UN Environment Programme GEMS/Water Capacity Development Centre

Workshop Report

Ambient water quality: monitoring for management and SDG Indicator 6.3.2 reporting

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1 INTRODUCTION

The United Nations Environment Programme (UNEP) GEMS/Water Capacity Development Centre (CDC) is a Centre of the UNEP GEMS/Water programme and is based in the Environmental Research Institute in University College Cork, Ireland. The Centre was established in September 2015, and since 2016 it has been delivering capacity development in freshwater quality monitoring and assessment globally. The key roles of the Centre include development and delivery of capacity development educational material, training and workshops, encouraging best practice for water quality monitoring and the sharing of monitoring data with the global water quality database, GEMStat, and support for the implementation of the Sustainable Development Goal (SDG) indicator 6.3.2 for ambient water quality.

The CDC organised a workshop in Amman, Jordan in December 2019. This workshop was the final in a series intended to obtain a global perspective of freshwater quality monitoring activities, and to identify any knowledge gaps that could be improved by the work of the CDC. It was aimed at countries in the West Asia and North Africa region. The objectives of the workshop were:

- To introduce the revised and restructured GEMS/Water programme;
- To discuss the fundamental principles of ambient water quality monitoring and different monitoring approaches;
- To explore monitoring needs in rivers, lakes, reservoirs and groundwaters in order to support information for management purposes;
- To introduce SDG indicator 6.3.2 for ambient water quality and to explore the potential for using the indicator as a water quality management tool;
- To identify capacity development needs relating to water quality monitoring and assessment in the region;
- To explore the potential for delivering capacity development for water quality monitoring in the region using training workshops and on-line courses.

There were 11 countries represented at the workshop: Bahrain, Egypt, Jordan, Lebanon, Morocco, Palestine, Sudan, Syria, Tunisia, United Arab Emirates and Mauritania, during which engagement between these countries and the GEMS/Water network was reinvigorated. Some of the countries of the West Asia and North Africa region attending the workshop had been actively involved with GEMS/Water in the previous five years and had reported results to the last SDG Indicator 6.3.2 data drive and some had submitted data to GEMStat.

After three days of discussions, the outcomes of the workshop were:

- New GEMS/Water contacts were made in the region and the GEMS/Water network was expanded as a result.
- Information was collected about current ambient water quality monitoring and assessment activities that will feed into the global assessment of water quality capacity needs and expectations. This will also contribute to informing the future capacity development activities of GEMS/Water and the World Water Quality Alliance.
- Participants were introduced to best practice and recent developments in water quality monitoring approaches and water quality data management.

- The potential for mutual support amongst countries in various aspects of water quality monitoring and assessment was highlighted.
- A better understanding was gained by participants of the requirements and methods for reporting SDG indicator 6.3.2 for ambient water and a request for advice and support in the region has been passed on to the GEMS/Water SDG indicator 6.3.2 support team.

2 WORKSHOP DAY 1

The workshop opened with a number of welcome remarks. The Head of GEMS/Water, Hartwig Kremer, and Etaf Chehade, UNEP Bahrain Programme Management Officer, joined the workshop on-line by video conference to welcome the participants. Sarah Dooley, Deputy Head of Mission for the Embassy of Ireland in Jordan, welcomed everyone on behalf of the Irish Ambassador to Jordan. Ahmed Uleimat, spoke on behalf of the host country, Jordan, to greet the visiting participants and express his wish for a productive workshop. The opening remarks were followed by round table introductions. The people present gave their name, organisation and their role within their organisation.

Introductory presentations were given outlining the workshop objectives, expected outcomes and the GEMS/Water programme. The rest of the day involved presentations from each of the countries represented at the workshop. These presentations gave an overview of the ambient water quality monitoring and assessment currently being carried out in each country. Each participant had been provided with a template for this presentation before the workshop to ensure a standard approach and comparability. In the next portion of the report, a summary of each country presentation is provided, followed by a brief comparison and synopsis. There was a distinct range in monitoring capacity with some countries facing much greater challenges in availability of resources for monitoring than others.

2.1 THE KINGDOM OF BAHRAIN

Water sources in the country include aquifers, treated sewage effluent (TSE) and desalinated water. The Water and Land Development and Protection Section are responsible for monitoring bore well water quality.

The Agriculture Engineering and Water Resources Directorate, Water and Land Development and Protection is in charge of monitoring groundwater and the Sanitation Engineering Directorate in Work Affairs monitors the water quality of TSE. Water distribution Directorate in Electricity and Water Authority (EWA) monitors domestic (potable) water quality. The Sanitation Engineering Directorate treats effluents and the treated sewage effluents are used for irrigation and landscaping as recommended by the World Health Organisation (WHO) Quality guidelines. The only ambient freshwater in Bahrain is groundwater, which is tested for salinity. The total dissolved solids (TDS) range between 2000 ppm and 15000 ppm. Groundwater monitoring stations are situated in the Alat, Khobar and Umm Radhuma aquifer with a total of 70 bore wells (around 118 sampling points). Groundwater quantity is monitored twice a year at 60 to 100 selected bore wells and others are randomly sampled. One in ten water bodies have both water quantity and quality monitoring.

The most commonly monitored parameters for all freshwater samples are pH, TDS, colour, taste, iron, nitrate, major ions, total coliform bacteria, faecal bacteria and *E. coli*. Heavy metals and some trace metals are measured annually in the samples taken from observation bore wells, part of groundwater monitoring stations. Different types of analysis are carried out by different laboratories. The various responsible organisations carry out their own sampling and each laboratory stores its own water quality data. Water quality data have been collected for the last 60 years. There is no main national reference laboratory, but most laboratories have a quality assurance plan in place.

Data are not available on-line but water quality data are published every two years and national water quality reports are produced for groundwater every year. State of the Environment reports, whenever they are published, include water quality data. The National Water Council uses water quality data to assist in developing national water policies and strategies.

2.2 ARAB REPUBLIC OF EGYPT

Egypt's water resources are mostly the Nile River, but groundwater, desalinated water, rainfall and flash floods are also used. There is water quality legislation and standards for freshwaters receiving treated effluents, industrial waters, irrigation water, drinking water and water for domestic uses.

National Water Research Centre (NWRC), the research branch of the Ministry of Water Resources and Irrigation (MWRI) of Egypt has an ambient water quality monitoring network. It is responsible for the monitoring programmes through the Nile Research Institute (NRI), Drainage Research Institute (DRI) and Research Institute for Groundwater (RIGW). Surface water quality monitoring of the Nile River, Lake Nasser, Damietta Branch and Rosetta Branch have altogether 29 sampling points that are sampled four times per year by the NRI. Groundwater quality monitoring activities are distributed over the five main aquifers with about 200 monitoring points nationwide. These are sampled once a year by the RIGW. There are a higher proportion of surface water sampling locations in the Nile than other surface water bodies and more groundwater sampling wells in the area of the river. There are 163 monitoring points in the irrigation and drainage canals that are sampled 12 times a year. This is carried out by the DRI.

Commonly monitored parameters include temperature, colour, pH, dissolved oxygen (DO), electrical conductivity (EC), suspended solids (SS), turbidity, ammonia, hardness, nitrogen compounds, chemical oxygen demand (COD), biochemical oxygen demand (BOD), phenols, oil and grease, major ions and trace metals, total algal count, chlorophyll, total bacterial count, total coliforms and faecal coliforms. Additional parameters are analysed during research projects, such as cyanide, sulphides, pesticides, surfactants, protozoa, nematodes, faecal streptococci, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. Sediment, soil and plants may also be analysed during complete analysis.

The Central Laboratory for Environmental Quality Monitoring (CLEQM) is accredited in accordance to ISO 17025: 2015. International accreditation has been obtained from the Canadian Association for Laboratory Accreditation (CALA) for chemical parameters since 2004. The laboratory also has national accreditation for microbiological parameters from the Egyptian Accreditation Council (EGAC) since 2015.

There are numerous publications each year concerning drainage water quantity and quality, drainage water being released to lakes or the sea, irrigation water quantity and quality, drainage rate and the salinity of drainage catchments.

Overall water quality is assessed using a Water Quality Index (WQI). This provides a quantitative approach for assessing the water quality conditions in relation to water quality objectives.

2.3 HASHEMITE KINGDOM OF JORDAN

Water resources in Jordan come from groundwater, surface water, desalinated water and reclaimed water from wastewater treatment. The estimated amount of water available from the groundwater basins is 418.5 MCM (million cubic metres) and 2.17 MCM from brackish water. Surface water supply was estimated in 2018 to be 259.5 MCM.

