World Health Organization

Meeting report

# Report

## JMP Technical Task Force Meeting on Monitoring Drinking-water Quality

16-18 November 2010

Chateau de Pizay, Villié-Morgon, France

## WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP)

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## Introduction

On 16, 17 and the morning of 18 November 2010, a Technical Task Force meeting of the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) was held at the Château de Pizay, Villié-Morgon, France. Fifteen international technical experts, four resource persons and two members of the JMP/GLAAS (Global Analysis and Assessment of Sanitation and Drinking-water) Strategic Advisory Group joined the JMP team members from UNICEF and the WHO in discussing a number of technical issues that relate to the monitoring of drinking-water quality in the context of the JMP efforts to monitor progress towards achieving the MDG target for drinking water and sanitation. A list of meeting participants is presented in Annex 1.

## Objectives

The Task Force on Monitoring Drinking-water Quality was established with the following Terms of Reference:

1. To review the current status of global monitoring by the JMP with respect to drinking-water quality and to determine the scope and focus of future drinking-water quality monitoring efforts within the context of the JMP mandate;
2. To review what options exist to strengthen drinking-water quality monitoring as part of the JMP activities within the MDG period and beyond;
3. To review experiences in drinking-water quality monitoring, in particular the JMP Rapid Assessment of Drinking-water Quality (RADWQ);
4. To review the options of new, rapid, direct measuring tools for drinking-water quality and their potential value for JMP;
5. To consider the role of sampling and statistical techniques to ensure the most cost-effective of national measurements feeding into a consistent global picture;
6. To make recommendations on the adoption of methods and procedures, on the need for further studies and pilots and on the linking to on-going activities in the field of drinking-water quality monitoring and surveillance at national and international levels.

Within this overall mandate, the Task Force was asked to address four sets of questions:

1. On rationale, scope and focus

    - For what purpose will JMP as a global monitoring mechanism compile information on drinking-water safety and drinking-water quality? What interests do, in particular low- and middle-income, countries share in the compilation of information on drinking-water safety and drinking-water quality at source or at household level?

    - What are the essential components of drinking-water quality monitoring and surveillance, what is the scope of the terms “drinking-water quality” and “drinking-water safety” in the context of the JMP mandate and what are the boundaries for the measurement of drinking-water quality indicators?

2. On what should be measured

   - What are feasible options for the direct measurement of drinking-water quality parameters that will usefully supplement the JMP datasets on access and use of drinking-water sources? What are the feasible options for assessing drinking-water quality through proxy (process) indicators that go beyond the current improved/unimproved categories (e.g. determining the number and coverage of functional water safety plans)? Would such an approach be compatible with the remit of the JMP?
   - What are the practical considerations for possible inclusion of drinking-water quality testing in MICS or DHS? What are the minimum drinking-water quality parameters that should be measured following a household sample survey approach?

3. On the RADWQ experience

   - What are the lessons learned from the RADWQ experience? RADWQ collected drinking-water quality samples at the source and at the point of use, in addition to performing sanitary inspections. Should drinking-water samples be taken at the point of use only, at the source only or at both? Should a sample survey approach include sanitary inspections?
   - Is the package of indicators measured by RADWQ adequate? Can the findings of RADWQ be applied to individual survey data for the RADWQ countries and beyond?
   - Are the costs incurred by a RADWQ type of water quality survey approach proportionate to the value of the information it yields? Is a household sample-based approach cost-effective compared to other options? If not, what options are more cost-effective? If it is more cost-effective, then what should be the frequency of a RADWQ type survey for global monitoring purposes and for country-level monitoring purposes?

4. On methods, procedures and tools

   - What are the optimal sampling techniques for the efficient measurement of drinking-water quality indicators? What are the contextual impediments towards a sampling and surveillance approach in different parts of the world, and how could they be overcome or compensated by statistical methods? Is there a role for data-sharing and management tools? Can the results of a limited number of nationally representative water quality surveys be used to extrapolate water quality information for a larger cluster of comparable countries?
   - Can the results of routine surveillance and monitoring by national regulatory bodies be adopted and consolidated into global and regional data? What level of harmonization can be achieved between these national processes? Alternatively, can monitoring and surveillance methods applied by national regulatory bodies be adopted and integrated into the JMP monitoring activities and how can experience and lessons learned be incorporated? What are the constraints and what are the opportunities? Is there a role for the WSP quality assurance tool?
   - What is the profile of the ideal tool for direct measurement of drinking-water quality? What are the new low cost rapid assessment tools currently under investigation and development? What criteria should they meet to be useful with respect to the JMP objectives?

## Background

The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) aims to accelerate progress towards universal, sustainable access to safe drinking-water and basic sanitation by 2025, including the achievement of the MDG target by 2015 as a key milestone. It wants to be the trusted source of global, regional and national data on sustainable access to safe drinking-water and basic sanitation, for use by governments, donors, international organizations and civil society.

As the official instrument to measure progress towards achieving the MDG 7 target C (*by 2015, to halve the proportion of people without sustainable access to safe drinking-water and basic sanitation*) the JMP lists among its strategic objectives: "To serve as a platform for the development of indicators, procedures and methods aimed at strengthening monitoring mechanisms to measure sustainable access to safe drinking-water and basic sanitation at global, regional and national levels."

Many countries lack the capacity to generate, periodically, reliable and nationally representative information on drinking-water quality. In the absence of such information, the MDG indicator for access to safe drinking-water distinguishes between the use of 'improved' and 'unimproved' sources of drinking-water. The designation 'improved' implies an acceptable level of probability that the source provides drinking-water that is safe. Studies have found repeatedly, however, that drinking-water from 'improved' sources does not necessarily meet the microbiological or chemical health-based guideline values established by the WHO Drinking-water Quality Guidelines, and can therefore not be considered "100% safe" (few studies have looked at the safety of drinking-water from unimproved sources; such studies would likely reveal that some unimproved sources in fact provide safe drinking-water).

In 2004/2005, the JMP conducted a set of pilot studies in six countries referred to as the Rapid Assessment of Drinking-Water Quality (RADWQ). These pilot studies tested drinking-water quality for seven parameters at both the source and at point of use. It also included a sanitary inspection for each of the drinking-water sources and usage points to map out and assess the risk factors for contamination of the water. The pilot was designed according to a cluster-based sample survey approach, similar to the design of two major international household surveys, the Multiple Indicator Cluster Survey (MICS) and the Demographic and Health Survey (DHS), which are key sources for JMP datasets.

The overall objective of the RADWQ was to test the value and feasibility of the sample survey-based approach, using field-based drinking-water quality testing to assess drinking-water quality and obtain reliable information that could be matched with the data on use of drinking-water sources obtained by household surveys.

The approach proved to be technically feasible and reliable in different national settings. Concerns have been raised about the cost of conducting similar assessments on a recurrent basis in multiple countries, but detailed comparative cost analyses have not been carried out and the required frequency and scope have not been determined. In one of the countries where the RADWQ was piloted, a middle-income country, the findings to a large extent matched the findings of the regular water quality surveillance system.

Both MICS and DHS have expressed an interest in complementary drinking-water quality information alongside the datasets resulting from their surveys. If this could be initiated, the JMP eventually would also be in a position to report on actual drinking-water safety as intended by the MDG drinking-water target.

There continues to be a demand from JMP clients to address aspects of water quality, reliability of services and affordability of access in a more adequate way, ensuring that the resulting information is nationally representative and comparable between countries. These issues are pertinent not only for the remaining MDG period, but also with a view to the post-2015 period.

In response to this demand, it was decided to establish a JMP Task Force on Monitoring Drinking-water Quality. In broad terms, its composition reflects the perspectives, interests and experience of three stakeholder groups: water quality regulators, water quality scientists and sampling/survey/statistical experts.

## Opening session

Peter Harvey (UNICEF) opened the Task Force meeting, placing it within the broader JMP Strategy 2010-2015, and linking it to the other Task Forces (Sanitation and Methods; Monitoring in Low-income (Peri-)-urban Settings), as well as to the recommendations by the JMP/GLAAS Strategic Advisory Group. The Terms of Reference for this Task Force were read out. Robert Bos (WHO) led a round of introductions and stressed the diversity of the group, and the opportunity for a dialogue that otherwise would not take place. The meeting agenda was reviewed and approved by the group. The approved agenda is presented in Annex 2.

## Proceedings

The meeting was co-chaired by two members of the JMP/GLAAS Strategic Advisory Group: Gareth Jones and Gérard Payen. All discussions were held in plenary and followed a sequence of twelve specific questions, framed in the approved agenda. Facilitation of the sessions was shared between members of the JMP team and resource persons. Richard Johnston served as the rapporteur for this meeting.

Each session began with a presentation on the review topic by a member of the WHO/UNICEF JMP team, after which the floor was opened for questions, comments and debate by the technical experts and other members of the Task Force. Each session concluded with a summary of the Technical Task Force's review findings and recommendations.

The following sections of the report provide a summary of the main elements of the discussions, findings and recommendations for each of the four sets of questions.

### 1. Rationale, scope and focus

- For what purpose will JMP as a global monitoring mechanism compile information on drinking-water safety and drinking-water quality? What interests do, in particular low- and middle-income, countries share in the compilation of information on drinking-water safety and drinking-water quality at source or at household level?

- What are the essential components of drinking-water quality monitoring and surveillance, what is the scope of the terms "drinking-water quality" and "drinking-water safety" in the context of the JMP mandate and what are the boundaries for the measurement of drinking-water quality indicators?

## Background and presentation

Two presentations by WHO and UNICEF staff described the Joint Monitoring Programme, and the Water Safety Framework for managing water quality. Five presentations were made by regulators.

