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Addressing Sustainability of Sanitation Systems:
Can it be Standardized?

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ABSTRACT

Recently, a technical draft of the international standard ISO/DIS 30500 for non-sewered sanitation systems has been developed (publication expected for 2018). Its innovative feature is the inclusion of sustainable aspects. This article discusses the motivation behind this standard and explores to what extent sustainability can be standardized. This research was based on the development of a concept-standard for sustainable sanitation and on surveys of experts working in sanitation and standardization.

KEYWORDS

Concept Standard, Consultations, ISO, Sanitation, Stakeholders, Sustainability Principles

1. INTRODUCTION

Lacking household-level access to safe water and hygienic toilets is still a global problem, affecting a third of the world population in 2015 (Cumming et al., 2014). The United Nations Sustainable Development Goal 6 asks governments to 'ensure access to water and sanitation for all', as 'due to bad economics or poor infrastructure, every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene' (UNO, 2018). The International Organization for Standardization (ISO) has developed several standards to support the realization of this goal (Naden, 2018).

The most recent contribution is the Draft International Standard ISO 30500 on non-sewered sanitation (ISO, 2017). It has been developed in view of the limitations of conventional approaches towards increasing toilet coverage: Millions of people live in rapidly growing irregular settlements (slums) without connections to sewers and with no community toilets in their immediate neighborhood, resulting in the widespread practice of open defecation (Brunner et al, 2015). The conventional approach, providing them with sewer connections and wastewater treatment at the end of the pipe,

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may not always be viable, as recent case studies confirmed for India: 58 sanitation systems either were not fulfilling national standards or their costs were not affordable for slum dwellers (Starkl et al., 2018). Further, alternative low-cost systems often were not accepted (destroyed) by the users, e.g. as they considered these systems as inferior (Brunner et al., 2010a). In response, the Bill and Melinda Gates Foundation (BMGF) has asked for radical technology transformation (Re-invent the toilet challenge) and industry developed various types of non-networked sanitation systems (Cheng et al., 2018). However, to ensure the technical functionality of the new systems and let technology users rest assured that these systems are technically mature, the need to develop a technical standard was identified (Starkl et al., 2015).

In order to tackle such issues, in 2015 the BMGF contracted a project to develop a private technical standard on non-sewered sanitation systems. Based on the work for this private technical standard, in June 2016 the American National Standards Institute (ANSI) organized an international workshop which led to an International Workshop Agreement that was published in September 2016 (IWA-24, 2016). In a next step, ISO established a Project Committee (PC 305) to develop the draft international standard ISO/DIS 30500. The experts participating came 'from 31 countries worldwide representing a broad range of stakeholder categories, such as industry, government, academia and non-governmental organizations' and they were supported by the African Water Association and the Toilet Board Coalition (Lewis, 2017; Roberts, 2017). The public enquiry about the draft international standard (ISO/DIS 30500) started on 19 January 2018 and the voting finished in April 2018. As per the voting results the DIS has been approved, and the final standard is expected to be published later this year.

2. GOAL OF THE PAPER

The paper contributes to the persistent discussion of how much ethical, social, economic, environmental and organizational issues can be addressed in a technical standard. This paper asks this question in the context of sustainable sanitation.

First, in order to identify possible barriers towards addressing sustainability in a technical standard, the paper summarizes the approach taken to address sustainability issues in the new technical standard ISO/DIS 30500. It should be noted that this draft standard has been designed as a product standard for industry. It acknowledged the well-established importance of sustainability aspects for sanitation and developed general guidance and recommendations for sustainability aspects such as cultural requirements, operation and maintenance, or affordability by the intended users. However, it did not go into context specific sustainability details, which might be considered at the implementation level of a sanitation project.

Second, in order to explore, what more could be done, the paper proposes an additional standard focusing on the assessment of sustainability of sanitation systems and asks, if such a standard could be beneficial. This proposal was informed from ISO Guide 82:2014 on sustainability (ISO, 2014) and the standard ISO 13065 about sustainability criteria for bioenergy (ISO, 2015a). This standard addresses a general issue, sustainability, by means of principles that focus on guidance rather than on stringent quantitative thresholds. (In a similar way, the general issue of product safety was addressed by ISO Standard 10377: ISO, 2013.) As experience has shown, project failures in the sanitation sector often occurred during the implementation phase due to negligence of context-specific economic, social and institutional sustainability aspects (Ramos-Mejía et al., 2017; Starkl et al., 2013b). Therefore, the question arose, whether an additional standard on sustainability of sanitation systems might be useful and which sustainability aspects such a standard should address. The authors therefore tried to sketch a framework on which a sustainability standard for (non-sewered) sanitation could be based on.