There is water quality legislation in place for drinking water, effluents and ambient waters in Jordan. The Water Authority of Jordan (WAJ) and water companies have water quality monitoring networks. All groundwater resources, surface water, treated springs and groundwater wells that do not comply with national standards are included in water quality monitoring networks. Brackish water, Mujib Dam and desalination units are also included in the monitoring networks. King Abdullah Canal (KAC), an irrigation canal, is monitored once a week. The water contained behind dams is monitored once per month, and groundwater is tested when it is used for drinking water. There are hydrological monitoring stations in the KAC, dams and groundwaters, and there are some telemetric stations monitoring continuously. All water bodies have both water quantity and quality monitoring. The common physical and chemical parameters are monitored in Jordan, as well as biological and microbiological parameters, including faecal coliforms, *Giardia*, *Legionella*, *Cryptosporidium*, algae and nematodes. Gross α and β activity, stable isotopes, ^{14}C, Radium and Radon are monitored occasionally when necessary.

WAJ Laboratories and Quality Affairs are responsible for water sampling together with water companies, the Royal Scientific Society (RSS) and Ministry of Health. WAJ laboratories analyse 98.4% of the water samples covered under the Jordanian standards regulations. Water companies, RSS and the Ministry of Health also analyse samples. Approximately 25% of samples analysed are ambient water quality samples. In 2018, 24,763 microbiology samples and 25,866 samples for different parameters were analysed by WAJ laboratories and other water companies.

Water quality data are stored in Laboratory Information Management Systems (LIMS), the Water Evaluation and Planning (WEAP) tool, the National Information System (NIS) and the Water Information System (WIS) at the Ministry of Water and Irrigation. Water quality data have been collected electronically since 1995 but prior to this, data in hard copy format were archived. Raw data are mostly unavailable on request (although they can be purchased) but average values are available. The Water Authority produces an annual report that includes information about compliance with the Jordanian Standard Regulations.

The WAJ laboratories are accredited to ISO 17025 for approximately 76 different tests. There are quality control procedures in place including national and international intercalibration exercises. There is regular coordination with the Ministry of Environment relating to water quality and pollution. Water quality data assist with the development of the National Water Strategy and Master Plans.

2.4 REPUBLIC OF LEBANON

Water resources in Lebanon comprise 38 River basins (nine major), a small number of reservoirs, two natural wetlands and groundwater. Some of the aquifers in Lebanon, especially near the coast, are under stress.

The Lebanese Standards Institution (LIBNOR) have drinking water standards that are followed in Lebanon. The Ministry of Environment legislates for effluent standards. Food and Agriculture Organisation (FAO) standards are used for ambient waters or ecosystem quality.

The Ministry of Energy and Water (MoEW) and the Ministry of Environment (MoE) are responsible for ambient water monitoring at national level. At basin level, the Litani River Authority (LRA) is responsible. The LRA is a public institution within the Department of Water Governance mandated to produce hydropower and supply water for irrigation. The Litani River is the largest river in Lebanon and is a major source of irrigation water and hydropower. The LRA performs monthly water quality monitoring on the Litani River, Quaroun Lake and the main canals of irrigation projects. Other rivers and water bodies are monitored irregularly by other agencies and research institutions. Twenty per cent of water bodies have both quality and quantity monitoring. There are four water establishments responsible for potable waters.

Commonly monitored parameters include conductivity, hardness, TDS, major ions, pH, sodium adsorption ratio, nitrate, ammonium-nitrogen, phosphorus-phosphate, total coliforms, faecal coliforms and *E. coli*. Heavy metals are not monitored very often.

The LRA collects samples for the Litani River system. The Lebanese Agricultural Research Institute and various universities carry out other sampling. Two hundred and ten samples are taken per year for the Litani River and Qaraoun Lake, but only ten per cent of water samples nationally are for ambient quality; most of the rest are potable water samples.

Water quality data are stored separately in each laboratory rather than in a central database. The LRA has been collecting water quality data since 2006. Data are available free on request and are published, but not on a regular basis. Lebanon has a national reference laboratory in the Lebanese Agricultural Research Institute. The American University of Beirut (AUB) is accredited to ISO 17025.

Water quality and quantity data are published on social media when necessary (e.g. flood and pollution risks). Currently, the LRA is the only authority in Lebanon producing water quality reports about the Litani River, Quaraoun lake and irrigation canals. These data are used by the LRA to assess the safety of the water and to manage risks in irrigation schemes, to warn local residents of potential river water pollution and to manage industrial pollution along the river.

2.5 ISLAMIC REPUBLIC OF MAURITANIA

In Mauritania, almost a third of the population live below the poverty line including three quarters of them in rural areas. In 2015, the government launched a Strategy for Accelerated Growth and Shared Prosperity (SCAPP) for 2016 to 2030, which aims to develop infrastructure projects to support growth and encourage development in the country. Within this strategy, the water and wastewater sector must be developed. The goal is to have sustainable access to water and sanitation by the year 2030. The Ministry of Water and Sanitation is the main institution in this sector with support from national technical directorates. The Ministry of Health, Ministry of Environment and Sustainable Development and Ministry of Development also play a role. The Ministry of Water and Sanitation is trying to ensure all developed or developing projects related to water comply with their standards.

The Water Law of 2005 mandated the Ministry of Water and Sanitation with the responsibility of treating and exploiting surface water and groundwater. There are at least six other strategies outlined related to aspects of water and sanitation including liquid sanitation, promotion of hygiene, health development, sustainable development, rural sector development and the conservation of wetlands. Climate change is predicted to impact upon Mauritania greatly, including decreases in average annual rainfall, the reduction of water and soil resources, and reduction in agricultural potential.

In 2018, more than three quarters of the water used was devoted to agriculture and less than 12% was used to provide drinking water. Groundwater provides water for cultivation, mainly in the oasis region and for livestock. The mining industry accounts for about 1% of groundwater withdrawals. Water abstraction is set to increase in the coming years, but groundwater resource mobilisation is limited by insufficient knowledge, monitoring and protection. The last detailed study of Mauritania’s groundwater was 15 years ago. The groundwater monitoring network is limited and has not been monitored since then, although hundreds of wells have been drilled in the last 15 years. In 2018, 80% of the population had access to drinking water across the country and 60% in rural areas. Work is ongoing to increase access. The water service price is very variable in rural areas and access is not equitable.

The amount of water currently being withdrawn from the Senegal River is only 20% of the potential resources that Mauritania can exploit and this water could be used to develop agriculture. The current dams and surface water barriers require renovation.

There are three hydrometric stations managed by OMVS (Organisation pour la mise en valeur du fleuve Sénégal) on the Senegal River. This organisation involves the Senegal River's riparian countries and allows for joint management of the river and its drainage basin. There is no monitoring of natural and man-made wetlands in Mauritania. Nouakchott, Nouadhibou and Zouerate are the only cities in Mauritania that are partly equipped with a wastewater collection and treatment network. Community-led sanitation is promoted in rural and peri-urban areas.

The national strategy for sustainable access to water and sanitation (SNADEA) by the year 2030 is in line with the country's national development plan (SCAPP) and guides the work of the water sector. The strategy was developed in five key areas: knowledge of water resources, monitoring and protection, improving access to drinking water for all, improving access to water for agriculture and livestock, improving access to drainage and sanitation and improving sector management.

2.6 KINGDOM OF MOROCCO

Morocco's water resources are estimated to be 22 billion m^3 per year from surface water and groundwater. There are nine river basins and main rivers in Morocco, as well as 144 large dams and 13 water transport systems which transfer 210 $m^3 s^{-1}$. The National Office of Electricity and Drinking Water (ONEE – Water Branch) is the main organisation responsible for drinking water and sanitation. They produce 85% of the overall national drinking water with 100% access rate in urban areas. The challenges in Morocco include water resources available per-capita which have decreased since 1960, the over-exploitation of 20 aquifers, siltation in dams decreasing the amount of water that can be mobilised and water pollution from urbanisation, industrialisation and agriculture.