### *Presentation: JMP overview*

Rifat Hossain and Rolf Luyendijk jointly presented the WHO/UNICEF Joint Monitoring Programme. The JMP is the official mechanism for monitoring progress towards the Millennium Development Goal Target 7C, "to halve, by 2015, the proportion of people without sustainable access to safe drinking-water and basic sanitation." The principal mandate of the JMP is to collect and compile nationally representative data for water and sanitation access indicators, and to analyze and present the data in such a way that inter-country comparisons can be made.

The JMP predates the Millennium Development Goals and formerly compiled global data on water and sanitation coverage using simple questionnaires filled out at the national level. Prior to 2000, coverage data were based on information provided by Ministries of Health in response to annual questionnaires which asked about current coverage levels. The quality of the information varied considerably and different sources often gave highly inconsistent figures. A revolutionary shift was made in 2000, to use, instead, data collected through household sample surveys and national censuses. The JMP does not directly field any surveys itself; its role is to collect and compile surveys supported by others. Such surveys notably include the Demographic and Health Surveys (DHS), which are partially funded by USAID; and the Multiple Indicator Cluster Surveys (MICS), supported by UNICEF. These cluster surveys are carried out in most developing countries every 3-5 years, and DHS and MICS teams coordinate both survey timing and content closely. Other national surveys also contribute to JMP datasets, including censuses, the World Health Survey, the Living Standard Measurement Survey, the Core Welfare Indicator Questionnaire, Household Budget Survey and reproductive Health Surveys. In high-income countries where DHS, MICS and other such surveys are not fielded, the JMP makes use of coverage data from national reporting systems.

While the text of the MDG Target 7C makes reference to "safe" drinking-water, the concept of drinking-water safety is not well defined and national surveys are only able to collect simple proxy indicators of drinking-water safety. Indeed, the phrase "sustainable access" is also inadequately precise, and may include dimensions such as time required for collection; temporal availability of water supplies over days or seasons; and affordability, which are not currently captured in household surveys. As an interim measure, the JMP has classified water sources and sanitation facilities into "improved" and "unimproved" categories. The underlying assumption is that water collected from "improved sources" is more likely to be "safe drinking water" than water collected from "unimproved sources". This classification system has the advantage of being relatively simple to adopt into national household surveys such as the MICS and DHS, and can also be applied retroactively to surveys done before 2000 which often allow for such classification by facility type. The JMP recognizes the evidence that water from some improved sources is unsafe to drink, and that conversely some water taken from unimproved sources may be of good quality (especially if water is treated at the household level).

### *Presentation: The WHO Water Safety Framework*

Bruce Gordon presented the WHO Framework for Drinking-water Safety (referred to as the "Stockholm Framework") which was articulated in the third edition of the WHO Guidelines for Drinking-Water Quality (2004) and represents a major shift from reactive to preventive action. The Framework consists of three main components:

- The setting of health-based targets by a national regulatory body, as described in the WHO *Guidelines for Drinking-water Quality* (fourth edition).
- Risk assessment and management in water supply through Water Safety Plans.
- Independent surveillance.

The proposed use of Water Safety Plans as an instrument for implementation of the Drinking-water Quality Guidelines implies a good understanding of the various steps in the water supply chain from catchment to consumer, and a capacity to assess where and when water quality can be compromised. By understanding all the steps in a system, risks can be identified and prioritized, and control measures put in place to prevent failures, based on a multi-barrier approach. The concept can be applied to basic or advanced systems. A major benefit of the system analysis is identifying and prioritizing areas where improvements should be made, thereby allowing more effective investment planning for system improvements. The Water Safety Framework explicitly encourages incremental improvements in water quality management, which aligns with the call of the Human Rights Council for Sates "to achieve *progressively* the full *realization* of human rights obligations related to access to safe drinking water and sanitation."

Water quality monitoring by water suppliers will be part of Water Safety Plans, but independent surveillance is also a critical component of the framework. The purpose of surveillance is not only to show that individual supplies are providing safe water, but also to verify that the water quality management practices which make up the Water Safety Plan are in fact effective. Surveillance serves as a check on the sector as a whole, in addition to confirming performance of individual supplies.

It is quite possible that results from national surveys such as MICS and DHS could give valuable feedback to those implementing Water Safety Plans. It is also conceivable that the existence or quality of Water Safety Plans could be taken as a proxy indicator of drinking-water quality, and could be used by the JMP to obtain better estimates of water quality in national surveys.

### *Presentations from regulators*

Regulators from Canada (Véronique Morisset), Kenya (Robert Gakubia), Mozambique (Manuel Carrilho Alvarinho), Portugal (Luis Simas), and the United Kingdom (Marcus Rink) presented some of their experiences with drinking-water quality monitoring. One common thread was the importance of clear institutional responsibilities. Another consistent message was that water quality monitoring was important at the national level, insomuch as it allows regulators to identify and improve areas of weakness. For this purpose, quantitative water quality measurements are much more useful than simple pass/fail tests. In most cases, regulators rely on water suppliers to carry out their own testing and to report results to the regulator at specific intervals.

Regulators have their own water quality monitoring systems, which serve the purpose of verifying data generated by suppliers. These systems may not be random, but may systematically target areas where poor performance could be expected.

## Technical Task Force Review

The Task Force considered the question for what purpose drinking-water quality data should be collected, and what different needs are at play at global and national levels.

### *Human Rights Perspective*

Water quality is also one dimension of the human right to safe water and sanitation, which was recently reconfirmed by the United Nations. On 28 July 2010, the United Nations General Assembly passed Resolution 64/292, which recognizes the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights. On 6 October 2010, the United Nations Human Rights Council passed Resolution 15/9 which calls upon States:

(a) To develop appropriate tools and mechanisms, which may encompass legislation, comprehensive plans and strategies for the sector, including financial ones, to achieve progressively the full realization of human rights obligations related to access to safe drinking water and sanitation, including in currently unserved and underserved areas;

(b) To ensure full transparency of the planning and implementation process in the provision of safe drinking water and sanitation and the active, free and meaningful participation of the concerned local communities and relevant stakeholders therein;

(c) To pay particular attention to persons belonging to vulnerable and marginalized groups, including by respecting the principles of non-discrimination and gender equality;

(d) To integrate human rights into impact assessments throughout the process of ensuring service provision, as appropriate;

(e) To adopt and implement effective regulatory frameworks for all service providers in line with the human rights obligations of States, and to allow public regulatory institutions of sufficient capacity to monitor and enforce those regulations;

(f) To ensure effective remedies for human rights violations by putting in place accessible accountability mechanisms at the appropriate level.

The Task Force considered that in the future these mandates will guide States towards more comprehensive and transparent monitoring of drinking-water quality, for use at both national and global levels.

### *Global needs*

At the global level the primary need for drinking-water quality data is to advocate for increased attention to the provision of drinking-water to the world's population that is actually *safe*, as specified in the current MDG drinking-water target. In the context of the Millennium Development Goals, it is important to have standardized, objective criteria whereby useful country comparisons can be made, and data from countries can be aggregated meaningfully to regional and higher levels. The need for international comparisons will continue after the MDG target deadline of 2015. Generally speaking, credible data about water quality can help to set international as well as national development policies and priorities.

The introduction of the 'improved/unimproved' classification to JMP reporting since 2000 has represented a major step forward in reflecting water quality in global monitoring. However, while the JMP has scrupulously noted that this is an imperfect metric of 'safe water', the two terms are widely conflated. Indeed, the UN General Assembly made this very error in its statement on the human right to safe water and sanitation, when it referred to 884 million people 'without safe drinking-water' instead of 'without an improved drinking-water source'.

As noted above, global monitoring systems such as the JMP could in the future contribute to monitoring of the fulfillment of the human right to safe water and sanitation.

### *National needs*

At the national level drinking-water quality data are seen as valuable indicators of how well national policies and regulations are being met. With this driver, national stakeholders are principally interested in water quality data to help to identify and correct deficiencies. This implies that for the data to be useful, they must be meaningful at sub-national levels, and ideally at the level of the water scheme. The types of data required may be different from those prioritized for global monitoring: it must be possible to clearly link national level water quality data to corrective actions in individual supply systems as well as to general public health concerns.

An example from Mozambique was given. While nitrate levels are routinely monitored in that country, water suppliers have few options for introducing corrective measures if regulatory limits are exceeded. Mozambique regulators see little value in such monitoring in the absence of capacity for subsequent remedial action. Similarly, quantitative measures of microbial contamination are much more valuable than simple pass/fail indications which might serve well for global purposes, in that they give more information to support the planning of corrective measures.

National regulators see water quality measurements as one tool in their toolbox, with the overall goal of ensuring delivery of safe drinking-water. In settings where regulatory and monitoring systems are well developed, monitoring water quality data is not the most important tool, since in the vast majority of cases measurements are within compliance. Countries like the United Kingdom and Canada must interpret thousands (or even millions) of water quality tests indicating good water quality, with only a handful of samples out of compliance. Such datasets do not easily lend themselves to improving water quality management - the problem of 'too many zeros'. On the other hand, in countries where water quality management is less advanced, intense water quality surveillance could potentially reveal problems and guide prioritization of remedial interventions, but might be beyond the capacity of suppliers and regulators. In both scenarios other risk management tools (e.g. regulation and verification of operator activities) become more important. This is consistent with the Water Safety Plan concept as described in various WHO reports.

Water Safety Plans, or some systematic approach to risk assessment and management, could also be considered as an indicator of drinking-water quality. The Task Force considered that national surveillance and Water Safety Plans have strong potential linkages, and that the institutionalization of Water Safety Plans does indicate at least some level of institutional commitment to water quality management. Nonetheless, the Task Force did not recommend that the presence of Water Safety Plans could be formally incorporated into JMP monitoring, noting that the "formal presence" of a Water Safety Plan is not necessarily a reliable indicator for either the Water Safety Plan's adequacy/quality or its degree of implementation in practice.