3. METHODS

3.1. Drafting a Concept-Standard for Sustainable Sanitation

The authors developed twelve non-technological sustainability principles P1 to P12 and 30 indicators (Px/y for principle Px) to assess the implementation of these principles (Table 1).

As to the rationale of this approach, recall (ISO 1365:2015) that principles mean ‘aspirational goals that govern decisions or behavior’, criteria denote ‘categories of conditions or processes that describe what is to be assessed without itself being a direct measure of performance’, and indicators are ‘quantitative, qualitative or binary variables that can be measured or described to assess an aspect of a defined criterion’. To illustrate this approach by means of a sanitation related issue, ISO 13065:2015 identified the principle ‘conserve and protect water resources’. For this it defined several criteria, amongst them: ‘The economic operator provides information on how quantity and quality of water drawn and released are addressed.’ In order to assess it, they defined several indicators, amongst them descriptions and lists of possible concerns, e.g.: indicator 1: ‘Describe procedures taken to identify potential impacts on water quantity including consideration of water depletion and other key chemical, physical and/or biological parameters. Describe procedures taken to identify potential impacts on water quality, including consideration of eutrophication and oxygen depletion and other key chemical, physical and/or biological parameters. Impacts to water quantity and quality shall address impacts to water sources and receiving bodies.’ As these examples indicate, a sustainability standard can be very detailed, as concerns the informational requirements, but at the same time it can be flexible, as concerns the concrete implementation by means of e.g. quantitative thresholds. Thus, such a standard is another approach towards better governance through information management (Soma et al., 2016).

The selection of the principles was based on own experiences and an initial literature review (100 sustainability criteria summarized in Starkl et al., 2015). The authors identified various known reasons for failure of sanitation systems (Starkl et al., 2013b) and formulated strategies to avoid these failures in the form of principles. For principles P1 to P8 a second level of more detailed criteria and non-quantitative indicators was added. However, the present work aimed at the proof of principle by means of a draft concept, which would only be a first step towards a fully developed draft standard, whence significant simplifications were used. Therefore, first, the four additional principles P9 to P12 for more specific issues were not refined by criteria/indicators. And second, below the level of the principles the paper did not distinguish between criteria and indicators. For, using consistently these three levels would have made the concept draft quite complex and this in turn might have deterred the contacted experts to respond to the authors’ questionnaire about the concept draft.

To illustrate this process by an example, in the past supply-driven planners of sanitation systems were often remote from the end-users and they ignored the local situation, resulting in stranded investments (Brunner et al., 2010b). The principle P1 therefore advises a more demand-driven approach. Minimal informational requirements for a demand-driven approach are the definition and study of the target area, which would define a criterion P1/1. Within this study, one would need a quantitative assessment of the demand, which would define an indicator P1/2. The concept draft combined these two levels into one.

3.2. Consultations with Selected Experts About the Concept-Standard

According to ISO Guide 82:2014, the relevance of sustainability principles should be examined based on stakeholder consultations. To this end, in 2015 the authors contacted experts involved in developing the private technical standard preceding ISO/DIS 30500 and inquired their views about the relevance of these principles by means of a questionnaire. Experts came mainly from Africa, Asia, Europe and North America and they worked in academia, in industry designing/producing innovative toilets, for NGOs with an interest in sanitation, in government, for public sanitation service providers, and in consulting. The expert responses took into account not only their personal