There are many different organisations involved in ambient, drinking, agricultural, fishing and waste water quality in Morocco, including the Departments of Health, Water, the Environment, Agriculture, Basin Agencies, ONEE-Water Branch and communes. Morocco has laws for the protection of water quantity and quality for ambient water, drinking water sources and supply, and domestic wastewater discharges. There is a National Plan for Water, a Plan on Integrated Management of Water Resources and a 'polluter-pays' policy. Ordinance No. 1275-02 provides standards for ambient water quality with the Surface Water Quality Grid, which characterises the quality of surface water using a simplified grid with a variety of parameters that suggest the quality status of the water body. Sampling for this Quality Grid calculation is carried out 12 times per year for areas affected by pollution and four times per year in unaffected areas. Order No. 1277-01 provides standards for the quality of surface water used for drinking water supply. Sampling of these source waters takes place 6-12 times per year depending on the production rate.

ONEE- Water Branch and the Water Department and River Basin Agencies have 1679 groundwater sampling points, 282 river monitoring points and 571 sampling stations in dam reservoirs. The Moroccan Hydrological network has hydraulic stations, climatological stations and gauging points.

The laboratories in Morocco can be divided into national level, regional/provincial, and private and each laboratory stores its own water quality data. Water quality data have been collected since 1972 in ONEE-Water Branch and since 1984 in the Directorate of Research and Planification Water Resources. Morocco has shared some of its water quality data with international databases such as GEMstat, MEDPOL, UNEP SDG indicators, and United Nations Statistical Division (UNSD/UNEP).

The different organisations that monitor water quality carry out their own sampling and analysis. The ONEE-Water Branch has one central laboratory, ten regional laboratories covering 112 decentralised laboratories (e.g. provincial laboratories and treatment plant laboratories) and two mobile laboratories for the characterisation of wastewater and the control of wastewater treatment plant discharges. These laboratories sample more than 7000 monitoring points and analyse over 250 parameters.

The Moroccan Accreditation Service of the Ministry of Industry, Investment, Trade and Digital Economy accredits 96 laboratories to ISO 17025. Those not accredited are working towards accreditation. The ONEE-Water Branch laboratories have double accreditation to ISO 17025 since 2002 by the Ministry of the Environment and the Fight against Climate Change, Canada and The Ministry of Industry, Trade and Green and Digital Economy, Morocco. They are also certified to ISO 9001 since 2016 and a World Health Organisation (WHO) Collaborating Centre since 1994 in the area of Water Quality Control and Applied Research. The laboratories participate in international intercalibration exercises and have organised national and African intercalibration exercises since 2010, which include Burkina Faso and Cameroon.

Water quality data are not published regularly. The Department/Directorate of Research and Planification of Water Resources produces a national water quality report every two years. The Health Department/Directorate of Epidemiology and the Fight Against Diseases produce a national report of Water Quality Served for Human Consumption. The State of the Environment reports include water quality data. These data are used to assist in the development of water policy and national strategies (e.g. National Water Plan).

2.7 STATE OF PALESTINE

Palestine relies mainly on aquifers for its water resources, but the total resources have been limited since the occupation in 1967. Groundwater provides more than 90% of all water supplies to Palestine (West Bank and Gaza Strip). There are three groundwater basins (Western, Eastern and North Eastern) in the West Bank and there is part of a Coastal Aquifer in the Gaza Strip.

The Palestinian Water Authority (PWA) Water Quality Central Laboratory is responsible for monitoring water quality of both domestic and agricultural water in the West Bank and Gaza. The Ministry of Health (Central Public Health Laboratory - CPHL) and service providers are responsible for monitoring drinking water supplied through municipal potable water distribution networks.

There is legislation for drinking water and effluents in Palestine. Drinking water standards are based on the Palestinian technical regulations, and effluents are treated to the standards for irrigation use and sludge.

Each laboratory has staff that collect samples from wells manually. These samples are analysed in separate laboratories. Samples are collected from groundwater wells twice per year, before and after rainfall. There are no permanent hydrological stations but the hydrological monitoring team carry out manual measurements, such as water level and discharge from springs and runoff wadies. Every two months 80% of wells are monitored for both water quantity and quality. Common physical parameters are monitored along with chlorine (residual and total), chloride, nitrate, bicarbonate, sodium, total hardness and sulphate. Total coliforms and faecal coliforms are also monitored. The PWA team analyse approximately 500 samples per year from groundwater wells and springs. The CPHL collect and analyse water from the municipal potable water distribution network, and occasionally domestic groundwater wells.

Water quality data are stored centrally in a national water quality database, MAWARED, and separately in each laboratory. Water quality data have been collected by the West Bank Water Department since 1967 and by the PWA since 1995. Data are freely available upon request but not on-line or in published form.

There is no national reference laboratory in Palestine. The Ministry of Health Laboratory (CPHL) is accredited to ISO 17025 and the PWA laboratory is in the process of accreditation. The CPHL has a quality assurance department. The laboratories in Palestine do not participate in national or international calibration exercises.

There is a section in the Annual Rainfall Effect report, published by PWA, devoted to water quality. Water quality data are not used in State of the Environment reports but are used to help develop water policy and projects.

2.8 REPUBLIC OF SUDAN

Sudan's water resources comprise rivers, wadis and aquifers. Many of Sudan's water bodies are transboundary. The Blue Nile has the largest volume of water followed by the White Nile and then the Atbara River. The groundwater in Sudan has a total storage of 15,900 km^3 with a recharge of 2,445 $\times 10^6$ m^3. Recharge is not a major issue but salinity is becoming a problem in some areas.

The Sudanese Standards and Metrology Organisation (SSMO) has drinking water standards and environmental emission standards for municipal and liquid industrial effluents. The Ministry of Health Environmental Law 1975 and Sudan Promulgate Water Act 1995 aim to regulate water resources, water quality, pollution and flood defences. The environmental pollution regulation was introduced in 2008, which prohibits the discharge of any waste into water resources or the environment in order to protect ecosystem quality. However, municipal wastewater discharge is an issue.

The Ministry of Irrigation and Water Resource/GWR has central water quality laboratories that carry out water quality monitoring. There are two transboundary river monitoring stations. One groundwater basin is monitored at three stations, but the other three groundwater basins are far from the laboratories and the means to monitor them are not available. River sampling is carried out twice a month from two stations each month. Three groundwater samples are taken seasonally per year.

Water quantity is monitored in rivers monthly with more stations than for water quality monitoring. There is one automatic water logger station that measures water level, temperature, pH and EC in a ground water aquifer. There are ten groundwater quantity stations in the northern region, where data are logged every month. The River Nile, Blue Nile and Atbara rivers have both water quantity and quality monitoring data. These data include discharge, water level and depth, together with automatic water quality monitoring for six common parameters. The common physical and chemical water quality parameters are monitored along with fluoride, total coliforms, faecal coliforms and *E. coli*. The microbiological parameters are measured on a daily basis where the water is treated with chlorine before being supplied for drinking water by the State Corporation. Heavy metals are measured during research projects and when urgently needed.

Sampling and analysis are carried out centrally and regionally by GWR laboratories, State laboratories, Ministry of Health and private bottled water companies. Different laboratories carry out different analyses. The GWR, State and Water Corporation laboratories collect raw water samples. Approximately 6% of samples analysed are ambient water quality samples. Each year, 24 river water samples and 30 groundwater samples are analysed. Water quality data have been collected for the last 15 years but regular annual monitoring began in 2015. Data are held in a central database and in each laboratory. Data are shared with international databases such as GEMstat.

There is no national reference laboratory and none of the laboratories are accredited to ISO 17025 or other national accreditation systems. The Ministry of Irrigation and Water Resources/GWR laboratories have a quality assurance plan in place but it is not fully implemented. The GWR laboratories participated in the GEMS/Water international intercalibration exercise in 2013.

Water quality data are not yet published but the data are used to help develop water policies. A river water monitoring report is submitted to the Sudan Egypt National Commission for the River Nile each year.

2.9 SYRIAN ARAB REPUBLIC

Water sources in Syria consist of permanent and temporary rivers, reservoirs and groundwater. Syria receives a share of the Euphrates and Tigris river water (6.6 billion m^3 from the Euphrates River and 1.25 billion m^3 from the Tigris River). The reservoirs created by the dams in Syria (Euphrates, Tishreen, Al-Baath, Al-Wahda, Qatina, Taldo and Muharda) have severely decreased storage capacities over the last ten years and are not sufficient for current uses. Syria has suffered from infringement and pollution of waterways and water bodies since the start of the political crisis in the country. Similarly, laboratories have been severely impacted. This has led to a significant decrease in the proportion of water bodies that are being monitored. Most drinking water is sourced from groundwater with some surface water being used from the reservoirs created by dams. When any source of water is used for drinking water supply, it is treated and checked against the drinking water standards No. 45 of 2007 prior to being supplied to the network.