However, national data collection systems used for JMP reporting could also play the important role of independent surveillance of Water Safety Plans. Task Force members noted that Water Safety Plans are more common in urban areas, and very rare for unimproved sources, so large proportions of populations will not be easily reached by Water Safety Plans in the near future. Data from small decentralized Water Safety Plans are also not easy to aggregate for meaningful analysis at the national level.

The classification of 'improved/unimproved' has not been particularly useful at the national level, and some countries have relatively little awareness of or concern for global definitions of improved and unimproved sources. A range of national reactions to JMP data were discussed – the JMP has spent much effort in reconciliation of global data with country-level data. This harmonization has been a useful exercise but in some countries agreement has not been reached and some national stakeholders remain unhappy with JMP reports.

The issue of water as a human right applies at the national level as well: all nations have a duty to ensure that their citizens can fulfill their right to safe water and sanitation, and increasingly countries are referring to the human right to water and sanitation in constitutions, policies and legislation.

## Technical Task Force Summary and Recommendations

The Task Force recognized that JMP data are valued globally, and that their main mandate and purpose is for global monitoring, advocacy and international comparisons. The JMP is the principal global monitoring mechanism on access to water. As such its reporting scope must include all necessary pieces of information about access to water and not only report on a single pass/fail indicator that is designed to monitor a time-bound, temporary policy.

The Task Force noted the value of the current 'improved/unimproved' classification system as a proxy indicator for drinking-water quality, and that the shift made towards this classification in 2000 had been a significant improvement. However, the classification is limited and further improvements are necessary. In some way, greater efforts must be made to communicate the difference between 'safe water' and the proxy indicators which are measured by the JMP.

The Task Force commented that the current survey method actually measures 'use' (or at least 'reported use') of water from improved sources, rather than 'access to' such sources.

Though beyond the scope of this meeting, the Task Force anticipated that 'second generation' indicators will be developed not only for water quality, but also for other aspects of the Human Right to Water and Sanitation including accessibility, availability and affordability.

Ideally, an improved indicator would be easy to measure, unambiguous, verifiable, acceptable, policy-relevant and developed with participation from stakeholders. It is important that indicators meet the needs of national governments. For JMP purposes, indicators should be globally applicable, be inter-country comparable and should reach back to 1990. But, clearly, such data have not yet been collected and it would be a mistake to limit new efforts in data collection to indicators which compare directly to 1990 levels.

### JMP response

JMP staff acknowledged that new indicators could be developed for future global targets which are not directly comparable to 1990 baselines, and that new baselines can be established for such indicators.

## 2. What should be measured

- What are feasible options for the direct measurement of drinking-water quality parameters that will usefully supplement the JMP datasets on access and use of drinking-water sources? What are the feasible options for assessing drinking-water quality through proxy (process) indicators that go beyond the current improved/unimproved categories (e.g. determining the number and coverage of functional water safety plans)? Would such an approach be compatible with the remit of the JMP?

- What are the practical considerations for possible inclusion of drinking-water quality testing in MICS or DHS? What are the minimum drinking-water quality parameters that should be measured following a household sample survey approach?

### Background and presentation

#### *Presentation: Water quality testing in national surveys*

Fred Arnold, speaking on behalf of the Demographic and Health Surveys (DHS) and frequently pointing out the parallels between the DHS and MICS surveys, presented a review of the DHS, which serve as one of the main sources of data for the JMP. More than 260 DHSs have been fielded in 90 countries since 1984. There have only been a few experiences with water quality testing in DHS: the 2004 Bangladesh DHS included testing household water for arsenic using field kits; the 2000 Peru DHS included measurement of residual chlorine; the 2011 fieldwork in the Peru Continuous DHS will include a measurement of faecal contamination, using the $H_2S$ assay in a MPN format. Biomarkers are, however, routinely measured, especially in areas where malaria or HIV are endemic. Much of the experience with collecting blood and urine samples can inform new plans for water quality testing in these surveys.

One issue that would affect data comparability in water quality testing is the **sample location**. Water samples could be collected from a point source outside the household, a household tap, household water storage containers, or from drinking vessels. Each of these sites might have different water quality characteristics.

A second issue is the problem of **seasonal variability**. Most DHS (and MICS) surveys are conducted during the dry season, to facilitate transport and logistics. However, water quality varies seasonally and in many settings is worse in rainy seasons. Even if one attempts to minimize inter-year variation by always conducting surveys in the same season, local variations in weather can lead to very different field conditions, which may make data less comparable or even misleading..

The main purpose of the DHS is to collect Demographic and Health information, covering a wide range of topics. Questionnaires are complicated, and have more than 600 questions, which can take hours to complete. Adding extensive questions or side visits (e.g. visiting water sources as well as household water points) could reduce the number of sites which could be covered in a day, or result in undue respondent fatigue. The logistics of field work are challenging, especially when biomarkers are to be collected. Any **additional burden on enumerators** must not compromise their data collection. Even the space requirements of additional water quality testing personnel or equipment could put serious strains on field teams.

**Environmental and health issues** could arise, related to the safe handling and disposal of biologically contaminated samples and/or reagents. Some water quality testing materials could require special disposal.

Finally, there are important **ethical considerations**: what duty do surveyors have to report back to households the results of water quality testing? If water quality problems are found, what duty do surveyors have to counsel households about health risks and potential remedial actions? The DHS has experience with linked surveys (e.g. households are informed of their malaria status) but also with unlinked surveys (e.g. HIV test samples are delinked from household identifiers such that DHS can never identify individual test results, and no report is made back to the person tested).

In spite of all these caveats, DHS is interested in improving water quality monitoring in household surveys. It was initially considered far too complicated to measure urine and blood samples through the DHS, but these are now routine, if not simple. Water quality testing could follow a similar process.

## Technical Task Force Review

The Task Force began by recognizing the value of adding direct measurements of drinking-water quality to JMP datasets. However, the question of 'what parameter(s) should be measured' is highly context-specific. Both the type of data to be collected and the means of data collection will vary depending on the capacity of the water quality management systems in the country. The Task Force recognized the difficulties of collecting data which are globally comparable, while at the same time meeting the specific needs of each country.

### *What parameters to report*

The Task Force recalled the text of the MDG target, which refers to *"…sustainable access to safe drinking-water."* Ideally, global data should report the proportion of the population which has access to drinking-water at all times throughout the year, month and day, which meets relevant standards. Such data are impossible to collect, and suitable proxy indicators must be used instead. The question of 'access' was taken to be outside the scope of the current Task Force and to be, in a certain sense, captured by the 'improved/unimproved' metric. This Task Force should rather focus on the issue of 'water safety'.

'Safe drinking-water' is defined by the WHO as drinking-water which "*does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.*" (WHO, 2004, p. 1). Water quality measurements should be seen as imperfect proxies of 'safe water', and will necessarily evolve and improve over time.

The 'Improved/unimproved' classification can be seen as a first step on a water quality monitoring ladder, or pyramid, in which the number of parameters monitored, as well as the frequency and sophistication of monitoring, increase along with the capacity of the sector. An example of such a pyramid is given below. Priority chemicals to measure as monitoring becomes more sophisticated will depend on specific national circumstances. Note that the bottom of the pyramid, with '000', represents the unfortunate situation prevailing in too many countries where there is essentially no monitoring of water quality.

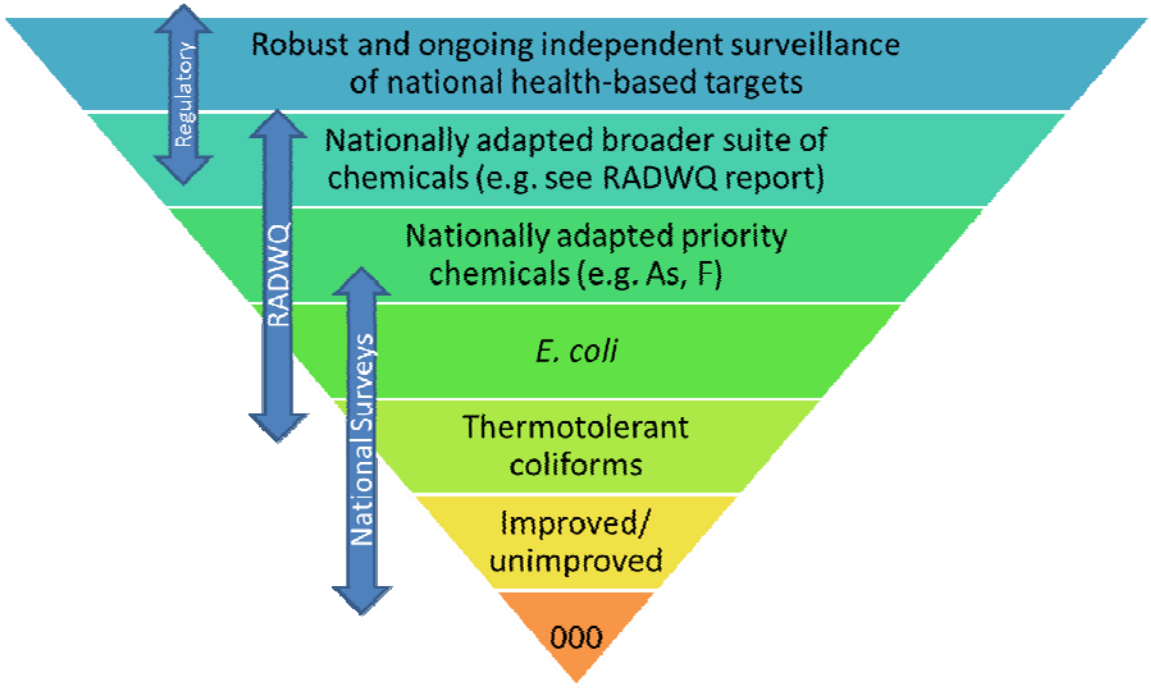


**Figure 1. Inverted pyramid reflecting the increasing level of sophistication in monitoring in contexts of increasing socioeconomic standards, in terms of numbers and complexity of parameters measured and frequency of the measurement.**

The Task Force recognized the primacy of microbial water quality in relation to public health. Microbial water quality measurements are also critical in that they can identify failures or different components of water supply systems, and thus lead to corrective actions. Different microbial indicators were discussed, and it was agreed that faecal contamination is the main public health threat, and that *E. coli* remains the best currently available indicator of faecal contamination. New enzymatic methods have made quantification of *E. coli* simpler, cheaper and more robust. Thermotolerant coliforms are an inferior but still acceptable proxy indicator. The hydrogen sulfide ($H_2S$) assay provides an alternative proxy indicator of faecal contamination, but is not as well characterized, nor as specific, as thermotolerant coliforms or *E. coli*.

