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ASSESSMENT OF POLLUTION AND VULNERABILITY OF WATER SUPPLY AQUIFERS OF AFRICA CITIES

Bénin, Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Niger, Sénégal, Zambia

LAUNCHING WORKSHOP

Nairobi, Kenya, 11th – 13th March 2003

Venue: **UNEP Gigiri, Conference room, X-344**

UNEP / DGDC / UNESCO / UN-HABITAT / ECA

EVALUATION DE LA POLLUTION ET DE LA VULNERABILITE DES AQUIFERES DES GRANDES CITES URBAINES D'AFRIQUE

Bénin, Burkina Faso, Côte d'Ivoire, Ethiopie, Ghana, Mali, Niger, Sénégal, Kenya, Zambie

REUNION DE LANCEMENT

NAIROBI - KENYA

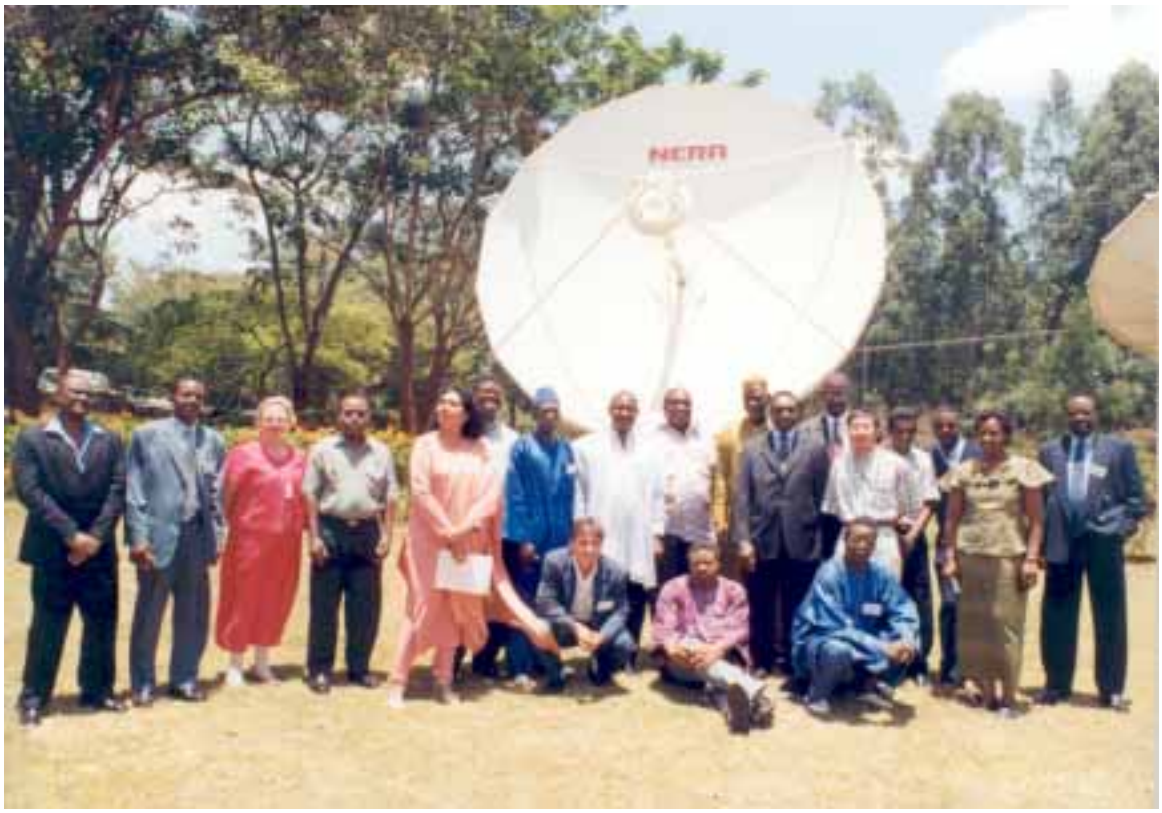
11 - 13 MARS 2003

PNUE Gigiri, Salle de Conférence, X-344

OPENING CEREMONY

Introduction

A launching meeting for the project on the *Assessment of pollution Status and Vulnerability of Water Supply Aquifers of African cities,* organised by UNEP / DGDC / UNESCO / UNCHS / ECA, took place from 11th to 13th March 2003 in Room X-344, Block X of the United Nations Environment Programme (UNEP) building at Gigiri. Nine of the ten countries (Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Niger, Sénégal, and Zambia) participating in the project attended the meeting, while the representative of the tenth country (Bénin) was absent. This project will precede the just ended assignment executed in West Africa entitled *Urban pollution of Surficial and Groundwater aquifers in Africa (i.e. Phase I).* Mr. Emmanuel NAAH chaired the meeting, while Messrs Abdoul Aziz TANDIA and Daniel C.W. NKHUWA were appointed Rapporteurs.



Participants at the Groundwater Project Launch Workshop (13th – March - 2003) outside the UNEP Headquarters Satellite dish near X-block

Opening Ceremony

The Acting Director of the Department of Early Warning and Assessment (DEWA) **Dr. Dan CLAASEN** officially opened the workshop with welcome remarks to participants during the launch of the project workshop on the ASSESSMENT OF POLLUTION STATUS AND VULNERABILITY OF WATER SUPPLY AQUIFERS OF AFRICAN CITIES.

In his speech, Dr. Claasen raised the following points, that:

- The project was necessitated by the unprecedented population growths in African cities, which pose great pollution threats to groundwater arising from unplanned expansions, sewage effluent leakage in open sewers, leaking septic tanks, latrines, domestic waste disposal and uncontrolled industrial and commercial activity.
- Since most of these cities use groundwater as their main source of potable water, unchecked levels of pollution and consumption of this water poses great public health risks to the urban population in these cities.
- The project on *Urban pollution of Surficial and groundwater aquifers in Africa* was conceptualised to protect the quality of groundwater resources through vulnerability mapping initially in the cities of Abidjan, Bamako, Cotonou, Dakar, Niamey and Ouagadougou.
- The activities of this project were achieved with a modest budget of US $ 280,000 (at a cost of US $ 20,000 a year for each country) from the United Nations Development account.
- Distribution of Early Warning Bulletins on the effect of urban waste pollution on water quality of the urban areas involved in the project from each of the various task forces have already had a clear, albeit local, impact on politicians and water managers in each country.
- Based on the findings of the project on *Urban Pollution of Surficial and Groundwater Aquifers in Africa,* the next Phase of the project entitled *Assessment of Pollution Status and Vulnerability of Water Supply Aquifers of African Cities* has been initiated. This is intended to build on the successes of the former in four new Anglophone countries i.e. Ghana, Ethiopia, Kenya and Zambia.
- One of the major tasks of the new project will be the development of suitable methodologies for assessing and monitoring of real and potential contamination of shallow and deeper groundwater aquifers, while building on information gathered in six West African countries.

He concluded his speech by thanking Ivar Baste, Beth Ingraham, Salif Diop, Patrick M'mayi, Audrey Ringler, Pacifica Mochache, Pravina Patel and Emmanuel Naah (UNESCO/IHP) for their contributions to the organisation of a very successful meeting.

Objectives of the Phase II Project

- To determine the status and vulnerability of groundwater supplies in the new cities of the selected countries.
- To establish a network for exchange of related information, and

- To develop suitable methodologies for assessing and monitoring of real and potential contamination of shallow and deeper groundwater aquifers, while building on information gathered in six West African countries.

The subsequent sections summarise the proceedings of the three-day inaugural workshop, which took place in Nairobi from 11 to 13 March 2003. The report layout is as follows:

- Opening Ceremony
- Workshop Keynote Presentations
- Presentations from Phase I participating countries
- Summary of recommendations from the evaluation of the Phase I Project
- South Africa's Perspective to Resource Directed Measures
- Introduction of Phase II of the Project
- Presentations from the *New Countries*
- Workshop Summary and Work plan for Phase II of the Project
- Closing Remarks
- Annex (*List of participants, Agenda/programme, Presentations)*

DAY 1 (11TH MARCH 2003)
WORKSHOP KEYNOTE PRESENTATIONS

CONSULTANT'S OVERVIEW OF THE JUST ENDED PROJECT ON *THE VULNERABILITY OF AFRICA'S SURFICIAL AND GROUNDWATER AQUIFERS TO URBAN POLLUTION*

Mr. Loic GIORGI, Route de Vahible, Mayotte

Introduction

The Consultant stated some of the major challenges of the West African cities dependent upon groundwater resources as follows:

a) That water sources / bodies are poorly protected from pollution from surrounding areas. In this regard, the constant increase in demand for water may compel city and sub-urban residents to depend more on very poor quality water from traditional wells for their daily consumption by the turn of the third millennium.
b) There is a growing risk of degradation of water quality in the concerned cities through private and collective sewerage systems, plastic materials, tin cans and batteries.