The Ministry of Local Administration and Environment, the Ministry of Water Resources, and the Ministry of Health carry out the various types of analysis on water. The Ministry of Water Resources is responsible for managing, protecting and distributing water resources. They have a number of laboratories that carry out various water analyses and the results are sent to the Ministry of Local Administration and Environment. The Ministry of Local Administration and Environment is responsible for monitoring the quality of water resources in accordance with Law 12 of 2012 and for implementing the Syrian standards related to water. The Ministry of Local Administration and Environment analyse chemical and bacteriological parameters monthly and heavy metals every three months. These analyses are conducted in the 14 environmental laboratories in every directorate of environment in the Provinces and one laboratory in the ministry. Additional analyses may be carried out when complaints are made and for specific projects. The Ministry of Water Resources analyses chemical and bacteriological parameters monthly and heavy metals every three months. The Ministry of Health analyses chemical, microbiological and pathogenic parameters in the event of a disease outbreak.

Syria has standards relating to water which are applied by the Ministry of Local Administration and Environment in coordination with other bodies. These standards cover drinking water, liquid waste, treated wastewater for irrigation, treated sludge, and discharge of treated effluents.

The laboratories of the Ministry of Local Administration and Environment and the laboratories of the Ministry of Water Resources had been accredited but, because of the political situation, some laboratories are currently not in operation and many have a shortage of staff and equipment. This makes comparing results from the various laboratories difficult. Calibration tests were being carried out in cooperation with the Atomic Energy Authority (a national organisation) or by an external organisation (such as the International Atomic Energy Agency). However, at the time of the workshop, there was no quality assurance programme in the laboratories.

The water resources monitoring network of the Ministry of Local Administration and Environment varies in each governorate depending on the water resources, their importance, environmental issues, laboratory equipment, available transportation and the security situation. In general, surface waters, reservoirs and springs are monitored and analysed monthly for chemical parameters. Groundwater is monitored every three months for chemical parameters. Microbiological parameters and heavy metals are analysed twice a year in surface and ground waters. The parameters analysed include nitrate, nitrite, DO, BOD, COD, TDS, EC, pH, temperature, turbidity, SS, ammonia, oil, phenols, faecal coliforms, *E. coli*, total coliforms, and major ions.

Syria has set nine strategic goals for the water sector. These include developing an integrated environmental management plan in water basins, determining the water quality in all major water bodies according to their 2016 Water Quality Index, developing their database, reactivating their quality assurance programmes, reporting the SDG goal 6 indicators and developing cooperative agreements between the agencies involved in water quality.

2.10 REPUBLIC OF TUNISIA

Water resources in Tunisia comprise surface water and groundwater. There is water quality legislation and there are standards for drinking water, and for surface water used as source of drinking water, for domestic and industrial treated wastewaters and reuse of treated wastewater for irrigation. Many stakeholders are involved in monitoring water quality in Tunisia. Within the Agriculture Ministry, the General Directorate for Water Resources monitors salinity and nitrates in surface and groundwater nationally, the General Directorate for dams monitors water quality in dams and the National Company of Water Use and Distribution monitors drinking water. The Health Ministry also monitors drinking water. Within the Environment Ministry, the National Agency for Environment Protection has a national network for monitoring water quality called 'Copeau' and the National Sanitation Office monitors treated wastewater discharges.

The 'Copeau' Network has more than 400 monitoring points in rivers, groundwaters, at discharge sites of treated and untreated waste, dams and wetlands. There are more monitoring points in water bodies where potential pollution sources exist, than in water bodies in unaffected areas.

Tunisia monitors some of the common physical and chemical parameters frequently, both *in situ* and in laboratories. Dissolved oxygen, BOD, hardness and heavy metals are monitored intermittently. In special cases, total coliforms, faecal coliforms, *E. coli* and hydrocarbons are monitored.

The 'Copeau' network has a central laboratory and one regional laboratory that carry out the sampling and analysis. These laboratories carry out the same methods of analysis but intercomparability tests are not performed. Additional analyses, such as bacteriological tests, and analysis for hydrocarbons, are outsourced. The network is part of a project with Aquapole, Liège and Belgium and has been operating in Tunisia since 2004, and was extended in 2010. There is a National Information System on Water (SINEAU) but it is not yet functional. Water quality information is published in a number of reports concerned with water resources and the environment, including the National State of the Environment report and the National report on the water sector. There is an ongoing project on the Policy Support Systems for SDG 6 to assess the progress made for creating an enabling environment for SDG 6.

2.11 UNITED ARAB EMIRATES

Water resources in the United Arab Emirates (UAE) comprise groundwater and desalinated water. The local and federal authorities are responsible for monitoring water quality in UAE.

The UAE has legislation and standards for drinking water in standard Emirates Quality Mark (EQMX).

There are hydrological monitoring stations for monitoring groundwater and the water in dam reservoirs. The dams are mostly for protection from flash flooding and recharging the groundwater aquifers. Groundwaters are sampled for water quality parameters. These parameters are analysed before and after the rainy season. Water quality data are stored in local and federal databases.

Emirates Metrology Institute is the only authority in the State with regard to metrology and acts with all competence and powers in order to organize measurement and calibration work inside the state.

National Measurement Standards are recognized by national authority to serve in a state or economy as the basis for assigning quantity values to other measurement standards for the kind of quantity concerned. The Federal Competitiveness and Statistics Authority (FCSA) act as the official source of statistics and monitoring of competitiveness performance in international reports, where FCSA is responsible for the development of and running a unified, comprehensive, accurate, consistent and up-to-date national statistical system across different sectors. It is also responsible for consolidating definitions, methodologies and classifications in the statistical and competitiveness work standards in coordination with governmental and international authorities.

2.12 SUMMARY OF COUNTRY PRESENTATIONS

The presentations given by each country and follow up question and answer sessions highlighted the similarities and differences between them with respect to their water quality monitoring activities. There was a large variation in water quality monitoring and assessment capacities with some countries being very well equipped and experienced, while others were developing or rebuilding their networks. All countries have government bodies responsible for water quality and legislation related to protection water quality for human use or wastewater discharge. However, the level of implementation and enforcement of this legislation is mixed among the countries. Ambient water was not specifically monitored in many of the countries. The focus of monitoring water quality was for specific uses, particularly drinking water supply, but the countries that carry out monitoring covered a wide range of parameters. While quality assurance and accreditation was important in many laboratories, there is a clear lack of sufficient quality assurance implementation in some countries. Performance evaluation of laboratories through national or international intercalibration exercises is carried out frequently by Jordan and Morocco and has been done in the past by Syria and Sudan with the aim of doing it again in the future.

Water scarcity and reliance on groundwater is more prevalent in this region than for other world regions where GEMS/Water has undertaken similar scoping exercises. Many of the countries mentioned saltwater intrusion and overexploitation of groundwater resources. The transboundary rivers and aquifers that some of the countries share with others have cooperative organisations to help manage these resources for future generations.

The financial resources necessary to monitor and assess freshwaters fully were insufficient in some of the countries. Many countries are feeling the burden of political and economic instability, which lessens their ability to protect and monitor water resources fully, which is compounded by the influx of refugees who increase pressure on the water resources.

Water quality data are not universally available, although summary data published in reports are common along with data being made available on request. Only two of the countries specified that they share data with GEMStat. Data sharing activities throughout the region could be improved. Nevertheless, six countries were involved in the first SDG Indicator 6.3.2 data drive in 2017: Jordan, UAE, Lebanon, Morocco, Sudan and Tunisia.

The Ministries responsible for water quality monitoring differed between countries. Many of the Ministries had multiple purposes, not just water resource management and protection. Not all of the countries had data sharing networks between their organisations. Establishment of these networks could avoid duplication of effort and enhance water resource management. Sharing of water quality and quantity data between the relevant agencies was also not occurring in many of the countries. However, some transboundary water bodies benefitted from both quantity and quality data being collected.

3 WORKSHOP DAY 2

Day two of the workshop introduced some technical aspects of water quality monitoring for management. During the course of the presentations, there were two designated discussion sessions but questions and dialogue were encouraged throughout the day. A brief synopsis of each presentation is provided below.