A first priority, therefore, should be to establish monitoring of *E. coli* in drinking-water. As monitoring becomes more sophisticated, greater temporal density will give a more defined indication of drinking-water quality, but even occasional snapshots would represent an important step forward where water quality monitoring is scarce.

Where microbiological testing is done, Sanitary Inspections of sources could add valuable information by identifying key risk factors and about what corrective measures should be prioritized. Information gleaned from Sanitary Inspection is more likely to be useful at national or local levels, rather than for global reporting purposes.

The second priority should be given to two naturally occurring chemicals which can cause serious health problems: arsenic and fluoride. The public health burden of these two chemicals far exceeds that of other chemical contaminants in drinking-water, but globally it is dwarfed by the public health impact of microbial contamination. Since the discovery of arsenic in Bangladesh, many countries have done at least some chemical testing, but in many cases there is little or no information about arsenic and fluoride in drinking-water.

The Task Force recalled that the issue of water quality in JMP figures took on special significance upon the discovery of widespread arsenic contamination of groundwater in Bangladesh. Although more than 97% of the Bangladesh population has access to drinking-water through boreholes/tubewells (an improved source), naturally occurring arsenic contamination affects much of the shallow aquifer which the boreholes tap. It would have been improper to report that Bangladesh had nearly universal coverage and had already met the MDG Target for drinking-water, while at the same time global attention was focused on the arsenic calamity. The JMP considered available hydrogeological surveys which estimated 27% of shallow boreholes contained arsenic above the national standard of 50 µg/L. Accordingly, a recalculation of 'safe coverage' was made for both baseline and current figures. Estimates were revised a few years later when a second, larger, borehole survey found only 20% exceeding the national standard. A further adjustment may be made, as the 2009 MICS included a measurement of arsenic in household drinking-water, and found only 13% above the national standard. It should be noted that the adjustments have been made with reference to the proportion of water meeting national standards, which are less strict than the WHO provisional guideline value of 10 µg/L.

After arsenic and fluoride, a next level of priority parameters is well expressed in the suite of critical parameters described in the RADWQ handbook for basic or initial assessments:

- Thermotolerant coliforms, faecal streptococci
- Turbidity, conductivity
- Arsenic, fluoride, nitrate, iron, residual chlorine (for treated supplies)
- Sanitary inspection

These parameters should be locally adjusted to reflect national risks and priorities. Higher in the water quality monitoring ladder different chemical parameters could be included according to national conditions and standards.

### *What standards to apply*

Apart from the question of which parameters to report, careful thought must be given to how to report water quality results, in the context of differing drinking-water standards. Especially for chemical parameters, legally acceptable limits may range widely, in some cases even within the same country. This does not necessarily reflect poor policy: different standards may be appropriate in different settings, depending on many factors such as:

- Relative importance of drinking-water as an exposure route.
- Extent of contamination.
- Practical quantification limits.
- Practical ability of water suppliers to remove the contaminant.
- Economic implications of compliance.
- Feasibility of standard enforcement.

Two prominent examples are fluoride, where standards range at least from 0.7 mg/L (Jordan) to 4.0 mg/L (USA), and arsenic, where standards range at least from 7 µg/L (Australia) to 50 µg/L (many countries, including Switzerland). Microbial standards are more uniform – most countries require no detectable indicator bacteria (typically thermotolerant coliforms, or *E. coli*) per 100 mL sample. However, some countries use different indicator bacteria (the standard in China is based on total coliforms) and many allow some proportion of positive results in small systems.

When compiling data for international comparisons, it is important to ensure that data are comparable. One approach for global harmonization would be to simply report compliance with the guideline values in the WHO Guidelines for Drinking-Water Quality (WHO, 2004). This approach has the benefit of being scientifically neutral but could cause political difficulties. For example, the JMP would consider US populations drinking more than 1.5 mg/L fluoride, or Chinese populations drinking more than 10 µg/L arsenic as non-compliant, even though their drinking-water meets all national standards. Task Force members noted that the WHO guideline values are periodically updated – in the near future the values for Se, U, and B are likely to be revised upwards – which could complicate longitudinal comparisons.

Another approach would be to report 'compliance with relevant national standards'. This is appealing in that it takes into account the country-specific context which is reflected in national standards. This approach would minimize conflicts with national reporting systems. However, it would complicate inter-country comparison and could even conceivably be a perverse incentive for countries to keep standards high.

### *Where should water quality be measured*

The question of the location of water quality testing relates closely to the purpose of the monitoring. Several terms are used to identify different sampling locations, but these are not always clearly defined and may vary in different settings. Some of these terms include:

- The *point of consumption* should be as close as possible to ingestion. This might involve asking households for a glass of drinking-water.
- The *point of use* could be taken as some point within the household where water is accessed for consumption. This could be a household storage container or a piped water tap.
- The *point of collection* should be the place from where households get their drinking-water. In the case of household piped water, the point of use and the point of collection may be identical.
- Water providers may consider a *point of delivery* as the location where finished water leaves the water supply infrastructure. In most cases this would be identical to the *point of collection*.

When fielding surveys and reporting results, these types of terms must be identified precisely. At this stage, there is confusion even among experts.

If public health is the driving concern, it makes sense to collect a sample which is as indicative as possible of what people actually ingest. This would imply sampling at the *point of use*, or *point of consumption*. If, on the other hand, the goal is to determine water quality in public supplies, it would be better to collect samples at the *point of collection*, or *point of delivery*, so that poor-performing systems could be identified and corrective measures taken.

Significant differences can be expected in the nature, diversity and exposure pathways at household (point of use or consumption) versus public (point of collection) areas. Pathogens acquired through household contamination may well pose health threats that differ from those acquired through external sources.

The Task Force discussed the likelihood that different sampling locations can yield information on varying levels of drinking-water quality between the point of collection and the point of use (i.e. ingestion), since water quality could dramatically change, either for better or for worse. Poor sanitation and hygiene practices can lead to gross microbial contamination of water during collection, transport, storage or transfer. Yet, Household Water Treatment to reduce microbial contamination is rapidly increasing globally and could lead to marked improvements in water quality between collection and consumption. Even within the household, microbial water quality can vary between primary and secondary storage containers, and drinking vessels (e.g. see Rufener et al., 2010). Sometimes different water sources are reserved for different members of the household (e.g. children), potentially adding a further complication.

The current MDG indicator is formulated in terms of the use of an improved drinking-water source. A water quality measurement at the point of collection could be readily applied to this indicator resulting in a measure of improved drinking-water sources which provide microbiologically safe or unsafe drinking water. A water quality measurement at point of use can't be linked back to the point of delivery due to the potential for the water quality to change between the point of collection and point of ingestion. If water quality samples are taken at both locations it would be possible to determine whether corrective measures are more needed at the level of the water supplier (e.g. improved control measures) or at the level of the user (e.g. better water hygiene).

It was also noted that microbial water quality can vary substantially with time and that a single snapshot taken every several years, probably during the season most favorable for field work, will not give a representative picture of actual risk to consumers. Some analysis of DHS datasets suggests that seasonal factors strongly influence WASH indicators. Including Sanitary Inspection provides a measure of the fundamental risks to the supply may result in lowered water quality during the rainy season or during rainfall events. Locally this information helps to identify and prioritize corrective measures and to provide a more comprehensive picture of water safety.

## Technical Task Force Summary and Recommendations

The Task Force confirmed the primacy of microbial water quality monitoring and of *E. coli* as the preferred indicator of faecal contamination.

For global monitoring purposes, the most practical indicator to strive for at present is the proportion of water samples for which no faecal indicator bacteria (i.e. *E. coli*) can be detected in a 100 mL sample (i.e. a pass/fail metric).

The Task Force recommended that the location of water sampling for global water quality monitoring purposes should be consistent, and that a location within the household would provide the best estimate of actual exposure to pathogens through drinking-water. From a human rights perspective it was argued that the responsibility to provide safe drinking water shifts from the provider to the user (with a potential role for the health sector) at the point of delivery/collection. The Task Force recommended that surveys should give priority to sampling at the household level, but should supplement household samples with samples from the point of collection to the extent possible. Standard protocols should be developed regarding the methodology for identifying and collecting household water samples, so that data are as comparable as possible in different surveys.

The Task Force recognized that when microbial measures of water quality are applied, compliance rates will be drastically lower than rates using the 'improved source' indicator. This will be shocking for some, especially those who have conflated 'water from an improved source' with 'safe drinking water'. However, the JMP should not refrain from collecting and publishing more accurate data reflecting the true condition of drinking-water quality in much of the world.

