WORKSHOP

REPORT

Ambient Water Quality:

Monitoring for Management

Nairobi

8th – 10th November 2016

UN Environment GEMS/Water Capacity Development Centre

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

School of
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Environmental Sciences

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WORKSHOP REPORT

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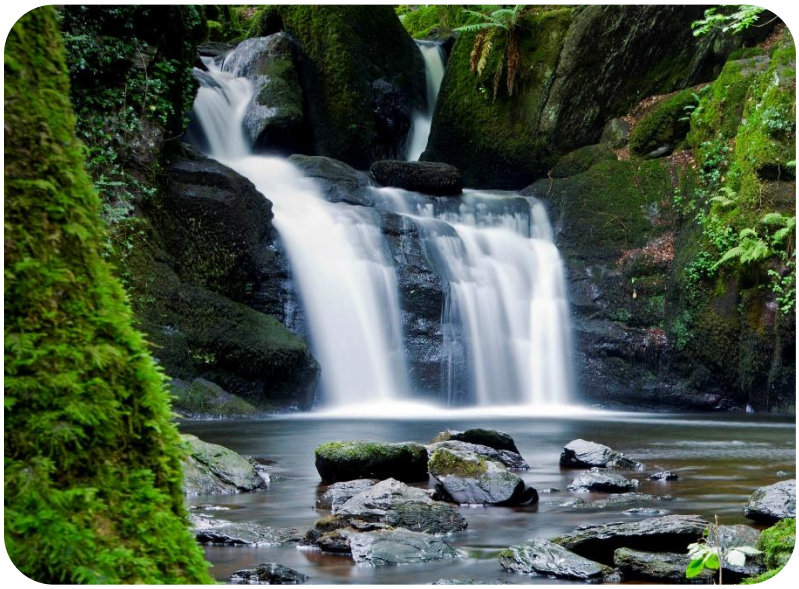
SUMMARY

The UN Environment GEMS/Water programme hosted a workshop at the United Nations Office at Nairobi (UNON) in November 2016. The aims of the workshop were to consider water quality monitoring in the context of management of water resources and to introduce the new Sustainable Development Goal indicator for ambient water quality. The workshop also aimed to identify capacity development needs for water quality monitoring in Africa. Proposed GEMS/Water training courses were discussed and on-line delivery of training was demonstrated. The workshop was held in conjunction with Cap-Net UNDP and UN Environment (UNEP) Freshwater Ecosystems Unit and included sessions to discuss the draft UN Environment International Water Quality Guidelines for Ecosystems (IWQGES) and a water pollution manual. Cap-Net UNDP is an international network for capacity development in sustainable water management. Currently Cap-Net UNDP is composed of 23 regional and national capacity development networks with over 1000 members in 120 countries.



The workshop provided an opportunity for the GEMS/Water team to meet participants from 11 GEMS/Water countries in Africa, together with representatives from Cap-Net's global network, the African Ministers' Council on Water (AMCOW) and United Nations Educational, Scientific and Cultural Organization (UNESCO).

All participants actively engaged in the workshop sessions and the objectives were met. The workshop provided a valuable overview of the water quality monitoring situation in a cross-section of African countries. There is a distinct range in monitoring capacity with some countries facing much greater challenges in availability of resources than others. It was also evident that the capacity development activities proposed by GEMS/Water are very much needed and this workshop proved vital in refining the proposed activities for the period 2017–2020.

1. BACKGROUND TO THE WORKSHOP

This workshop addressing "*Ambient water quality: monitoring for management*" was facilitated by the UN Environment GEMS/Water Global Programme Co-ordination Unit (GPCU) in Nairobi and the GEMS/Water Capacity Development Centre (CDC) at University College Cork, Ireland and took place from 8th to 10th November 2016 at the United Nations Office in Nairobi. There were 16 participants from 11 GEMS/Water programme countries, together with representatives from AMCOW and UNESCO, and five members of the GEMS/Water team (see Annex A Participants list). The majority of the participants from GEMS/Water countries were newly established National Focal Points (NFPs). NFPs are the designated contact people who coordinate participation between the country and GEMS/Water. The GEMS/Water team comprised representatives from the three Centres: the GPCU, the CDC and the Data Centre (DC). In addition, AMCOW was represented by Nelson Gomonda, (Monitoring, Evaluation and Reporting Project Manager), and UNESCO by Simone Grego (Science Officer, UNESCO, West Africa). The workshop was held in conjunction with Cap-Net's Partners and Network Managers Meeting which included over 30 members from Cap-Net's global network.

Ambient water quality, which was the focus of this workshop, is under pressure from human activities and climate change. If further deterioration of water quality is to be prevented, appropriate policies need to be designed and implemented and appropriate management action taken. Evidence-informed decision making requires a thorough knowledge of the status and trends in surface water and groundwater quality, achieved by collecting quality assured monitoring data. Apart from a financial commitment from governments, water quality monitoring requires capacity in a wide range of activities: setting up monitoring systems, collecting and analysing samples, storing and interpreting data, and reporting. The UN Environment GEMS/Water programme, with its renewed mandate from the first UN Environment Assembly (UNEA) in 2014 plays a crucial role in assisting countries in this respect. This workshop contributed to a review of the current situation with respect to water quality monitoring in the Africa region, and took the first steps in the process of assisting countries to meet the ambitions of the 2030 Agenda.

The new SDG 6 on water and sanitation is a dedicated goal with interlinkages to many others dealing with health, food, energy and ecosystem services. Whereas in the Millennium Development Goals (MDGs) there was a focus on the quantitative aspects of drinking water supply and provision of sanitation, the SDGs follow a more holistic approach to water and take into consideration water quality, because it is directly linked to human and ecosystems health. Water quality also governs the amount of water that is usable and therefore it is also linked to water security and water scarcity.

