UN Environment GEMS/Water Capacity Development Centre

Workshop Report

Ambient water quality monitoring: current status and opportunities for global engagement and SDG 6.3.2 reporting

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1 INTRODUCTION

The UN Environment GEMS/Water Capacity Development Centre (CDC) is a component of the UN Environment GEMS/Water programme[1]. It is based in the Environmental Research Institute, University College Cork and was founded in September 2015 to provide global capacity development in freshwater quality monitoring and assessment. GEMS/Water is also the support programme for data collection for Sustainable Development Goal (SDG) indicator 6.3.2 of UN Water's Integrated Monitoring Initiative. The CDC therefore currently has two main roles: (i) providing training and advice that encourages and supports water quality monitoring and the sharing of monitoring data with the global water quality database, GEMStat, and (ii) providing information, advice and capacity development for the SDG indicator for ambient water quality.

The CDC hosted a workshop in Cork, Ireland in March 2019. This workshop was part of a series designed to build a global picture of freshwater quality monitoring activities, and to identify strengths and capacity gaps that could be addressed by the work of the CDC. This event, which focused on countries from the Eastern Europe and Central Asia regions shown in Figure 1, added to the list of successful workshops held in the Africa region, in the Latin America and Caribbean region, and in the Asia Pacific region. The objectives of this workshop were to:

- introduce the revised and restructured GEMS/Water programme;
- introduce the fundamental principles of ambient water quality monitoring and the monitoring approaches that can be used;
- identify monitoring needs in rivers, lakes and reservoirs that will provide appropriate information for management purposes at national, regional and global levels;
- introduce indicator SDG 6.3.2 for ambient water quality and explore the barriers to reporting at national level; and
- identify capacity development needs relating to water quality monitoring and assessment in the region and explore mechanisms for increasing capacity.

Engagement between GEMS/Water and countries in the Eastern Europe and Central Asia regions had been limited prior to the workshop. As demonstrated during the successful implementation of similar events, this workshop served as a catalyst and helped to establish the foundation for engagement between countries and GEMS/Water. The outcomes of the workshop include:

- creation of a regional network of GEMS/Water partner countries with new national focal points established in each country;
- information was gathered about current ambient water quality monitoring and assessment activities and capacities;
- information and national views on the role of water quality monitoring in providing information for water resources policy and management were collated;
- data exchange links and co-operation between the region and UN Environment and the GEMS/Water Centres were established;
- capacity development needs and the modes of the delivery for future GEMS/Water training courses in the region were discussed; and
- SDG indicator 6.3.2 for ambient water quality was presented and feedback was gathered on engagement with the Indicator in the region.

[1] https://www.unenvironment.org/explore-topics/water/what-we-do/monitoring-water-quality

2 WORKSHOP DAY 1

The workshop opened with an official welcome and opening remarks from the Director of the CDC, Dr Deborah Chapman. Warm regards and comments were also provided by Hartwig Kremer, the head of GEMS/Water via a video link from Nairobi. This was followed by a round the table session that gave each participant the opportunity to introduce themselves and their institution.

Introductory presentations were delivered outlining the workshop objectives, the GEMS/Water programme, the GEMStat database and the future plans of the programme. The remainder of the day was given to the country representatives to describe and discuss their freshwater quality monitoring and assessment activities. Each participant worked to a presentation template that had been provided prior to the workshop. This ensured that the information presented was standardised and comparable. A summary of each country presentation is given below, followed by a section listing key points identifying similarities and differences, as well as strengths and weaknesses between countries.

Figure 1: Countries represented by the workshop participants

2.1 ALBANIA

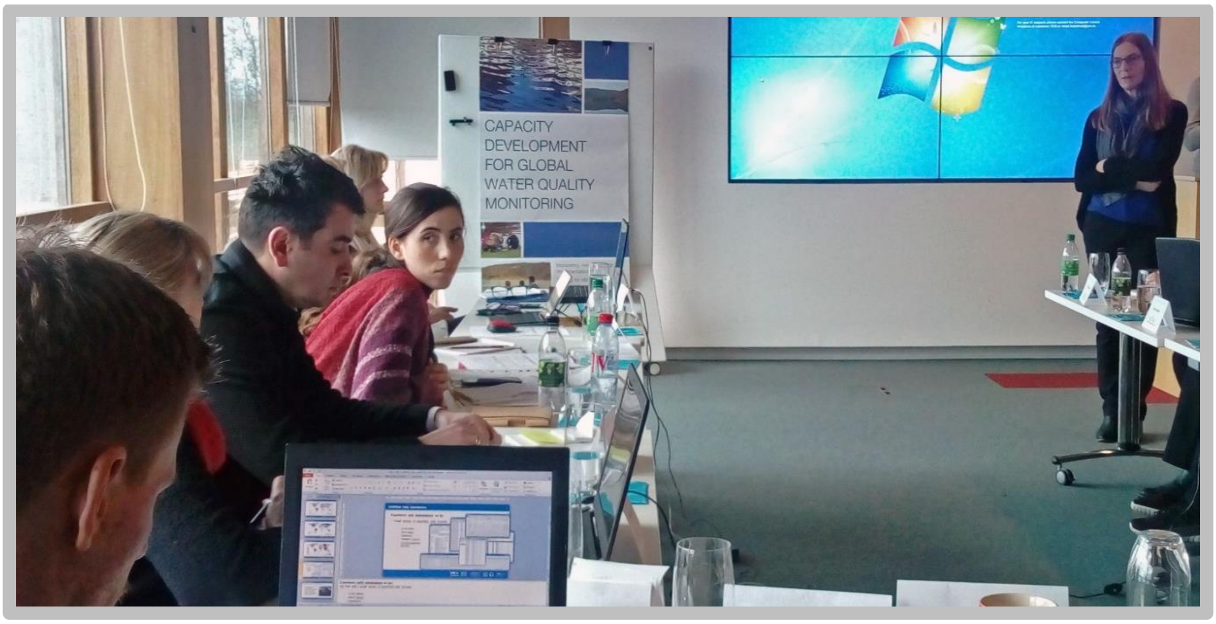
In Albania the responsibility of water resource management is divided between several organisations. Up until 2018 it was divided between Ministry of Agriculture, Food and Rural Development, the Ministry of Tourism and Environment and National Environment Agency and Technical Secretariat of National Water Council at the Prime Ministers' office. Then in 2018 the National Agency of Water Resources (NAWR) was established. This organisation includes the directorate of Water Policies of the Ministry of Agriculture, and the Technical Secretariat of the Water Council. Water quality monitoring is coordinated by the National Environment Agency

(NEA). The NEA undertakes monitoring programmes that are approved by the Minister of Environment.

Water quality sample collection and analysis is subcontracted to specialised institutions such as the Institute of Public Health that analyse bathing waters quality for beaches. The data are gathered and analysed by NEA and published in the annual State of Environment Report.

In preparation for membership of the European Union (EU) Albania is working towards compliance with requirements of the Water Framework Directive (WFD). This falls under the jurisdiction of NAWR and includes the drafting and approval of six river basin management plans, based on a water strategy document compiled with the assistance of a consultancy in 2017.

AquaNEX is an EU funded Interreg project aimed at improving sustainable water resources management in the region and enhancing its efficiency with the WFD application. This project is using the Vjosa river basin as a pilot study, and aims to identify new indicators for monitoring under the guidance of Aristoteles University of Thessaloniki.