As the experience of the water and sanitation MDGs target has made clear, a single pass/fail indicator is not sufficient to track progress and provide incentives to decision-makers. While the main metric of global reporting for the near future should be pass/fail in nature, important information can also be gained from analysis of quantitative data (i.e. < 1, 1-10, 11-100, 101-1000, > 1000 cfu/100 mL). Not all data collected by the JMP will be disaggregated by risk level, but for those datasets where such disaggregation is possible, JMP could present case study analyses. Such case studies would also serve to promote this type of analysis at national and sub-national levels.

For national monitoring purposes, information about water quality at the point of collection is more relevant to the water supply stakeholders. Water quality data at sources or points of collection should be complemented with Sanitary Inspections, because these provide important additional information about vulnerabilities in the supply that could result in higher levels of contamination during adverse conditions such as heavy rainfall. As much as possible, national monitoring systems are encouraged to sample water quality at the point of use as well; and to analyze changes in water quality from collection to consumption to identify needs for hygiene and sanitation interventions, and consumer education. Particularly in light of the human right to safe drinking-water, monitoring at the point of collection alone may not be adequate.

Whatever new indicators of drinking-water quality are developed for global reporting, these will not guarantee 'safe water'. Possible ways to refer to differing degrees of water quality include 'non-contaminated water', or 'unsafe, poor, and good quality water'. As the current experience with JMP reports has shown, it is easy for the public to miss the distinction between proxy indicators and actual water safety.

The Task Force endorsed the concept of a 'water quality monitoring ladder', in which countries progressively improve water quality monitoring systems (e.g. Figure 1). However, water quality monitoring should not be done only for the sake of reporting; it must be linked to systems to identify and manage risks which could lead to provision of unsafe drinking water. *Water quality monitoring* ladders should be linked with *water quality management* ladders. An example of such a ladder (or pyramid) is shown on the following page (Figure 2).

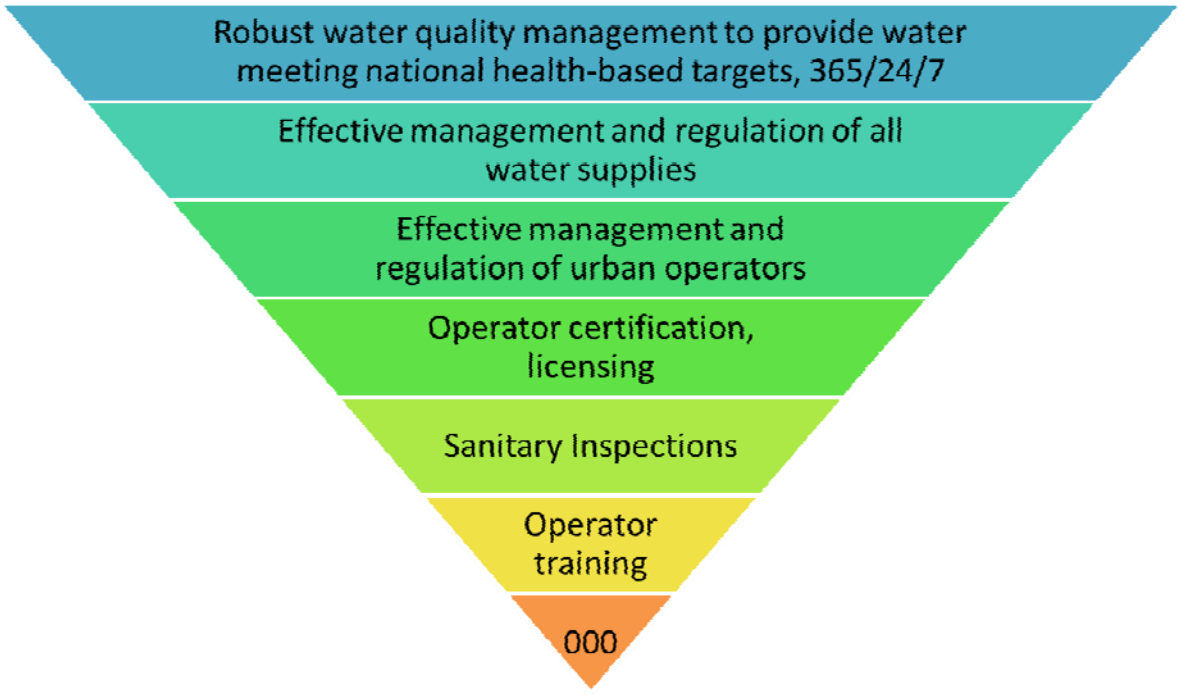


**Figure 2. This inverted pyramid reflects advances in water quality management, linked to water quality monitoring, that require substantial capacity development at the national and sub-national levels. Capacity development could become a more explicit objective for interventions aimed at collecting water quality data.**

## 3. The Rapid Assessment of Drinking Water Quality

- What are the lessons learned from the RADWQ experience? RADWQ collected drinking-water quality samples at the source and at the point of use, in addition to performing sanitary inspections. Should drinking-water samples be taken at the point of use only, at the source only or at both? Should a sample survey approach include sanitary inspections?

- Is the package of indicators measured by RADWQ adequate? Can the findings of RADWQ be applied to individual survey data for the RADWQ countries and beyond?

- Are the costs incurred by a RADWQ type of water quality survey approach proportionate to the value of the information it yields? Is a household sample-based approach cost-effective compared to other options? If not, what options are more cost-effective? If it is more cost-effective, then what should be the frequency of a RADWQ type survey for global monitoring purposes and for country-level monitoring purposes?

## Background and presentation

### *Presentation: The RADWQ experience*

Oliver Schmoll and Federico Properzi presented the Rapid Assessment of Drinking-Water Quality (RADWQ) experiences, which involved water quality surveys in six countries (China, Ethiopia, Jordan, Nicaragua, Nigeria and Tajikistan). Related surveys were carried out in India and Bangladesh.

The surveys used a multi-stage cluster design, and targeted improved drinking-water sources serving at least 5% of the national population. The focus of testing was at the source, and was complemented by household sampling in 10% of cases. Physical, chemical and microbial tests were carried out, as well as a Sanitary Inspection.

The surveys were logistically complex and human-resource intensive, lasting in most cases around six months. The cost per source tested was approximately $75, though in India where the survey was government-led and local testing equipment was used, it was lower at $50 per source.

Reports have been compiled from five of the countries. No public report will be made from the China survey which did not fully adhere to the standard protocol. One complication with the China pilot was that the Chinese drinking-water standard for microbial water quality uses total coliforms as the indicator and is, therefore, not directly comparable to a standard based on thermotolerant coliforms or *E. coli* data.

National stakeholders in nearly all RADWQ countries reportedly greatly appreciated the surveys. In some cases it led to the first ever nationally representative compilations of water source and water quality data records. In some countries unexpected problems were found in some areas, and in some cases findings of poor water quality led to remedial action. The surveys in many cases created a national forum for discussing drinking-water quality issues which had been lacking previously. These experiences show that greater awareness and increased capacity development were important outputs, though this was not explicit in the survey objectives.

## Technical Task Force Review

The Task Force recognized the value of the RADWQ surveys, in particular the fact that they collect ‘upstream’ data (i.e. water quality at the point of collection) which can be useful to national regulators and water suppliers to identify and rectify problems. Especially when complemented with Sanitary Inspections, upstream data led to valuable insights in several RADWQ countries.

The Task Force considered that testing of household drinking-water quality is at least as important as testing at the source. In Tajikistan there was surprisingly little difference between microbial water quality at the point of collection and within the household. In contrast, data from Nigeria and Ethiopia showed there were large differences. However, due to the lower sampling density at the household level (10% of sources) the resulting data were statistically less meaningful.

Capacity development was an important if unintended component of the surveys and should be more explicitly targeted in future RADWQ exercises. RADWQ-like surveys are likely more useful for countries with relatively weak monitoring systems: for example, the field equipment used represented a step down from technologies commonly used in Jordan. In India, water quality

stakeholders were initially uninterested in data collection at the household level, but much interest was stirred when survey reports were analyzed. The RADWQ-like survey in India helped to influence policies and guidelines for drinking-water quality and surveillance. Similar feed-back was received from Nigeria and Ethiopia.

The Task Force noted that some chemical parameters were analyzed which have relatively little importance (e.g. copper). Even some parameters with health impacts result in a relatively low disease burden and are difficult to correct (e.g. nitrate). Measurement of such parameters will be valuable in some countries but less in others. A minimal set of parameters to measure in future RADWQ-like surveys was agreed upon: *E. coli*, arsenic, and fluoride. Arsenic and fluoride could be omitted if known to be absent, but should be included otherwise. Thermotolerant coliforms are considered less adequate but still an acceptable alternative to *E. coli*. There should be a national process for consideration of other parameters and a WHO guidance document (Thompson et al. 2007) can be of use for this. In addition to these tests, Sanitary Inspections of the water source should be made and some measure of aesthetic quality of water collected.

The Task Force considered that RADWQ-like surveys were also fit instruments for field testing and evaluating new analytical methods or indicators (e.g. faecal streptococci or $H_2S$ tests).

Task force members called for clarification of the theoretical basis for the sample size calculation made in RADWQ, in particular the estimated Design Effect. It is possible to calculate post-hoc the actual Design Effect from completed survey data; this should be done if possible with the existing RADWQ datasets. Task Force members also noted that the calculations give a sample size adequate for reporting results at the national level, but that the sample size is likely inadequate for precise reporting of data disaggregated by technology or by sub-national area.

The Task Force called for more detailed analysis of the costs of the RADWQ surveys. In particular, it should be clarified what portion of costs were for hardware investments, as compared to consumables. Water quality testing instruments are expensive; if these can be used in future surveys unit costs could be reduced. Comparison should also be made to the RADWQ-like surveys which were made in India and Bangladesh.