Table 1. Principles and indicators for a sustainability standard

P1	The sanitation system should be provided based on evidence of actual and future demand.	
	P1/1	Definition of the target area and study of actual and expected future situation and demand for sanitation improvements in that area.
	P1/2	Percentage of targeted users that have expressed the need for a toilet/sanitation system.
P2	The sanitation system should be designed taking into account local availability and reliability of water and energy.	
	P2/1	Required daily water volume to operate sanitation system.
	P2/2	Availability of water supply.
	P2/2a	Reliability of water supply.
	P2/3	Required energy to operate the sanitation system.
	P2/4	Availability of energy supply.
	P2/4a	Reliability of energy supply.
P3	The sanitation system should be accepted by the users in view of their cultural norms.	
	P3/1	Study on the suitability of the sanitation system with existing cultural habits (cleaning material, ease of use).
	P3/2	Percentage of users (identified under P3/1) that have expressed acceptance or non-acceptance of the proposed sanitation system.
	P3/2a	Assessment of the stability of user preferences with time (required behavioral changes).
	P3/3	Will there be equal access to the sanitation system by vulnerable user groups?
P4	The sanitation system operation shall be supported by sufficient funds for its full life time.	
	P4/1	Operational expenditures for the entire design life of the sanitation system including any financing costs.
	P4/2	Breakdown of sources of funding (includes expected user contributions) with maximum and minimum expected amounts for each source for the entire design life.
	P4/3	Risk classification of sources of funding (secured funding is no risks of default; c.f. P5).
P5	If users should contribute to the costs, then their contribution should be affordable for them.	
	P5/1	Expected contribution from users (as listed under P4).
	P5/2	Household income of the users and affordability of the expected user contribution.
	P5/3	Willingness to pay of the users (comparing median WTP with the expected user contribution).
	P5/4	Possibility to cross-finance the user contribution of those who cannot afford by those who could afford more.
P6	The local availability and capability of operation and maintenance services providers shall be proven.	
	P6/1	Description of the expected activities in terms of skills required.
	P6/2	Identification of existing local service providers and description of their skills.
	P6/2a	If none of the existing service providers has the required skills, is there a possibility to upgrade their skills through training to meet the requirements?
P7	If users are expected to perform any operation and maintenance activities, these activities ought to be in line with their capabilities.	
	P7/1	Description of the expected user activities in terms of time required per week (average) and level of skills required by the users.
	P7/2	Minimum skill of the targeted users, and possibility to upgrade the skills through training to meet the requirements.
	P7/3	Assessment of willingness of users to spend the required time on a long term basis.

continued on following page

Table 1. Continued

P8	The sanitation system shall be subject to regular and reliable monitoring.	
	P8/1	Is there an institutional framework for monitoring that enforces regular monitoring at the site?
	P8/1a	Is there a voluntary framework of regular third party monitoring at the site?
	P8/2	Do local monitoring organizations have the required equipment and skills to perform the required monitoring tasks?
	P8/2a	If the required equipment for monitoring is not available, will there be provisions to provide the equipment before the start of the monitoring phase?
	P8/2b	If the skills for monitoring are not yet available, is there a possibility to provide the required skills to the monitoring companies?
P9	In case of a public toilet, it should be protected against vandalism and crime, have a caretaker during operational hours, and have inviting appearance.	
P10	The sanitation system should reuse nutrients as much as feasible.	
P11	The sanitation system should minimize fresh water consumption as much as possible.	
P12	The sanitation system should minimize energy consumption as much as possible.	

views, but also their expectations about which principles might reach consensus in the international stakeholder participation process of ISO.

Experts assessed the relevance of these principles and indicators for sustainability on a scale from relevant, rather relevant, rather not relevant, and not relevant, quantified as 1, 0.5, −0.5, −1. Multiple answers were replaced by their mean value, in most cases 0, and missing answers by 0 (indifference). Confidence intervals were computed using Clopper-Pearson's conservative method for small samples at 95% significance, using one-sided limits (Casella & Berger, 2001).

Subsequent analysis used methodology developed in Starkl et al. (2013a). In order to extract a typical view shared by a larger group of experts, experts were compared and clustered, based on the nearness of their views. To this end, agglomerative hierarchical clustering (AHC) was applied (Chipman & Tibshirani, 2006). Thereby, nearness was measured by the Pearson correlation coefficient. This method was also used by other authors for stakeholder analysis (Gomez-Limon & Atance, 2004; Lienert et al., 2013). Next, significant differences in the importance assessments between the cluster and non-cluster experts were identified from non-parametric Mann-Whitney test. (The phrase stochastically higher/lower refers to this test.)