2.2 AZERBAIJAN

Monitoring of surface freshwaters is under the remit of the National Monitoring Department of the Ministry of Ecology and Natural Resources. Azerbaijan is divided into 44 river basins, with seven major lakes. Groundwater bodies have been delineated for the north west of the country and are monitored by the National Geological Intelligence Service.

Rivers are monitored at either monthly or quarterly frequencies. Some surface waters are monitored for water quality in conjunction with hydrological monitoring, but there is limited overlap between these monitoring locations and those used exclusively for water quality monitoring.

Water quality sample analysis is managed by the central laboratory based in Baku with support from two smaller regional laboratories in Gazakh and Beilagan. The three laboratories together analyse 1086 samples per year, with approximately 80 per cent being analysed by the central laboratory. Biological monitoring is undertaken at 21 river monitoring locations, and for three suburban lakes of Baku City.

Water quality data are stored within each laboratory and are forwarded to the State Statistical Committee who have the responsibility to submit relevant data to the Food and Agriculture Organization (FAO) for inclusion in their Aquastat database, although this database does not explicitly include information on ambient water quality. Data have been available in electronic format since 1994. Water quality and hydrological data are freely available.

The central water quality laboratory is switching from operating under GOST standards to the ISO 17025 standard by the end of 2019. The GOST standards were developed during the Soviet Union era and are maintained under Euro-Asian Council for Standardization, Metrology and Certification (EASC). All laboratories employ a quality assurance plan and participate in international intercalibration exercises such as one in conjunction with the Environment Agency Austria in 2018.

The National Monitoring Department publishes a monthly water quality bulletin which is forwarded to the Ministry of Ecology and Natural Resources. Additionally, collated information is forwarded to the Environmental Policy Department of the Ministry to help inform policy.

2.3 BOSNIA AND HERZEGOVINA

Responsibility for monitoring water quality is divided between three institutions: the Agency for the Watershed of Sava River (AWSR); the Agency for Watershed of the Adriatic Sea (AWAS); and the public institution “Vode Srpske” (PIVS).

Bosnia and Herzegovina is divided into the Sava and the Adriatic river basins. There is one large and several smaller lakes. Groundwaters have been divided into 108 distinct groundwater bodies. There are approximately 500 monitoring stations defined to monitor surface waters and 25 monitoring wells for groundwaters. Of the defined water bodies, approximately 30 per cent of surface water bodies and 23 per cent of ground water bodies have a monitoring station. The frequency of sample collection ranges between monthly to quarterly for rivers, quarterly for lakes and biannually for groundwaters. There are 135 hydrological monitoring stations across the country. Around ten per cent of water bodies are assessed for both quality and quantity.

Physico-chemical parameters are routinely monitored including heavy metals and EU priority list substances. Biological and microbiological approaches to monitoring are also used - these include phytoplankton, phytobenthos and macroinvertebrates. There are also limited fish and macrophyte monitoring programmes. Between the three institutions responsible for monitoring, there are approximately 1900 samples analysed, with the majority being analysed by the AWRS laboratory.

Each institution maintains their own separate database. Some of the AWAS data are made available online, with additional data are available upon request. Data are shared with the International Commission for the Protection of the Danube River (ICPDR), and the Trans National Monitoring Network (TNMN).

All laboratories that perform water quality analyses are accredited according to ISO 17025. There is no national accreditation system, but two Ministries give authorisation for laboratories that conduct analysis of water (waste and ambient). In total there are 20 laboratories that are authorised. There is currently no national inter-laboratory calibration initiative, but laboratories participate in several international schemes that operate in the region.

AWAS publishes water quality data on-line annually for surface and groundwaters. To date, there has only been a single State of the Environment report which was published in 2012. Water quality data were used in this report.

Water quality data are used for developing strategies in water management for two entities: Integrated Water Management Strategy of Federation of Bosnia and Herzegovina; and the Integrated Water Management Strategy of the Republic of Srpska. In addition, water quality data are used for river basin management plans prepared in line with WFD.

2.4 CROATIA

Monitoring of water resource quality is the responsibility of Croatian Waters which is under the Ministry of Environment and Energy. Croatia is divided primarily into the Danube and Adriatic river basins with seven natural lakes and 39 artificial reservoirs as well as karstic and alluvial aquifers.

As a member of the EU, Croatia reports to the European Commission under the WFD. Croatia has set targets to achieve full compliance with reporting requirements, and currently uses an extensive monitoring network that includes over 700 monitoring locations for surface waters, and over 450 groundwater locations that are used to fulfill objectives of surveillance, operational and investigative monitoring programmes. Rivers and lakes and karstic aquifers are sampled on a monthly basis, whereas alluvial aquifers are sampled quarterly. In addition, there is an extensive hydrological monitoring network.

Monitoring programmes include physico-chemical, priority substances as described in the WFD, biological and microbiological parameters. In addition, macrolide and sulphonamide antibiotics are also monitored.

The majority of analyses are completed by the Central Water Management Laboratory of Croatian Waters. The laboratory is supported by universities, research institutes, public health institutes and private laboratories, which help with analyses that require specialised techniques.

Water quality data are stored centrally and are made freely available via requests for information. Online summary reports will be made available in the near future. A requirement of the WFD is that countries submit data to the Water Information System for Europe (WISE).

Data are also shared with the International Commission for the Protection of the Danube River (ICPDR) and the International Sava River Basin Commission (ISRBC).

Any laboratory that analyses water quality on behalf of Croatian Waters must be authorised by the Ministry, and therefore requires accreditation issued by the Croatian Accreditation Agency in accordance with ISO 17025.

Water quality data are not currently published but national water quality reports are produced every year for rivers, lakes and groundwaters. Water quality data are used for river basin management plans for the assessment of water body status and water quality data are also used in the annual State of the Environment Report. This report supplies information that assists in developing water policy and national strategies.

2.5 GEORGIA

The National Environmental Agency of the Ministry of Environment Protection and Agriculture is the organisation responsible for monitoring water quality in Georgia. Routine monitoring began in the 1960s, activity reached a peak during the 1980s but then declined during the 1990s until 2004. With the assistance of foreign assistance programmes, monitoring activities were reinvigorated around 2004 with upgrades to the monitoring infrastructure. Georgia signed an Association Agreement with the EU in 2014. As part of this agreement, River Basin Management Plans are to be prepared, water quality monitoring programmes established, and polluted waters identified.

Surface waters drain either west to the Black Sea or east towards the Caspian Sea. At present, the water quality monitoring network covers only a small portion of water bodies. In total 1,000 water samples were analysed in 2017. From the Black Sea catchment 408 samples were taken from 44 rivers at 70 monitoring locations. From the Caspian Sea catchment 560 samples were taken from 35 rivers at 62 monitoring locations. In addition, 15 lakes and 2 reservoirs were sampled, and during the bathing season 17 samples were taken at three locations of Tbilisi Sea, Lisi Lake and Turtle Lake. Lastly, studies have been conducted on 41 groundwater monitoring locations. Depending on the significance of the monitoring location, samples were either collected monthly or quarterly for surface waters, and two times per year for ground waters. There is an upward trend in the number of monitoring stations and analyses year on year.