Objectives

The Consultant outlined the overall goal of the project as to raise awareness of decision-makers of the negative impacts of unplanned urban development on potable water resources and the need for more efficient pollution controls in the cities of West Africa, while some of the specific objectives were:

i) To comprehensively evaluate urban pollution pressures on groundwater from the water table to deep aquifers.
ii) To undertake a follow-up evaluation of the development of several major urban pollution sources.
iii) To produce an Early Warning Bulletin on the effect of urban waste pollution on water quality and a 'Vulnerability Map' of the urban areas involved in the project for dissemination to city planners and the general public.

Project activities and execution

Attainment of the above objectives required establishment of teams of experts including hydrogeologists specialising in urban pollution in each of the participating countries alongside the provision of computers and financial support for field and laboratory analyses.

Some of the major activities for the Research Teams for Dakar, Abidjan, Cotonou and the peripheral districts were as follows:

- Sampling and analysis of the aquifer systems for hydrogeological and chemical parameters
- Identification of pollutant sources and improvement of cartographic data.
- Collection of precipitation data
- Collation of progression trend indicators to identify parameters for raising awareness among city planners on the increase of pollution in their groundwater aquifers.

In their execution of their project, the Research Teams in Bamako, Niamey, Ouagadougou and their peripheral districts executed the following activities:

- Sampling and analysis of the aquifer systems for hydrogeological and chemical parameters.
- Identification of pollutant sources and improvement of cartographic data. The approach of the Ouagadougou Early Warning Bulletin was slightly different due to the heterogeneity of the aquifer.
- Collection and storage of precipitation data and integrating it into data relating to flow the regimes of the Niger River recorded in Bamako and Niamey and into those relating to the replenishment of drinking water reservoirs in Ouagadougou.
- Collation of progression trend indicators to indicators to identify parameters for raising awareness among city planners on the increase of pollution in their groundwater aquifers. In Bamako, only field analyses on conductivity were obtained.
- Establishment of a network of six West African countries with Ghana being included towards the end of the project.

- Establishment of an Early Warning monitoring system for the pollution of groundwater in large urban areas.

Through collection and comparison of comprehensive and easily accessible data, the teams identified sources and locations of pollution, where contaminated water was directly or indirectly influencing the quality of groundwater.

OUTPUTS FROM THE PROJECT

Six out of the seven participating countries in the project were said to have regularly presented and disseminated reports on their activities and contributions to the database. Five countries (Benin, Burkina Faso, Côte d'Ivoire, Niger and Senegal) presented original data of different quality in relation to their specific urban hydrological contexts. One country (Mali) partially implemented its work programme, namely some field activities planned at the meetings of December 2000 and September 2001.

The seventh country, Guinea, was unfortunately excluded from the project on account of not submitting any data except for some general maps that had no direct connection to the project objectives. Ghana was invited into the project to replace Guinea.

However, work and activities executed by Ghana will only be presented in phase II of the project due to the time limit set for the end of the project.

General scientific and technical outputs

The following outputs were achieved:

a) A compilation and update of existing hydrogeological information
b) Generation of data on pollution caused by developments without efficient or fully operational sewerage systems.
c) Generation of Vulnerability Maps for each area surveyed.
d) Periodic follow-up studies of water quality and controls on its degradation.
e) Establishment of the indisputable links between polluted shallow aquifers and groundwater tapped by boreholes for urban water supplies.
f) Preparation of Vulnerability Maps and dissemination of Early Warning Bulletins from each of the various task forces, which have already had a clear, albeit local impact on politicians and water managers in each country.
g) Creation of a regional Early Warning Network on urban pollution in West Africa.
h) The completion of a M.Sc. thesis produced from the work done by the Abidjan team
i) Establishment and strengthening of the interactive analysis of groundwater pollution in two areas with different climatic zones: the dry Sahelian and the humid coastal zones.
j) Establishment of a project web site that will provide a window into the project for the international community

The results generated by the network of researchers had the following impacts:

i) Establishment of a clear basis for cooperation between the countries and a sense of commitment in the national task forces.
ii) An information network for Early Warning Bulletins was preliminarily identified.
iii) Information Bulletins were disseminated (although there is need for improvement in the dissemination procedure).

The final project output was the Early Warning Bulletin, which carries a summary of all activities executed by all national teams working on the issue of urban pollution in West African cities. Following the two Early Warning Bulletins issued by each country to date, it is still too early to evaluate the impact of the project on development planners in the involved cities.

Project review

Two years after the launch of the work programme in Bamako (Mali) in December 2000, all the country teams prepared and submitted their progressive reports, scientific and technical reviews for peer review:

- Activities and outcomes of each country team implemented under the project up to the September 2001 Abidjan meeting were evaluated by a team headed by Brian Morris, Principal Hydrogeologist of the British Geological Survey. The team made some recommendations for additional guidelines to improve some aspects of the project in the context of Africa's current needs.

- The activities executed between September 2001 and March 2002 were evaluated in July 2002 by a team, which included Professor Lewis Clark of the University of Reading and Ms Susanne Bech from UNEP's Evaluation and Oversight Unit. The team reviewed each country's research findings, assessed the central database in Abidjan and reviewed the project's ongoing activities. Dissemination of Early Warning Bulletins to the Public Health Sector was identified to have had some major shortcomings.
- For the data collected by the country teams between March and November 2002, it was recommended that the country teams improve their results and consider the observations of the evaluation of July 2002.

All project outcomes have now been stored in a database. Two Early Warning Bulletins were disseminated to decision-makers to raise their awareness on the negative impacts of unplanned or poorly planned urban development.

Constraints faced during the implementation of the project

The Consultant highlighted a number of difficulties that were encountered in the early stages of the implementation of the project activities, many of which could not be completed because of inadequate or absence of data. Some of the other constraints included:

- The limiting nature of teams drawn from a single professional sector in Mali and Benin served to limit both the research teams' own experience and their interaction with the other teams.
- There was a widespread lack of water analysis equipment for sampling operations at the monitoring sites, which caused discrepancies among the participating countries.
- Arising from the above, there were problems in attempting to standardise the data submitted by each country, which should have been modelled into a single format.
- There was poor access to communication facilities, limited IT skills and insufficient use of the Internet by research workers, most of who were not used to disseminating data files on the web site.

In addition, several activities initially proposed in the work programmes agreed upon in Bamako in December 2000 and in Abidjan in September 2001 were not effectively implemented due to lack of available or adequate data. Laboratory analytical data and *hot spots* mapping were poorly presented, while piezometric monitoring of shallow aquifers and boreholes were not effectively carried out. This resulted in the modification of the activities planned in Bamako with practical suggestions that presented a more realistic set of targets at the September 2001 Abidjan meeting.

Concluding Remarks

The Consultant concluded his presentation by pointing out that:

- Each of the six participating countries in West Africa in the project *The Vulnerability of Africa's Surficial and Groundwater Aquifers to Urban Pollution* has produced two Early Warning Bulletins based upon the Vulnerability Maps that summarised analyses of groundwater samples from a series of carefully selected sites.
- Pollution targets have been identified and will be followed up cost effectively in line with each country's operating budgets.
- The Early Warning Bulletins have undoubtedly contributed to the creation of a regional Early Warning Network on urban pollution in West Africa. The sustainability of this project is guaranteed by the production and dissemination of timely Early Warning Bulletins in each participating country.
- In addition, special attention ought to focus on the sampling process in order to pave way for more standardised usage of the Early Warning system.

NEPAD ENVIRONMENTAL ACTION PLAN – PROGRAMME AREA 4: CONSERVATION AND SUSTAINABLE USE OF COASTAL, MARINE AND FRESHWATER RESOURCES

Marie PRACHLOVA, Programme Officer, UNEP/DGEF Coordination (GEF Coordination), Nairobi, Kenya

Ms Prachlova started her presentation by stating that the **Goal of the Action** is *to incorporate environmental concerns to the development agenda of countries through targeted actions that address not only the environmental aspects, but also institutional, regulatory, policy and capacity-building elements.*

It was said that **The Action Plan is based on** *a development of a series of potential interventions and projects to address the problem of conservation and sustainable use of coastal and marine resources and related freshwater ecosystems in Africa.*

The overall objective(s) of the programme areas(s):

a) To support the implementation of the objectives of the Abidjan and Nairobi Conventions
b) To contribute to the implementation of the decisions of the Super PreCom of the African Process regarding the management of Africa's coastal and marine resources in an integrated manner, which were reaffirmed by the Partnership Conference, held during the WSSD in Johannesburg.
c) To support the elaboration and implementation of the African Regional Programme of Action on freshwater which shall be adopted at first session of the African Ministerial Conference on Water (AMCOW) in 2003.
   [It was mentioned that activities in the areas of fresh water will be undertaken in the context of AMCOW pursuant to its mandate. AMCEN and AMCOW will coordinate on areas of mutual interests within their respective mandates].