These computations (clustering and comparison of clusters) were repeated for standardized relevance assessments, $(x-\mu_i)/\sigma_i$, where x is the response, μ_i the mean value of the 42 responses of respondent R_i, and σ_i the standard deviation. Here, the mean value μ_i represented the overall bias of respondent R_i towards the use of non-technological principles and the standard deviation σ_i represented cultural differences. As for standardized responses these influences were removed, for the standardized responses significant differences in the consensus of cluster respectively non-cluster respondents could be meaningfully identified by using the Fisher F-test. (It identifies significant differences of sample variances.) The above methods were chosen to reduce the impact of bias and cultural differences on the outcome.

4. RESULTS

Table 1 explains the principles and indicators that were developed for the suggested concept-standard and Table 2 displays the outcome of 16 expert responses to these principles.

Each of the twelve principles and 26 of the 30 indicators were found to be relevant or rather relevant by a majority (8 or more) of the respondents. Also the mean value μ_i (overall approval towards

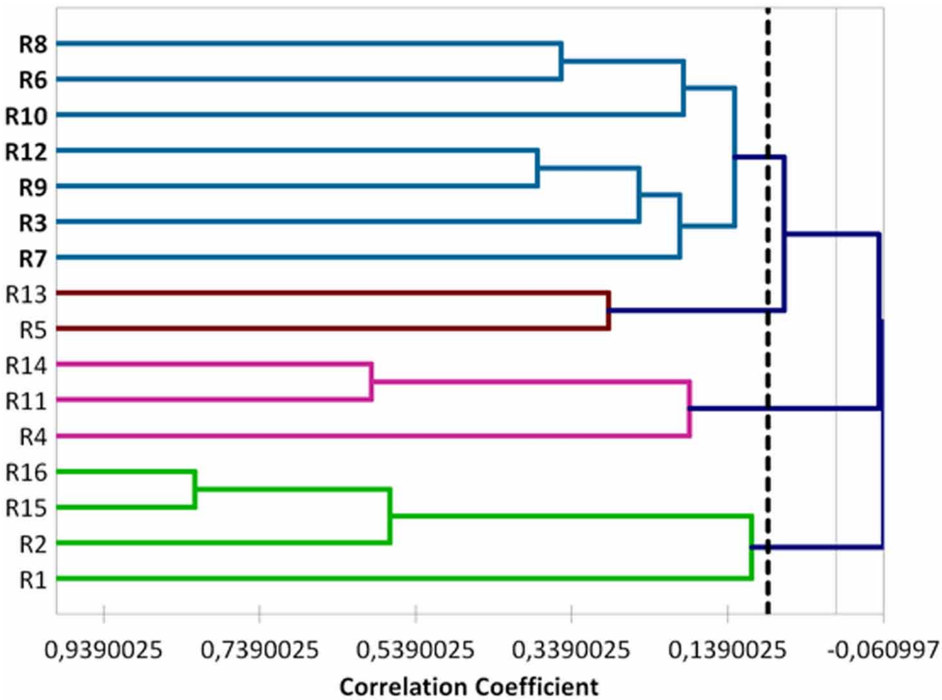
Table 2. Views of 16 experts about the relevance of certain sustainability principles and indicators

Principle Indicator	Relevance > 0		95% confidence		Principle Indicator	Relevance > 0		95% confidence	
	Count	percent	lower	upper		Count	percent	lower	Upper
P1	10	63%	39%	82%	P5/2	10	63%	39%	82%
P1/1	11	69%	45%	87%	P5/3	11	69%	45%	87%
P1/2	11	69%	45%	87%	P5/4	9	56%	33%	77%
P2	11	69%	45%	87%	P6	10	63%	39%	82%
P2/1	11	69%	45%	87%	P6/1	11	69%	45%	87%
P2/2	11	69%	45%	87%	P6/2	10	63%	39%	82%
P2/2a	12	75%	52%	91%	P6/2a	11	69%	45%	87%
P2/3	11	69%	45%	87%	P7	12	75%	52%	91%
P2/4	10	63%	39%	82%	P7/1	12	75%	52%	91%
P2/4a	10	63%	39%	82%	P7/2	10	63%	39%	82%
P3	13	81%	58%	95%	P7/3	10	63%	39%	82%
P3/1	14	88%	66%	98%	P8	10	63%	39%	82%
P3/2	12	75%	52%	91%	P8/1	9	56%	33%	77%
P3/2a	8	50%	28%	72%	P8/1a	11	69%	45%	87%
P3/3	11	69%	45%	87%	P8/2	11	69%	45%	87%
P4	9	56%	33%	77%	P8/2a	7	44%	23%	67%
P4/1	11	69%	45%	87%	P8/2b	7	44%	23%	67%
P4/2	10	63%	39%	82%	P9	10	63%	39%	82%
P4/3	7	44%	23%	67%	P10	6	38%	18%	61%
P5	12	75%	52%	91%	P11	14	88%	66%	98%
P5/1	12	75%	52%	91%	P12	14	88%	66%	98%