## Technical Task Force Summary and Recommendations

The existing RADWQ experience should be analyzed and disseminated. The five country reports have been put on-line. A Synthesis Report, bringing together lessons learned, and the methodological Handbook should be finalized and put on-line as well. RADWQ findings should be included in the 2011 JMP thematic report on Water, as well as in the JMP update report planned for 2012. An additional Strategic document, reflecting among other things the deliberations of this Task Force meeting, would be very useful in planning for future RADWQ-like surveys.

Future surveys should be conducted, in at least a small number of strategically selected countries. Monitoring efforts should be linked with sector initiatives for improving water quality. Because of the possible linkages with Water Safety Plans, countries which are developing Water Safety Plans could be targeted for future RADWQ surveys.

The national capacity development element should be made more explicit in future surveys. For example, a goal could be the devolution of leadership of RADWQ surveys from international to national staff.

Future surveys should collect water from all sources (unimproved and improved) and target households to the same extent as sources. Ideally, locations should be geo-referenced for spatial analysis.

In future surveys, attempts should be made to address the ethical issues highlighted in discussions. Results of tests should be reported back to households, and where water quality does not meet standards, consumers should be given at least basic information about the risks posed by continued consumption, and what kind of remedial actions could be taken.

A discussion about in which settings RADWQ-type surveys would be most appropriate follows in the next section, on page 23.

## 4. Methods, procedures and tools

- What is the profile of the ideal tool for direct measurement of drinking-water quality? What are the new low cost rapid assessment tools currently under investigation and development? What criteria should they meet to be useful with respect to the JMP objectives?
- What are the optimal sampling techniques for the efficient measurement of drinking-water quality indicators? What are the contextual impediments towards a sampling and surveillance approach in different parts of the world, and how could they be overcome or compensated by statistical methods? Is there a role for data-sharing and management tools? Can the results of a limited number of nationally representative water quality surveys be used to extrapolate water quality information for a larger cluster of comparable countries?
- Can the results of routine surveillance and monitoring by national regulatory bodies be adopted and consolidated into global and regional data? What level of harmonization can be achieved between these national processes? Alternatively, can monitoring and surveillance methods applied by national regulatory bodies be adopted and integrated into the JMP monitoring activities and how can experience and lessons learned be incorporated? What are the constraints and what are the opportunities? Is there a role for the WSP quality assurance tool?

### Background and presentation

#### *Presentation: Microbial Testing Questions*

Daniele Lantagne presented a compilation of emerging tests for microbial quality and led a presentation (compiled with inputs from Graham Alabaster, Ranjiv Khush and Jamie Bartram) about how appropriate microbial testing methods could be identified and selected.

Innovations have been made particularly in the food safety industry to develop enzyme-based tests which are specific to certain bacteria. A number of assays have been developed which identify either total coliforms *or E. coli* (e.g. see Olstadt et al., 2007). Enzyme-based methods make use of substrates which are chemically cleaved by certain enzymes, producing a by-product which is easily detectable – either through absorbing color at certain wavelengths or fluorescing under ultraviolet light. In many commercial configurations, enzyme-active substrates are premixed with appropriate growth substrates (and inhibitors to prevent growth of competing microbes). Enzyme-

based methods tend to be more specific than conventional methods and tolerant of a broader range of incubation temperatures.

While some enzyme-based tests have been approved for use in water quality testing in the USA and other countries, other assays are still in the process of being certified. It is important to distinguish between validating a method (e.g. the use of 4-methylumbelliferyl-B-D-glucuronide (MUG) for detection of *E. coli*) and validating a commercial product (e.g. Colilert) for a particular application.

Microbial testing products are available in an array of configurations, including:

- Pre-poured plates and films designed to measure approximately 1 mL samples, typically providing quantitative or semi-quantitative measurements.
- Pre-measured reagents in 10 mL or 100 mL containers, typically providing presence/absence (P/A) results.
- Containers having multiple chambers, allowing calculation of a Most Probable Number (MPN) from multiple Presence/Absence results. This is an area of active development, because it eliminates the need for membrane filtration in the field.
- Membrane filtration (typically of 100 mL samples) followed by incubation with various specific growth media.

All of these tests require some time for sample preparation and an extended incubation period, typically of 24 hours. Quantitative results may be reported as a numeric value (e.g. 32 cfu/100 mL), classified into logarithmic risk levels (e.g. 1-10 cfu/100 mL = low risk), or reported as Passing or Failing some threshold value (e.g. > 0 cfu/100 mL = Fail). An important semantic point is the difference between presence/absence tests, and pass/fail classifications. Presence/absence tests simply indicate whether a contaminant is present or not at some certain concentration or density. Pass/fail classifications compare a water quality measurement to some acceptable threshold: this can be done with either quantitative or presence/absence data, as long as the test is sufficiently sensitive.

Different products have different characteristics which will make them more or less suitable for different applications. A tentative list of selection criteria was proposed, for water quality professionals to use in considering different products for use in national surveys:

- Does the test measure a WHO-endorsed indicator species (i.e. *E. coli* or thermotolerant coliforms)?
- Is the technology approved by standards authorities (e.g. ISO/SM)?
- Does the test allow reporting by risk level?
- How sensitive is the technology to variations in incubation temperature and time?
- Does the required instrumentation fit into small, portable containers?
- Could survey enumerators do the test themselves?
- Can the test be done without electricity?
- Are the test and its associated products environmentally safe?
- Does the test present a health risk to users or the uninformed public in field settings?

Quality control is an important component of field surveys, and might include the analysis of blanks, replicates or known standards in the case of microbial testing. Any national surveys should carefully consider what quality control measures would be appropriate and achievable.

## Technical Task Force Review

### *Microbial testing methods*

The Task Force agreed that for water quality data to be useful at national or sub-national level, they should be quantitative. However, the results which are 'skimmed off' by the JMP for global monitoring purposes will most likely be binary, or Pass/Fail, with reference to a national standard of zero *E. coli* (or thermotolerant coliforms) per 100 mL sample. Naturally, such results can only be reported when at least 100 mL samples were analyzed.

The JMP can and should make global analyses using semi-quantitative data, for example risk levels. However, given the paucity of reliable microbial water quality monitoring in many countries, it is likely that for the near future, pass/fail results will be more practical for international comparisons.

The Task Force considered that the enzyme-based assays hold much promise and should be promoted where possible. Any assay which allows on-site testing would offer a large advantage over technologies which require transport back to a central location for analysis. There are good examples of enzyme-based tests being used in the field in Kenya, Tanzania and other countries. However, some form of independent method validation should be made before data collected with these tools are used for global reporting purposes.

The issue of holding time and conditions (i.e. between collection and analysis of samples) was briefly discussed. The Task Force noted that water quality testers are normally advised to analyze samples within 4-6 hours of collection (e.g. Howard, 2002), or a maximum of 24 hours of collection (e.g. WHO, 1976). It is commonplace to stipulate that samples be stored at low temperature until analysis. There is some evidence that the more rigorous holding time requirements were appropriate for saline or brackish waters, but that coliform populations are more stable in fresh waters. Indeed, the USEPA allows holding times of up to 30 hours and encourages but does not require that samples be held below 10°C during transit. National or local governments may have requirements which should be adhered to if data are to be locally accepted.

The Task Force noted that holding times and conditions are much less strict for chemicals.

### *Modalities of data collection*

A fundamental question considered by the Task Force was that of how nationally representative water quality data could and should be collected. Given that different countries have different needs and capacities, a single methodology could not be applied globally. However, different methodologies can be identified and recommendations can be made regarding which tools are more appropriate for different settings. Ideally there should be transparent criteria which apply to any methodology and which would determine whether or not datasets could be used for global reporting purposes.

Three modalities of data collection were identified by the Task Force:

- Adding water quality modules on to ongoing nationally representative surveys.
- Fielding dedicated national surveys for collection of water quality information.
- Using regulatory data to report on national access to safe drinking-water.

## Add-ons

Nationally representative cluster surveys currently represent the bulk of surveys used by the JMP to measure progress towards MDG Target 7C and are additionally important tools for tracking progress towards other MDG targets. The most regularly fielded surveys are the DHS and MICS, though other surveys contribute important data as well.

Adding a water quality module to such surveys would be relatively cost-effective. Another important advantage of add-on water quality modules is the possibility of linking water quality data with other survey questions, such as WASH indicators or wealth indices. Such surveys are made at the household level, so it would be easiest to collect a drinking-water sample within the household, which would reflect actual exposure to contaminants through drinking-water. As previously noted, clear guidance should be given to surveyors and enumerators regarding the site of sampling.

However, the logistical challenges of adding water quality testing to ongoing surveys are considerable and field enumerators are already heavily burdened. It is likely that any water quality testing would have to be very simple. While it could be relatively straightforward to collect Presence/Absence results which would satisfy global reporting needs, the collection of quantitative data which would be more useful for national stakeholders is more complex. One approach to overcome these challenges could be to support additional human resources to travel along with enumerators, dedicated to water quality sampling. The Task Force also noted that it might not be necessary to collect water quality samples at all households surveyed.

Ethical and environmental aspects of water quality testing identified through prior experience with DHS surveys are not trivial and should be taken into consideration when designing add-on surveys.

Two examples of add-on surveys are the National Drinking-Water Quality Survey linked to the 2009 Bangladesh MICS, in which samples were collected and analyzed for multiple chemical contaminants in a reference laboratory; and the 2011 Peru DHS, in which a newly developed MPN assay will be made, using $H_2S$ media.

## Dedicated surveys

The RADWQ surveys are examples of dedicated surveys designed to collect water quality information. By using dedicated teams surveys can be designed exactly to meet national requirements. A major advantage of RADWQ-style surveys is that they can more easily collect water samples from the Point of Collection, and can additionally conduct Sanitary Inspections. Such tasks would be difficult to implement in add-on surveys (unless dedicated human resources were provided). Even in the RADWQ surveys, several months were required to complete field work. Both add-on surveys and RADWQ-type surveys produce a “snapshot” of the water quality situation and do not study any seasonal variations.