Under a funding agreement between Irish Aid and UN Environment, the CDC is carrying out a scoping exercise to determine current water quality monitoring activities in countries in Africa. It is also consulting with government agencies and other relevant organisations to identify gaps in knowledge and skills in order to develop a GEMS/Water capacity development strategy for the period 2017–2020. This workshop provided an opportunity to discuss experiences and challenges, and to identify capacity needs at the country level for sustainable water quality management. To maximise the reach and influence of GEMS/Water, the workshop took place in parallel with a workshop organized by Cap-Net UNDP, which highlighted the importance and potential synergies of such partnerships.

The main objectives of the workshop were:

- To introduce the fundamental principles of ambient water quality monitoring and the monitoring approaches that can be used.
- To identify monitoring needs in rivers, lakes and groundwaters that will provide appropriate information for management purposes.
- To explore the potential for using the indicator for Sustainable Development Goal (SDG) 6.3.2 as a water quality management tool.
- To identify capacity development needs relating to water quality monitoring in African countries and other world regions.
- To explore the role of on-line material in delivering capacity development for water quality monitoring.
- To obtain feedback on prototype e-learning and delivery platforms in Africa.

To facilitate the multi-purpose scope of the workshop and broad range of participants, parallel sessions were used (see Annex B Full programme). Combined sessions allowed Cap-Net UNDP and the UN Environment Freshwater Ecosystems Unit to contribute to the GEMS/Water focussed sessions (see Annex C GEMS/Water programme). For the majority of Day One all participants were together, but they were divided in the afternoon for discussion sessions on the International Water Quality Guidelines for Ecosystems (IWQGES) and challenges for monitoring water quality in Africa. There was a feedback plenary to bring together the observations of both groups.

Day Two started with a joint session on the Cap-Net water pollution management manual, after which participants were divided into four groups to discuss improvements and how to maximise outreach and impact of the manual. Following the plenary session on the manual, the workshop participants were divided into two groups, with the first focussing on water quality monitoring and the second on ecosystem functions and services. Participants were brought together in the afternoon for presentations from AMCOW and Cap-Net and presentations on the SDG indicators 6.3.2, 6.5.1 and 6.6.1. The indicators were discussed in two separate sessions: 6.5.1 alone, and 6.3.2 and 6.6.1 jointly. Day Two concluded with a feedback plenary.

The workshop was divided for the morning of Day Three: GEMS/Water participants focused on water quality monitoring capacity development, and Cap-Net commenced their Annual Network Managers and Partners Meeting. An optional field visit for all participants in the afternoon of Day Three visited a number of sites along the Nairobi River to observe examples of pressures on a freshwater system. This report concentrates mainly on the content and outcomes of the sessions for GEMS/Water participants

2. DAY 1 AMBIENT WATER QUALITY AND ECOSYSTEM GUIDELINES

A joint welcome address was given by Joakim Harlin of UN Environment Freshwater Ecosystems Unit, Themba Gumbo of Cap-Net and Hartwig Kremer of GEMS/Water.

2.1 Keynote presentations

Kilian Christ of the GEMS/Water GPCU gave a brief overview of the GEMS/Water structure and programme. GEMS/Water was established in 1978 but received a renewed mandate from United Nations Environment Assembly (UNEA) with funding from the Irish and German Governments. The new structure includes three key parts: the Global Programme Coordinating Unit (GPCU) in Nairobi, the Capacity Development Centre (CDC) in University College Cork, Ireland and the Data Centre (DC) in the Federal Institute of Hydrology in Koblenz, Germany. Additionally, there is currently one Regional Hub at Agência Nacional De Aquas (ANA), in Brasilia, Brazil, with further hubs planned for the future.

The presentation summarised the different aspects of the revised GEMS/Water programme including global network development, capacity development, the GEMStat database and how data are used for assessments such as the World Water Quality Assessment (WWQA) and Global Environment Outlook (GEO) 6. The presentation also outlined GEMS/Water's role in support of SDG Indicator 6.3.2 reporting, and demonstrated the tools being developed for data handling, reporting and visualisation.

Joakim Harlin of UN Environment Freshwater Ecosystems Unit, specified the relevance of freshwater ecosystems, including both direct and the indirect services provided from drinking water sources to habitat creation. The necessity of, and links between, both quantity and quality of water were highlighted, and the threats to freshwater ecosystems were given context showing percentage of rivers affected by human impact on a regional basis. The need for a second WWQA was identified and the aims of such an assessment outlined.

Deborah Chapman of the GEMS/Water CDC presented the different approaches used to monitor water quality. The relationship between water quality characteristics and its suitability for different uses was summarised, with each use having its own set of requirements. The different methods of classifying water quality using physical, chemical or biological characteristics were described and how these characteristics change both spatially and temporally. A range of methods, from measuring basic parameters to quantifying waste emissions that may occur at trace concentrations were covered. Additionally, the use of biological indices, indicator species and microbiological techniques were examined.

Emmanuel Ngore of UN Environment presented the progress of the International Water Quality Guidelines for Ecosystems (IWQGES). The need for such guidelines was highlighted arising from a global deterioration in freshwater ecosystem health and a reduction in associated goods and services to society. The advisory nature of the guidelines was mentioned and how they have the potential to be used as a base for setting national water quality policy and implementation. Workshop participants sought clarification concerning the title of the guidelines, and whether the IWQGES should be titled both "international" and "guidelines". In response it was agreed that the IWQGES are in reality a "framework" rather than "guidelines" and, although international

consultation was sought, a call for further feedback is being circulated. It was stated that the guidelines are a living document and the process has been overtaken by that of Agenda 2030 and the SDGs.