Programme activities, on the other hand, aim, among others, at:

i) Strengthening the capacities of relevant local and national authorities.
ii) Supporting the implementation of the strategic action plan on municipal wastewater.
iii) Promoting demonstration projects on the implementation of the guidelines on Integrated Coastal Area River Basin Management (ICARM) African.
iv) Supporting the preparation and implementation of the African Regional Programme of Action on Freshwater.

Ms Prachlova concluded her presentation by mentioning some of the programmes included in the Final Plan of Action such as the one on ***augmentation of water resources (surface- and groundwater)***, which she imagined GEF and UNEP would possibly collaborate on. In this programme, there are a number of projects on which collaboration could be built, among which are:

- **Those concerned with Coastal, Marine and Freshwater pollution, which include;**
  - Municipal Solid Waste Management and Enhancement of Environmental Quality in Sub-Sahara Africa
  - Management of Municipal Sewage in Sub-Sahara Africa through appropriate technologies
  - Control of eutrophication in semi-enclosed areas
- **Those dealing with Physical changes/alterations in the coastal and freshwater environment, such as:**
  - ☞ Mitigation of Coastal Erosion and Restoration of Degraded Areas in Sub-Saharan Africa
  - ☞ Assessment of the Vulnerability of sub-Saharan Coastal Zones to the different Impacts of Climate Change (included sea level rise)
  - ☞ Development of Sound Land-use Practices and Reduction of Suspended Solids in Estuaries and Lagoons in Sub-Saharan Africa
  - ☞ Establishment of adaptation strategies for impacts of climate change on water availability and quality
  - ☞ Addressing land degradation to mitigate sediment impacts on the aquatic environment

- **Those addressing the Augmentation of surface- and groundwater resources (under development),** which are envisaged to include activities for;
  - ***Augmenting urban water resources*** – The urban areas in Africa are characterized by sharp water deficiency and disrupted water supply and degradation of quality of water supplied. The objective of this project is to establish a management strategy for demand management and improvement of water supply efficiency. (Project idea)
  - ***Groundwater vulnerability*** - Initial global assessment of threats to transboundary groundwater resources with a view to providing strategic scientific guidance to assist the GEF and countries to make informed groundwater management decisions, to assess globally the main threats to groundwater resources and define hotspots for future GEF interventions in integrated transboundary groundwater management will be conducted. Case study on selected sites in Africa will be prepared. (Under development)
  - ***Management of the Iullemeden Aquifer System***
  - ***Regional Strategy for Water Resources Management in the North-western Sahara Aquifer System***
  - ***Kalahari Aquifer System (Botswana, Namibia, Angola and Zambia)***
  - ***Great Oriental Erg Aquifer System (Algeria, Tunisia)***
  - ***Nubian Aquifer System (Egypt Libya, Sudan, Chad)***

A detailed Action Plan is envisaged to be submitted to AMCEN for adoption by July 2003

Discussions

Q: Issues of capability in groundwater management / international waters in Africa have been raised. Is the GEF in a position to assist in building such capacity?

A: From the start, the GEF funds projects that have emphases on capacity building. And related to the operational programmes on International Waters that the GEF is currently funding, some of these capacity building programmes can be incorporated. If not from the GEF, other implementing Agencies (e.g. UNDP, World Bank, etc.) should be in a position to support such programmes.

Q: Is it possible for universities to submit research proposals for funding to the GEF?

A: Yes, but the country in which the university is domicile must endorse the proposal as this indicates to the GEF that the project is also important for the country.

Q: Submitting proposals through government may introduce unnecessary bureaucracy in the processing procedure. Would there be any exceptional possibility for the GEF to allow such institutions to submit these applications directly to the GEF?

A: Yes, it is possible for as long as the country of domicile of the university endorses the proposal, as this is indicative of the country's support for the project.

Q: Could research by PhD candidates be funded by the GEF without the endorsement of the host country?

A: The increase of scientific level of researchers would not attract direct support from the GEF. Such activities would need to be incorporated into major projects.

Ms. Prachlova concluded by saying that this workshop set a good platform for discussing possible cooperation between UNEP and GEF, which would allow for sub-regional issues to be tackled and at which higher-level capacity building activities (e.g. at PhD programmes) could be incorporated.

The Nairobi River Basin and its Water Divide.

Henry NDEDE, Nairobi River Basin Project, Regional Office for Africa (ROA), UNEP, Nairobi, KENYA

Introduction

Rapid population growth, urbanisation and industrialisation have put enormous pressure on Nairobi's Rivers (Nairobi, Ngong/Montoine and Mathare). Untreated industrial effluent, raw sewage and solid waste from human settlements along the river courses have turned the once clear and pure water into a health hazard.

Accelerating pollution, in particular dangerously high coliform counts in all the rivers are destroying the aquatic system posing a serious danger to any household consumers of river water. High coliform counts have been a result of the regular tampering with sewage pipes upstream for the purposes of irrigation, while solid waste and raw sewage drain directly into the rivers from the riverside *slums*. Untreated industrial effluent, dumping of textiles, waste packaging, and scrap metal have caused serious environmental pollution.

Heavy metal pollutants enter the water streams right from the rivers' sources, posing great threats to crops irrigated with this polluted water. Water related diseases such as typhoid, amoebiasis and diarrhoea have become quite prevalent in these areas. in many parts of Nairobi, where no formal water or sewerage infrastructure exist, these contaminated waters are still being consumed by the river basin communities that depended on the river for their livelihood.

Remedial Activities

UNEP promoted the Nairobi Initiative, which started in April 1999 with the aim of addressing problems such as pollution problems, waste management, urban greening, community participation, public awareness and legislation. This initiative evolved into the Nairobi River Basin Project, focusing on the above elements as they relate to the main rivers in the Nairobi River Basin (Nairobi, Ngong/Montoine and Mathare). Some of the major activities of the project have included:

- Crucial mapping of the river system and water quality testing has been undertaken by a local NGO (Africa Water Network), UNEP and Habitat to create a thematic map to illustrate the impact and status of pollutants on the rivers.
- Identification of twenty-four water sample points and testing along the three rivers to demonstrate a sustainable water monitoring system looking at different types of pollution in the watercourses. Test samples have been taken and the results show alarming levels of pollution along the entire basin.
- Launching of a campaign ***(Save Nairobi Rivers – Everyone Lives Downstream)*** to examine and evaluate the reality of life along the riverbanks.

Currently, six project components are being implemented, which aim at showing the value of proper sanitation and waste management practices, demonstrating the utility of wetland systems in improving the quality of impacted water systems and promoting community involvement in safeguarding and monitoring the river basin as a vital resource. The six project components are:

- Kibera Pilot Project
- Pollution Monitoring Network
- Public Awareness Campaign
- Constructed Wetland at Nairobi Dam
- Constructed Wetland at KWS Headquarters
- Water Hyacinth Utilisation

The project will be executed in two phases:

Phase 1- Meant to make a situation assessment of pollution and develop community outreach and educational programmes to enable capacity building amongst stakeholders. This phase hopes to address sustainable management of the river basin through education, promotion of awareness of available legislation and development of an Environmental Management Information System (EMIS).

Phase 2- Will focus on a section of the river basin upstream of the Nairobi Dam on Ngong/Montoine River, the Dam itself and downstream to the confluence with the Athi River. This phase is aimed at addressing the pollution problem in Nairobi's Rivers and to put in place capacity building educational programmes for the community.

Expected outcomes

Improvement of health and well being of residents of the Nairobi River Basin, and in particular in the Ngong/Montoine River area by increasing the availability and quality of the water supply entering and emanating from the Nairobi Dam to the communities downstream

Discussion

Q: Is there any indication of water quality impairment in the Nairobi boreholes?

A: There has not been any borehole quality data collected under this project. That information is with the owners but hope that the next phase would attempt to acquire this information.

PRESENTATION FROM PARTICIPATING COUNTRIES

OUAGADOUGOU / Burkina Faso

Alain Nindaova SAVADOGO, Universite de Ouagadougou, Ouagadougou 03, Burkina Faso

Started by outlining the geology of the city as comprising Precambrian Basement rocks and that it had an average annual precipitation of 700 mm.