The drawback associated with these advantages is a relatively high cost. Even if the costs of assays used in RADWQ are reduced, the human resources and transport costs will be considerable.

It might be feasible to link a dedicated survey intimately with an ongoing MICS or DHS survey, to reduce some of the survey costs while allowing linkage with a wide range of household-level information such as wealth indices.

As noted above, the Task Force recommended that in future RADWQ-like surveys samples should be collected both at the Point of Consumption and the Point of Use, to allow quantification of any changes in water quality due to collection and storage. The Task Force also recommended that such surveys include sampling from unimproved as well as improved sources. Survey planners should consider carefully if the survey design should be based on distribution of households, rather than of sources as in the first RADWQ surveys.

The Water Safety Framework outlined by WHO calls for independent surveillance to verify performance of Water Safety Plans. Where Water Safety Plans are well-established, dedicated surveys could contribute to independent surveillance.

### Regulatory reporting

It is conceptually appealing to make use of data collected through national regulatory systems for global reporting purposes. This approach is easily harmonized with national mandates, priorities and data collection systems. It potentially taps much greater financial resources than are available through add-on or dedicated surveys. Regulatory data can also explicitly link with programmes to improve water quality management, and thus improve water quality, not simply report it.

Regulatory data are already used in JMP reports for industrialized countries, where MICS and DHS surveys are not fielded. However, this leads to a two-track system in JMP reports which is not fully transparent. It is clear that the water supply regulation systems in many countries are not adequately developed to allow reliable reporting using globally consistent indicators. In fact, in 2000 the JMP shifted from reporting that included in part regulatory surveillance data to household survey-based reports, in an attempt to improve data quality. In the past decade, however, significant progress has been made in many countries to improve water supply regulation and associated surveillance.

Ideally, transparent criteria should be used to assess whether or not a country's regulatory reporting data could be accepted for global reporting purposes. This would both help to ensure inter-comparability of globally reported data and to give incentives to countries to improve their regulatory systems and 'graduate' into a class of countries with recognized water quality systems.

A risk of relying on regulatory data is that regulatory systems may miss out on those not using piped water, particularly those using unimproved and informal sources. Regulatory systems are typically weaker in rural than in urban areas. Informal settlements and slums may be completely missed by regulatory systems. However, an example from Kenya was given where slum dwellers were included in national monitoring systems because of regulatory mandates.

## Technical Task Force Summary and Recommendations

The Task Force recognized the potential of new enzyme-based tests to simplify and improve measurement of *E. coli*. The Task Force acknowledged that such methods should be validated prior to widespread application and recommended that any water quality testing surveys should carefully plan for quality control measures (e.g. blanks and duplicates) to be applied.

The Task Force requested Daniele Lantagne to further develop the criteria and matrix for selection of microbial testing technologies which were presented in draft form, and to circulate these among Task Force members.

The Task Force recommended that new modalities of data collection should be explored which can lead to incorporation of water quality measurements into the JMP. However, by 2015 such experiences will still be early, and it will not be possible to report globally on water quality. The final MDG report should be made on the basis of the improved/unimproved classification. Over the next five years, new systems should be tested so that whatever system follows the MDGs can more accurately target and report on water quality. At the same time, experience must be gained regarding how data collected through different modalities can be aggregated and compared consistently. There is no need to limit new approaches to those which would generate data directly comparable to 1990 levels.

The purposes of water quality monitoring are different at national and global levels. At national levels quantitative data are necessary to support and improve service delivery, while at international level pass/fail data may be adequate for tracking progress towards targets and making inter-country comparisons.

A sub-group of the Task Force was established to consider how regulatory data could be used for global monitoring purposes, and what kind of criteria should be introduced for acceptance of regulatory data. Members of the sub-group include Graham Alabaster, Jamie Bartram, Robert Gakubia, Gareth Jones, Oliver Schmoll and Luis Simas.

The International Network of Drinking-Water Regulators (RegNet) can provide some information to this sub-group regarding what types of data are available with regulators, and how such data could be validated or used for global reporting purposes. Dominique Poulin agreed to take the lead on this task, and to link with the above sub-group.

The JMP should develop descriptions of the advantages and limitations inherent to each of the three data collection modalities identified, and endeavor to develop guidance on the conditions under which different data collection modalities might be more appropriate. For example, some CEE/CIS countries are reportedly considering doing a RADWQ-like survey to help revitalize neglected water quality monitoring infrastructure. Such guidance could help target limited resources to achieve the best effect.

Future initiatives by JMP to include water quality testing should more explicitly target capacity development at the national level. For example, if RADWQ-style surveys are made, a goal could be to stage multiple surveys, with a gradual transition of leadership and funding from international to national levels. Second generation RADWQ initiatives should have a strengthened economic component that will help clarify outstanding questions on costs, cost-effectiveness and cost-benefit.

## JMP response

The JMP team members endorsed the recommendations and Rolf Luyendijk volunteered to take the lead in dialogues with MICS and DHS teams to explore inclusion of add-on water quality modules in upcoming surveys. He acknowledged the value of collecting water quality data at 'upstream locations' (i.e. the point of collection) but expressed concerns about the practical feasibility of doing so alongside a MICS or DHS surveys. He also questioned the need for including unimproved sources in future RADWQ-like surveys, since it appears likely that a future indicator would exclude those relying on unimproved sources. Inclusion of unimproved sources could significantly impact study designs and increase costs, with relatively little added value.

JMP members voiced their plans for moving forward with dissemination of RADWQ reports and to consider the possible scope and location of future RADWQ-like surveys.

## Conclusions and recommendations

The JMP Task Force on Monitoring Drinking-water Quality had a productive two and a half days of meeting at the Château de Pizay, France.

The Task Force appreciates the contribution made by the JMP in global monitoring of progress towards MDG Target 7C. In 2000 the JMP shifted from reliance solely on regulatory data to collection of nationally representative data through cluster surveys. Since that time the proxy indicator for 'sustainable access to safe drinking-water' has been self-reported use of 'improved drinking water sources'. This indicator monitors the different physical means of *access*. However, the number of people actually consuming '*safe* drinking-water' is still unknown. As capacities for water quality monitoring through different modalities have improved, it is now possible to adopt more sophisticated proxy indicators of safe drinking-water, which include limited water quality testing.

### Global monitoring

The Task Force strongly supports the JMP's intent to build 'second generation' indicators that would include some type of direct water quality measurement. At this stage it would be unrealistic to look for reliable indicators guaranteeing water quality on a permanent basis (24/7), in all situations (at home, at work, at school, etc.) and in compliance with all parameters affecting health. Therefore, in this second phase, water quality will be assessed through measuring the three water quality parameters most strongly linked with health impacts: microbial contamination, arsenic and fluoride.

With the short time remaining before 2015, final reporting on MDG achievement will have to use the current metric of 'use of improved sources.'

Water quality reporting is one key component of the reporting needs on access to water. The Task Force considers it essential that improved water quality indicators be available to support the new global targets that should be adopted for post-2015 efforts. Furthermore water quality is a key criterion of the Human Rights Framework that includes also accessibility, availability, affordability and non-discrimination. The challenge of convincing national governments to agree on new, international post-2015 drinking-water and sanitation targets has been stimulated by the adoption of the UN-GA and UN-HRC resolutions on the human right to water and sanitation. This encourages the JMP to perform its function as a neutral platform for post-2015 indicator development as contained in its strategy. The JMP should move assertively to gain experience in collecting nationally representative water quality data so that these experiences can inform and guide new strategies and indicators.

It is anticipated that other refinements will be made to methodologies for measuring 'sustainable access'; these can be combined with the improved indicators of 'safe drinking water' considered by this Task Force, to yield a better estimate of 'sustainable access to safe drinking water'.

## National monitoring

Different countries will have different needs and capacities for water quality testing. A 'water quality monitoring ladder' is proposed, which should link to a 'water quality management ladder'. A clearly expressed ladder or pyramid can serve as a roadmap for countries to progressively increase the amount and quality of water quality monitoring done and at the same time improve the quality of drinking water management and service delivery.

## Methodology for data collection

*Parameters.* As noted above, for global monitoring purposes, only three parameters will be assessed: microbiological quality, arsenic and fluoride. At the global level the most suitable indicator for microbiological quality is the proportion of samples having no detectable *E. coli* in a 100 mL sample. At national levels quantitative data are likely to be more useful, and additional parameters may be included as appropriate.

*Where and when.* To maximize the relevance of these measurements with regard to disease burden, the principal aim should be to report test results from household drinking-water samples, under conditions representative of typical drinking-water use. Data should be collected at the point of use irrespective of the physical means of access (unimproved, piped, other improved). Surveys should still record self-reported water source, so that means of access can continue to be measured.

*Data collection means.* The Task Force has identified three modalities by which water quality testing data could be collected and used for global reporting purposes: add-on modules to national surveys, dedicated national water quality surveys, and regulatory reporting. Each of these might be appropriate in different circumstances, and the JMP should further explore each in the coming years. The JMP should furthermore elaborate the settings in which each of these modalities is more appropriate; and should define criteria to be met in order for regulatory data to be considered for global reporting purposes. It should also clarify how different data will be combined.

*Overall framework.* The JMP should develop an overall framework for water quality monitoring describing data collection in the field, data combination to build indicators at national level and consolidation at global level having in mind that indicators should allow measuring progress and should be available to be selected as targets for national and/or global policies.

A diagram of elements for this overall framework is shown on the following page. This framework could be considered as a 'second stage' of drinking-water quality monitoring, building on previous work (e.g. improved/unimproved classification) and anticipating that in the future additional refinements and advances will follow.

