Journal of Environmental Science and Engineering A 6 (2017) 587-593
doi:10.17265/2162-5298/2017.12.001

Measuring the Accessibility of Safe Drinking-water: From Millennium Development Goals Experience to Sustainable Development Goals Prospects

Léandre Ngogang Wandji
African Centre for Statistics, Economic Commission for Africa, Addis Ababa, Ethiopia

Abstract: The access to safe drinking-water is a global priority for sustainable development, as it has been recognized within the MDGs (Millennium Development Goals). Although the MDG's target of halving the proportion of people without sustainable access to safe drinking-water was met in 2010, the measurement method of the monitoring and evaluation indicator used ignored certain elements including the quality of water that should be underlined. Starting with a review of drinking-water and improved water source concepts, this study examines the limitations of measuring access to safe drinking-water in the context of the MDGs, and learns from the lessons to ensure a better performance in achieving the SDGs (Sustainable Development Goals).

Key words: SDGs, MDGs, drinking-water, improved water source, water quality.

1. Introduction

At its 93rd General Assembly held on December 22, 1992, the United Nations declared the day of 22 March of each year as the WWD (World Water Day). With this decision, the Assembly invited States to devote this Day for concrete activities on the conservation and development of water resources according to their national context. In addition, the Assembly calls the members states to consider the implementation of the recommendations of the United Nations Conference on the Environment and Development contained in chapter 18 of 1992 Agenda 21. The WWD theme for 2018 namely "Water: the answer is in nature" leads to explore the different ways in which nature can be used to overcome the challenges of water. It is now accepted that environmental damages which currently the world is experiencing is exacerbated by the action of human beings, particularly through atmospheric pollution, degradation of soils, vegetation and rivers.

Access to safe drinking-water remains a challenge for many people, especially in poor countries. In 2017, at least 2.1 billion people in the world did not have access to safe and readily available water at home [1] and therefore used a source of water potentially contaminated with materials, exposing them to cholera, dysentery, typhoid and polio. In cities and especially in rural areas where access to safe water for drinking is limited, people generally resort to alternative water sources, including for instance wells, rivers and lakes.

The 2018 theme of WWD calls for adequate responses in nature to warrant access to safe water for all and to ensure sustainable management of water resources. Access to safe drinking-water already had a quite importance to be addressed within the MDGs (Millennium Development Goals). Consequently, and according to the MDG Implementation Report, the goal of halving the proportion of the population without sustainable access to safe drinking-water was achieved in 2010. The purpose of this paper is to question the methodology used to measure and monitor access to safe drinking-water in the MDGs

Corresponding author: Léandre Ngogang Wandji, economist and statistician, main research fields: official statistics and statistical development.

framework and to suggest ways to improve it in the context where the indicator will still be used in the SDGs (Sustainable Development Goals).

2. Concepts of Drinking-water and Improved Water Source

The seventh goal of the MDGs was to ensure environmental sustainability. One of its targets was to halve the percentage of the population without sustainable access to safe drinking-water (and basic sanitation). This target was measured and monitored by the proportion of the population using an improved water source. The target and its indicator for monitoring progress highlight two concepts namely: safe drinking-water and improved water source.

According to the WHO (World Health Organization) [2], "Safe drinking-water does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages". This definition emphasizes that drinking-water is water that can be safely drunk. Therefore, its microbial, chemical and physical characteristics should meet WHO guidelines or national or regional standards for the quality of drinking-water. The standards that apply to drinking-water may vary from one country to another or from one region to another [1]. However, the common feature of these standards is that safe drinking-water does not contain pathogens or chemicals at levels that may be harmful to health. WHO has defined the list of these agents and the threshold concentrations.

An improved drinking-water source as defined in the MDGs is: "A facility that, by nature of its construction, is protected from outside contamination in particular from contamination with fecal matter" [3]. For example, a spring protected by brickwork, masonry or concrete surrounding it so that water can be collected at the end of a pipe without exposing the source to the runoff, rain and a possible contamination by humans or animals, is considered an improved water source.

The above definition assumes that water sources protected from outdoor contaminants are likely to produce drinking-water.