2.2 Discussion on challenges for water quality monitoring in Africa

There were two discussion groups: Group A focused on the IWQGES and was comprised primarily of Cap-Net participants, and Group B focussed on challenges faced in water quality monitoring in Africa and was comprised mainly of GEMS/Water participants. This report focusses on the GEMS/Water session.

GEMS/Water participants were given the opportunity to present an overview of the water quality monitoring framework in their countries and to identify the key challenges they were experiencing in obtaining water quality data. Participants were provided with a questionnaire prior to the workshop to help frame their presentations. The sessions were informal and participants were given the option to present their country situation.

Cameroon

Presented by Dr. Fantong Wilson of the Ministry of Scientific Research and Innovation (MINRES). There are five river basins in Cameroon, with many hydrological stations. Across the various sectors that use hydrological data, there is an inconsistent level of satisfaction with the data, with groundwater data users being the least satisfied. It was noted that geogenic fluoride is a major issue leading to serious health problems. Monitoring equipment has been donated in the past for specific projects, and work has been undertaken along with the Global Water Partnership (GWP).

Challenges:

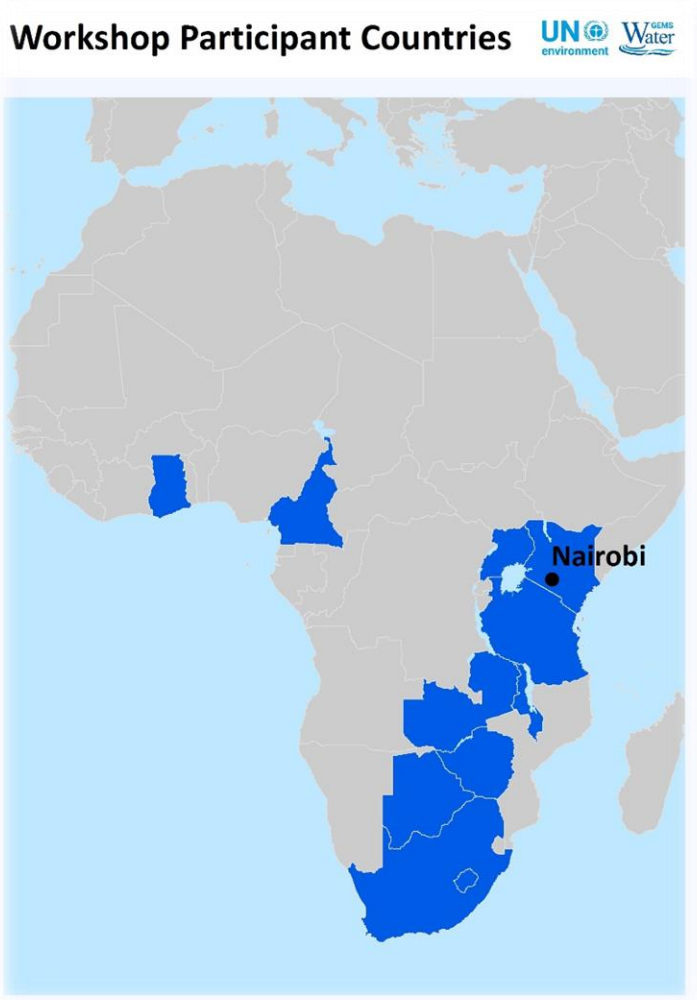
- Systematic monitoring and assessment of ambient surface or groundwater quality is lacking.
- Conflicting institutional roles and responsibilities with respect to water quality hinder action.
- A national database for management of water resources that includes water quality is needed.
- The budget available fluctuates between years

Zambia

Presented by Mr Frank Nyoni of the Water Resources Management Authority (WARMA). WARMA is two years old, and mandated by the Water Resource Management (WRM) Act to set standards, control pollution, specify environmental flows, develop water conservation practices, issue water use permits and fines. Zambia has the inter-agency group including WARMA, ZEMA (Zambia Environmental Management Agency) and ZABS (Zambia Bureau of Standards) to set standards. Zambia has one central laboratory and two regional laboratories with 168 hydrological monitoring sites, of which 65 are telemetrically linked, with plans to upgrade these to include quality as well as quantity instrumentation. Additionally there are 11 groundwater monitoring wells in mining areas.

Challenges:

- Quality assurance
- Focus on groundwater quality is needed



Tanzania

Presented by Eudosia Materu of the Ministry of Water and Irrigation. There are nine river basins in Tanzania with approximately 20 monitoring stations per basin, but there are no dedicated laboratories in the basins. However, the 16 laboratories in the Water Services Division are used, requiring collaboration and sharing of data. The intention is to collect samples four times per year, but in reality it is closer to once per year. There is a programme to equip laboratories and it will soon be possible to monitor most water quality parameters. Project-specific monitoring occurs, for example for the Lake Victoria Environmental Monitoring Programme (LVEMP) which monitors nutrient loads and trends. Additionally there is routine monitoring of drinking water sources.

Challenges

- Too few staff for laboratories
- Equipment is donated but often training is lacking
- There is no central database for water quality data, but one will be established soon
- The effects of mining on water quality are a serious problem in Tanzania, especially mercury use in gold mining. Mercury is not routinely monitored in surface waters.

Republic of South Africa

Presented by Mr Elijah Mogakabe of the Department of Water and Sanitation. The monitoring activities are well supported by legislation and mandate. There are many monitoring programmes with specific objectives, for example the National Chemical Monitoring Programme (NCMP), which are currently being consolidated and revised. Currently there are 950 monitoring sites with 325 priority sites concentrating mainly on inorganic chemical parameters. Biannual summaries and annual water reports are produced. There is a national microbiological monitoring programme for water bodies mostly in rural or informal settlements but some of these analyses are outsourced, together with analyses for the pilot radioactivity monitoring programme.