The city had two main sources of water supply – surface sources (contributing about 80 % of the production) and groundwater sources (contributing the remaining 20 % of the production).

Currently, only about 40 % of the demand is met by the production by the water authority. As a result, the larger group of the population has resorted to using traditional hand-dug shallow wells. Within the context of this project, it would appear that, to satisfy the shortfall in demand, there might be need to increase production from ground sources.

However, one matter of great concern for the ground source is the threat that is posed to the water quality by various anthropogenic activities arising mainly from unplanned settlements.

Groundwater quality monitoring

Monitoring activities were conducted at three key sites in the city – *Boulmiougou, the main Channel and Kossodo*. In all cases, the indications were that the water in the Surficial aquifer tapped by the city's shallow wells are more polluted than that in local boreholes. Most pollutants were generated by agricultural inputs, wastewater and industrial refuse and their levels fluctuate during year, with particularly high concentrations in August and September, due to the percolation of heavy rainfall. Nitrate was identified as a useful index for anthropogenic pollution.

After the dramatic increase in various pollutants observed in August and September 2001, nitrate concentrations progressively decreased during the dry season. Five of the six boreholes examined showed concentration levels below the acceptable threshold, with the exception of the Kossodo borehole, which showed concentrations above 50 mg/L.

Vulnerability of the aquifer to pollution is governed by such factors as *thickness of the unsaturated zone, slope and fracture intensity* of the area. On the basis of the vulnerability mapping, the aquifers of Ouagadougou show an ***average to high*** vulnerability to pollution. Areas of high vulnerability appear to coincide with areas with population densities. Three bulletins have been distributed to decision-makers

Conclusion

The project has shown high-risk areas to pollution, particularly from nitrates. One hundred sampling points have been identified, which should allow the team to establish the source and levels of pollution in the city of Ouagadougou. Early Warning Bulletins have been distributed to raise decision-makers' awareness of the negative impacts of unplanned and/or poorly planned urban developments.

Activities Envisaged for the next Phase

These will include:

- Follow-up sampling and issuance of more Early Warning Bulletins to decision makers
- Sensitisation of stakeholders in the water sector through workshop and seminars
- Setting up a web site for the project for public consumption

NIAMEY / Niger

Boureima OUSMANE, Universite Abdou Moumouni, Niamey, Niger

The presentation started with a brief outline of the geology, which was said to consist of Precambrian rocks overlain by continental and alluvial deposits. The older Precambrian rocks constitute the deep aquifer, while the continental and alluvial deposits form the shallow aquifers.

Water Quality Assessment

Four areas were considered for water quality assessment:

Zone 1, which lies in the north-western part of the city
Zones 2 and 3 that stride the Niamey River in the southern part of Niamey

Zone 4, which lies in the eastern part of the city

Chemically, conductivity shows some variation depending upon the area under consideration and ranges between 1000 and 4000 µS/cm.

Bacteriological quality shows highly contaminated water with faecal coliforms. Although the water was chemically acceptable in some zones, it was found to be microbiologically very contaminated. Since the city has no treatment system, a chlorine plant is envisaged to take care of bacteriological pollution.

Sources of pollution were identified to be mainly dumpsites and a proliferation of pit latrines in the unplanned settlements. As discussed in the Ouagadougou report, anthropogenic pollution was fingerprinted by the presence of nitrates. And through the use of isotopes, nitrates found in the water were identified to have originated from septic tanks.

Conclusion

Due to the large volumes of drinking water being drawn from shallow wells and boreholes in the sub-urban areas of Niamey, urgent preventive measures must be taken to stop further chemical and bacteriological contamination of the Surficial and groundwater aquifers in the city. These may include creation of protective zones around the various water sources and recharge areas.

CÔTE D'IVOIRE / Abidjan

*Patrice Jean **JOURDA**, Labratoire des Sciences et Techniques de l'Eau et de l'Environment – UFR – STRM – CURAT, Universite de Cocody, 22 BP 582 Abidjan 22, Côte d'Ivoire*

The presentation started with a general outline of the objectives, namely:

a) To set up an Early Warning Network
b) To recommend protection measures for the water sources
c) To carry out vulnerability mapping for the city of Abidjan
d) To produce hydrogeological models

Geologically, the city of Abidjan is underlain by a Quartenary Sedimentary sequence that thickens southwards.

The city experiences two rainy seasons *(April – July and October – November)* and two dry seasons *(August – September and December – March)*. Hydrological assessments indicate most of the recharge occurs during the period of October – November.

Water Quality Assessments

Four sites were selected for monitoring the quality of groundwater in the city of Abidjan. This sampling campaign revealed that the boreholes used for Abidjan's water supply showed a steady increase of salt (NO_3 and NH_4) concentration and thus a progressive increase in groundwater pollution from north to south. The cause for this pollution was identified to arise mainly from percolation of highly polluted surface waters caused by the lack of a proper sewerage system to handle the city's growing solid and liquid waste problems.

Since October 1999, concentrations of the nitrates have substantially exceeded the limits for potable water. During the rainy season in 2001, one sampling site recorded high levels of ammonia and aluminium. The study has also revealed that pollution is steadily spreading towards the *unpolluted* northern part of the city.

Other major outcomes of the project

i) Establishment of a database including cartographic data to facilitate the elaboration of thematic maps such as pollution, recharge zones, dumpsites, et cetera.
ii) Production of Vulnerability Maps and Early Warning Bulletins.
iii) Promotion of collaboration among scientists from Niger and Côte d'Ivoire
iv) Capacity building through the production of two M.Sc. theses.

Envisaged Future activities

- Acquisition of equipment
- Sensitisation campaigns to all stakeholders in the water sector
- Analysis and monitoring for heavy metals
- Development of a Pollutant transmission model
- Setting up of an Early Warning Network

BAMAKO / Mali

Mr. Amadou Zanga TRAORE, Conseiller en Formation, 410, Av. Van Vollenhoven, BP E 4018, BAMAKO, Mali

Introduction

The presenter gave the following facts about Bamako:

Is supplied with water from a supply system from the water authority, private boreholes, traditional shallow wells and kiosks.

That only water provided by the authority is treated although it is conveyed through a very old system.

It has an average annual precipitation of 1000 mm with an average of about 70 – 80 days of rainfall.

Geology and Hydrogeology

Bamako is underlain by a Granitic basement, which is overlain by a quaternary sedimentary cover consisting of sandstones, laterite and alluvium. The city has two interlinked aquifers, which are formed from the fissures and a quaternary laterite.

Water quality monitoring

Thirty sampling sites were set up for groundwater quality monitoring across the city. These included two sites on the River Niger, four boreholes, two sites from freshwater sources and twenty-two traditional wells.

Results

- Physical parameters such as conductivity had values ranging from 20 to 1,200 µS/cm in shallow wells; 100 to 600 µS/cm in boreholes and 40 to 50 µS/cm at River level. PH values were 3.7 – 7.8 for the shallow aquifer and 7.5 at the River level.
- Chemically, the water showed the following values:
  - Nitrates 0 – 53.7 mg/l and the majority of the water samples contained these nitrates.
  - Heavy metals;
    Arsenic (2.5–15 µg/l); Zinc (8–570 mg/l); Nickel (8–30 mg/l); Lead (16 mg/l) and Copper (9.1–11 mg/l)
- Bacteriological parameters: faecal coliforms (10 – 200,000 counts / l) and total coliforms (10 – 300,000 counts / l). This shows that this water is unsuitable for human consumption.

Sources of pollution

These include domestic wastewater, industrial wastewater, agricultural practices (minor) and dying activities. Old districts of the city, which are also densely populated, show the highest pollution

Vulnerability mapping

Factors such as geology, infiltration capacity, depth to the saturation zone, population density, among others, were used in Vulnerability mapping. Thus, shallow aquifers and areas of dense population appeared very vulnerable to pollution.

Conclusion

The Bamako aquifers are chemically and bacteriologically contaminated, with deep aquifers being less affected than the shallow ones. In this regard, it was strongly recommended that monitoring of shallow wells must be continued and measures must also be taken to critically review the current sanitation arrangements in the city.

DAKAR / Senegal

Abdoul Aziz TANDIA, Département de Géologie, Faculté des Sciences, Université CHEIKH ANTA DIOP, BP 5005, DAKAR, Sénégal

Hydrogeology

The city of Dakar has two aquifers:

i) The confined Basaltic aquifer, which is usually intersected at depths of 70 metres.

ii) An unconfined quaternary sand aquifer, which extends between 30 and 80 metres.