Using the proxy indicator, the proportion of the population using an improved drinking-water source to monitor and evaluate access to safe drinking-water supply, it was implicitly assumed that improved water sources did not or had little health risk. One of the reasons could be that these sources were protected from outdoor contaminants. However, water sources can be contaminated in different other ways and can contain chemical agents in concentrations that can harm human and animal health. This can be illustrated by the methodology used to estimate this indicator in the context of the MDGs.

3. Measurement of the Use of Improved Water Sources in the MDGs

Several national development plans and policies have adopted many goals and targets of the MDGs including the target on access to safe drinking-water. The main sources of data used to measure this indicator at the national level were household surveys. These included: MICS (Multiple Indicator Cluster Surveys) , DHS (Demographic and Health Surveys) , WHS (World Health Surveys), LSMS (Living Standards Measurement Surveys) or national surveys with modules on access to water built on one of the previously cited surveys. The measure of access to safe drinking-water is made through the use of an improved water source by the households. The surveys cited above identify households with access to an improved water source through the following question: What is the main source of drinking-water for the household? This question is then used to identify the different water sources mainly used by households and to categorize them into either improved or unimproved sources.

Usually, these surveys identify nine types of water sources used by households. They are well illustrated in the generic MICS tools [4] as:

• Tap: Water from this source is usually produced by a public service. The tap may be located in the dwelling, in a common yard outside the dwelling, in a dwelling different from the household one, a public tap or standpipe.

• Tube well: It is an underground water source built with casing or pipes that prevent the small diameter hole from collapsing and provide protection against runoff infiltration[1].

• Dug well: It is usually a circular cavity in the ground to reach an underground water table. The well is protected when it satisfies the following conditions: (a) It is preserved from runoff by a surface that rises above the ground level; (b) It has a platform or deck diverts the water discharged from the well; and (c) it is covered so that humans, animals, bird droppings and other harmful substances cannot fall into the well. A well is considered unprotected if it does not meet one of the preceding conditions.

• Spring: It is usually a place where water naturally springs up from the ground. A spring is protected when it is secured by a brick, masonry or concrete construction surrounding it so that water can be collected at the end of a pipe without exposing the source to runoff, rain water, and possible contamination by humans or animals.

• Rain: This is water collected on the roof of a building and stored in a container or tank until it is used.

• Tanker truck: It is a service provider that transports and distributes or sells water to households and communities through a tanker truck.

• Cart with small tank: It is a service provider that transports and distributes or sells water to households and communities through a small reservoir or barrel that can be transported with a donkey cart, a small motorized vehicle or some other way like rickshaw.

• Surface water: These are water collected directly on the surface of the earth, usually in rivers, lakes, canals.

• Bottled water or sachet water: These are water sold in small or large bottles or in sachets.

MICS considers taps, tube wells, protected dug wells, protected spring and rains water as the improved water sources.

WHO's recommendations and the results of some empirical work show that these sources do not always provide safe water, which can be consumed without risk to health, biasing and therefore inflating the proportion of the population using safe drinking-water.

4. Limitations of the Measurement Approach of the Access to Safe Drinking-water in the MDGs

To point out the main drawbacks of the measurement of access to safe drinking-water as can be derived from the five improved water sources defined by MICS survey shown in section 3, this study will classify these improved water sources into three groups namely: (i) tap water; (ii) underground sources; and (iii) rain water. The underground sources in turns, are composed of tube wells, protected dug wells and protected springs, as defined in the previous section.

4.1 Tap Water

According to the WHO's guidelines for drinking-water quality [2], water circulating within a building's piped distribution system can be subject to chemical or microbial contamination. Examples are provided in the guidelines. This study underlines only the following two examples:

(1) Water can be subject of fecal contamination due to deficiencies in roof storage tanks and cross-connections with wastewater pipes, for example, poorly designed plumbing systems can cause stagnation of water and provide a suitable environment for the proliferation of *Legionella*.

(2) Plumbing materials, pipes, fittings and coatings can result in elevated heavy metal (e.g. lead) concentrations in drinking-water, and inappropriate

[1] MICS classifies boreholes as an example of tube well [4].

materials can be conducive to bacterial growth or generate inappropriate water chemical composition.