Challenges

- Current programmes evolved rather than designed, therefore consolidation needed
- Conflicting interests between Government Departments

Lesotho

Presented by Ms. Matsolo Migwi of the Department of Water Affairs. There are three main catchments in Lesotho with 79 monitored rivers and streams, with two stations per river. Additionally ten dams are also monitored giving an approximate total of 187 monitoring locations. A range of analyses are performed including physico-chemical and the River Health Monitoring programme using South African guidelines. The intention is for regular monitoring, including some monthly sampling, but this is only achieved for about 12 stations.

Challenges:

- Financial resources
- Limited personnel

Uganda

Presented by Ms. Lilian Idrakua of the Ministry of Water and Environment. There are 115 natural river monitoring stations, 19 stations in Lake Victoria and ten transboundary water quality stations. Surface water stations are generally monitored twice a year, rather than six times as intended. There are many institutions monitoring water quality in Uganda, and therefore coordination is a challenge. Although there are regulations, there is no clear regulator, which leads to poor enforcement. Data are stored in a "depository" rather than a data management system, and therefore data are not readily available for analysis. A water information system is currently being developed.

Challenges

- Coordinating monitoring efforts and data sharing between various agencies
- Importance of water quality monitoring is not clearly understood by policy makers
- Training is needed to link water quality monitoring to sustainability of infrastructure
- Resource allocation
- Inadequate human resources
- No current ambient water quality standards
- Gap in understanding about data analysis and presentation
- Replenishing and maintaining laboratory consumables – some suppliers don't order until they receive an order from a laboratory and this can lead to long delivery times.

Zimbabwe

Presented by Ms. Sylvia Yomisi of the Environmental Management Agency (EMA). The EMA falls under the Ministry of Water, Environment and Climate and is responsible for monitoring and environmental protection. The Zimbabwe Water Authority is responsible for quantity and distribution, and for issuing allocation permits. There are seven hydrological zones, one for each major river, with 374 monitoring stations which are mainly monitored monthly for approximately 18 parameters (physico-chemical, heavy metals, nutrients and major ions). The central main

laboratory, which is accredited to ISO17025, is used for all analyses with accreditation for 26 of 60 parameters. Additionally field kits are used for some parameters and biomonitoring is performed at 21 sites using the South African standards methodology. There are water quality standards but they apply to effluent and drinking water. A State of the Environment Report is published every five years.

Challenges:

- A laboratory information management system (LIMS) is needed to handle the water quality data because they are currently hard to retrieve
- Maintaining and upgrading equipment
- Maintaining through flow of samples with current resources in the laboratories
- Need the capacity to test for Mercury

Malawi

Presented by Mr. Innocent Manda of Ministry of Water Development and Irrigation. There is one division responsible for water quality monitoring in Malawi, with several monitoring programmes running, including rivers, lakes and dams, groundwater boreholes and wells, point source control monitoring and drinking water. The National Water Resources Authority (NWRA) was established in 2013. Much of the water quality monitoring has been carried out in response to demands for information. There are also catchment level projects in operation, for example the Lake Malawi Monitoring Project (LMMP), which provide funds for monitoring for a fixed time period.

Challenges:

- Data management and storage, which is exacerbated by the lack of a LIMS
- Financial resources are inadequate and ad-hoc

Ghana

Presented by Mr. Jeremiah Asumbere of the Environmental Protection Agency. There are sector-specific guidelines in Ghana, for example for manufacturing and mining. Unannounced monitoring of industry is conducted to check for compliance. Ambient water quality monitoring is conducted on selected water bodies in collaboration with other agencies, but the focus is mainly on effluent monitoring.

Challenges:

- Need to develop water quality guidelines for ecosystems

Botswana

Presented by Ms. Kene Dick of the Ministry of Minerals, Energy and Water Resources. There are two relevant authorities in Botswana involved in monitoring: the Department of Water Affairs (now in Ministry of Lands) who are responsible for protection of water bodies, and the Water Utility Corporation which oversees water supply and sanitation. There have been reforms in recent years, resulting in the Department of Water Affairs being responsible for water resource management. As water is scarce, policy makers give priority to water supply and an Integrated Water Resources Management (IWRM) and water efficiency plan have been developed to assist with scarcity issues. There are three laboratories in Botswana, with one central and one regional being fully equipped

and which promote ISO17025. Microbiological analysis is performed but more is needed. There are currently no standards for ecosystems.

Challenges:

- Policy makers understand importance of monitoring but water scarcity is a higher priority
- Lack of data for decision making
- Financial resources
- Capacity needed for field operations training, particularly quality control aspects
- Upskilling needed for staff with respect to ambient water quality monitoring
- Data management is very ad hoc and systems need to be integrated
- Harmonised standards at river basin level needed

2.3 Summary of challenges to water quality monitoring

Representatives from the countries identified a number of recurring challenges which are common in each country:

- The complexity of institutions involved in water quality monitoring and the lack of communication between them.
- The lack of a centralised database for water quality data, with different institutions collecting and storing their own data.
- There is often a lack of appropriate data management, storage, interpretation and reporting of water quality data.
- Appropriate standards are needed for ambient water quality. In many countries there are only standards for drinking water and/or effluents.
- Transboundary standards are needed, with agreements between countries.
- In many countries water scarcity takes priority over water quality.

Discussions between representatives at the GEMS/Water Workshop

Other relevant comments and suggestions included:

- Legislative frameworks are gradually changing and the move to the basin or catchment approach is very positive.
- The private sector could be engaged to fill gaps in water quality monitoring.

The overall conclusion was the issues raised need a resolution which will maintain long-term monitoring at the appropriate frequency, not just on a short-term or project basis.