Settlement patterns

Most of the densely populated settlements in the city are located in the eastern part of the city. Since they originated as *illegal* settlements, government has not recognised them and has thus, not provided them with any basic needs and services such as water supplies and sanitation services.

As such, there is a proliferation in the use of shallow wells as sources of water supply and pit latrines as a way of excreta disposal. Thus, the major source of pollution is anthropogenic.

Major project outcomes

- From monitoring of thirty wells, the months of May to September showed major anomalies. Conductivities and nitrate concentrations are highest on the periphery of the city, which coincide with areas without sanitation. In the peninsula, pollution is comparatively low.
- Cemeteries and markets also pose very high pollution problems to the city aquifer.
- The vulnerability shows peripheral areas to be more susceptible to pollution.

Conclusion

Vulnerability to pollution is highest in the peripheral areas of the city, which have no provision for sanitation.

General summary statement of the day

That issues raised in the day's presentations was to show the ***new countries*** what has been done in the phase I project and to draw some experiences that should assist them on how to proceed with the execution of their project activities.

DAY 2 (12 MARCH 2003): PRESENTATIONS (CONTD.)

SUMMARY OF RECOMMENDATIONS FROM THE EVALUATION OF THE [1]PROJECT

Patrick M'mayi, Division of Early Warning and Assessment (DEWA), United Nations Environment Programme.

The Day started with a presentation from the previous day on made this presentation.

He gave the background and outlined the objectives, aims, the identified needs and specific goals and expected results of the project.

Participating cities and their Coordinators

PARTICIPATING CITY / Country	Coordinator
COTONOU / Benin	Dr. Felix AZONSI
OUAGADOUGOU / Burkina Faso	Prof. Alain Ninadaoua SAVADOGO
ABIDJAN / Cote d'Ivoire	Dr. Jean Patrice R JOURDA
ACCRA- KETA /[2] Ghana	Dr. Bruce BANOENG - YAKUBO
BAMAKO / Mali	Dr. Traore Amadou Zanga
NIAMEY / Niger	Prof. Bouramine OUSMANE
DAKAR / Senegal	Dr. Abdoul Aziz TANDIA

New cities include Addis Ababa (Ethiopia), Mombasa (Kenya) and Lusaka (Zambia).

Some important project Activities

These involved:

- Collection and collation of data
- Preparation of provisional maps and data

All countries EXCEPT Guinea and Mali delivered contributions judged as satisfactory by senior consultants (Abidjan, Sept. 2001)

- Training seminar on the Arc View and its application to GIS (Abidjan, April 2002)

Important project outputs

i) A network of six West African countries with Ghana being included was established towards the end of the project.
ii) A clear basis for cooperation between the countries and a sense of commitment was established in the national task forces.
iii) Setting up of an Early Warning monitoring system for the pollution of groundwater in large urban areas.
iv) Distribution of Early Warning Bulletins by each of the various task forces, which have already had a clear, albeit local, impact on politicians and water managers in each country.
v) Completion of a M.Sc. thesis from the work done by the Abidjan team.
vi) Establishment of a project web site that is envisaged to provide a window into the project to the international community.

Outreach programmes have been carried out involving mainly the distribution of Early Warning Bulletins.

Among the most **important recommendations** were the following:

- Expeditious incorporation of Ghana into the Early Warning network of countries and proposed eastern and southern African countries
- Inclusion of Anglophone African countries in Eastern and Southern Africa
- Enforcement of methods and methodologies of project outputs
- Securing of policy development in groundwater management at UNEP Programme level.

The main conclusion of the presentation was that the tangible planned outputs of the project were largely attained.

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[1] *Vulnerability of Africa's Surficial and Groundwater Aquifers to Urban Pollution*
[2] *Replaced Guinea*

Resource Directed Measures – the South African Perspective

Yongxin XU, Groundwater Group, University of the Western Cape, 7535 BELLVILLE, South Africa

Resource directed measures (RDM) involves:

- Classification of the resource *(into pristine, protected and unprotected)*. This establishes a set of classification rules for the ecosystem, basic human needs and water users. Criteria for classification is the degree of modification of the systems from un-impacted conditions
- Reserve concept, which takes into account environmental needs. This establishes (i) the basic per capita requirement (which is 25 l / day in South Africa), (ii) the ecological reserve for the ecosystem, and (iii) the eventual location of the remaining resource to other needs.
- Reserve quality objectives, pattern and timing of water levels and the character, condition and distribution of dependent biota.

Resource Directed Measures in South Africa have been strengthened by the introduction and enforcement of the following legal instruments:

- Water Service Act of 1997, which is supposed to address water equity and distribution
- Water Act of 1998 for Integrated Water Resources Management (IWRM) – a basin policy adopted in South Africa.
- National Environmental Management Act of 1998.

Water Pollution issues in South Africa

These have been addressed though:

- Continuous borehole-monitoring programmes by the Department of Water Affairs and Forestry.
- National Guidelines.
- WRC research projects such as inventory, identification and prioritisation of contaminants in urban catchments.

The presentation also described the pathways of contaminants and some basic problems of aquifer contamination and he finally outlined a step-by-step procedure for water resource protection as follows: Step 1 Delineate management units

Step 2 Evaluate data and assess present situation
Step 3 Reference conditions and current status
Step 4 select desired classes
Step 5 Assess groundwater reserve
Step 6 Set resource quality objectives (RQOs)
Step 7 initiate monitoring programmes
Step 8 Review reserve determination

He ended the presentation by saying that good assessment of the geology / hydrogeology assists in predicting the pollution pathways and the possibility for an early warning alert.

Discussion

Q: What would cause the introduction of pollution into a confined aquifer by drilling activities that go through an aquiclude?

A: This would have something to do with the inappropriate construction of the borehole, particularly the casing.

Q: How far must a borehole be constructed from a waste dump to avoid hydraulic reversals?

A: This would depend on the geology, water levels, and type of contaminant. Thus, water authorities must examine potential borehole sites for sources of pollution before drilling their water supply boreholes.

Q: What are some of the groundwater protection measures?

A: one method involved delineating zones around a water source, where certain human activities must be restricted. However, there two major problems of zoning as a method of groundwater protection in most of the African countries:

- The basic lack of understanding of pollutant transmission mechanisms by many water authority staff.
- Water supply in many African countries is demand-driven. Therefore, the situation is usually such that the location of supply boreholes is sometimes done without much consideration to sources of pollution other than the sheer consideration to satisfy a need / demand.

PHASE II PROJECT:
ASSESSMENT OF POLLUTION STATUS AND VULNERABILITY OF WATER SUPPLY AQUIFERS OF AFRICAN CITIES

Patrick M'mayi, Division of Early Warning and Assessment (DEWA), UNEP, Nairobi, Kenya

This is a joint Project of UNEP – DEWA in collaboration with UNESCO – IHP as the implementing agency with funding from the Belgian Governments, Development Cooperation (DGDC). UNCHS – Habitat and ECA as regional and political partners. The aim of the project is to build on the successes achieved in the work carried out in West Africa.

Participating Countries

These will include four new Anglophone countries of Ethiopia, Ghana, Kenya and Zambia.

Timeframe and Funding arrangements

Duration of the Project: 24 months
Commencing: December 2002
Completion: November 2004

Cost of the Project (in US $)

		Total	%Counterpart
Contribution by the Belgian Government (Cash)		400,000	80
Cost to DEWA	(in kind)	15,000	3
Cost to UNESCO/IHP	(in kind)	15,000	3
Cost to 10 Countries	(in kind)	70,000	14
Total		**500, 000**	**100**

The project is expected to raise awareness on the status of groundwater at all levels and the enhancement of institutional capacity. The findings obtained will form the basis for formulating groundwater use policy and options for safeguarding and sustaining the resource.

Discussion

Q: Although phase I has attained most of its targets, the executing teams faced a lot of constraints to attain them largely because of the size of the budget. The current commitment of US $500,000 meant for the 10 countries for Phase II may make it just as difficult to undertake and execute the project.

A: The project had initially targeted GEF funds, which it eventually could not get because the project was not in the operational programme for GEF. When the Belgian funds became available, though limited in amount, it was decided to devote them to the second phase of the project. (To participate in this project, GEF needs to find international priorities in this groundwater vulnerability project).

Q: what would be activities of the West African countries in Phase II of the project?

A: The new countries will need to start collecting data (geological, meteorological, groundwater data), sampling / monitoring, digitisation of geological, topographic and hydrogeological maps and combining this data in a GIS analysis to come up with vulnerability maps and distribution of bulletins.