Analyses are undertaken by three laboratories under the Agency: Batumi, Kutaisi and Tbilisi laboratories. The parameters measured include physico-chemical, biological and microbiological. In addition, specific compounds including heavy metals and organics, such as polycyclic aromatic hydrocarbons (PAHs) and similar compounds, are measured.

Data are stored in each of the three laboratories, but are also stored centrally in the main Tbilisi laboratory. Since records began, the data have been available upon request and, more recently, monthly and annual summaries are published online. Data are not currently shared with international databases such as GEMStat.

Georgia does not currently have a reference laboratory, but almost all laboratories that analyse ambient water quality samples are accredited by the national accreditation body and have quality assurance plans in place, and partake in both national and international inter-laboratory calibration exercises.

In addition to the monthly and annual reports, data generated are used to inform the State of Environment Report and to develop water policy and national strategy.

2.6 KAZAKHSTAN

The organisation responsible for monitoring ambient water quality in Kazakhstan is Kazhydromet based in the Ministry of Energy. The agency was established in 1922 and currently employs approximately 3500 staff in 15 branches across the country.

Kazakhstan is divided into eight river basins and has numerous large lakes and reservoirs. There is an extensive hydrological monitoring network with 307 surface water monitoring locations. These stations are also used to collect water quality samples. Including the hydrological stations, there are a total of 404 sites on 133 water bodies that are used to collect water quality data.

There are approximately 60 water quality parameters measured as part of the monitoring programme. These include commonly measured physico-chemical parameters as well as specific pollutants such as petroleum products, phenols, heavy metals and pesticides. For water bodies identified as fisheries, maximum allowable concentrations have been defined for certain pollutants such as metals. For assessment purposes a water quality index called the Comprehensive Index of Impurity of Water is used. This process categorises water bodies into groups such as *normative clean*, through to *extremely high level of contamination.*

Water bulletins include information on water quality, and are available through the Kazhydromet website. These reports are available at monthly, quarterly, biannual and annual frequencies. Reporting on the quantity and quality of water is especially relevant in Kazakhstan for transboundary waters. There are shared water bodies with the Russian Federation, Kyrgyz Republic and Republic of Uzbekistan comprising 31 transboundary rivers.

The Water Resources Committee of the Ministry of Agriculture is involved in developing State policy on use and protection of water supply and wastewater management. The committee develops plans for integrated use and protection of water resources of the main rivers and other water bodies in the Republic.

2.7 MONTENEGRO

The Department for Water Management based in the Ministry of Agriculture and Rural Development is responsible for proposing, and the implementation of, policies in the water sector and for adoption of planning documents.

Montenegro is divided into two main river basins: the Adriatic and the Danube. There are 36 natural lakes and the geology is divided 60 to 40 per cent into karstic, non-karstic respectively.

Legislation around water quality in the country focusses on drinking water supply and effluent discharges, but classification of ambient water quality is embedded in the Water Law that stipulates routine monitoring. This is undertaken by the Institute for Hidrometeorology and Seizmology (IHMS). The monitoring network specifies 36 stations on rivers, 36 on lakes and six monitoring wells for groundwaters. There is an established hydrological monitoring network.

Many common physico-chemical parameters and microbiological parameters are monitored routinely. These analyses are performed by the accredited central Laboratory for Water Quality Testing. The EU priority monitoring list and biological analyses will be added to the list of parameters monitored, and these will be done by support laboratories until the necessary capacity can be developed in the central laboratory. Other accredited laboratories in the country include the Centre for Ecotoxicological Testing of Montenegro, the Institute for Public Health of Montenegro and the Institute of Marine Biology.

Data management uses an Excel-based system that is stored centrally, but The Water Administration plans to develop a Water Information System in the future. The central laboratory was first accredited in 2010, and currently has valid accreditation until 2022. In accordance with the requirements of MEST EN ISO/IEC 17025, a quality assurance plan is in place. The laboratory also participates in a performance evaluation scheme organised by Sigma-Aldrich.

Water quality data are used in an annual Water Quality Report that is available online, and findings of this report are used in the Environmental Report of Montenegro. Under the conditions of an EU accession country, Montenegro also submits data to the European Network for Observation and Information (EIONET).

2.8 RUSSIAN FEDERATION

Roshydromet is the department responsible for services in the field of hydrometeorology, environmental monitoring and pollution. This organisation has several divisions such as seven territorial Departments, 24 regional Administrations of Hydrometeorology and Environmental Monitoring with 62 local Centres, 17 Research Institutions and other subordinate organisations.

There are several legal standards for ambient water quality established for the maximum permissible concentrations for chemicals in the water used for drinking and domestic use, and for harmful substances in water bodies of fisheries significance.

Hydrological monitoring is undertaken by the State Hydrological Institute. There is an extensive monitoring network and 56 per cent of stations are used for both hydrological and water quality monitoring.

The Hydrochemical Institute is responsible for water quality monitoring. In excess of 1100 water bodies have been defined and are included in the monitoring network. Approximately 90 per cent of these waterbodies are routinely monitored using over 1600 monitoring stations. The frequency of sampling depends on the station category and ranges from four to 365 times per year.

The water quality parameters monitored include common physico-chemical parameters (temperature, colour, turbidity, odour, pH, ORP, EC) and chemical parameters (suspended solids, dissolved gases, major ions, nutrients, BOD5, COD, oil products, phenols, surfactants, metals, pesticides, PAH and some specific substances). Biological analyses include structural and functional characteristics of ecosystems using zooplankton, phytoplankton, zoobenthos, periphyton and macrophyte characteristics. Optional measures of water quality include substances attached to particulate matter such as pesticides, PAHs, oil products and heavy metals.

The laboratories of the Local Centres organise sampling, depending on the programme objectives, season and hydrological state of the water bodies. Analyses are either performed *in situ*, using mobile laboratories or transported to one of 100 local laboratories. In 2017 there were 27,498 water samples and 236 sediment samples analysed. This produced 697,874 results for more than 100 parameters.

Data are stored centrally in the Hydrochemical Institute. Since 1991, data from 27 water observation stations for 22 parameters have been shared with GEMStat annually. Analytical results are collated into the "Surface Water Quality of the Russian Federation" report annually.

Most water quality laboratories are accredited to ISO 17025 by the Federal Service for Accreditation. All laboratories participate in national intercalibration exercises provided by the Hydrochemical Institute annually.

2.9 SERBIA

Water resources in the Republic of Serbia are monitored by two agencies: water quantity is measured by the Hydrometeorological Institute for Water Quantity; and water quality by the Serbian Environmental Protection Agency (SEPA) of the Ministry of Environmental Protection.

The vast majority of Serbia drains to the Danube River, although a small section in the south of the country drains to the Adriatic Sea. In preparation for EU membership, Serbia has defined 498 surface water bodies. These have been classified into rivers, heavily modified water bodies, artificial water bodies and lakes. The surface water monitoring network includes 50 monitoring locations for surveillance monitoring. For groundwaters, 153 water bodies have been defined.

The legal basis for the management of freshwaters is supported by adoption of the Water Law in 2010. Bylaws have been passed that ensure adequate conditions for harmonization of monitoring of surface water status with the requirements of the WFD. These include bylaws such as the "R*egulation on emission limit values of priority and priority hazardous substances which pollute surface waters and deadlines for their achievement".*

Monitoring of freshwaters includes physico-chemical, biological and EU priority list parameters, as well as non-priority list substances as described by the WFD. Biological monitoring includes methods that use macro invertebrates, phytobenthos, phytoplankton (within SEPA), macrophytes and fish. A mobile laboratory is available for investigating lakes and incidents.