3. DAY 2 WATER QUALITY MONITORING: PRODUCING INFORMATION FOR MANAGEMENT

3.1 Keynote presentations

The importance of monitoring network and programme design to generating information for management

Stuart Warner of the GEMS/Water CDC presented an overview of water quality monitoring programme design. The presentation outlined the necessity of sound and robust programme design for providing reliable data to inform management decisions, policy formulation and environmental protection. The relative low cost of monitoring programmes compared with the value of water resources was highlighted. Each of the necessary steps in the programme was detailed from setting objectives through to evaluating the efficacy of the programme.

The role of quality assurance in water quality assessment

Building on the previous presentation, Deborah Chapman of the GEMS/Water CDC focused on the importance of quality assurance and quality control throughout a monitoring programme to ensure credible and reliable data are produced. The necessity of quality assurance and control measures at the design phase of the project, through field and laboratory operations, to data storage were highlighted. Examples of good practice and how errors often occur were presented. The value of external quality control, such as the GEMS/Water Performance Evaluation exercises, was emphasised.

Water quality data – providing information for management

Philipp Saile of the GEMS/Water DC demonstrated how water quality data can provide information for management. The importance of data management planning was outlined to ensure data integrity to maximize use of data and to meet information requirements of monitoring programmes. The necessity of quality assurance and control measures throughout the entire data life cycle were outlined, including the need for data backup and archiving features. Examples of various data analysis methods were given, but the choice of analysis must be related to the underlying data and scope of the project.

The Water Sector and Sanitation Monitoring System (WASSMO) of the African Ministers' Council on Water

Nelson Gomonda of AMCOW, presented an overview of the history and activities of the organisation and outlined AMCOW's mission: *to provide political leadership, policy direction and advocacy in the provision, use and management of water resources for sustainable social and economic development and maintenance of African ecosystems*. During the Sharm El Sheikh Summit (2008) AMCOW, as the regional mechanism, was given the mandate to monitor and report on progress being made across Africa with regard to addressing Africa's water and sanitation challenges. The WASSMO web portal designed by DHI (Danish Hydraulic Institute) was demonstrated and is available at *www.africawat-sanreports.org*. The system includes 43 indicators over seven themes. The database is currently being updated.

A number of gaps in water quality management in Africa were identified, including a lack of enforcement, inadequate effluent collection, high effluent discharge standards, a shortage of data collection, a need for more well-equipped laboratories and a lack of awareness of the importance of water quality monitoring. As part of the solution to the challenges posed, the private sector was identified as having a role to play. Enforcement is primarily a government function but initiatives and interventions in raising awareness, providing technology and capacity development would be welcome.

3.2 Sustainable Development Goal for Water

Peter Bjørnsen of UN Environment DHI provided an overview of the progress made on the SDG 6 indicators to date. Indicators 6.3.1 through to 6.6.1 are coordinated under the GEMI (UN Water Global Monitoring Initiative) framework. GEMI is an inter-agency initiative formed in 2014 to provide coherence to the monitoring efforts of indicators across a broad water sector. The range of indicators is extensive, therefore groups of indicators were divided between different UN agencies. UN Environment coordinates efforts for indicators 6.3.2, 6.5.1 and 6.6.1. GEMI implemented a "proof of concept phase", which tested the draft methodologies in five countries globally (Uganda, Senegal, Jordan, Peru and Netherlands). This process was drawing to a close and feedback was being compiled, leading to the revision of indicator methods. A description of the three UN Environment indicators was given.

Indicator 6.5.1

Peter Bjørnsen continued by providing an overview of indicator 6.5.1 which is the *Degree of integrated water resource management implementation*. The indicator is determined by a national survey which focusses on four main components: the creation of an enabling environment, the range and roles of institutions, the management instruments and the financing available from various sources.

Indicator 6.3.2

Indicator 6.3.2 is defined as the *Proportion of bodies of water with good ambient water quality* and was presented by Stuart Warner of GEMS/Water CDC. This indicator is relatively complex compared with others due to the large amount of data and infrastructure needed. One of the key elements of the method is the setting of useful target values against which "good" status is measured. These values are to be set by each country, and whether national or waterbody-specific targets would be more useful was considered. Other points highlighted during the presentation were the existence or access to monitoring data, how to select monitoring sites, the importance of quality assurance of monitoring data, and also data storage and reporting facilities.

Indicator 6.6.1

Lis Bernhardt of UN Environment Freshwater Ecosystems Unit presented Indicator 6.6.1 which is the *Change in extent of water-related ecosystems over time*. This indicator includes sub indicators on spatial extent, the quantity of water contained within, and the health of ecosystems. These sub indicators can be determined by a variety of means. For example the spatial extent of a wetland can be measured using remotely sensed data, the quantity of water in river systems can be measured by measuring streamflow, and ecosystem health can be measured by applying a biological index.

Challenges to monitoring and reporting indicator SDG 6.3.2

These discussions provided an opportunity for participants to provide feedback on the feasibility of collecting data and reporting the indicator and to guide the content of SDG Indicator 6.3.2 training material which would be made available in 2017. Five key questions were addressed and the comments are summarised below:

Ambient water quality monitoring network coverage

This question aimed to ascertain whether there is an existing monitoring network in countries that could be used for SDG 6.3.2 monitoring.

- Zimbabwe: There is a monitoring network which has adequate coverage for rivers and lakes, but there are gaps in the groundwater network. There are two units of study used: hydrological units based on the river catchments and agro-economical units based on common land-use types in adjacent areas.
- Botswana: There is improvement needed in the groundwater monitoring network.
- Kenya: There is a monitoring network but the country is only partially covered. Design guidance is needed to complete the network. There are 140 groundwater stations which are used to record level and these can therefore be used for water quality also. There are 264 surface water locations but rationalisation is needed.
- Uganda: There is adequate coverage for rivers and lakes but not for groundwaters. There is very high spatial variability in groundwater quality and there is a problem delineating groundwater bodies.