Meanwhile, the old (West African) countries will continue with more data acquisition (e.g. water quality monitoring) to add more value to what they have so far done.

PRESENTATIONS FROM NEW COUNTRIES

Early Warning Report for Keta shallow Aquifer

Bruce Banoeng-Yakubo, Geology Department. University of Ghana, Accra, Ghana

Geology and Hydrogeology

Recent unconsolidated beach sands, lagoon clays and middle tertiary limonitic argillaceous sands and gritty sands underlie the Keta-Anloga area. With the Middle Tertiary rocks, being very permeable, the greater part of the rainfall infiltrate underground to contribute to the groundwater resources.**Project activities**

Involved an initial sampling campaign of 106 points in June 2002. These were subsequently reduced to 52. Four sampling campaigns and water level measurements were undertaken within the period from mid-June to September 2002 in four major zones. The presentation was based on the results of these four sampling campaigns.

Results

- There was a general rise in **water levels** from June through August to September. In a few cases, water levels declined during the period in questionAt the peak of the rainy season, **pH** was high at all sampling points except one. During the second campaign (towards the end of the major rainy season), pH values dropped in almost all the sampling stations (values ranged between 6.6 and 7.6 over the measurement period).
- **Fluoride / chloride** - generally high values of chloride. Although fluoride was low, it was above WHO Guidelines for drinking water.
- **Nitrates** had high values and generally increased with increase in rainfall (probably from farming and sewage).
- **Bacteriological** results showed a very widespread contamination problem over most of the areas.

Conclusion

- Nitrate (NO3), Ammonium, Fluoride, Chloride and Phosphate concentrations were all high and in excess of the WHO Guidelines for drinking water.
- Bacteriological quality (for both total and faecal coliforms) was very bad presenting values in excess of 200,000 counts per 100 ml.

Future activities

- Consolidation of the monitoring process to determine long-term trends and to establish a network of monitoring wells.
- Dissemination of the findings through the District Assembly and Community Water and Sanitation Agency and to vide a platform for public discussion

Management of Groundwater Resources in the Lusaka Aquifer

D.C.W. Nkhuwa, School of Mines, University of Zambia, Lusaka, Zambia

Introduction

Groundwater resources in most urbanised areas of the world are increasingly becoming susceptible to quality degradation and quantity depletion arising from various forms of anthropogenic activities that have been generated by the ever-increasing population

In Lusaka, three factors appear to be responsible for the degradation and depletion of groundwater resources:

- The nature of bedrock underlying the city.
- Current Practices of groundwater abstraction to satisfy the ever-increasing water demand.

- Increased use of the ground to dispose of various forms of wastes

The Nature of Bedrock underlying the city

The Lusaka plateau stands at 1,200 metres above sea level. It is a flat terrain, which is conspicuously lacking in surface drainage. This physiography is controlled by the underlying geology, which dominated by thick and extensive sequences of marbles. Differential dissolution has developed in the marbles a well-developed system of conduits and solution channels.

Groundwater Abstraction Parctices

Lusaka, with a population estimated at two million, has grown from only 196,000 at independence in 1964, to 536,000 in1980, and rising to 769,000 in 1990. With no commensurate increase in the provision of social services, Lusaka appears to have failed to cope with this high rate of population increase. For instance, at a per capita consumption of 200 litres of water per day, about 400,000 m^3 would need to be supplied to satisfy the inhabitants' daily water requirements. However, current supply is only 200,000 m^3 per day. To augment this shortfall in supply the city aquifer has experienced indiscriminate drilling of boreholes. In places, this has caused aquifer over-abstraction. Exacerbated by drought episodes, this has initiated lowering of the water table.

Liquid Waste Disposal Practices

About 25 % of the city's two million inhabitants are serviced by a sewer system, about 20 % by septic tanks, while 55 % rely on pit latrines to dispose of their excreta. The 55% consist of high-density residential townships that have generally developed in close proximity to areas of natural groundwater discharge or springs. These locations are in areas, where the groundwater table is very high.

Systems of Solid Waste Disposal

Of the current estimate of 800,000 kg of solid waste generated in the city per day, most of it ends up into *unofficial* dumps scattered over the city. Most of these have turned out to be sinkholes and surface depressions, some of which have direct connection to the groundwater store. Since most of these sites are located, in the main, over the aquifer recharge area, subterranean channel-network in the marbles allows for little likelihood of leachate control at the waste-bedrock boundary into the surrounding strata.

Current Indications of Groundwater Quality

Sporadic quality monitoring has indicated that certain physico-chemical and bacteriological parameters do not meet the acceptable WHO Guidelines for drinking water, particularly in the high-density areas. Especially the conspicuous use of pit latrines in the affected areas would appear to be responsible for most of the bacteriological contamination

Concluding Remarks

Current trends of human activities in Lusaka - the uncontrolled settlement patterns, methods of waste Disposal and unrestrained abstraction of groundwater point to a resource that may have been inefficiently and unsustainably managed. This raises serious risks of groundwater contamination and dwindling water levels in the aquifer, both of which may have far-reaching public health implications for the current and future residents.

To this end, a number of programmes have been undertaken to assess gaps and/or shortcomings in the environmental set-up of our city, with a view to developing strategies for mitigating the impact of urbanisation on fresh water resources. One such major activity includes the UN-Habitat's Water for African cities, which involved:

- Formulation of a citywide strategy for enhanced aquifer-management to deal with pollution & problems of aquifer over-abstraction
- Development of early warning and monitoring systems for the aquifers
- Initiation & promotion of community-based aquifer management system with special focus on water supply and sanitation in a selected area.**Freshwater Shortage and Groundwater Quality in the Coastal Area of Kenya**

Daniel Munga, KMFRI, P.O. Box 81651, Mombasa. Kenya

Introduction

An indication of the shortage of freshwater along the coastal area is reflected by the demand and availability of potable water in Mombasa, with an estimated population of 900,000. Mombasa Island and North Coast areas receive about 35,000 m^3 per day of piped drinking water, against a demand of 70,000 m^3 per day.

Sources of water supply

- Piped water from the Mzima Springs (with the catchment in the Mt. Kilimanjaro area)
- Sabaki River.

- Borehole and well water

The rising population and diminishing capacity of the local authorities to render essential services to the urban dwellers, is expected to increase the demand for potable water and reliance on groundwater.

Groundwater Pollution

The shortage of freshwater in the urban centres is, however**,** exacerbated by pollution of the groundwater (Table 1):

Table 1: Microbial contamination of well and borehole water in Mombasa District

Source	No.	Coliform Count / 100 ml	E. coli count / 100 ml	Potability
Wells	20	25 – 1800+	0 – 1800+	No
Wells	3	0 – 4	0	Yes
Boreholes	11	17 – 1800+	0 – 5	No
*Boreholes	1	0	0	Yes

**Borehole water treated with ultraviolet radiation.*
Drinking water standards in Kenya are: Coliform count <10 per 100 ml; E- coli count nil.

Nitrate / nitrogen was the dominant nutrient, with concentrations as high as 2,500 µM l^{-1}.

Sources of Pollution

Pit latrines and septic tank / soakage pit systems used for sewage disposal (for about 87 % of the population) form the main source of pollution for borehole and well water.

Impact on Public Health

There has been a high incidence of child mortality associated with the quality of water related to the methods of domestic sewage, which has manifested in high gastrointestinal diseases.

Conclusion

Public awareness of the vulnerability of groundwater to pollution is quite low. However, it worth of note that the impacted and affected population has, in most cases, absolutely no alternative source of potable water.

Surface and ground water pollution status in Addis Ababa, Ethiopia

Tamiru Alemayehu, Addis Ababa University, Ethiopia
Solomon Waltenigus & Yirga Tadesse, Addis Ababa Water Supply & Sewerage Authority, Ethiopia

Introduction

Addis Ababa with:

A population of more than 3,000,000 inhabitants

City area of about 530 km^2

An altitude varying from 2100 m a.s.l. to 2700 m a.s.l

is threatened by severe pollution due to anthropogenic activities.

Geology

Constituted by volcanic rocks ranging from acidic to basic in composition.

Current situation

High fracturing in the rocks permits fast circulation of the pollutants over large distances and to a great depth. Exacerbated by widespread uncontrolled waste disposals, groundwater in Addis may generally be considered highly vulnerable to any type of pollution.

Streams that serve as natural sewerage lines for domestic and industrial wastes have been greatly infested with hyacinth.