the use of non-technological principles) was positive for most respondents (13 = 81%; confidence limits 77±18%). However, only for five of the principles (P3, P5, P7, P11, P12) and for five indicators was the approval high enough to ensure with 95% confidence that at least 50% of respondents in a similar survey would consider them as (rather) relevant.

Using AHC (see Figure 1) and measuring differences by correlation defined a clustering of experts into four groups of similarly minded ones with a largest cluster (henceforth core cluster) of 7 of the 16 respondents (44% of respondents, confidence limits 45±22%). For this core cluster, Mann-Whitney test identified 95% significant differences between cluster and non-cluster respondents in the assessment of principle P1 (evidence of actual and future demand) and the following indicators, all of stochastically higher relevance for cluster members: P1/2 (percentage of users with a demand), P2/1 (water volume for daily operation), P2/2a (reliability of water supply), and P3/1 (suitability with existing cultural habits). Further, with 90% significance cluster respondents had stochastically higher assessments of the relevance of principles P2 (availability and reliability of water and energy), P5 (affordability for the users) and indicators P1/1 (identification of target area, actual and future situation, and demand), and stochastically lower assessments for indicator P8/2a (where equipment for monitoring is not available, there shall be provisions to provide it). In terms of these indicators, the cluster respondents could be characterized as follows: They considered principles P1 and P2 as relevant

Figure 1. Arrangement of expert responses (R1 to R16) by their nearness (high correlation), whereby boldface (R7 and above) identifies the core cluster; graphics with XL-Stat of AddinSoft



or highly relevant, but considered indicator P8/2a as not highly relevant. A simpler characterization using insignificant differences defined cluster respondents as considering both the principle P1 and the indicator P8/1a (voluntary framework for a regular third-party monitoring) as relevant or highly relevant. Further, all cluster respondents considered indicator P3/1 as highly relevant.

For standardized responses, measuring differences by the correlation and applying AHC resulted again in the above core cluster, but slightly different outcomes of the Mann-Whitney test: With 95% significance, and compared to non-cluster respondents, the standardized cluster responses were stochastically higher for the relevance of the principles P1, P2 and the indicators P1/2, P3/1, and stochastically lower for the indicators P4/1 (operational expenditures), P8/2a, P8/2b (where skills for monitoring are lacking, knowledge transfer is possible). With 90% significance, the standardized cluster responses were stochastically higher for the principle P5 and indicators P1/1, P2/1.

Further, with respect to significant differences in the variances for the standardized responses, for cluster respondents, with 95% significance there was a higher consensus (lower variance: F-test) about the relevance of principles P1, P2 and the indicators P1/1, P2/4a (reliability of energy supply). By contrast, non-cluster respondents had a higher consensus about the indicators P4/2 (breakdown of sources of financing), P5/3 (users' willingness to pay), and P6/1 (description of activities in terms of skills).

Summarizing these findings, a core cluster of experts in comparison to the other experts had a strong consensus about the relatively higher relevance of principles P1 and P2. They thus asked for demand-driven planning with consideration of the local situation. They also tended to support principles P3 and P5 more strongly than the others, thus acknowledging the importance of cultural factors and affordability. However, compared to the other experts, their support for monitoring was lower (indicators P8/2a, P8/2b for principle P8).

Thus, most principles and indicators were supported by a majority of experts, but different groups of experts had different preferences. The paper elaborates on how such differences in the preferences may affect consensus finding on a sustainability standard.