Human resources and/or technical expertise for field and laboratory measurements

This question was aimed at assessing the human resource in countries and whether the capacity is available to facilitate the SDG monitoring. Comments below are not attributed to specific countries and have been summarised.

- It is difficult to determine human resource requirements without an assessment of existing capacity across the various agencies involved in water quality monitoring.
- There is a need to train field staff.
- There is a capacity need for staff to be trained in heavy metal analysis.
- Currently field officers are trained in-house.

Selection or definition of target values

The setting of realistic target values is critical for the usefulness of the indicator at the national level. The comments below are not attributed to specific countries.

- The unique characteristics of waterbodies need to be considered when setting target values. There is large natural variation in some of the parameters which is unrelated to anthropogenic activities.
- Target values should be based on un-impacted conditions within a given system.
- Accurate geological information is needed, which is missing in the country.
- For some waterbodies different targets for specific stretches would be needed based on use.
- The intended use of the waterbody needs to be accounted for.
- Targets should be aligned with the IWQGES.

- Existing international target values should be used and adapted for national use
- Ecosystem values should be used.
- The setting of values should start with highly studied waterbodies
- Extra parameters beyond the five core parameters should be included in the methodology.

From these points it is apparent that differences of opinion exist on the mechanism for setting target values. Some participants recommend the intended use of the water should be included, with the proposal that within the same river system the targets should change longitudinally. This was countered with the suggestion that only water quality at un-impacted sites truly represents "good" water quality.

The question was put to the participants that, in the absence of historic water quality monitoring data, how long would it take to collect sufficient data to set meaningful targets. The answers included:

- At least one year's data would be essential.
- Between one and two year's data would be needed.
- Even beyond the data collection, a period of time would be necessary to convert the information into national legislation.

Data handling, analysis and calculation of indicator

An assessment of the data handling and analysis capability of the countries was sought with this question. It was generally agreed that a capacity gaps exists in this regard. Specific comments included:

- Real-time data collection would be an advantage including in-situ water quality measurement equipment.
- Help is needed in the area of data integration.

4. DAY 3 WATER QUALITY MONITORING CAPACITY DEVELOPMENT NEEDS CONSULTATION

4.1 Capacity development for water quality monitoring: options and approaches

Stuart Warner of GEMS/Water CDC gave a presentation on the activities of the Centre and the various modes of delivery of training content planned for 2017 onwards. These include packaged short courses, webinars, face-to-face training workshops, a new guidebook, revision of the GEMS/Water Operational Guide and a UCC (University College Cork) accredited online postgraduate diploma. Additionally, participants were all provided with a sample of a packaged online course created by GEMS/Water CDC on a USB memory stick and via a live internet link for review.

The group was primed with a number of points to help focus the discussion on scoping the need and format of capacity development for water quality monitoring. The points considered and the associated feedback are summarised below.

Topics for training courses

There were a number of specific topics that were suggested by the group. These included:

- A general quality assurance and quality control course which would cover both field and laboratory operations.
- A specific course on groundwater monitoring including risk assessment of septic and fuel tanks.
- Modules to integrate with IWRM
- A module that covers the legislative elements of water quality
- A course linking water and economics, designed to raise the awareness of financial implications of poor water quality
- Training on specific pieces of equipment
- A course on the developmental stages of creating water quality indices
- Guidance on how to disseminate results effectively
- A module on water quality modelling
- A course on rapid stream-side biological assessment, similar to the South African SASS system
- Training in communication for different audiences

Method of delivery – guidebooks, on-line, workshops, webinars

No specific comments were made on the method of delivery.

Level of delivery – management, technical, graduate, professional development

There was general agreement that courses should be aimed at multiple levels. It was suggested that material should be aimed at postgraduate level and also simplified into discrete courses provided for continuous professional development (CPD). Additional suggestions included:

- A general foundation course (comprised of material from various modules) which could be used to capacitate graduates who arrive from university without the relevant skills and

knowledge. The view was held that much of what is taught in universities in participating countries needs updating.

- It was also suggested that material could be aimed at three tiers:
    - Management
    - Scientific
    - Application (technical)

Requirement/desire for university or professional accreditation

There were no specific comments on the necessity of a university accredited course during this session, but it was generally agreed to be a positive mechanism by which to engage staff in pursuing additional training.

Other

A number of comments were made which fell outside the above categories. These included:

- A cost-benefit analysis of a water quality monitoring programme relative to the loss of value of water resources would be a useful tool to help increase advocacy at the policy making level. The formation of collaborative project groups is needed to answer specific water quality questions.
- How can a mutually beneficial link between GEMS/Water and CAP-Net be formed?
- Could GEMS/Water facilitate links with the private sector to provide training?

Representatives from the GEMS/Water countries in Africa and the GEMS/Water Team

5. CONCLUSIONS

The workshop proved to be a success due largely to the active participation of all the GEMS/Water country representatives, with each of the planned objectives being met. It provided a valuable overview of the status of water quality monitoring in a cross-section of African countries.

A number of recurring challenges facing countries in Africa were identified during the workshop and it provided a useful opportunity to gain feedback on the SDG Indicator for ambient water quality. Valuable insight was gained into the potential difficulties countries will face using the draft methodology, and the feedback received will be used to improve the document in the next revision. The methods proposed by GEMS/Water to meet some of the training capacity needs for water quality monitoring were well received by the participants and a number of additional topics for training were suggested.