These two examples have been empirically demonstrated in different studies, including those conducted by Arvand, M., et al. in 2011 [5] and Beattie, A. D., et al. in 1972 [6, 7]. Arvand, M., et al. [5] evaluated *Legionella* contamination in cold and warm water supplies of healthcare facilities in Hesse, Germany, and found that the cold water supply may be heavily contaminated with *Legionella* species. Studying environmental lead pollution in urban soft-water area from a sample of 23 Glasgow households, Beattie, D., et al. [6] found that lead content of water from cold taps was up to 1,850 µg, 18 times the upper acceptable limit and was proportional to the amount of lead in the plumbing system. In a similar study, they [7] established that domestic water supply of sampled households in rural parts of Scotland were contaminated by lead acquired from lead plumbing systems and this affected health of household members.

4.2 Underground Sources

Underground sources can also be contaminated. This was highlighted in a pilot study conducted in 2013 by the National Institute of Statistics of Cameroon in a study on the quality of underground and surface water in the city of Yaoundé [8].

This study collected groundwater samples that were analyzed in laboratory. In total, the samples were taken from 39 water sources (21 wells, 14 springs and 4 boreholes) used by households. These sampled sources were used by households either deprived from connection to public water distribution system or during breaks in household water supply. The results are unequivocal: a large presence of fecal bacteria in these water sources and half of the sources had higher nitrate concentrations than the WHO standards. It should be noted that in high concentration, nitrates can pose health risk to pregnant women, fetuses, babies under 6 months of age, the elderly and people with weakened immune systems or chronic heart, lung and blood diseases [9, 10]. Furthermore, Levallois, P. and Phaneuf, D. [9] pointed out that nitrates reduce the amount of oxygen in the blood. This can cause the appearance of blue spots on babies less than 6 months of age and cause their death if proper treatment is not given to them on time. The study concluded that water from half of the sources studied in Yaoundé was unfit for consumption. This also includes water from 50% of the boreholes sampled which by MICS' definition are classified as protected water source.

4.3 Rain Water

Rain water is a consequence of the condensation of the water contained in the air. It is charged with gas flowing into the atmosphere from the burning of fossil fuels, industrial and agricultural activity and car traffic. Before arriving in tanks or storage containers, rain water undergoes this air pollution. The most spectacular effect of this pollution is the acidity of rain water [11]. Quoting a study conducted by Sigha, N., et al in 2003, the aforementioned INS' study [8] pointed out that the average nitrate concentrations in rain water in Zoétélé, a village in south Cameroon, in the order of 0.42 mg/L, not far from the limit value of 0.50 mg/L given by the WHO [12]. One can observe there is an explicit risk of statistical flaw since this result claims the rain water of this village is safe for drinking with regard to nitrate concentrations given that the average nitrate concentrations was below the WHO threshold. The use of average may lead to statistical flaw if at least the value of one case exceeded the allowed limit. This doubtful result is quite legitimate, unless each of the cases value satisfies the limit requirement in such a case there is no need to use the average, instead using a range will ensure the confidence in the reported results. Thus, this study suggests to avoid using the average in reporting such results unless the values of all cases are also reported and instead it is more efficient and accurate to replace the average by the highest case value.

Rain water can also be polluted by roofing materials and gutters as proved in a study by Gromaire, M. C. et al. [13], since they have measured concentrations of zinc, the main material of some roofs, sometimes exceeding the standards[2] for drinking-water in the city of Paris in France. Apart from zinc, there are also other materials that go into the composition of certain types of roof and gutter such as plastic, tar, aluminum or bitumen that can also pollute rain water. Some equipment placed on roofs such as solar panels, nails, hooks, etc. can also contaminate rain water with toxic metals [11].

Although this paper focuses on the quality of improved water sources, it is important to emphasize that rain water storage methods can also be the source of water pollution. Indeed, water preserved in transparent containers and exposed to the light of the day can favor under certain conditions the development of mushrooms and algae. Chemical reactions between polluted elements from roofs and the compositions of rain water storage tanks can also alter the quality of stored water [11].