The frequency of sample collection is based on the parameter and classification of the water body. For example, physico-chemical samples from rivers are collected and analysed on a monthly basis, whereas macroinvertebrates are analysed biannually.

Data are stored centrally by SEPA, and there is a plan to introduce a Water Information System in the near future. There are historical water quality data from the 1950s. Data are not directly available, but there are summary reports published annually. Data are shared internationally with the ICPDR and the EEA.

SEPA laboratories have been accredited since 2006 and are currently undergoing preparation for the next review. Participation in performance evaluation studies is part of the quality assurance procedures, and the laboratory participates annually.

Efforts to expand the monitoring network are ongoing, and a project to complete a river typology study to allow water quality of unmonitored water bodies to be inferred from monitored water bodies is planned. A key priority is to build the capacity of SEPA staff to enable compliance with WFD reporting. There is currently a staff shortage but regional monitoring centres are required to ensure the timely analysis of samples.

2.10 SUMMARY OF COUNTRY PRESENTATIONS

The country presentations and follow up question and answer sessions highlighted many interesting similarities and differences between the countries. As a general observation, the monitoring activities and capacity of countries to monitor and assess their freshwaters was much greater than for other world regions where GEMS/Water have undertaken similar exercises. Also, the data management and reporting structures were more advanced and nearly all countries mentioned that they published annual reports that included a water quality aspect. Also, the value of quality assurance was recognised universally and all countries applied ISO standards and used at least one accredited laboratory. Where all laboratories were not accredited, efforts were being made to seek accreditation for all laboratories.

The influence of the WFD was noted in the different country presentations. The EU member country (Croatia), EU candidate or potential EU candidate countries (Albania, Bosnia and Herzegovina, Montenegro and Serbia) emphasised the importance of developing biological methods if they were not already in place. This was to help meet the reporting requirements of the WFD which places a high priority on biological methods to monitor freshwater ecosystem health. The importance of biological methods was not limited to the EU-related countries because most countries commented on biological methods. The Russian Federation described an extensive use of biological methods using multiple taxa, and also Georgia which signed an

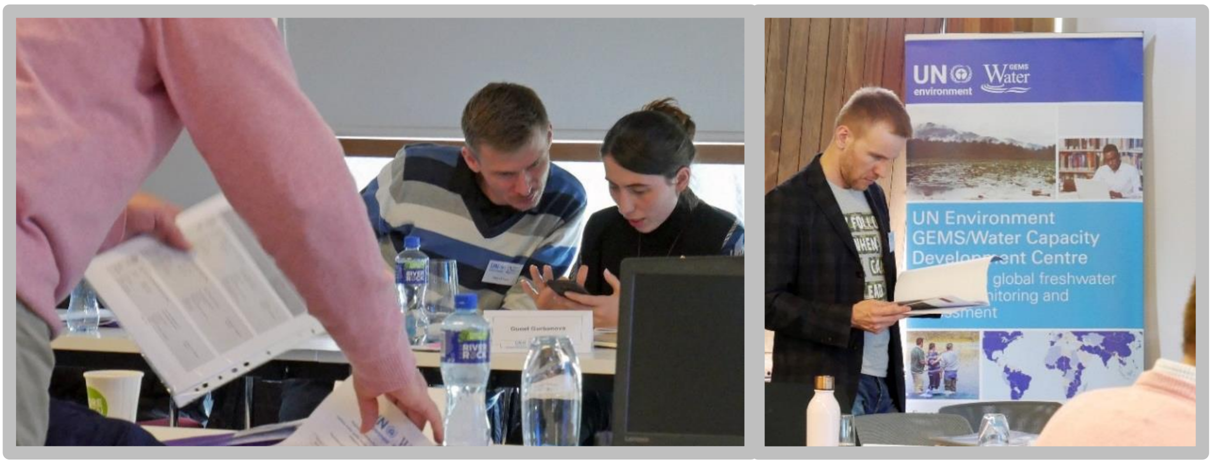
Association Agreement with the EU in 2014 are planning to fully harmonise with EU WFD baseline legislation in the near future.

As noted in other world regions, the financial resources necessary to monitor and assess freshwaters fully were insufficient in certain cases. This has led to monitoring programmes that may have been designed in full, but only implemented in part. Efforts to expand monitoring activities to cover all defined water bodies were highlighted by several participants.

Water quality data were universally available to the public, although in some cases these data were available upon request only. In most cases aggregated or summarised data were available as part of annual reports or bulletins.

It was made clear that the alignment between water quantity and water quality monitoring programmes was not fully harmonised. In many cases the defined monitoring stations had a degree of overlap, but it was not universal. Collecting water quality data at water quantity locations allows accurate flux estimates of compounds such as nutrients or suspended solids to be made. This is particularly important for transboundary monitoring stations. Similarly collecting accurate water quantity information at defined water quality sites is useful for interpreting water quality data which are often dependent on the changing flow conditions.

The host Ministries of the bodies responsible for monitoring ambient water quality differed considerably between countries. This was made clear by the difference of the primary mandate of the Ministries which included agriculture, energy and environment. This pattern is recognised globally and develops as a consequence of the history of the organisation. The point was raised that this can lead to a conflict of interest if the agency responsible for monitoring ambient water quality falls under the Ministry that is responsible for agricultural output. It was raised that this agricultural output may be prioritised over freshwater ecosystem health. In most cases the host ministry had a specific remit of environmental protection and it was felt that this was the preferable situation.



3 WORKSHOP DAY 2

The format of the second day included presentations from GEMS/Water interspersed with discussion sessions on the topics raised. The presentations were framed in a way to stimulate discussion, and participants were encouraged to interact during the presentations. A summary of each presentation is provided below.

3.1 APPROACHES TO AMBIENT WATER QUALITY MONITORING

This session looked at various approaches to monitor ambient water quality. Water quality can be monitored in different ways using physical, chemical and biological approaches and the most suitable approach depends on what you need to know in order to manage water resources, and is also influenced by the human and financial resources available and the target audience of the data generated.

Water quality is defined by the characteristics or properties of the water and these characteristics govern its suitability for different uses such as drinking water, water for irrigation, assimilating wastewaters, fisheries and aquaculture, or to maintain healthy aquatic ecosystems. Water quality can be monitored using basic parameters that help to characterise the geological and climatological influences on the water body; ecosystem-related parameters that demonstrate potential human influence on the whole aquatic ecosystem; or contaminants that demonstrate specific waste emissions and the potential for ecosystem damage or potential risk for human uses.

There are alternative approaches to collecting water quality data that can be considered in addition to traditional physical and chemical monitoring. Some of the main advantages of these are that they may be less expensive or may provide a greater spatial or temporal coverage. This session looked at different approaches including: biological, continuous monitoring and sensors, remote sensing methods and also citizen and community monitoring approaches, and identified advantages and disadvantages that should be carefully considered. The reasons for considering alternative approaches were also reviewed, such as: financial constraints, restricted access to advanced instrumentation; the need for large spatial coverage and the need for high frequency of data collection.

3.2 PROGRAMME DESIGN AND NETWORK DEVELOPMENT

The steps of developing a monitoring and assessment programme were described in this session, including details of each step, and how these steps are organised into three phases: design; implementation; and assessment, reporting and management.