KEY MESSGES FROM THE WORKSHOP

- The relationship between institutions involved in water quality monitoring is complex and there is often a lack of communication between them. This can lead to potentially useful data being scattered in different locations or stored in inaccessible data repositories, where they are not available to inform decision making.
- There are very few examples of appropriate standards for ambient water quality compared with standards for drinking water and/or effluents. Guidance is needed to help countries set target values against which to measure “good” water quality.
- There is a need for transboundary standards and discussions on how to develop standards between countries.
- Groundwater monitoring networks are lacking in many countries, and assistance will be needed to design and install the necessary network.
- There is a strong need to develop the capacity for data handling and interpretation.

ANNEXES

Annex 1 GEMS/Water participants in the workshop

Name	Country (where based in)	Organization	e-mail address
Deborah Chapman	Ireland	GEMS/Water Capacity Development Centre	d.chapman@ucc.ie
Elijah Mogakabe	South Africa	Department of Water and Sanitation	
Eudosia Materu	Tanzania	Ministry of Water and Irrigation	
Fantong Wilson	Cameroon	Ministry of Scientific Research and Innovation (MINRESI)	
Frank Nyoni	Zambia	Water Resources Management Authority (WARMA)	
Hartwig Kremer	Denmark	UNEP, GEMS/Water Global Programme Coordination Unit	hartwig.kremer@unep.org
Innocent Manda	Malawi	Ministry of Water Development and Irrigation	
Jeremiah Asumbere	Ghana	Environmental Protection Agency	
Kene Dick	Botswana	Ministry of Minerals, Energy and Water Resources	
Kenneth Koreje	Kenya	Water Resources Management Authority	
Kilian Christ	Kenya	UNEP, GEMS/Water Global Programme Coordination Unit	kilian.christ@unep.org
Lemmy Namayanga	Zambia	Water Resources Management Authority (WARMA)	
Lillian Idrakua	Uganda	Ministry of Water and Environment	
Margaret Abira	Kenya	Water Resources Management Authority	
Matsolo Migwi	Lesotho	Department of Water Affairs	
Naftaly Mutuma Thiaurij	Kenya	Water Resources Management Authority	
Nelson Gomonda	Nigeria	AMCOW	
Philipp Saile	Germany	GEMS/Water Data Centre	saile@bafg.de
Simone Grego	Nigeria	UNESCO (West Africa)	
Stuart Warner	Ireland	GEMS/Water Capacity Development Centre	s.warner@ucc.ie
Sylvia Yomisi	Zimbabwe	Environmental Management Agency	

Annex 2 Full workshop schedule – GEMS/Water and Cap-Net

Towards implementation of the Sustainable Development Goal on Water (SDG 6)

8-11 November 2016, United Nations Complex, Gigiri, Nairobi, Kenya

OVERVIEW

<table>
<tr><th>Session Type</th><th>Tuesday
Nov 8</th><th colspan="2">Wednesday
Nov 9</th><th colspan="2">Thursday
Nov 10</th><th>Friday
Nov 11</th></tr>
<tr><td>ALL</td><td>Room 13
08:45 – 18:00

Ambient water quality and ecosystem guidelines
(ALL)</td><td colspan="2">Room 13
09:00 – 11:00
Water pollution management (ALL)</td><td>Room 13
09:00 – 12:00

Water Quality monitoring:
capacity development needs consultation</td><td>Room 10
08:45 – 12:00

Cap-Net Partners and Network Managers Meeting</td><td>Room 10
08:45 – 18:45

Cap-Net Partners and Network Managers Meeting</td></tr>
<tr><td>GEMS</td><td></td><td>Room 13
11:00 - 18:00</td><td>Room 10
11:00 - 14:30</td><td></td><td></td><td></td></tr>
<tr><td>Cap-Net</td><td></td><td>Water quality monitoring: producing information for management</td><td>Ecosystems functions and services</td><td></td><td></td><td></td></tr>
<tr><td>Event</td><td>19:00
WELCOME RECEPTION</td><td colspan="2">FREE EVENING</td><td>FREE EVENING</td><td>12:00
TECHNICAL VISIT</td><td>19:00
CAP-NET DINNER</td></tr>
</table>

Annex 3 GEMS/Water workshop programme

GEMS/Water Capacity Development Centre workshop

Ambient water quality: monitoring for management

8-10 November 2016, United Nations Complex, Gigiri, Nairobi, Kenya

Tuesday 08 Nov	**Opening plenary**	**Facilitator**
08:45 – 09:15	Welcome remarks: UNEP, IW:Learn, Cap-Net and WaterCap	Juliette Biao Koudenoukpo, Hartwig Kremer, Joakim Harlin, Mish Hamid, Themba Gumbo, Wangai Ndirangu

Tuesday 08 Nov	**Ambient water quality and ecosystem guidelines**		**Facilitator**
09:15 – 09:30	Objectives of the workshop		Hartwig Kremer, Joakim Harlin
09:30 – 10:00	Brief overview of GEMS/Water		Hartwig Kremer
10.00 – 10.30	Water quality and ecosystem health		Joakim Harlin
10:30 – 11:00	Break		
11:00 – 12:00	Approaches to monitoring water quality: physical, chemical and biological		Deborah Chapman
12:00 – 13:00	Managing water quality: standards and guidelines		Joakim Harlin/Lis Bernhardt
13:00 – 14:00	Lunch		
14:00 – 15:00	International Water Quality Guidelines for Ecosystems (IWQGES)		Emmanuel Ngore
15:00 – 15:30	Break		
15:30 – 17:30	Group discussion A: How can IWQGES be applied in countries that lack guidelines for water quality of ecosystems?- invited speaker(s) to give specific country example(s)	Group discussion B: Challenges for water quality monitoring in Africa (country summaries)	A: Joakim Harlin/ Emmanuel Ngore B: Deborah Chapman /Stuart Warner
17:30 – 18:00	Feedback plenary		All
19:00	Welcome cocktail and dinner for all		All