The above examples show that improved qualified water sources do not necessarily guarantee the production of safe drinking-water. Based on these findings, it is clear that the measurement of access to safe drinking-water through the use of an improved water source may have been overestimated in the MDGs. This result may challenge the achievement of the MDG 7 target on access to safe drinking-water in 2010.

5. Perspectives for the Sustainable Development Goals

Access to safe drinking-water is still a global priority for the next decade as reflected in target 6.1 of the Sustainable Development Goals. The target is to achieve universal and equitable access to safe and affordable drinking-water for all by 2030. According to metadata [14] developed by the custodian agencies (United Nations Children's Fund and World Health Organization), the achievement of this target will be assessed and monitored by the proportion of the population using safe drinking-water services. However, as for the MDGs, the metadata specifies that this indicator will be indirectly measured by the proportion of population using an improved basic drinking-water source which is located on premises, available when needed and free from fecal (and priority chemical) contamination.

The metadata defining SDG Target 6.1 stresses that the improved drinking-water sources include: (i) piped water into dwelling, yard or plot; (ii) public taps or standpipes; (iii) boreholes or tube wells; (iv) protected dug wells; (v) protected springs; (vi) packaged water; (vii) delivered water and (viii) rain water. In addition, the normative criteria of the human right to water are also taken into account through the accessibility, availability and quality of water. This paper will focus here on the quality criterion.

The definition of improved basic drinking-water source provided by the metadata is still the same as for the MDG as well as main data sources, however, the main emphasis of the SDGs in this regard, is on both factors, namely (a) water free from fecal and on (b) priority chemical contamination. This means that water should comply with relevant national or regional standards. In the absence of such standards, reference should be made to the WHO Guidelines for Drinking-water Quality. The metadata further highlight that *E. coli* or thermotolerant coliforms are the preferred indicator for microbiological quality, while arsenic and fluoride are the priority chemicals for global reporting.

By focusing on water quality, SDG 6.1 aims to address the MDG gaps in this area. However, the recommended water quality assessment is strictly limited to *E. coli* for the microbiological aspect and arsenic and fluorine for the chemical aspect to narrow this gap. This study has shown that these two factors

[2] Maximum value measured at 9,855 µg/L almost double the limit value for drinking water (5,000 µg/L) defined by the WHO according to the authors.

are not exhaustive since there are other elements that can make improved water sources unfit for consumption as provided in section 3. Certainly due to ecological and environmental variations, the incidences of these elements will have different intensities from one region to another or from one country to another. For example, underground water in agricultural areas where fertilizers are intensively used is likely to have very high nitrate or pesticides concentrations, particularly during the dry season.

The recommendation would be for each country to develop microbiological and chemical quality indicators rather than to restrict the quality of safety water only to the two factors defined in the SDGs. The potential developed indicators should be selected on the basis of: (a) national or regional relevant standards or those of WHO, where appropriate; (b) studies and field work; and (c) taking advantage of existing pertaining administrative data sources. For example, the study on underground and surface water quality in the city of Yaoundé did not detect arsenic and showed that fluoride concentrations were in the range of 1.5 mg/L with 0.08 mg/L for shallow wells and 0.07 mg/L for underground water points, well below the WHO limit. However, nitrate concentrations were very high in some sources even improved ones. This study therefore suggests retaining nitrate for this city with respect to chemical indicators.

6. Conclusion

By developing metadata to evaluate and monitor target 6.1 of the SDGs, which aims to achieve universal and equitable access to safe and affordable drinking-water for all by 2030, the international community wanted to go beyond basic access and address the safe management of drinking-water services, including the dimensions of accessibility, availability and quality.

This paper has shown that the quality dimension of water sources was not sufficiently taken into account in regard to the MDGs indicator designed to measure the access to safe drinking-water. This gap has been highlighted by several studies, including the study on the quality of underground and surface water conducted by the National Institute of Statistics of Cameroon and other studies done in France, Germany and Scotland. The study has also highlighted the mal practice of using the concept of average that masks and endangers some communities to consume unsafe water and suggested an alternative measure.

Within the SDGs framework, although, the shortcomings on water quality started to be addressed as priority for the global report by considering two quality indicators to assess water safety namely, the microbiological (*E. coli*) and chemical (arsenic and fluorine) quality indicators, however, these two indicators may not be relevant to some countries. The study has also shown the existence of other chemical in some countries such as nitrate or zinc that also can pose hazard to the safety of water.