The essential role of the process in designing a sound and reliable monitoring programme was illustrated, with a focus on how each step relies on the previous ones. The iterative nature of the design process, and how essential it is to define the monitoring programme objectives clearly from the outset, and then to refer to them throughout the design process, was described. The steps are illustrated in Figure 2 below.

3.3 QUALITY ASSURANCE FOR WATER QUALITY MONITORING AND DATA GENERATION

Errors can be introduced at all stages of sampling and analysis, and data are not credible if their quality cannot be assured. This session covered the importance of quality assurance plans and the associated procedures, and how these can help to minimise errors. The importance of applying quality assurance to field, laboratory and data storage operations and how this should be considered at the monitoring programme design phase, was highlighted. An overview of internal and external quality control procedures in a laboratory and some practical measures for ensuring the quality of monitoring results in the field and in the laboratory were also considered. One of the key messages during the session was the need to assign adequate resources to implement a quality assurance plan - approximately 10 to 20 per cent of the total resources needed for a monitoring programme should be devoted to quality assurance, i.e. financial, technical and personnel.

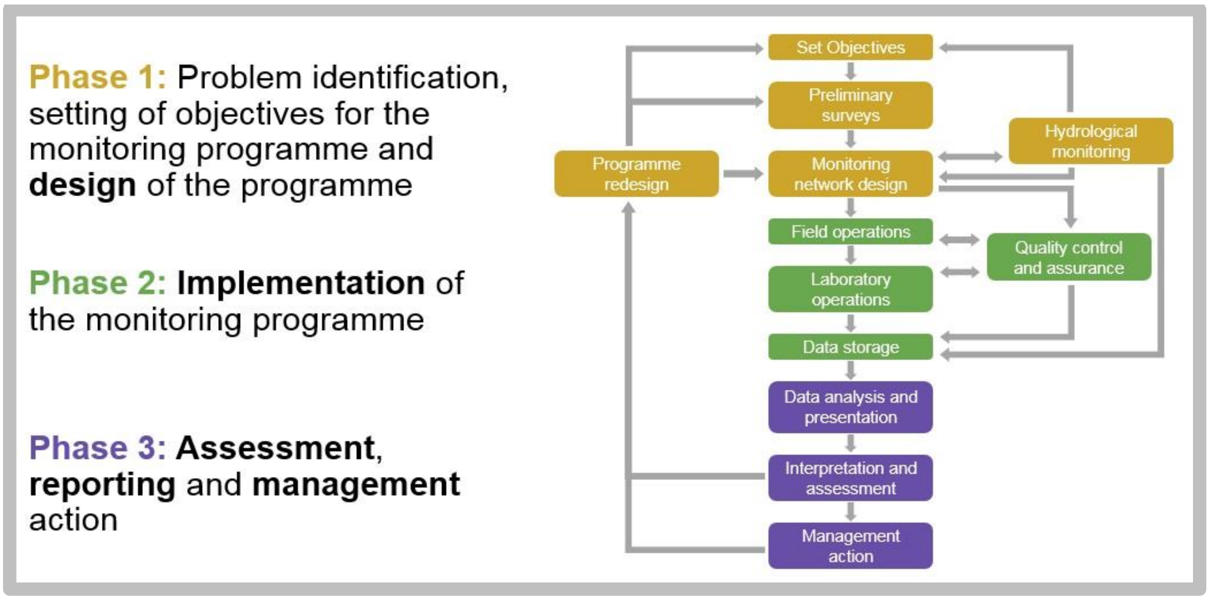


Figure 2: Monitoring and assessment process flowchart (adapted from (Chapman *et al*., 2005)[2]

3.4 STORAGE AND QUALITY CONTROL OF WATER QUALITY MONITORING DATA

Accurate and quality-assured water quality monitoring data are the prerequisite for subsequent data analysis, interpretation and sound management of water resources. This session looked at the data component of design and implementation of a monitoring and assessment programme and how effective data management helps to:

- meet the data quality objectives and information requirements;
- maximize the effective use and value of data and information products;
- ensure appropriate use of data and information;
- facilitate data sharing and re-use; and
- ensure sustainability and accessibility in the long term for re-use of data.

Well planned and managed data storage is essential to ensure data integrity, to maximize use of data and to meet information requirements of a monitoring programme. The need to plan and ensure quality control and assurance measures through the entire data life cycle was highlighted, and examples of good practice were provided.

This session also examined the importance of quality assurance processes for water quality data. It looked at the various steps of data collection, data entry and transcription and the potential for the introduction of errors. The four basic activities of data quality assurance were described, namely ensuring the quality of data before entry into the data storage; strategies for preventing errors from entering the data storage; monitoring and maintaining data quality during and after data entry; and documenting the credibility and quality of stored data. If these

[2] Chapman, D. V, Meybeck, M. & Peters, N.E., 2005. Water Quality Monitoring. In *Encyclopedia of Hydrological Sciences*. Chichester, UK: John Wiley & Sons, Ltd. Available at: http://doi.wiley.com/10.1002/0470848944.hsa094 [Accessed January 21, 2019].

steps are followed, it is then possible to detect and clean-up data errors that were introduced during the various steps of data transcription and to interpret anomalous values.

3.5 GEMSTAT DATA SUBMISSION AND SHARING OF DATA

GEMStat currently holds over four million data points from over three thousand monitoring stations. Based on the usage restrictions imposed by the data owners under the GEMStat data policy, selected data are available on request for research and assessment purposes. The procedures for submitting water quality data to GEMStat and a case demonstrating the benefits of doing so were presented during this session. The data submission procedures were described in detail, and these can be found at https://gemstat.org/data/data-submission/.

The benefits of sharing data include:

- reducing uncertainty over water quality-dependent investments, thereby leading to greater private sector investor confidence;
- increased international investments based on agencies recognising the need for country infrastructure loans, international aid and collaboration in technology in order to develop and expand data availability;
- a better overview of water resource quality by allowing researchers to analyse data leading to information on status, trends and hotspots in water quality issues and the connected drivers;
- improved bilateral cooperation where synergies aimed at tackling similar water quality challenges have been identified – especially relevant for transboundary waters;
- more support from United Nations programmes aimed at building or improving monitoring networks, measurement methodologies and technologies.

The new GEMStat data portal and its improved functionality that includes new maps, data visualisation and analysis tools was demonstrated. Figure 3 illustrates an example of one of the data products available. This shows the average (mean) annual phosphorus concentrations at the river basin and monitoring station levels for India.