Wednesday 09 Nov	**Water quality monitoring: producing information for management: UNEP GEMS Water**		**Facilitator**
09:00 – 09:30	The role of water quality monitoring in water pollution management		Deborah Chapman
09:30 – 10:00	Water pollution management manual overview		Callist Tindimugaya, Gareth James Lloyd
10:00 – 10:15	Break		
10:15 – 10:45	Group discussions		Groups
10:45 – 11:00	Feedback plenary and discussions		All
11:00 – 11:45	The importance of monitoring network and programme design to generating information for management		Stuart Warner
11:45 – 12.15	The role of quality assurance in water quality assessment		Deborah Chapman
12.15-13.00	Water quality data - providing information for management		Philipp Saile
13:00 – 14:00	Lunch		
14:00 – 15:00	Sustainable Development Goal for Water: indicators SDG 6.3.2 and 6.6.1		Stuart Warner and Joakim Harlin/Lis Bernhardt
15:00 – 15:30	Group discussion: The role of the SDGs in national water quality and ecosystem management		Deborah Chapman /Stuart Warner and Joakim Harlin/Lis Bernhardt
15:30 – 16:00	Break		
16:00 – 17:30	Group discussion A: Ecosystems monitoring	Group discussion B: Challenges to monitoring ambient water quality for indicator 6.3.2 in Africa	A: Joakim Harlin/ Lis Bernhardt B: Deborah Chapman/ Stuart Warner/ Philipp Saile
17:30 – 18:00	Feedback plenary for Groups A and B		All

Thursday 10 Nov	**Water Quality Monitoring capacity development needs consultation: UNEP GEMS/Water**	**Facilitator**
09:00 – 09:30	Capacity development for water quality monitoring: options and approaches – demonstration of on-line material	Stuart Warner
09:30 – 10:00	Test session for on-line training course	Deborah Chapman/ Stuart Warner
10:00 – 11:30	Focus group session on capacity development needs (inc. Coffee break)	Deborah Chapman/ Stuart Warner/ Philipp Saile

11:30 – 12:00	Feedback and conclusions	All
12:00 – 18.00	Optional tour	
14.00 -16.00	Opportunity for individual meetings/discussions with GEMS/Water team	Deborah Chapman/ Stuart Warner/Philipp Saile/Hartwig Kremer/Kilian Christ

Annex 4 - Questionnaire circulated to participants prior to workshop

1. Who is responsible for monitoring ambient water quality in your country/region?
   - Government Ministry (please give name of organisation)
   - National Water Agency (please give name of organisation)
   - National Environment Agency (please give name of organisation)
   - Water Company (please give name of organisation)
   - Other
2. From which water bodies are ambient water quality samples currently taken?
   - Rivers
   - Lakes
   - Groundwater
3. Ambient water quality is measured in what proportion (percentage) of your water bodies?
   - Rivers (Percentage of rivers monitored)
   - Lakes (Percentage of lakes monitored)
   - Groundwater (Coverage of monitoring wells)
4. How frequently are ambient water quality samples collected from rivers?
   - Less than once per year
   - Once per year
   - 2 – 4 times per year
   - 12 times or more per year
5. How frequently are ambient water quality samples collected from lakes?
   - Less than once per year
   - Once per year
   - 2 – 4 times per year
   - 12 times or more per year
6. How frequently are ambient water quality samples collected from groundwater monitoring wells?
   - Less than once per year
   - Once per year
   - 2 – 4 times per year
   - 12 times or more per year
7. What parameter groups are currently used to monitor ambient water quality in your country/region?
   - Physical
   - Chemical
   - Microbiological
   - Biological (e.g. invertebrates, fish)
8. Which of the following water quality parameters are currently monitored in rivers, lakes and groundwater in your country/region?
   - Electrical conductivity/total dissolved solids
   - Dissolved oxygen
   - Faecal coliform bacteria
   - E-coli
   - Dissolved inorganic nitrogen and/or total nitrogen
   - Dissolved inorganic phosphorus and/or total phosphorus
   - None of the above
   - Other
9. Is the same organisation/authority responsible for the collection and the laboratory analysis of the ambient water quality samples?
   - Yes
   - No

10. Are all ambient water quality samples processed in a centralised laboratory or are regional laboratories used?
    - One centralised lab
    - Regional laboratories
11. If regional laboratories are used, how do staff ensure comparability between results from each laboratory?

12. How many water samples does the main water quality laboratory process each year?
13. How many of these samples are ambient water quality samples?
14. In your country/region, is there annual reporting of ambient water quality of water bodies?
    - Yes
    - No
15. Is the same organisation responsible for the monitoring and reporting of ambient water quality in your country?
    - Yes
    - No
16. What format does National/Regional water quality reporting take?
    - Laboratory facilities
    - Laboratory equipment
    - Technical expertise
    - Data storage and handling software/facilities
    - Data analysis and interpretation expertise
    - Financial
    - Policy/legislation framework
    - Other:
17. In which monitoring area is capacity (e.g. technical resources, trained personnel etc.) most lacking?
    - River monitoring
    - Lake monitoring
    - Groundwater monitoring
18. What aspect of water quality monitoring training would benefit your country/region?
    - Network and programme design
    - Sampling and analysis
    - Quality assurance
    - Data analysis
    - Data reporting
    - Biological monitoring
    - Other
19. At what level is training most urgently required?
    - Technical level (field sampling/laboratory analysis)
    - Laboratory management level (quality assurance and performance evaluation studies)
    - Programme planning and management level
    - National reporting level