initiative) and the Community of Sahel-Saharan States (CEN-SAD) studied the lessons of these setbacks for the Great Green Wall of Africa project. The project, which got underway in 2005-2007, is designed to combat desertification by erecting a discontinuous barrier, involving a range of actions and multi-sector interventions to protect natural resources. The Great Green Wall, built in the Sahel, uses local plant species with an economic value, and will ultimately be 7,000 km long, and 15-20 km wide.

Eleven countries are involved, from Senegal to Djibouti. This is therefore a transcontinental project, which will not be completed until about 2080. It is one of the Millennium goals. The political coordination is performed by an African Union committee. A pan-African agency oversees the national agencies, while the inter-agency body AIRD directs research and supports development on the ground.

Reference: "Le projet majeur africain de la Grande Muraille Verte : concepts et mise en œuvre", Éditions de l'IRD.

## D Training and education

*Dominique Preux (National Water Training Center (CNFME), La Souterraine): "The services provided by the international office for water".*

In France, 130,000 persons are employed in the water sector, half of them in drinking water and sanitation, with 30,000 service points. Mr. Preux began by describing the missions of the International Office for Water (IOWater), in the context of its National Water Training Center (CNFME).

This body is exclusively dedicated to updating the knowledge of personnel who have already received initial qualifying training. These are professional training courses, governed by French vocational training legislation, with a specific financing system. More than 500 different modules are available, covering the many specialist fields of the water sector, from pumping to the distribution of drinking water, and from water collection to wastewater treatment, not forgetting water chemistry, metrology, automation, service management, and safety.

Every year, IOWater trains some 6,000 people, of every level, in courses lasting an average of 4 days, at its training center at La Souterraine in central France. The current breakdown of courses is 64% technical, 16% customer service, with the rest being management oriented. The breakdown by category: approx. 40% technicians and employees (high school graduate level and above), 20% engineers, 40% operators. These are high-level courses with demanding standards of performance, quality and safety; the trainees are placed in work situation contexts on high-quality technical platforms. On-site training is also available.

On the international level, training needs are particularly acute in emerging or developing countries. In many countries, there are no real initial or continuing training resources appropriate to the water sector. Durable training structures have to be created in situ with local trainers. This is what IOWater has done by designing the curriculum of training centers in numerous countries (including Poland, Saudi Arabia, Kenya, Morocco, Nigeria, Tunisia and Mexico).

In 2008, IOWater set up the International Network of Water Training Centers (RICFME), which seeks to encourage donors to earmark 1% of their payroll costs for training, to draw up medium and long-term plans, and to factor in investment projects from the outset.

IOWater is not the only training actor. Veolia, for example, has developed Campus Veolia, and devotes 4% of its payroll to training.

*Taoufik Fousseni (Savalou, Benin): "Educating local populations".*

As part of his fieldwork actions in the villages of Benin, Mr. Fousseni has striven to put in place community health education programs for local populations. He told the Forum about the methods used and the difficulties encountered.

The community health education initiative involves setting up a management committee of some fifteen people. The committee members are given training in the management, upkeep and maintenance of the apparatus, through fortnightly training/refresher sessions. A toolkit has been developed: technical data sheets on water-related topics (utility, dangers of dirty water, water hygiene, use of pumps), with picture boxes and posters that graphically illustrate these topics and point to appropriate and unacceptable behaviors.

The difficulties encountered are due to the low level of availability of management committee members, and their lack of engagement with their role.

We should nonetheless retain the positives: the strong mobilization of communities around the project, the coupling of community health education sessions with the installation of drinking water apparatus, and—above all—a new type of leadership, with the management committees taking in a large number of women and young people, which amounts to a genuine revolution.

## E Conclusions of the forum

Our African colleagues hailed the relevance and quality of the Forum. While avoiding digression, the Forum reported in great detail on new water management technologies, and established an inventory of access to water in different countries of Africa. It also highlighted the priorities in terms of sanitation and access to drinking water, insisting on the complex socio-economic issues involved, and on the need to integrate water management into public health policies while respecting local democracy—without which local people will not come on board. The role and place of education for women and children will be critical to the success of ongoing initiatives.

Our colleagues are very keen to continue sharing information, and a number of channels have been proposed for circulating documents (the GID website, open to COPED, the WHEP website, and the NASAD conference in January 2012).

### Endnotes

<sup>1</sup> [www.coped.org/](http://www.coped.org/)

<sup>2</sup> <http://g-i-d.org/>