5. DISCUSSION

5.1. Limitations for Achieving Consensus on Sustainability Aspects

The main drawback of the present consultation exercise was a weak consensus of experts about the very need for sustainability principles: While some were enthusiastic about providing decision-makers with a tool to avoid the stranded investments of the past (toilets that were not used), others considered them rather as a marketing tool. In addition, there were cultural differences, also in stating the strength of preferences. Thus, with respect to implementation, a core group of sanitation experts was open to sustainability standards for sanitation system implementation, while the other experts would rather count on ensuring technical criteria by more monitoring. Industry representatives were concerned that the inclusion of criteria whose fulfillment would depend on implementation (proper use of the technology) could burden them with unforeseeable risks. Despite the small sample size, this finding may generalize to expert panels in general. This observation may explain, why in the development of most technical standards consensus on sustainability criteria could only be found, if such criteria were moved to non-binding recommendations or annexes. This observation is in line with similar findings from literature (de Vries et al, 2017). Also, in the different context of information management, Spring (2016) found that security issues were of lower concern for developers of new standards.

In the authors view, both monitoring and the consideration of technical and non-technical aspects are important for ensuring the sustainability of sanitation systems. However, without a standard, it may depend on the individual preferences of the local decision-makers, if more or less emphasis is put on monitoring or on user preferences. Consequently, in view of individual bias not all principles and indicators for sustainability might actually be considered. Therefore, in the implementation phase additional guidance may be required for adequately considering all relevant sustainability aspects rather than merely selected ones. A sustainability standard for sanitation could ensure this.

The considered principles and indicators were a first step towards development of such a standard. As qualitative, quantitative and binary variables may be used as indicators, a to be developed sustainability standard may include thresholds for go or no go. Where feasible (for limitations see Brunner & Starkl, 2004), it may define a scoring over large subsets of indicators and these scores in turn might be further aggregated. This, in turn, would facilitate ranking of the sustainability of different sanitation alternatives under each principle or even to define a ranking in terms of overall sustainability.

5.2. Inclusion of Sustainability Aspects in a Technical Standard

ISO/DIS 30500 on non-sewered systems addressed amongst others general requirements, technical requirements and performance testing. As also technologies meeting a technical standard may fail in the actual implementation due to non-technical reasons, a sustainability chapter plus an informative annex on sustainability were added. These chapters have been the outcome of an intensive discussion in many workshops and voting.

As a major consideration, a chapter within a standard should only concern product-related aspects for which the manufacturer would be responsible. This resulted in clauses that demand the manufacturer to provide environmentally relevant information (water demand, energy demand and balance, nutrient contents and recovery). Further, it was discussed to what extent affordability could be included in a sustainability chapter. It was concluded that the manufacturer could not provide costs, which were contingent on the local situation. However, the manufacturer could include all information related to the recurring operational requirements, as these are known to drive costs (listing the activity, its frequency, duration/man hours, complexity/required technical competence, and the required spare parts). Consequently, users knowing the local salaries could estimate in advance the running costs of the systems.

Other sustainability aspects not directly related to the product, but relevant to its implementation, were summarized in an informative annex, with a focus on costs of use and affordability, complexity, and cultural considerations. Cultural aspects were considered as particularly relevant for smaller scale technologies, where the front-end (user interface) is a part of the sanitation system.

For larger scale sanitation systems similar considerations apply. In addition, for defining sustainability the applied planning methodologies including stakeholder participation should be considered (Starkl et al., 2013a). Further, well-established mechanisms for monitoring and enforcement of environmental compliance would be needed (Starkl et al., 2013b). Usually, such larger systems do not include the front-end, hence cultural considerations are of lower relevance. However, the acceptability of recycling products (recycling treated waste water for toilet flushing, applying treated sludge as fertilizer for vegetables) is a major issue. These aspects have been discussed in a new international workshop on community-scale resource-oriented sanitation treatment systems, led by ANSI and supported by BMGF, which has been approved as International Workshop Agreement (IWA-28, 2018). Following this IWA, a project committee PC 318 (Community scale resource-oriented sanitation treatment system) was established and its first meeting is scheduled for July 2018.