Based on the findings of this study, there is an urgent need to develop national priority indicators of microbiological and chemical quality based on relevant standards and field work to gain in efficiency and to invest on the opportunity provided by the existence of pertaining administrative data sources. This recommendation has a ground on the fact that the elements that causes water pollution are several and vary from one geographical area to another.

Acknowledgements

The author’s acknowledgements are due to Dr. Khogali Khogali of the Economic Commission for Africa and Mr. Romain Tchakoute of the National Institute of Statistics of Cameroon for their comments and the review of the study.

References

[1] UNICEF and WHO. 2017. *Progress on Drinking Water, Sanitation and Hygiene Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG.* World Health Organization.

[2] WHO. 2011. *Guidelines for Drinking-water Quality*. 4th

ed. Edition. Accessed March 16, 2018. http://apps.who.int/iris/bitstream/handle/10665/44584/9789241548151_eng.pdf?sequence=1.

[3] MDG. 2012. "Indicators for Monitoring the MDGs. Definitions, Rationale, Concept and Sources, 7.8 Proportion of Population Using an Improved Drinking Water Source". Accessed March 20, 2018. http://mdgs.un.org/unsd/mi/wiki/7-8-Proportion-of-population-using-an-improved-drinking-water-source.ashx.

[4] UNICEF. 2017. "Multiple Indicator Cluster Surveys-Instructions for interviewers". Accessed March 20, 2018. http://mics.unicef.org/files?job=W1siZiIsIjIwMTcvMTEvMzAvMTkvMzAvNDEvODY4L01JQ1M2X0luc3RydWN0aW9uc19mb3JfSW50ZXJ2aWV3ZXJzXzIwMTcxMTI5LmRvY3giXV0&sha=fbb2d8eef474e7b2.

[5] Arvand, M., Jungkind, K., and Hack, A. 2011. "Contamination of the Cold Water Distribution System of Health Care Facilities by Legionella Pneumophila: Do We Know the True Dimension?" Euro Surveillance. Accessed March 22, 2018. http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19844.

[6] Beattie, A. D., Dagg, J. H., Goldberg, A., Wang I., and Ronald, J. 1972. "Environmental Lead Pollution in an Urban Soft-water Area." *British Medical Journal* 1972 (2): 491-3.

[7] Beattie, A. D., Dagg, J. H., Goldberg, A., Wang, I., and Ronald, J. 1972. "Lead Poisoning in Rural Scotland." *British Medical Journal* 1972 (2): 488-91.

[8] INS. 2017. "Pilot Study on Groundwater Quality and Health in Yaoundé." INS report. Accessed March 18, 2018. http://www.stat.cm/downloads/2018/Rapport_EPESS-Yaounde_2013.pdf.

[9] Levallois, P., and Phaneuf, D. 1994. "The Contamination of Drinking Water by Nitrates: Health Risk Analysis." *Canadian Journal of Public Health*. 85: 192-6.

[10] Healthlink, B. C. 2017. "Nitrate in Well Water." Accessed March 22, 2018. https://www.healthlinkbc.ca/hlbc/files/documents/healthfiles/hfile05a.pdf.

[11] EAUATARCIE. 2003. "The Quality of Rainwater from a Cistern." Accessed March 20, 2018. http://www.eautarcie.org/03b.html.

[12] WHO. 1993. "Drinking Water Standards 1993." Accessed March 16, 2018. https://www.lenntech.com/applications/drinking/standards/who-s-drinking-water-standards.htm.

[13] Gromaire, M. C., Chebbo, G., and Constant, A. 2002. "Impact of Zinc Roofing on Urban Runoff Pollutant Loads: The Case of Paris, Water and Science and Technology." *Water Science and Technology* 45 (7): 113-22.

[14] UNICEF and WHO. 2017. "Metadata for Indicator 6.1.1: Proportion of Population Using Safely Managed Drinking Water Services." Accessed March, 18 2018. https://unstats.un.org/sdgs/metadata/files/Metadata-06-01-01.pdf.