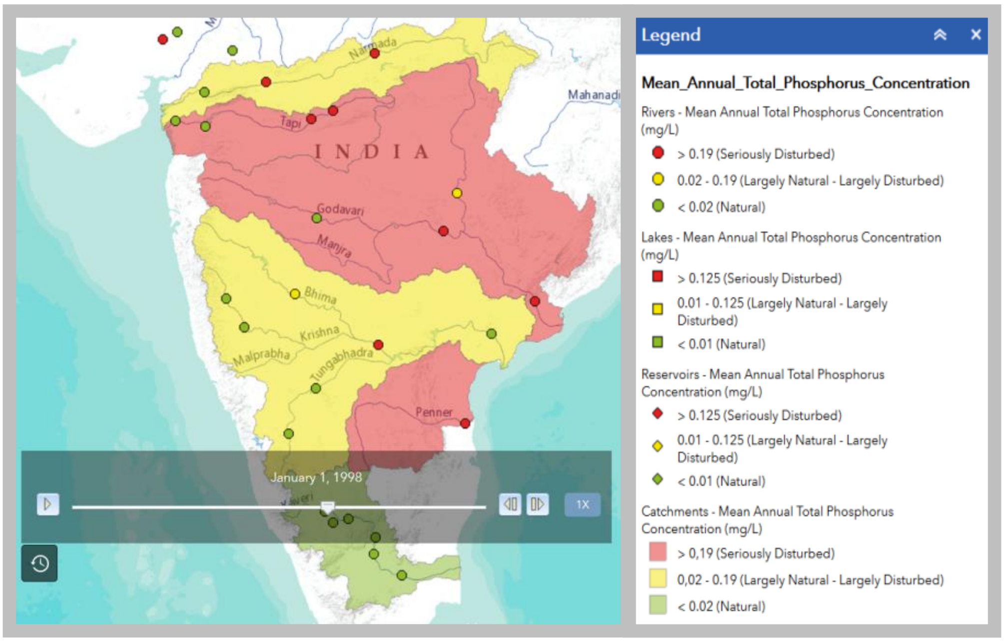


Figure 3: Data product example from GEMStat data portal showing the mean annual phosphorus concentration in India on basin and station level

3.6 DISCUSSION SESSION – CHALLENGES TO DATA MANAGEMENT AND SHARING OF DATA

There were noticeable differences in the approaches to data management applied by the countries. Some countries employed an Excel-based system in laboratories. The data were then migrated to a database platform for central storage. In some instances countries then export the data back into Excel for trend analysis because they felt the database platform was not user-friendly for these kind of analyses.

One of the key discussion points was the protocol for storage of data that are below the analytical limit of detection (LoD), or a limit of quantitation (LoQ) applied by a laboratory. This is particularly relevant when different laboratories in the same country are using different limit values. As a recommendation a practise applied in many laboratories is to record the value in question as half of the LoD (or LoQ), but the LoD itself is recorded along with the method details. This allows for any uncertainty to be accounted for in future trend analysis. This is especially relevant as analytical methods improve over time, and analytical LoDs improve.

A point regarding the protocol for managing historical data was raised. For some countries historical data can be searched and viewed but, as far as the participants were aware, they are not used for any particular assessment. The format in which historical data are stored can present a challenge. For example, some data may be stored on floppy disks or in database formats that are at risk of becoming obsolete – in these cases measures should be taken to "future proof" these data to ensure they are not lost. This can be achieved by archiving in a comma separated value format, or text format that can be read by any platform. An example was provided by Dmytro Lisniak of the GEMS/Water Data Centre who described the mammoth task that was undertaken to transcribe the historical GEMS/Water database to the modern GEMStat version – it took two years for this to be accomplished.

The importance of recording the correct analytical method used, together with the water quality data, was also raised. This is relevant to ensure that users of the data are comparing like with like over space or time. There is a risk that comparisons drawn without using this information could lead to incorrect conclusions. It was pointed out that the Chemical Abstract Number used by the EU system is cumbersome but powerful.

It was raised that efforts to share data with international organisations burdens the data owners. The data sharing process requires the data to be formatted according to the needs of the target database, and this is not always possible using current resources. An added issue for some countries is that the database platform and associated instructions are often in English alone.

4 WORKSHOP DAY 3

The third day followed a similar structure to day two, with active discussion sessions between presentations. A summary of each presentation and the interactive sessions is given below.

4.1 INTRODUCTION TO SUSTAINABLE DEVELOPMENT GOAL INDICATOR 6.3.2 AND THE INTEGRATED MONITORING INITITIVE FOR GOAL 6

This session described the background of Agenda 2030 and the Sustainable Development Goals, with a focus on indicator 6.3.2 on ambient water quality. The role of GEMS/Water to implement the indicator methodology was described. The value of the indicator in assessing the effectiveness of measures to reduce pollution of freshwaters was emphasised. The indicator as a measure of change over time in the quality of water in rivers, lakes and groundwaters was also explained. An overview of the methodology was given, and the results from the 2017 global data drive were summarised.   below shows the indicator scores reported (colour of circle); an estimation of the proportion of the country included in the calculation of the indicator (size of circle) and the monitoring effort in terms of the number of monitoring stations and measurements taken (location of circle). Countries located at the upper right of the figure used considerably more data than those located at the bottom left.

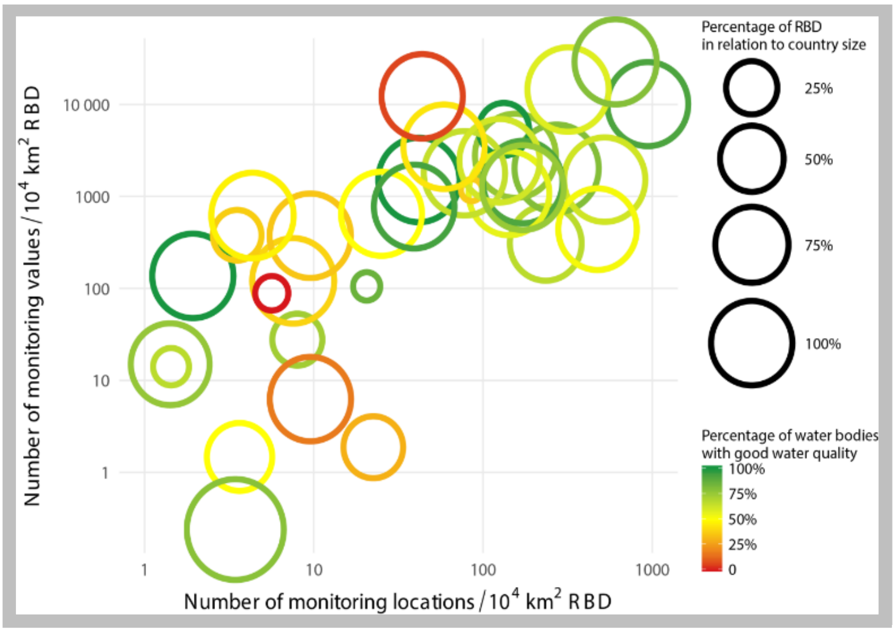


Figure 4: Summary of the 2017 indicator 6.3.2 results (UN Environment, 2018)[3]

4.2 SDG INDICATOR 6.3.2 METHODOLOGY: DEVELOPMENT, IMPLEMENTATION AND REVISION

This session described the development of the SDG indicator 6.3.2 methodology together with, its implementation, and summarised the findings of the feedback process.

The methodology is derived from a water quality index developed in 2007 which was revised in 2015 specifically to meet the needs of SDG indicator 6.3.2. In 2016, the index was tested by five countries in a *Proof of Concept* phase to determine its suitability and ease-of use. In parallel to the *Proof of Concept* testing, feedback was obtained from experts and international organisations who reviewed the methodology. As a result of the diverse comments and the practical attempts to implement the methodology, the approach was simplified at the end of 2016 and a revised methodology was developed. This revised version was tested globally in 2017. Following the 2017 data drive, when 27 per cent of United Nations Member States submitted data, a review and feedback process was initiated with the goal of improving the methodology and increasing the level of engagement by Member States in readiness for the next data drive. The revision and feedback process led to clear suggestions such as improving the guidance and level of support provided to countries. For example, it was reported that there

[3] UN Environment (2018) *Progress on Ambient Water Quality, Piloting the monitoring methodology and initial findings for SDG indicator 6.3.2*. Available at: http://www.unwater.org/publications/progress-on-ambient-water-quality-632.

was a need for further explanation of reporting requirements. Also, during the next data drive a much greater level of interaction between GEMS/Water and countries will be required. This will help remove the reporting burden on countries and serve to smooth the reporting process.