3.1 APPROACHES TO AMBIENT WATER QUALITY MONITORING

Deborah Chapman, the Director of the GEMS/Water CDC, outlined the various approaches used for monitoring ambient water quality. John Weatherill, of the School of Biological, Earth and Environmental Sciences in University College Cork, was at hand to add groundwater specific information, particularly during the question and answer session following the presentation. This presentation gave a definition of ambient water, i.e. natural water in the environment (rivers, lakes, wetlands and groundwaters) before it is designated for any human use. Ambient water supports biodiversity, fisheries, and recreational uses, and supplies raw water for human consumption, industry and agriculture, all of which require their own particular water quality.

The most common reason for monitoring water quality is to check whether it is suitable for the intended purpose.

Monitoring water quality can be undertaken using a variety of media (water, sediment and biota) and there are many physical, chemical and/or biological characteristics that can be measured. It is vitally important to understand why you are monitoring in order to decide which media and parameters to include in a monitoring programme. The most common approach globally is to collect water samples for the analysis of physical and chemical parameters. The choice of monitoring techniques depends on the availability of human and financial resources, as well as the type of water body and the target audience for the data generated. There are many alternative approaches to monitoring that can be employed, in addition to the traditional physical and chemical parameters, including biological and microbiological methods, remote sensing, and citizen monitoring. Some of these approaches offer advantages, such as lower costs or greater spatial or temporal coverage. The advantages and disadvantages of each monitoring approach were reviewed and the need to consider the choice of approaches in relation to the monitoring objectives was emphasised.

3.2 PROGRAMME DESIGN AND NETWORK DEVELOPMENT

This presentation, also delivered by Deborah Chapman with groundwater specific questions answered by John Weatherill, covered the steps involved in developing a good monitoring and assessment programme for water quality. The different steps in the process, which are organised into three key phases, were described: (i) design, (ii) implementation, and (iii) assessment, reporting and management (Figure 1).

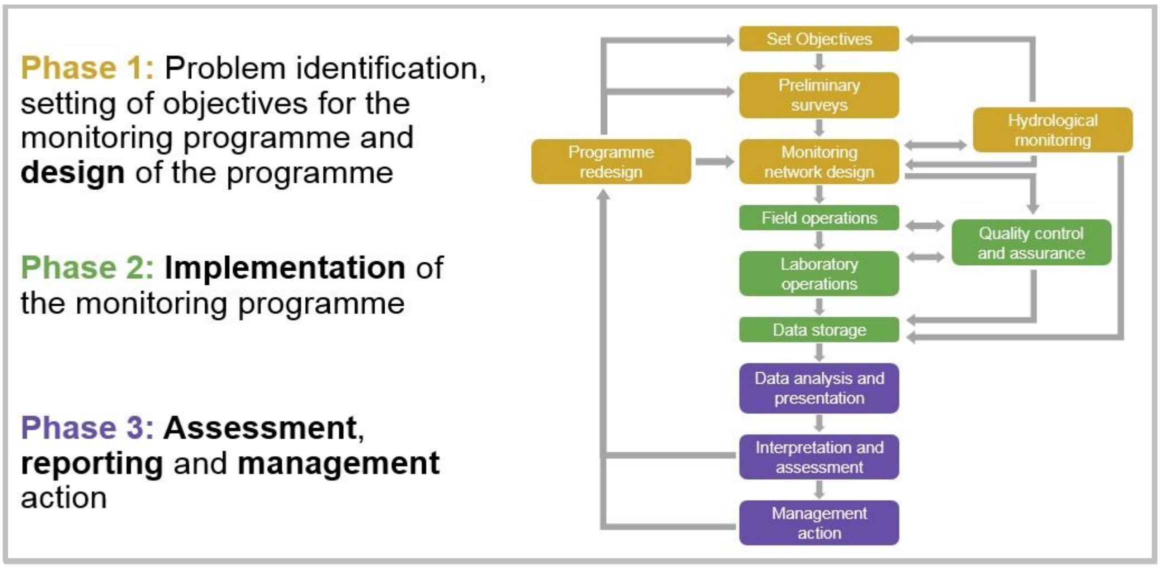


Figure 1 Monitoring and assessment process flowchart. Adapted from Chapman *et al.* (2005)1

The presentation re-emphasised how important it is to define clear and realistic monitoring programme objectives from the beginning and to consider them continuously throughout the

[1] 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].

design process. An essential part of the monitoring programme is quality control and quality assurance, and this session emphasised this aspect because it is sometimes omitted, especially if there are financial constraints.

3.3 QUALITY ASSURANCE FOR WATER QUALITY MONITORING

This session concentrated on the steps in the monitoring process that can affect the quality of data produced by a monitoring programme and the practical methods used to minimise these sources of error as much as possible. One of the crucial points in this session was the need to allocate sufficient resources to quality assurance before the programme begins, i.e. personnel, technical and financial rersources.

The presentation by Deborah Chapman described the many different aspects of quality assurance that are necessary in a water quality monitoring programme in order to produce credible data, and to ensure comparability and compatibility between monitoring laboratories and programmes. It covered quality control in the field, laboratory and data storage, and how to test and maintain accuracy and precision when generating analytical results. Quality control and assurance must be planned during the monitoring network design phase because it affects field operations, laboratory operations and data storage steps. An overview of internal and external quality control in laboratories was also provided.

3.4 DISCUSSION: CHALLENGES TO WATER QUALITY MONITORING FOR MANAGEMENT OF FRESHWATER RESOURCES IN THE REGION

This discussion session revealed the common challenges faced in monitoring water quality for management in this region. Water resources in arid areas are under pressure, so desalinisation is used but the cost and the energy required are a disincentive to many countries.

There were queries about how many samples per year are needed to interpret water quality in general. This query was briefly discussed because it depends on many factors (hydrology, parameters, and duration of monitoring). The minimum recommended is one sampling occasion per season but, ideally, at least four times per year. The usefulness of water quality indices was raised. No one index was deemed the best amongst the participants but there was a general consensus that they are useful in the region especially for gauging trends over time or for comparison across large areas.

The difficulties encountered for sampling, storage and analysing isotopes were considered. If the ^{14}C and nitrate isotope samples are frozen, they are stable and suitable for analysing for a long time provided the container is inert. For the few countries analysing these parameters this is important because they are not tested regularly.

It was noted that ambient surface water quality, especially in arid regions, can impact groundwater quality during recharge. If ambient water quality monitoring is not carried out then the impact of surface waters and drainage on groundwater quality cannot be determined. It was mentioned that some Ministries have strategic plans to protect ambient water quality but it is unlikely that they will reach the implementation and enforcement stage. There was hope amongst participants that SDG 6 will highlight the importance of ambient water quality, and water quality for uses other than drinking, and put pressure on governments to prioritise them.

There were opinions amongst the participants that policy makers are only effective in the short-term because they do not search for and implement long-term solutions. For example, if there is a pollution emergency in the region, they will act quickly, otherwise there is no regular action.

One of the discussion points was the multitude of organisations involved in collecting water quality monitoring data for their own purposes with little or no sharing the data. This was causing frustration. Ambient water quality monitoring is advised by legislation in most of the countries but there is little willingness to fund it. For example, Tunisia monitors ambient waters twice a year due to financial constraints but knows that four times a year is considered the minimum requirement. The same scenario is true for quality assurance in monitoring for ambient water, food security and irrigation - the desire to do it is there, but the investment is not.

It was mentioned that when a single organisation in a country is solely responsible for the water sector, with very little private sector involvement, it is more likely to be very aware of water issues because, if there is a pollution event or deteriorating in quality, the burden falls directly to that organisation to monitor and manage the situation. There were examples discussed where there had been investment in projects to improve water quality, such as the building of wastewater treatment plants or the introduction of sanitation plans with latrines, but no follow-up monitoring was funded to assess whether they had improved water quality or led to reduced health risks.

Evaporation is a major source of water loss in the region, especially for reservoirs with large surface areas. A major reduction in water quantity can impact water quality and affect the survival of aquatic species present. The use of floating rubber objects to reduce evaporation from dammed reservoirs was discussed. The alternatives to floating rubber objects, such as floating solar panels for electricity production, and concerns about plastic leaching chemicals into the water were raised among the participants.

The discussion around field staff and their level of training resulted in contrasting answers from the different participating countries. Some participants described their training for field staff as inadequate while others felt it was adequate, but the need for equipment was more pressing.

Potential future training was suggested in the area of compliance with standards and benchmarks against other laboratories and organisations. This aspect of monitoring and assessment is very new to some of the countries that have not been monitoring on a regular basis for very long.