Waste disposal

This is characterised by septic tanks, open dumps and surface impoundments. Most of the private septic tanks have open bottoms or peculiar channels, which facilitate seepage in depth or are in direct connection with nearby streams. Large and small-scale factories are clustered within the city have unregulated waste disposal systems. Some of the known large-scale human activities producing dangerous refuse include *chemical and paint factories, slaughterhouses, tanneries, hospitals, paint factories and cemeteries.*

Water supply Scenario

- Three dams that supply the city with treated water
- At least about 271 boreholes
- Numerous cold and thermal springs

Pollution

Surface water pollution is mainly with turbidity and algae. Groundwater pollution is mainly from Heavy metals, total coliform and nitrate.

Conclusion

Shallow aquifers are highly polluted with heavy metals, coliforms and pathogens

DAY 3 (13 MARCH 2003) SUMMARY AND ACTIVITIES OF THE SECOND PROJECT PHASE

Introduction

This session began with re-outlining the objectives for this phase as have been elaborated earlier and went on to discuss major points from the West African project and some experience arising thereof. This was followed by a discussion of the programme and budget for the next phase.

General Observations – West African Countries

- The key activity of this phase will be the collection of data. It will also be imperative to standardise data and the presentation of results.
- Results got from the West African project during their two year-activities will assist in the application for GEF funding. Their activities and results, which were evaluated by Lewis Clark in July 2003 enabled the agenda / programme for the next phase to be set up.
- Drafting of maps has been very good by each country. The only critic is that legends need to be standardised.
- West African countries must continue with a weekly / monthly update of their activities to improve results of the performed tasks.
- Changes in the environmental situation are usually dependent upon rainfall. Therefore, efforts must be made to report, probably at the beginning, middle and towards the end of the rainy season.
- Identified trends should be confirmed and communicated through monthly reports.
- Sensitisation of medical personnel must be encouraged. In Burkina Faso, the Ministry of Health is very satisfied with the dissemination activities because they have become aware of the importance of monitoring water sources as preventive measure to most of the waterborne diseases. Senegal's has also a sensitisation programme in place and have included a medical person on their research team with knowledge of pathogens that are responsible for certain ailments.

General Observations – New Countries

- For the four new countries joining the project, only Kenya must intensify the collection of data.
- If other countries could adopt visualisation given in the Zambian presentation, it'd help water authorities with no hydrogeological knowledge to understand what is going on in the aquifers from which they win the water for supply to their cities.
- Each country requires developing a programme of activities including reporting schedules as appropriate. The programme of activities was generally agreed as outlined in Table 3.
- If a firm stand has not been made by new countries as to what / how they intend to execute the project, this must be done at the earliest convenience followed by a harmonisation of tasks among them. This will include *(i) Synchronisation of maps and data files, (ii) Adoption of a single methodology to avoid submission of different formats of documents to donors, and (iii) Presentations in Bulletins must be in simple formats to facilitate decision-makers to understand them. Therefore, the first harmonisation will require a review of the West African Bulletin and circulating it to the new countries as a model.*
- There will be need to cooperate with and sensitise governments of participating countries so that the outputs of the project are well received.

Needs

Training and Software (all hydrogeological software is available with Prof. Yongxin Xu at the University of the Western Cape). Training for Arc View software will be hosted for the new countries, as they will still need to produce vulnerability maps using the same software. To be more effective, some courses must be conducted regionally and only allow the consultant to travel.

Budget

This is given in Table 2. A summary of the discussions on few budget lines were as follows:

Line 2003 on training – that there will be training on the production of vulnerability maps, which will concentrate mainly on the new countries. The training programmes will be identified on an annual basis and will follow the format of country or sub-regional training, where only the trainer / consultant travels.

Line 4201 Computers – that these will only be bought for the new countries and Côte d'Ivoire. Use of this line will be the responsibility of each country.

Table 2: Budget for Counterpart Contribution of Belgium (in US$)

		2002	2003	2004	Total
20	**Sub-Contracts Component**				
2201	Data Generation in new countries	0	15,000	15,000	30,000
2202	Data Generation in other countries	0	20,000	20,000	40,000
2203	Field Survey in other countries	0	11,500	11,500	23,000
2204	Field Survey in new countries	0	9,000	9,000	18,000
2299	Sub-total	0	55,500	55,500	111,000
2999	**Component total**	**0**	**55,500**	**55,500**	**111,000**
30	**Training Component**				
3200	Group training				
3201	Training on identification/estimation of recharge areas	0	15,000	0	15,000
3202	Training on the use of GIS	0	0	15,000	15,000
3203	Training on the management of waste disposal	0	0	15,000	15,000
3299	Sub-total	0	15,000	30,000	45,000
3300	**Meetings/Conferences**				
3301	Workshop to launch the project	8,000	0	0	8,000
3302	Expert Group meting: mid-term evaluation	0	4,000	0	4,000
3303	Stakeholder workshop	0	0	4,000	4,000
3304	Seminar	0	0	4,000	4,000
3305	Expert Group meeting: final evaluation	0	0	4,000	4,000
3399	Sub-total	8,000	4,000	12,000	24,000
3999	**Component total**	**8,000**	**19,000**	**42,000**	**69,000**
40	**Equipment and Premises component**				
4100	Expendable Equipment				
4101	Software	0	3,000	0	3,000
4199	Sub-total	0	3,000	0	3,000
4200	**Non-Expendable Equipment**				
4201	Computers	0	8,000	0	8,000
4202	Sampling bottles	0	4,000	0	4,000
4203	pH-meters	0	1,500	0	1,500
4204	Conductivity meters	0	1,500	0	1,500
4205	Water level measuring instruments	0	10,500	0	10,500
2299	Sub-total	0	25,500	0	25,500
2999	**Component total**	**0**	**28,500**	**0**	**28,500**

Table 3: List of Activities for Phase III

Project Work Plan (Proposed)	2003									2004											
	Ap	Ma	Ju	Ju	Au	Se	Oc	No	De	Ja	Fe	Ma	Ap	Ma	Ju	Ju	Au	Se	Oc	No	De
TASKS																					
1: Site Selection & Data Collection (Literature - Field Work)																					
Digitisation of topographic maps																					
Piezometry of areas identified																					
Meteorological data																					
2: Purchase and Scanning of Materials																					
Air Photos / Satellite Images																					
3: Mapping of Key Pollution sources																					
4: Analyses, Synthesis and Presentation																					
Inclusion of Geological data, structures																					
First Vulnerability maps																					
Pollution status																					
5: First REPORTING to UNEP Bulletin																					
6: Dissemination Workshop - to promote awareness & influence policy formulation																					
7: Draft Thematic Maps																					
More sampling and analysis																					
8: 2nd Report to UNEP Bulletin																					
9: Continuation of Work																					
10: Final Report, Evaluation and Proposal for Up-scaling																					
11: 2nd Dissemination Workshop																					

CLOSING REMARKS

Mr. Emmanuel Naah closed the meeting by thanking the people at the centre of the organisation of this meeting, namely Patrick, Pravina, Pacifica, the resource persons, Loic and Yongxin and the participants. He said that he learnt and benefited greatly from the contributions at the meeting and said that even when he had made the issue of money as a joke, he learnt something from it.

He emphasised the fact that this network of researchers is intended to build friendship, which is the most important aspect. To this effect, he outlined benefits of such friendship from an account of his visits to a few countries involved in the project.

Finally, he hoped that this project will sale and enable the team to proceed and wished all workshop participants a good and safe trip back home.

A VOTE OF THANKS

Alain Nindaoua SAVADOGO moved a vote of thanks on behalf of the participants. He hoped that his colleagues from the countries on the project will eventually appreciate Mr. Naah as much as he has done.
He *joked* that with this interaction, he hoped future meetings might not need interpreters / translators as participants from Anglophone countries will probably have learned enough French, while those from Francophone countries would have learned enough English.

He apologised to Loic for some of the discussions, which may have turned very hard, but hoped that he took them purely as scientific discussions. He thanked Yongxin for sharing his experience with the participants and hoped that this was only the beginning of many more such interactions in the future.

Finally, he thanked, on behalf of the paricipants, Patrick, Pravina, Pacifica and Martin for their contribution to a very successful meeting.