5.3. Alternative Approach: Stand-Alone Sustainability Standard

ISO/DIS 30500 on non-sewered systems has been drafted as a product standard and as such it was intended to regulate the quality of the manufactured product, without going into depth with issues related to the implementation process and the operation and maintenance. As shown above, the inclusion of sustainability aspects in a technical standard is limited in general, as binding requirements can be formulated only with respect to the product, while other aspects can only be addressed in the form of general guidelines and recommendations.

The difficulties of standardizing sustainability can be underlined by the intensive debates even about core aspects for a technical standard. For instance, some authors argued that concentration standards for effluents would not be appropriate for non-sewered systems with low water use (Udert et al., 2017). As soon as implementation aspects are considered, multiple additional aspects need to be considered and put into a unified perspective. This can be illustrated by comparing the public health aspects considered in two international recommendations for water recycling in agriculture, the WHO guidelines (WHO, 2006) about the safe use of wastewater and the ISO 16075:2015 guidelines about treated wastewater for irrigation (ISO, 2015b). These guidelines define different and not always comparable reuse categories and apply different indicators and thresholds (Table 3).

Also, the above outlined expert consultation has shown, that whereas there was strong overall consensus about the importance of considering sustainability aspects for sanitation project implementation, there was no strong consensus about all individual principles and indicators. Even if one of the many existing sustainability assessment frameworks would be used (Wallis et al., 2011, counted 54 different frameworks), the outcomes from different frameworks might not be comparable. This lack of a common understanding of sustainability clearly hinders the development of a sustainability standard, whereas the lack of such a standard may be a barrier for the implementation of innovative and more sustainable technologies.

However, the development of a stand-alone sustainability standard is not out of reach and it may remedy this situation and lead to an international consensus. Such standard would need to include consensus on the key principles, indicators and methods to measure these indicators, but not necessarily on thresholds. An example is the above cited bioenergy standard ISO 13065:2015. It defines sustainability principles, criteria and indicators for bioenergy, but explicitly does not define thresholds or limits; these are to be defined in the local context (by the 'economic operator'). Therefore, a stand-alone standard on sustainability criteria for non-sewered sanitation systems

Table 3. Comparing guidelines for irrigation water quality with respect to health (sources: WHO, 2006; ISO, 2015b)

WHO 2006 Guidelines			ISO 16075:2015				
Purpose	E. coli per 100 mL (maximum)	Helminth eggs per L (maximum)	Purpose	Thermo-tolerant coliforms per 100 mL		Helminth eggs per L	
				95% percentile	maximum	average	maximum
unrestricted irrigation: root crops	10^3	1	unrestricted urban irrigation and agricultural irrigation of food crops consumed raw	10; or not detectable	10^2	NA	NA
unrestricted irrigation: leave crops	10^4	1					
unrestricted irrigation: drip irrigation, high growing crops	10^5	NA	restricted urban irrigation and agricultural irrigation of processed food crops	200	10^3	NA	NA
unrestricted irrigation: drip irrigation, low growing crops	10^3	1					
unrestricted irrigation: no additional barrier	10 or 1	NA	agricultural irrigation of non-food crops	10^3	10^4	1	5
restricted irrigation: labor intensive	10^4	1	restricted irrigation of industrial and seeded crops	NA	NA	1	5
restricted irrigation: highly mechanized	10^5	1	restricted irrigation of industrial and seeded crops	NA	NA	1	NA
restricted irrigation: subsurface irrigation	10^6	NA					

may be an optimal supplement to the ongoing development of technical standards. The existing annexes to ISO standards would be the appropriate start for elaborating more detailed principles, criteria and indicators.

5.4. Recommendations

ISO/DIS 30500 is one of the first international technical standards that addresses sustainability aspects that go beyond the product requirements. Thereby, in the context of non-sewered sanitation systems, the standard promotes a global common understanding of innovative and sustainable sanitation solutions. However, as shown above, there are limitations to what extent sustainability can be considered within a technical standard. Therefore, the paper suggests developing a stand-alone sustainability standard. This points on the one side to the need of review, revision and careful selection of the principles and indicators on which a sustainability standard would be based, and on the other it reinforces the value of a uniform approach for assessing sustainability of sanitation systems to avoid arbitrary consideration of sustainability aspects based on personal preferences or vested interests.

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