3.5 STORAGE AND QUALITY CONTROL OF WATER QUALITY MONITORING DATA

Dmytro Lisniak from the GEMS/Water Data Centre gave a presentation on the importance of managed storage and quality control for water quality monitoring data. Effective management of data can significantly increase the value of a monitoring programme and help to ensure it meets its objectives. It also facilitates data sharing and data re-use. One of the key messages was that data should be stored in such a way that they remain valuable in the future, beyond the lifespan of the water quality monitoring programme.

The fundamental steps for data quality assurance include: data quality checks before and after data entry into the data storage; following strategies to avoid error introduction; and maintaining quality of data after storage. These quality assurance mechanisms make the achievement of credible data possible with the least chance of errors.

Quality control checks should be carried out routinely to detect simple errors throughout the production and storage of data. The best approach is to have sufficient checks in place to stop errors getting into a database in the first place. This aspect of the monitoring programme should be well planned in advance of carrying out data storage and should be managed throughout the programme to ensure data integrity.

3.6 GEMSTAT DATA SUBMISSION AND SHARING OF DATA

The final GEMS/Water presentation of the day on GEMStat, the global water quality database, was presented by Dmytro Lisniak. The aim of GEMStat is to aggregate scientifically-sound global water quality data and information to provide a global overview of the condition of freshwater bodies, and trends in water quality, in order to help inform policy making in the future. The presentation introduced some of the benefits to submitting data, such as transparency for water quality-dependent investors to increase investments, bilateral cooperation, a detailed overview of your data, and advice from United Nations programmes and experts for improvement and further development. The spread of data provided to GEMStat is illustrated in Figure 2 below.

The focus of the presentation was how to submit data to the GEMStat database. The submission of data from different countries poses a challenge to uniformity because each country may collect and store data differently. During the session participants were guided through the process, using the template for data submission. The submission of metadata is very important. This process was familiar to only two of the participants.

The GEMStat data Visualisation Portal has a wide range of functionalities that can be used to generate meaningful visualisations of the data in the database. Such functionalities include: allowing users to create time series of monthly means, aggregated statistics like histograms and boxplots, and the production of multivariate scatterplots.

Following submission, a country can control how their data may be shared: i.e., open, limited or restricted access. The restricted data policy does not allow the data to be shared with anyone outside of GEMS/Water. GEMS/Water use of the data is limited to UN mandated assessments and aggregated data products.

Further information on the data submission procedure for GEMStat can be found here: https://gemstat.org/data/data-submission/

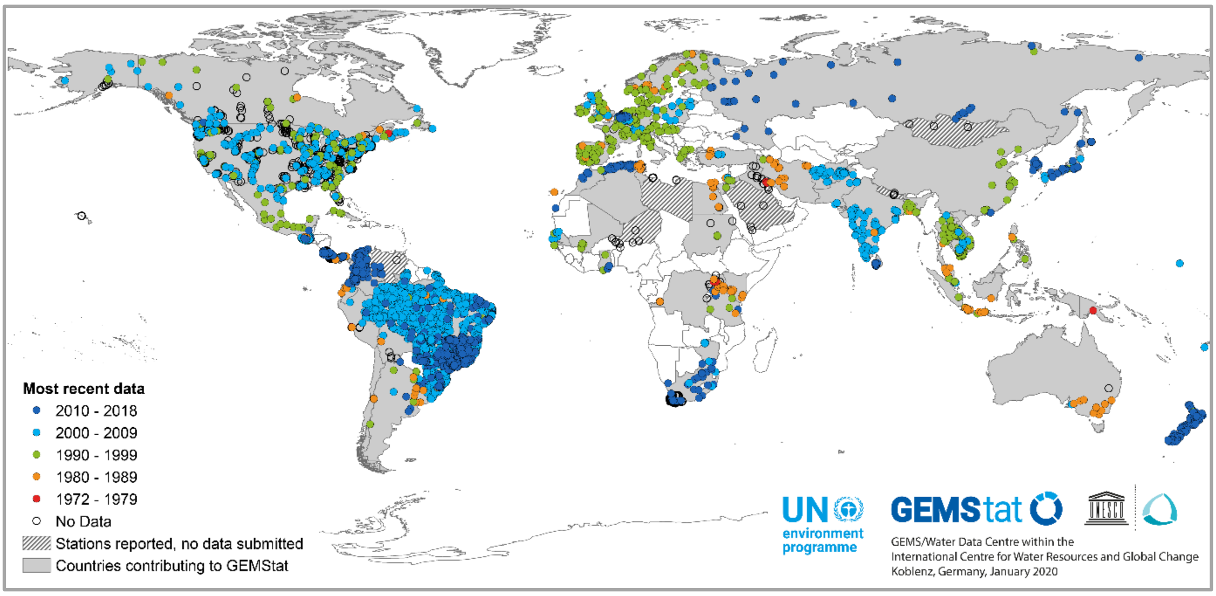


Figure 2: World map of countries contributing to GEMStat as of December 2018. The colour legend shows the data submitted by countries around the world from different years.

3.7 DISCUSSION: CHALLENGES TO MANAGEMENT OF NATIONAL WATER QUALITY MONITORING DATA IN THE REGION

The discussion that followed the data presentations was diverse. The differences in sharing data in the region ranged from being freely available to anyone, to being available to other organisations involved in water quality monitoring, to being completely restricted to one laboratory and their responsible agency. This led to a discussion about sharing with international databases like GEMStat. Laws and regulations are in often in place which, in some circumstances, restrict and control data and how it is shared.

The possibility of the Capacity Development Centre providing funding to countries was raised but the Centre only provides knowledge, training and advice. Complex data training, e.g. data analysis and modelling, was raised as a possible requirement for future capacity development, together with establishing compliance standards for parameters in a river system or groundwater body.

The demands of legislation in some countries could not be met because the expertise and funding are not available to fulfil the monitoring requirements. The advice was to start with a small targeted monitoring programme and to increase from there. The potential of historical data was raised but in some cases these data, prior to2014, were in paper form. This way of storing old data is common but poses an issue for data analysis, because digitalisation is time-consuming. The GEMS/Water Data Centre has, in the past, digitalised data on behalf of countries when the data are shared with GEMStat.

It was pointed out that if a country submits data from only a small portion of the country to GEMStat it may give a misleading impression of the water quality situation of the entire country. This highlighted that, the more data provided, the more accurate the representation for the overall country. Some of the data GEMStat has are old, or are from very few locations – nevertheless they can still help feed into data modelling. The more data available the better the assessment of global and regional water quality. The World Water Quality Assessment is hoping to improve this situation by using Earth Observation and modelling as extra tools to assess water quality on a global scale. Participants asked whether the same problem was experienced with water quantity data. The World Meteorological Organisation (WMO) has a lot of data from river discharge monitoring stations globally which helps to assess the water quantity situation in many places, but similar issues with spatial and temporal coverage also occur with water quantity data.

Some countries suggested that more incentive is needed to encourage them to share data, such as to provide help with neglected projects like databases and indices. GEMS/Water would like to be able to do this but additional personnel time and funding are needed to facilitate travel and workshops or to assign personnel to help a country on-line with a very specific project. Participants were encouraged to share such needs with GEMS/Water so that solutions may be explored.

The groundwater-specific data collection discussion focussed on measuring groundwater level in a well with a contact meter and diver from which data can be downloaded.

4 WORKSHOP DAY 3

The Integrated Monitoring Initiative for SDG 6, SDG 6 targets and their associated indicators were first introduced, followed by discussion of capacity development needs and options for water quality monitoring.