4.3 SDG INDICATOR 6.3.2 DATA SUBMISSION AND FUTURE REPORTING

This session focused on the steps needed to complete the data submission template used in the 2017 data drive. Also, scope for improvement of the process in readiness for the next data drive was highlighted. The participants were led through the five main steps of data submission. Each step is listed below:

1. **Information on the submitter** – This is information about the individual submitting the data, such as name, contact details and their organisation.
2. **Reporting basin district (RBD) information** – this section lists the sub-national reporting units applied by the country. Information such as the name of the district, its size, and whether or not it is classed as transboundary are included here.
3. **Water quality** – this section is dedicated to summarise the water quality data. The actual water quality data are not included, but these data are aggregated prior to entry into the sheet both by RBD, and by water body type. A row is automatically generated based on the RBD entries, and columns are included for each water body type (river/open/groundwater).
4. **Water quality targets** – this allows the user to describe the values with which their measured values were compared.
5. **Indicator value** – At this stage the indicator score generated by the inputs of the user can be viewed. The score is the aggregated sum of all river basins, but the score disaggregated by water body type is visible in addition to the national score.

Feedback received since the 2017 data drive led to the following proposals to improve the data submission workflow.

- A unified dataset for identification of RBDs and water bodies is needed. This would be useful for comparability with other water-related indicators, and also remove some of the workload from countries.
- Some ambiguous descriptions in the submission template need further clarification.
- Many countries misunderstood how to complete the target value information. This needs a detailed explanation of the target value concept and clearer steps on how the information should be entered correctly.
- More robust and informative automated validation checks are required.
- More prominent guidelines on best practices for the minimum number of monitoring locations and monitoring values are needed.

SDG reporting continues until 2030. The objective of the indicator is not to measure just the current state of water quality worldwide, but also progress towards target 6.3 until 2030. There is scope to develop tools and products that allow a more meaningful analysis in conjunction with other indicators, for example with human health, sanitation or industry.

The possible integration of data that are already contained within the GEMStat database for automated indicator calculation is being investigated. This would significantly reduce the burden on countries to report, and could be done based on the data contained in GEMStat alone. This option would still rely on interaction with countries to set meaningful target values and to align reporting units and water bodies that may be applied in the country already.

4.4 DISCUSSION SESSION – CHALLENGES IN MONITORING AND REPORTING SDG INDICATOR 6.3.2 IN THE REGION

Those countries that report to the European Commission under the requirements of the WFD, or who are preparing to do so, raised questions surrounding the alignment between the WFD and SDG reporting frameworks. This issue was one of the key points highlighted during the feedback process of 2018, and steps needed to reduce this double reporting burden on countries are being investigated.

The challenges surrounding the setting of relevant target (threshold) values was raised by several countries. This is especially relevant for transboundary countries which may choose to apply target values that are either more lenient or stringent than their neighbours. This challenge has been raised previously. Establishing target values is the responsibility of countries and cooperation between neighbouring transboundary countries is encouraged to ensure that the same target values are used where applicable. From the 2017 data drive, it was found that existing transboundary organisations were the only examples where countries worked together.

4.5 PRESENTATION OF GEMS/WATER CAPACITY DEVELOPMENT OPTIONS

This session covered the capacity development activities and the engagement strategies employed by the CDC. These focus on bilateral country outreach and regional organisation engagement to identify specific capacity development needs. The methods used to meet these needs include online training courses, online academic courses, targeted training workshops, and customised training course in response to specific requests. Examples of the approaches used were demonstrated, along with the virtual learning environment adopted by UCC: Blackboard. Details of the online Postgraduate Diploma and Masters programmes were described, along with the short continuous professional development courses. The topics currently available for on-line and workshop-format training are:

- Monitoring programme design for freshwater bodies
- Quality assurance in freshwater quality monitoring programmes
- Data handling and presentation for freshwater quality monitoring programmes
- Monitoring and assessment of surface waters
- Monitoring and assessment of groundwaters
- Freshwater quality monitoring in the field
- Freshwater quality monitoring using biological and ecological methods
- Freshwater quality monitoring with particulate material

4.6 DISCUSSION SESSION – CAPACITY DEVELOPMENT NEEDS IN THE REGION

The interest of the participants in the capacity development activities of the Centre was encouraging. Many participants expressed interest and committed to forwarding details to colleagues within their organisations. One limitation that was raised was that the courses and material were available in English only. For them to be of more use to build the capacity in the Eastern Europe and Central Asia region there is a need for them to be translated into other languages. One suggestion was Russian, which would be useful for the former Soviet Union countries.

There was considerable interest in the new part-time, on-line, taught MSc programme. The final year of this programme comprises a research-based dissertation on a water quality-related topic that will require an academic supervisor in UCC and also oversight in the student's own country. It was pointed out that both the MSc and the Postgraduate Diploma use written assessments instead of formal examinations, but that the short on-line CPD courses are examined through electronic marking only.

A requirement for ISO 17025 accreditation is a certificate in sampling procedure and the potential for the MSc module on *Freshwater Quality Monitoring in the Field* to fulfil this requirement was discussed. Since some of the field staff are not graduates in Bosnia and Herzegovina, postgraduate courses may not be suitable and training courses would need to be tailored to meet this requirement. A question was raised whether GEMS/Water could work with countries to carry out training on a regional basis, or maybe to work towards initiating a regional laboratory performance evaluation study. This is the model followed in the Latin America and Caribbean Region (LAC) where the National Water Agency of Brazil (ANA), which was formerly the GEMS/Water Regional Hub, used this approach. Through the Sao Paulo State Environment Agency - Companhia Ambiental do Estado (CETESBE), ANA delivered training to several countries in the region.

5 WORKSHOP CONCLUSIONS

This workshop forged new relationships between GEMS/Water and countries from the Eastern Europe and Central Asia regions. In most cases the relationship was a new one created directly as result of the workshop. Bringing the countries together provided unique conditions for sharing and discussing information on the water quality monitoring activities and capacities of each country. This helped to promote data-exchanges between countries and GEMStat; to identify how the capacity development activities of GEMS/Water can be of use to address capacity deficits; and enabled countries to define their own networks and identify synergies and challenges that may be more regionally relevant.

During the 2017 data drive for SDG indicator 6.3.2, there was limited engagement with countries from these two regions: of the nine countries attending the workshop, only two submitted data for the indicator (Montenegro and Bosnia and Herzegovina). The in-depth engagement that this workshop provided was useful to enable connections to be made between GEMS/Water and the correct person in each country who will be involved in reporting the SDG indicator. It also provided a first-hand opportunity to demonstrate the detailed methodological steps and the reporting requirements that are necessary. It also was useful for participants to seek clarification and provide feedback on the methodology from their national perspective.