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ANNEX 2: WORKSHOP PROGRAMME OF ACTIVITIES

Tuesday 11th March 2003

Time	Activity	Responsibility
8.30 a.m.	Registration	Pacifica/Pravina
9.00 - 9.15	Opening Speech	Director DEWA
9.20 - 9.30	Election of Chairman, Rapporteurs	
9.30 - 10.00	ROA	Henry Ndede
10.00 - 10.30	GEF -MSP in the NEPAD context	Marie Prachlova
10.30 - 10.45	Coffee/Tea Break	
10.45 - 11.15	Consultants Over view of the just completed project	Loic Giorgi
11.15 - 12.15 p.m.	Presentations by participating countries	Benin, Burkina Faso, Cote d'Ivoire, Mali, Niger Senegal
12.15 - 12.30	Summary and recommendations from the evaluation of the project	Salif Diop/Patrick M'mayi
12.30 - 1.00	Discussions on issues raised	Chairman and Rapporteurs
1.00 - 2.00	Lunch	
2.00 - 2.45	South Africa's - Groundwater pollution, Technical, political and protective measures	Yongxin Xu
2.45 - 4.00	Discussions on GIS, Modeling, Capacity Building, Collaboration and Best practices	Yongin Xu, Loic Giorgi
4.00 - 4.15	Tea/Coffee break	
4.15 - 5.00	Discussions continued	
	End of Day one	

Wednesday 12th March 2003

Time	Activity	Responsibility
9.00 - 9.30 a.m.	Presentation of new project	Salif Diop/Patrick M'mayi
9.30 - 10.00	Clarifications and discussions	Chairman to lead
10.00 - 10.15	Tea/Coffee Break	
10.15 - 11.40	New countries presentations on their project sites, available maps, GIS facilities, Sampling equipment and materials, Laboratories, Personnel and team work, communication means e.g. e-mail and possibilities for country exchanges	Ghana Ethiopia, Kenya, Zambia
11.45 - 1.00 pm.	Discussions and - Setting up of country teams - Availability assessment of equipment, facilities and human resources (digitalisation possibilities – Use of GIS) - Identification of areas of difficulty	Chairman
1.00 - 2.00	Lunch	
2.00 - 3.00	- Identification of sites on a map - Development of field implementation methodologies (display of topographic, hydrogeological maps and localization of sites)	Loic Giorgi/ Yongxin Xu
3.00 - 3.30	Presentations of the programme of work	Loic Giorgi
3.30 - 4.00	Discussions	Salif Diop/Naah Emmanuel
4.00 -4.15	Tea/Coffee break	
4.15 - 5.00	Discussions continued	
7.00 - 9.00	Reception	
	End of Day two	

Thursday 13th March 2003

Time	Activity	Responsibility
8.30 - 10.00 a.m.	Presentation of Programme of Work - Building on past work Input from Yongxin's presentations	Loic Giorgi & Yongxin Xu
10.00 - 10.15 a.m.	Tea/Coffee break	
10.15 - 1.00 p.m.	Integration of policy aspects into scientific findings - Local seminars - Legislation - Awareness	
1.00 - 2.00	Lunch	
2.00 - 4.00	Country needs identification - Training - Equipment, Office and field	Old and new countries Loic Giorgi and Yongxin Xu
4.00 - 4.15	Coffee/Tea Break	
4.15 - 5.00	Administrative issues - MoU's and funding mechanism - A.O.B	Salif Diop/Naah Emmanuel/Finance section
5.00 - 5.30	Closing	
	End of Day Three	

Annex 3: Opening speech by Dr. Dan Chasen, Acting Director, DEWA

Ladies and Gentlemen:

It is my great pleasure to welcome you to Nairobi to this workshop to launch the project, the ASSESSMENT OF POLLUTION STATUS AND VULNERABILITY OF WATER SUPPLY AQUIFERS OF AFRICAN CITIES.

I hope that you have all been well looked after by the support team here in Nairobi, and that your stay will be productive and pleasant.

Introduction and background

- As you all know, unprecedented population growth in African cities, mainly through rural urban migration and natural population growth had a significant impact on groundwater.
- Those cities that use groundwater as their main source of potable water are experiencing threats to those supplied from pollution arising from unplanned expansions, sewage effluent leakage in open sewers, leaking septic tanks, latrines, domestic waste disposal and uncontrolled industrial and commercial activity.
- The concept of the project "Urban pollution of Surficial and groundwater aquifers in Africa" was conceptualised at a UNESCO/IHP regional workshop held in Ouagadougou, Burkina Faso, in October 1998.
- Benin, Burkina Faso, Cote d' Ivoire, Guinea, Mali, Niger and Senegal attended this workshop, which dealt with the subject of mapping groundwater vulnerability and the need to protect the quality of groundwater resources.
- In the project, UNEP and the UNESCO/IHP worked as facilitators and catalysts to establish and strengthen regional coordination, water management and monitoring systems.
- The project was supported by the United Nations Human Settlements Programme (UN-HABITAT), which has similar complementary activities, and the United Nations Economic and Social Development for Africa (ECA).
- It should be noted that this was the first UNEP project to be funded through the United Nations Development Account in New York.

I understand that **the objectives of the initial project** were to:

a) Establish a network on urban groundwater vulnerability;
b) Develop methodologies for optimal monitoring of the contamination of shallow and deep groundwater aquifers in Africa's urban areas as the basis for an early warning and trend detection system for possible water supply pollution.

The project -

vii) Established a network of six West African countries with Ghana being included towards the end of the project
viii) Was able to establish a clear basis for cooperation between the countries and a sense of commitment in the national task forces.
ix) Reached agreement between UNEP, UNESCO and the participating countries on establishing an early warning monitoring system for the pollution of groundwater in large urban areas.
x) Distributed Early Warning Bulletins from each of the various task forces, which have already had a clear, albeit local, impact on politicians and water managers in each country.
xi) A M.Sc. thesis was produced from the work done by the Abidjan team. A project web site has also been established and will provide a window into the project for the international community.
xii) All this has been achieved with a modest budget of US $ 280,000 from the United Nations Development account.
xiii) At the cost of US $ 20,000 a year for each country, this has been indeed an inexpensive project and a learning experience.
xiv) The seven country networks can now be a springboard for future progress.

Phase Two

- Building on the successes of that projectwe now embark on an expansion of the project into the Eastern and Southern part of Africa.
- The **"Assessment of Pollution Status and Vulnerability of Water Supply Aquifers of African Cities",** project is based on the findings of the 'first phase' "Urban Pollution of Surficial and Groundwater Aquifers in Africa".
- It is funded by the Belgium Government contribution to the tune of US $ 400,000, which are about 80% of the total funding.
- As before, this is a joint Project of UNEP-DEWA in collaboration with UNESCO-IHP as the implementing agency and partnered by UN-Habitat and ECA.
- The project aims to build on the successes achieved in earlier work carried out in six West African countries and will include four new Anglophone countries i.e. Ghana, Ethiopia, Kenya and Zambia. Its aims are similar to those of the first phase i.e.
  a) determine the status and vulnerability of groundwater supplies in the new cities of the selected countries,
  b) establish a network for exchange of related information, and
  c) develop suitable methodologies for assessing and monitoring of real and potential contamination of shallow and deeper groundwater aquifers, while building on information gathered in six west African countries.
- In the process, awareness on groundwater status at all levels will be raised and institutional capacity enhanced.
- The findings obtained will form the basis for formulating groundwater use policy and options for safeguarding and sustaining the resource.
- We anticipate that the implementation process will be more focused as we have gathered experience from work in 'phase I'.
- We are also hoping to strengthen our inter-divisional collaboration (ROA and GEF), and inter agencies cooperation (UN agencies i.e. UN-Habitat, ECA during the implementation phase of this project), while contributing to on going Programmes and projects e.g. Global Environmental Outlook (GEO) and African Environmental Out Look (AEO).
- We expect to see more
  (a) Targeted technical reports, including a set of city vulnerability maps.
  (b) Reports on the status of urban groundwater pollution for each participating country's selected city;
  (c) City water infrastructure maps to guide governments and other decision-makers towards environmentally sound decisions regarding land use and protection of urban groundwater quality.
  (d) Standardized methodological guidelines for optimal monitoring of wells to serve as early warning and trend detection systems for water supply contamination in seven West African countries.
  (e) Bulletins suitable for educating and informing planners, legislators, decision-makers and the public regarding the need for groundwater protection and contamination prevention.

Concluding remarks.

- In conclusion, I wish to thank all of you for making the effort to be here.
- I want to acknowledge the work of the Assessment Branch and Water Unit of DEWA, Ivar Baste, Beth Ingraham, Salif Diop, Patrick M'mayi, Audrey Ringler, Pacifica Mochache who have worked to organize the meeting.
- I particularly want to thank Pravina Patel, for ensuring that your travel, hotel bookings, hospitality and other logistical concerns are taken care off.
- Last but not least I want to make special mention of Mr. Emmanuel Naah from UNESCO/IHP, who worked very hard in collaboration with us to ensure that tickets and other arrangements were successfully concluded.
- Again, I wish you a good stay in Nairobi and a productive time in your deliberations.

End