4.1 INTRODUCTION TO THE INTEGRATED MONITORING INITIATIVE AND SDG 6

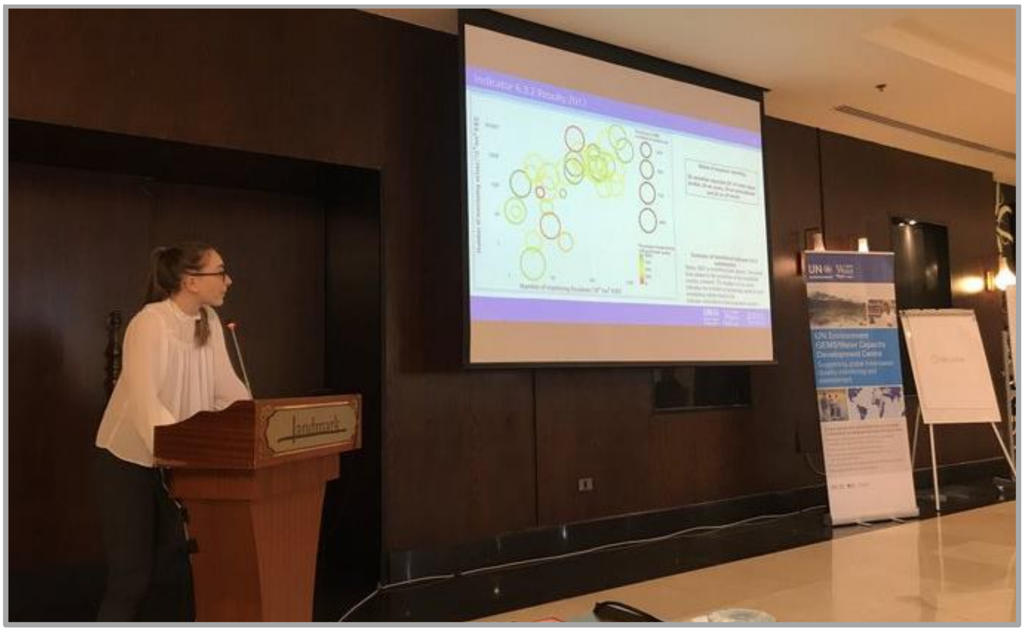
Deborah Chapman introduced the session with a brief explanation of the Integrated Monitoring Initiative (IMI) and the Sustainable Development Goal for Water, Goal 6, which aims to ensure availability and sustainable management of water and sanitation for all. This presentation clarified the various roles and responsibilities of UN agencies for the six targets and 11 indicators within Goal 6. Each indicator has a custodian agency and UNEP is the custodian agency for three SDG 6 Indicators: 6.3.2, 6.5.1 and 6.6.1. The UNEP GEMS/Water programme provides support to countries with their implementation and data submission for Indicator 6.3.2, which aims to report the proportion of bodies of freshwater with good ambient water quality. Over time the use of this indicator will help countries to assess change in water quality and determine whether management strategies are working.

4.2 SDG INDICATOR 6.3.2 METHODOLOGY: DEVELOPMENT, IMPLEMENTATION AND PREPARATION FOR THE NEXT DATA DRIVE

Katelyn Grant from the GEMS/Water CDC described the rationale behind SDG Indicator 6.3.2, its development, and briefly how to obtain the information to calculate it. The results of the 2017 data drive and the follow-up feedback were also described.

The indicator is calculated using a simplified water quality index suitable for global use. It was tested by a small number of countries and refined before being used globally in the SDG 6 baseline data collection in 2017. A network of monitoring stations in ambient water bodies is essential to calculate the water quality index. The index is applied to individual water bodies designated for monitoring. Each country delineates their own water bodies, which can then be aggregated into Reporting Basin Districts (RBDs) if appropriate. The reporting mechanism requires a country to decide on their own reporting basin districts (RBDs), which can be made up of one or more river basins. Measurement of one parameter from each of the five core parameter groups is required for at least one station from each designated water body. The monitoring results are compared with target values for each parameter to determine whether the water quality is good or not good. The benefits of having individual country, region or water body-specific target values were discussed. If 80% of the monitoring results meet the specific target values in a water body, then the water body is considered of good quality. The indicator score for the whole country is simply the percentage of all assessed water bodies that were classified as good quality based on the index criteria of 80% compliance.

The feedback obtained from the first data drive in 2017 has led to a revision of some aspects of the indicator, including the introduction of Level 2 monitoring. This allows countries to report additional parameters not included in the core parameter groups, as well as quality classifications based on Earth Observation data and citizen science data. The request for more detailed support material made during the feedback process is being addressed for the upcoming reporting period which starts in April 2020.



4.3 SDG INDICATOR 6.3.2 DATA SUBMISSION AND FUTURE REPORTING

Dmytro Lisniak described in detail the reporting mechanism for SDG Indicator 6.3.2, using the data submission template. The delineation of RBDs and water bodies was described in some detail, and the setting of target values, particularly when there are no pre-existing standards for a country or water body, was discussed. An example of assessing the ambient water quality status of a river was worked through with hypothetical parameter results and target values.

The five main steps of data submission were outlined: (i) providing information, e.g. contact details, about the person submitting the data, (ii) the RBD information, (iii) the entering of water quality data, (iv) water quality targets values used and, (iv) the final generation of the indicator value. The submission template has some quality control measures included to ensure that valid values are entered, i.e. correct river basin names, water quality parameters and reporting units. The entering of water quality data was explained in some detail, with the aid of an example.

The next reporting period for the indicator begins in April 2020 and ends October 2020.

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

There was a detailed discussion about the five core parameter groups and how these were chosen. Several countries in the region monitor many more parameters than those represented in the indicator. The choice to use easy-to-measure, common parameters that can reveal pressures on water quality was explained. The intention was to make the indicator methodology accessible for as many countries globally as possible. Therefore, more complex and expensive analysis, like heavy metals, were excluded from Level 1 monitoring.

Participants who had reported results in 2017 appreciated the enhanced clarity provided by the data submission presentation given by Dmytro in the workshop. On-line tutorials are anticipated to support countries in the 2020 data drive and there will be limited resources available for some *in situ* training and support. If any country is having difficulty calculating the indicator scores they can contact the SDG support team at GEMS/Water for assistance.

Some countries in the region have large amounts of data, which make the calculation process for the indicator very time consuming. As in other world regions, other reporting responsibilities take precedence, such as legislative responsibilities.

There was a query about how to proceed if a country could only monitor two out of the three groundwater parameters suggested for the methodology. It is advised to discuss such issues with the SDG indicator 6.3.2 support team but, in general, it is valuable to report even if all the necessary data or the spatial coverage of monitoring locations are lacking.

The discussions around the challenges for SDG Indicator 6.3.2 monitoring and reporting led to some dialogue around the possibility of collaboration between countries. A group of neighbouring countries working together to report the SDG indicators has worked previously, and would be greatly encouraged. GEMS/Water can potentially support cooperation between countries, for example by sending a representative to help with discussions, clarifications and the technical calculation and submission.

The difficulty of setting appropriate target values was raised, especially given that water bodies can have unique natural variability. It was emphasised again that target values should be set, if possible, for individual countries, for regions or even for individual water bodies. The same target value should be used by neighboring countries for transboundary water bodies; therefore cooperation between countries is extremely important.

Some countries felt that the potential benefits from reporting the SDG indicators were not obvious, especially when it is such a major undertaking, because of the large amount of data involved or perhaps because a monitoring network is not yet established. It was pointed out that countries themselves should use and benefit from the information generated, for example by using the results to improve monitoring programmes, or to show the value of monitoring to policy makers.

4.5 CAPACITY DEVELOPMENT FOR WATER QUALITY MONITORING AND ASSESSMENT

Deborah Chapman introduced the current GEMS/Water capacity development activities to support water quality monitoring for environmental assessments at national, regional and global scales. The key activities are training workshops, education programmes, and advice and support on request, including for SDG Indicator 6.3.2. Training workshops can focus on any aspect of the water quality monitoring and assessment process, as described on Day 2 of the workshop, or can be tailor made to suit the needs of a country or region. The educational programmes comprise a part-time, on-line MSc and Postgraduate Diploma in Freshwater Quality Monitoring and Assessment, as well as short on-line courses for continuing professional development. The educational courses are accredited by University College Cork and have heavily subsidised fees for participants in low-income countries. The SDG Indicator 6.3.2 *in situ* training focusses on monitoring programme design, target setting, water body delineation and indicator calculation. Webinars, on-line tutorials and short monitoring guidebooks are also being finalised as an additional form of capacity development. Citizen science, as a potential tool for increasing monitoring capacity in a country, is also being explored in Ireland and Africa.

4.6 DISCUSSION: CAPACITY DEVELOPMENT NEEDS IN THE REGION

There was considerable interest amongst the participants of the workshop in the capacity development activities of the GEMS/Water CDC. Participants from countries with limited freshwater monitoring activities expressed their desire to have further training in most aspects of water quality monitoring and assessment, quality assurance and the correct storage and use of data. The benefits of on-line access to training materials was discussed. Overall, the response was positive with on-line material being considered sufficient for many aspects of water quality monitoring and assessment.

The current limitation of offering capacity development for SDG Indicator 6.3.2 and the other activities predominantly in English limits accessibility in the West Asia and North Africa region. Arabic was suggested as an additional language.