*Partnerships.* Whatever modality is used for collection of water quality testing data, capacity development of local partners should be an explicitly stated goal. Large-scale capacity development is beyond the capacity of the limited resources available to the JMP, and strategic linkages will need to be made with the mainstream WHO and UNICEF programmes, but also broader sector stakeholders such as the WSP, bilateral or multilateral donors, or professional organizations such as IWA and AWWA.

The JMP is requested to develop an Action Plan to follow up on recommendations made by the Task Force, and to nominate individuals or small groups from the Task Force to make further contributions as necessary.

**Data collection**

| What | Who/How | Means of access | Where | When |
|---|---|---|---|---|
| E.Coli<br>As<br>F<br><br>quantitative | HH surveys<br>+<br>RADWQs<br>+<br>Regulators (incl. WSP) | All categories:<br>Piped supply<br>+<br>Other improved<br>+<br>Unimproved | PoU<br><br>+<br>PoC where possible | Typical situation<br><br>(worst situation will be monitored in a later phase) |

*Data combination, mixing*

National WQ data

**Data analysis**

*Data sorting, screening, interpretation*

National WQ indicators

*Information extraction, cluster inference, extrapolation*

**WQ reporting**

Global WQ indicators
(compliance with global & national standards
In understandable language)

*Physical means*

*Quality*

*Accessibility, time to collect*

**Access reporting**

Global indicators on access to water

*Availability*

*Affordability*

**Policy reporting**

Overall indicators for:
- current global policy
- human right to safe drinking water

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## ANNEX B: Approved Agenda

*Tuesday 16 November 2010*
Chair : Gareth Jones, Canada

09 :00 Opening of the meeting, tour-de-table, objectives and expected outputs

*Robert Bos, WHO*
*Peter Harvey, UNICEF*

09:20 Setting the stage

09:20 Water quality in the context of JMP – improved versus unimproved

*Rifat Hossain, WHO*
*Rolf Luyendijk, UNICEF*

09:40 Practical considerations for including water quality testing in a DHS or MICS type of household sample survey

*Fred Arnold, ICF-MACRO*

10:00 Water Safety Planning – the approach towards implementing the WHO Drinking-water Quality Guidelines

*Bruce Gordon, WHO*

10:20 Refreshments

10:45 Setting the stage (continued)

10:45 Rapid Assessment of Drinking-water Quality – a synthesis of experiences

*Oliver Schmoll, Germany*
*Federico Properzi, WHO*

11:30 Plenary discussion on issues arising, on the proposed list of questions to be addressed and on additional questions that may need answering.

*Moderated by Robert Bos*

12:00 A round of contributions from the regulators: practical insights into what are the characteristics of effective monitoring of drinking-water quality in different settings.

*Moderated by Peter Harvey*

12:30 Lunch

14:00 Plenary discussion

14:00
*Question 1.*
For what purpose will JMP compile information on drinking-water safety? What interests do countries share in the compilation of information on drinking-water safety and drinking-water quality at the source or at household level?

This discussion should clarify the rationale for JMP to engage in the monitoring of drinking-water quality in the context of monitoring access to and use of drinking-water. With the MDG target calling explicitly for "access to safe drinking-water", the Task Force should determine what part of water quality monitoring coincides with the JMP mandate and whether there are parts that do not.

*Moderated by Peter Harvey, UNICEF*

14:45
*Question 2.*
What are the essential components of drinking-water quality monitoring and surveillance, what is the scope of the terms "drinking-water quality" and drinking-water safety" in the context of the JMP mandate and what are the boundaries for the measurement of water quality indicators or proxy indicators?

This discussion should identify essential components of drinking-water quality monitoring and surveillance in the JMP context and define the optimal scope of monitoring and surveillance that is practically feasible. Attention should be given to opportunities for immediate implementation, as well as to what can be developed for the post-2015 period.

*Moderated by Bruce Gordon, WHO*

15:30 Refreshments

15:45 Plenary discussion (continued)

*Questions 3-7.*
What are feasible options for the direct measurement of water quality parameters that will usefully supplement the JMP datasets on access and use of drinking-water sources? What are the feasible options for assessing water quality through proxy (process) indicators that go beyond the current improved/unimproved categories (e.g. determining the number and coverage of functional water safety plans)? Would such an approach be compatible with the remit of the JMP?

What are the practical considerations for inclusion of water quality testing by MICS or DHS? What are the minimum drinking-water quality parameters that should be measured following a household sample survey approach?

What are the lessons learned from the RADWQ experience? RADWQ collected drinking-water quality samples at the source and at the point of use, in addition to performing sanitary inspections. Should drinking-water samples be taken at the point of use only, at the source only or at both? Should a sample survey approach include sanitary inspections?

Is the package of indicators measured by RADWQ adequate? Can the findings of RADWQ be applied to individual survey data for the RADWQ countries and beyond?

Are the costs incurred by a RADWQ type of water quality survey approach proportionate to the value of the information it yields? Is a household sample-based approach cost-effective compared to other options? If not, what options are more cost-effective? If it is more cost-effective, then what should be the frequency of a RADWQ type survey for global monitoring purposes and for country-level monitoring purposes?

This discussion should consider and list the options for JMP drinking-water quality monitoring and for each viable option assess its potential according to criteria (including, among others, practical feasibility, reliability under different circumstances, economic criteria) agreed by the Task Force, and identify any obstacles or limitations to its application.

*Moderated by Federico Properzi*

17:15 Wrap up by the Chair – review of next day's programme

*Wednesday 17 November 2010*
Chair : Gérard Payen, France

08:30 Recapitulation of day 1

*Rapporteur*

09:00 Plenary discussion (continued)

*Questions 3-7 (continued)*

What are feasible options for the direct measurement of water quality parameters that will usefully supplement the JMP datasets on access and use of drinking-water sources? What are the feasible options for assessing water quality through proxy (process) indicators that go beyond the current improved/unimproved categories (e.g. determining the number and coverage of functional water safety plans)? Would such an approach be compatible with the remit of the JMP?

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This discussion should consider and list the options for JMP drinking-water quality monitoring and for each viable option assess its potential according to criteria (including, among others, practical feasibility, reliability under different circumstances, economic criteria) agreed by the Task Force, and identify any obstacles or limitations to its application.

*Moderated by Rolf Luyendijk, UNICEF*

10:30 Refreshments

11:00 Plenary discussion (continued)

*Question 8.*
What are the optimal sampling techniques for the efficient measurement of drinking-water quality indicators? What are the contextual impediments towards a sampling and surveillance approach in different parts of the world, and how could they be overcome or compensated by statistical methods? Can the results of a limited number of nationally representative water quality surveys be used to extrapolate water quality information for a larger cluster of comparable countries?

This discussion should consider sampling techniques and recommend those that are applicable to the identified approaches for monitoring, as well as produce ideas on how smart sampling techniques may simplify the actual monitoring process.

*Moderated by Rifat Hossain, WHO*

12:30 Lunch

14:00 Plenary discussion (continued)

*Question 9.*
Can the results of routine surveillance and monitoring by national regulatory bodies be adopted and consolidated into global and regional data? What level of harmonization can be achieved between these national processes? Alternatively, can monitoring and surveillance methods applied by national regulatory bodies be adopted and integrated into the JMP monitoring activities and how can experience and lessons learned be incorporated? What are the constraints and what are the opportunities? Is there a role for the WSP quality assurance tool?

Lessons learned from national monitoring and surveillance programmes implemented by drinking-water regulators should be included in the final recommendations.

14:45 New tools for rapid water quality testing on the horizon – two presentations

*Ranjiv Khush, USA*
*Jamie Bartram, USA*

15:00 Review of testing tools

*Daniele Lantagne, USA*

15:15 Application of a rapid water quality testing tool in East Africa

*Graham Alabaster, UN-Habitat*

15:30 Refreshments

16:00 Plenary discussion (continued)

*Question 10.*
What is the profile of the ideal tool for the direct measurement of drinking-water? What are the new low cost rapid assessment tools currently under investigation and development? What criteria should they meet to be useful with respect to the JMP objectives?

This discussion should consider all aspects of new tools under development and recommend what components should be included in their evaluation protocols to show their value for the JMP drinking-water quality component.

*Moderated by Jamie Bartram, UNC, USA*

17:15 Wrap-up by the Chair – Review of next morning's programme

*Thursday 18 November 2010*
Chair : Gareth Jones, Canada and Gérard Payen, France

08:30 Recapitulation of day 2

*Rapporteur*

09:00 Plenary discussion (continued)

*Question 11.*
Can different monitoring and surveillance approaches be adopted for urban and rural settings whose results can later be merged into a representative national picture? And can the use of different approaches in different countries be allowed without jeopardizing comparability and the composition of a global picture? What are the criteria that apply and what can be the safeguards against differences in quality of evidence, bias and prejudice?

This discussion will consider the potential and desirability of disaggregation of drinking-water quality data, by rural/urban or otherwise.

*Moderated by Rolf Luyendijk, UNICEF*

09:45 Plenary discussion (continued)

*Question 12.*
How can expansion of JMP monitoring to address the issues of drinking-water quality include capacity developmentapacity development components and contribute to the sustainability of drinking-water quality monitoring while staying within the JMP mandate, and how can efforts on the short term feed into the development of indicators to be measured after the 2015 MDG milestone?

This discussion aims at synthesizing the various elements that have emerged from the discussion of the previous nine questions and should result in clear recommendations for the JMP to optimally address drinking-water quality on the short term and how monitoring post-2015 should perform in this connection.

*Moderated by Didier Allély, WHO*

10:30 Refreshments

11:00 Conclusions and recommendations – further work to be carried out by the Task Force – linkages to on-going activities – pilot studies

*Moderated by the Chairs*

12:15 Closure of the meeting

12:30 Lunch

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