Group photo of workshop participants and the GEMS/Water team

6 ANNEXES

Annex 1a – Participant List

Country	Name	Institution/Organisation
Albania	Pëllumb Abeshi	Ministry of Tourism and Environment
Azerbaijan	Gunel Gurbanova	Ministry of Ecology and Natural Resources
Bosnia and Herzegovina	Ana Sudar	Adriatic Sea Watershed Agency
Croatia	Marija Pinter	Head of the Department of International Cooperation. Water Management Directorate
Croatia	Valerija Musić	Croatian Waters
Georgia	Elina Bakradze	Air, Water and Soil Analysis Laboratory at the National Environmental Agency
Georgia	Levan Papachashvili	Emergency Situations Management Crisis Management Center
Kazakhstan	Arman Sarsenov	Executive Board of the International Fund for Saving the Aral Sea in the Republic of Kazakhstan
Montenegro	Zorica Duranovic	Department of Water Management at the Ministry of Agriculture and Rural Development
Russian Federation	Yury Andreev	Head of the Laboratory of Water Analysis Methods and Equipment at the Hidrochemical Institute in Rostov-on-Don
Serbia	Zoran Stojanović	Head of the National Laboratory for Environment at the Serbian Environmental Protection Agency (SEPA)

Annex 1b - GEMS/Water Staff

Name	GEMS/Water
Deborah Chapman	GEMS/Water Capacity Development Centre
Katelyn Grant	GEMS/Water Capacity Development Centre
Dmytro Lisniak	GEMS/Water Data Centre
Stuart Warner	GEMS/Water Capacity Development Centre
Peter Webster	Formerly of the Environmental Protection Agency of Ireland

Annex 2 – Workshop Programme

Regional Workshop for Eastern Europe and Central Asia
Ambient water quality monitoring: current status and opportunities for global engagement and SDG indicator 6.3.2 reporting
5 – 7 March 2019
Environmental Research Institute, University College Cork, Cork, Ireland

Tuesday 5 March	**Registration, welcome, objectives of workshop and introduction to GEMS/Water and national activities**	
09.00-09.30	Registration	
09.30-10.00	Opening of the Workshop and welcome remarks	Deborah Chapman
10.00-10.15	Introduction of participants around the table	Participants
10.15-10.30	Objectives of the workshop and expected outcomes	Deborah Chapman
10.30-11.00	Coffee and tea break	
11.00-12.00	Overview of the GEMS/Water Programme, GEMStat and future plans	Deborah Chapman and Dmytro Lisniak
12.00-12.30	Discussion	All participants
12.30-14.00	Lunch	
14.00-15.30	Presentations by National Focal Points (NFPs), country and regional representatives (max 10 min each)	Participants
15.30-16.00	Coffee and tea break	
16.00-17.00	Continuation of presentations by National Focal Points (NFPs), country and regional representatives (max 10 min each)	Participants
17.00-17.30	Group discussion and summary	All participants
19.00	Group dinner in the Market Lane restaurant, Cork	All participants
Wednesday 6 March	**Technical aspects of water quality monitoring for management**	
09.00-10.00	Approaches to ambient water quality monitoring	Deborah Chapman
10.00-11.00	Programme design and network development	Stuart Warner
11.00-11.30	Coffee and tea break	
11.30-12.15	Quality assurance for water quality monitoring and data generation	Katelyn Grant
12.15-13.00	Discussion: Challenges to national water quality monitoring in the region	All participants
13.00-14.00	Lunch	
14.00-15.00	Storage and quality control of water quality monitoring data	Dmytro Lisniak
15.00-15.15	Discussion	
15.15-15.45	Coffee and tea break	
15.45-16.45	GEMStat data submission and sharing of data	Dymtro Lisniak
16.45-17.30	Discussion: Challenges to data management and sharing of data	All participants
19.00	Group dinner in the Cornstore restaurant, Cork	All participants

Thursday 7 March	**Sustainable Development Goal 6 and the indicator for water quality, SDG 6.3.2**	
09.00-09.30	Introduction to SDG 6 and GEMI	Stuart Warner
9.30-10.30	SDG Indicator 6.3.2 Methodology: development, implementation and revision	Stuart Warner
10.30-11.00	Coffee and tea break	
11.00-11.30	SDG Indicator 6.3.2 Data submission and future reporting	Dmytro Lisniak
11.30-12.30	Discussion: Challenges in monitoring and reporting SDG 6.3.2 in the European region	All participants
12.30-13.30	Lunch	
	Capacity development needs for water quality monitoring in the Eastern Europe and Central Asian region	
13.30-14.00	Presentation of GEMS/Water capacity development options	Katelyn Grant
14.00-14.30	Discussion of capacity development needs in the region	All participants
14.30-15.00	Coffee and tea break	
15.00-16.00	Workshop conclusions and recommendations	
16.00	Close of workshop	
19.00	Workshop dinner in Kingsley Hotel	All participants

Annex 3 – Workshop Feedback Summary

		Rating									
Question No.	**Question**	**Disagree Strongly**	**%**	**Disagree mildly**	**%**	**Don't know/No comment**	**%**	**Agree mildly**	**%**	**Agree strongly**	**%**
1	The objectives of the workshop were clear	0	0%	0	0%	0	0%	5	45%	6	55%
2	The content of the workshop was relevant to you	0	0%	0	0%	0	0%	3	27%	8	73%
3	The workshop introduced you to the purpose of GEMS/Water	0	0%	0	0%	0	0%	2	18%	9	82%
4	My country does already, or will in the future . Share data with GEMSStat	1	9%	0	0%	4	36%	1	9%	5	45%
5	The workshop will enable you to prepare for reporting SDG indicator 6.3.2	0	0%	0	0%	0	0%	6	55%	5	45%
6	Capacity development currently offered by GEMS/Water is useful and relevant	0	0%	0	0%	1	9%	2	18%	8	73%
7	Presentations were generally clear and well presented	0	0%	0	0%	0	0%	1	9%	10	91%
8	The logistics of the workshop were well organised	0	0%	0	0%	0	0%	0	0%	11	100%
9	Accomodation and travel was satisfactory	0	0%	0	0%	0	0%	0	0%	11	100%

A: Did you find any section or topic of the workshop particularly useful?

The section on SDG indicator 6.3.2 methodology and implementation*	Storage and management of data.	Almost all topics were useful.	The session on GEMStat	The question and answer session	Different approaches to monitoring water quality	The sampling topic was very useful
3**	2	2	1	1	1	1

*some responses have been paraphrased so that similar responses can be collated

**numbers denote the number of participants agreeing with statement

B: Did you find any section of the workshop of little interest or use to you in your current role?

All sections were relevant	Data sharing	Future reporting
8	1	1

C: Are there any topics that were not included that you think should be? It so, suggest topics

None/no comment	Recommendations and action taken based on monitoring water quality Groundwater Quality	Information on the awareness raising of the importance of water quality monitoring aimed at university and school-level	More on UN Water structure	More focus on countries that implemented the WFD
7	1	1	1	1

D: In your opinion, how could the structure or content of the workshop be improved?

hard to say/none	Site visit	more interactive presentations	move third day content to first day	more focus on indicator 6.3.2
5	2	1	1	1

E: Have you any other comments or suggestions about any aspect of the workshop?

No I haven’t. Thank you so much
Thank you so much. Very informative.
It could have been condensed into two days
More focus on the WFD would have been useful
Thank you so much for the invite. Very good workshop