The participants of the workshop together with the GEMS/Water team

5 WORKSHOP CONCLUSIONS

The workshop provided a good opportunity to demonstrate the importance of ambient water quality monitoring and the value of reporting for SDG Indicator 6.3.2 to contribute to determining the global status of ambient water quality. It brought together people from 11 different countries in the West Asia and North Africa region involved in freshwater quality monitoring, and with varying levels of capacity for monitoring and assessing freshwater bodies. Information about the current ambient water quality capacity needs and expectations was obtained. This will contribute to the development of future capacity development activities.

Data exchange between countries, GEMStat and SDG Indicator 6.3.2 was promoted and a collaborative approach was discussed in relation to the next SDG Indicator 6.3.2 data drive. There was a collective request for advice and support in the region to assist with reporting data for SDG indicator 6.3.2 in 2020. This could involve bringing the countries together again for training. The new relationships and connections made during the workshop may also lead to the countries with more developed monitoring practices advising and helping their neighbouring countries with less experience.

6 ANNEXES

Annex 1a – Participant List

Country	Name	Institution/Organisation
Bahrain	Hasan Ali Al Thawadi	Ministry of Works, Municipalities Affairs and Urban Planning
Egypt	Mr Mohsen Darwish	Central Laboratory for Environmental Quality Monitoring, National Water Research Centre, Ministry of Water Resources and Irrigation
Jordan	Ahmed Aluleimat	Ministry of Water & irrigation
Jordan	Basim Hasan	Ministry of Water & Irrigation
Lebanon	Nassim Abou Hamad	Litani River Authority
Morocco	Mrs Lalla Khadija Ghedda	Head of Water Governance and Basin Management
Palestine	Mrs Azhar Ghbeish	Palestinian Water Authority
Sudan	Mrs Nadia Shakak	Ministry of Irrigation and Water Resources
Syria	Mrs Dareen Sulieman	Ministry of Local Administration & Environment
Tunisia	Olfa Sebai	National Agency for Environmental Protection
UAE	Mr Naser AlKatheeri	Ministry of Energy & Industry
Mauritania	Mr Mohamed Abdellahi Ali	Ministry of Water & Sanitation
Jordan	Mohammad Al Dewiri	Ministry of Water & Irrigation
Jordan	Muna Al Shunnaq	Ministry of Water & Irrigation / Strategic Planning
Jordan	Maher Hrishat	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Refaat Bani Khalaf	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Mr Mohamed Tawfik	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Mr Mohiuddin Hussein	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Yousef Abu Nawas	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Dr Mohammad Rushdi	Jordan Valley Authority/Laboratory
Jordan	Jumana Al-dwiri	Jordan Valley Authority
Jordan	Samah Al Salhi	Water Authority of Jordan/Laboratory & Quality Sector
Jordan	Lama Saleh	Water Authority of Jordan/Laboratory & Quality Sector

Annex 1b - GEMS/Water Staff

Name	GEMS/Water Centre
Deborah Chapman	GEMS/Water Capacity Development Centre
Katelyn Grant	GEMS/Water Capacity Development Centre
Dmytro Lisniak	GEMS/Water Data Centre
John Weatherill	School of Biological, Earth and Environmental Science, University College Cork

Annex 2 – Workshop Programme

Regional Workshop for West Asia and North Africa
Ambient water quality: monitoring for management and SDG Indicator 6.3.2 reporting
16 – 18 December 2019 Amman, Jordan

Day 1	**Registration, welcome, objectives of workshop and introduction to GEMS/Water and national activities**	
08:30-09:00	Registration	
09:00-09:30	Opening of the Workshop and welcome remarks	Hartwig Kremer UNEP GEMS/Water; Host country representative; Irish Embassy representative
09:30-09:45	Introduction of participants	Participants
09:45-10:00	Objectives of the workshop and expected outcomes	Deborah Chapman, GEMS/Water
10:00-10:30	Coffee and tea break	
10:30-11:00	Overview of the GEMS/Water Programme and future plans	Hartwig Kremer, UNEP GEMS/Water
11:00-12:30	Presentations by National Focal Points (NFPs) - country and regional representatives (max 10 min each)	Participants
12:30-14:00	Lunch	
14:00-15:30	Continuation of presentations by National Focal Points (NFPs) - country and regional representatives (max 10 min each)	Participants
15:30-16:00	Coffee and tea break	
16:00-16:30	Continuation of presentations by National Focal Points (NFPs) - country and regional representatives (max 10 min each)	Participants
16:30-17:00	Group discussion and summary	
Day 2	**Technical aspects of water quality monitoring for management**	
08:30-09.15	Approaches to ambient water quality monitoring	Deborah Chapman, GEMS/Water and John Weatherill, UCC
09:15-10:00	Programme design and network development	Deborah Chapman, GEMS/Water and John Weatherill, UCC
10:00-10:30	Coffee and tea break	
10:30-11:15	Quality assurance for water quality monitoring	Deborah Chapman, GEMS/Water
11:15-12:30	Discussion: Challenges to water quality monitoring for management of freshwater resources in the region	
12:30-14:00	Lunch	
14:00-15:30	Storage and quality control of water quality monitoring data	Dmytro Lisniak, GEMS/Water
15.30-16.00	Coffee and tea break	
16.00-16:30	GEMStat data submission and sharing of data	Dmytro Lisniak, GEMS/Water
16:30-17:00	Discussion: Challenges to management of national water quality monitoring data in the region	

Day 3	**Sustainable Development Goal 6 and the indicator for water quality, SDG 6.3.2**	
08:30-09:00	Introduction to IMI and SDG 6	Deborah Chapman GEMS/Water
09:00-10:00	SDG Indicator 6.3.2 Methodology: development, implementation and preparation for the next data drive	Katelyn Grant, GEMS/Water
10:00-10:30	Coffee and tea break	
10:30-11:30	SDG Indicator 6.3.2 Data submission and future reporting	Dmytro Lisniak, GEMS/Water
11:30-12:30	Discussion: Challenges in monitoring and reporting SDG 6.3.2 in the West Asia region	
12:30-14:00	Lunch	
	Capacity development needs for water quality monitoring in the West Asia region	
14:00-14:30	Presentation of current GEMS/Water capacity development options	Deborah Chapman, GEMS/Water
14:30-15:30	Discussion of capacity development needs in the region	
15.30-16.00	Coffee and tea break	
16.00-16.30	Workshop conclusions and recommendations	
16.30	Close of workshop	

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%	3	18%	14	82%
2	The content of the workshop was relevant to you	0	0%	0	0%	0	0%	7	41%	10	59%
3	The workshop introduced you to the purpose of GEMS/Water	0	0%	0	0%	3	18%	6	35%	8	47%
4	My country does already, or will in the future, share data with GEMStat	0	0%	0	0%	3	18%	8	47%	6	35%
5	The workshop will enable you to prepare for reporting SDG indicator 6.3.2	0	0%	0	0%	2	12%	9	53%	6	35%
6	Capacity development currently offered by GEMS/Water is useful and relevant	0	0%	0	0%	1	6%	10	59%	6	35%
7	Presentations were generally clear and well presented	0	0%	0	0%	0	0%	5	29%	12	71%
8	The logistics of the workshop were well organised	0	0%	1	6%	0	0%	7	41%	9	53%
9	Accommodation and travel was satisfactory	3	17.6%	0	0%	1	5.9%	3	17.6%	10	59%

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

All topics were useful.	SDG Indicator 6.3.2 reporting mechanism	IMI 6 and SDG Indicator 6.3.2 in general	Data Storage and Quality Control	Quality Assurance	The experiences of other countries	No comment
10**	1	4	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?

No, all were of interest	Yes, some was of little interest or use in current role	Data Storage	Data sharing	Data analysis	No comment
6	3	1	1	1	5

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

No/No comment	More detailed examples like those in Dmytro's presentations	Field visit to a site	GIS applications in water quality management	Risk assessments	Drinking water and treatment	Data reporting exercise
11	1	1	1	1	1	1

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

None/No comment	Exchange Indicator 6.3.2 results between countries	Practice the theory in working groups	Visit laboratories	Increase length	Include more examples related to the topics
8	1	3	2	2	1

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

Thank you for organising the workshop and for the high standard.
Include more topics, increase the number of participants.
Yes, more detail about 6.5.1 and 6.6.1. Thank you, hope to go to another one.
Recommend adding one day for study tour in host country (e.g. visit WQ laboratory or dam).
Provide a hard copy of the workshop objectives and agenda.