Towards an international standard: The ISO/DIS 18504 Sustainable remediation

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Abstract
Sustainable remediation is the elimination and/or control of unacceptable risks in a safe and timely manner while optimizing the environmental, social, and economic value of the work. Forthcoming International Organization for Standardization (ISO) Standard on Sustainable remediation will allow countries without the capacity to develop their own guidance to benefit from work done over the past decade by various groups around the world. The ISO standard has progressed through the committee draft (ISO/CD 18504) and draft international standard (ISO/DIS 18504) stages. The risk-based approach to managing the legacy of historically contaminated soil and groundwater has been incorporated into policy, legislation, and practice around the world. It helps determine the need for remediation and the end point of such remediation. Remediation begins with an options appraisal that short lists strategies that could deliver the required reduction in risk. A remediation strategy comprises one or more remediation technologies that will deliver the safe and timely elimination and/or control of unacceptable risks. The ISO standard will help assessors identify the most sustainable among the shortlisted, valid alternative remediation strategies. Practitioners presenting case studies claiming to constitute sustainable remediation should now report how they have aligned their work with the new standard. Indicators are used to compare alternative remediation strategies. The simplest metric that allows a characteristic to act as an indicator should be chosen. Weightings indicators can become a contested exercise and should only be undertaken where there is a clear desire for it by stakeholders and a clear need for it in identifying a preferred strategy. The simplest means of ranking alternative remediation strategies should be adopted.

Keywords Sustainable remediation; **international standard; risk-based land management**

1. Introduction

The risk-based approach to managing the legacy of historically contaminated soil and groundwater has been incorporated into policy, legislation, and practice around the world (Nathanail, 2013). The approach helps determine the need for remediation and the end point of such remediation.

Sustainable remediation is remediation that seeks to apply the principles of sustainable development to the process of selecting and then implementing a remediation strategy at a specific site. For the concept to be meaningful and useful to practitioners, regulators, and the wider group of stakeholders in land quality, clear definitions of terms and of ways of demonstrating that a specific remediation strategy is a sustainable remediation strategy are needed.

Over the past decade several national initiatives have been set up to develop a shared understanding and to disseminate good practice in the field of sustainable remediation. These initiatives take a variety of forms. They range from standalone not for profit membership organizations (e.g., the Sustainable Remediation Forum, SURF, is a USA non-profit corporation with broad membership), specialist subgroups of pre-existing bodies (e.g., SuRF

Australia New Zealand, SuRF ANZ, is a Special Interest Group operating as a Practice Forum of the Australian Land and Groundwater Association, ALGA, and the Sustainable Remediation Working Group of the Network for Industrially Contaminated Land in Europe, NICOLE) and projects (e.g., Contaminated Land Applications in Real Environments (CL:AIRE) set up SuRF-UK on this basis). The spreading geography of national SURFs (e.g., they exist in Brazil, Canada, Colombia, Italy, Taiwan, and The Netherlands) shows a growing interest in the concept of sustainable remediation. There has been much sharing of ideas, concepts, and guidance among the various SURFs and many publications as a result. However, there has not been harmonization in terminology or distillation of the essentials in a way that could be used worldwide and that would benefit countries without a local SURF and/or without the resources to develop in-country guidance.

In recognition of the above interest and richness of knowledge, a need was identified, during the 19th meeting of SURF held in January 2012 at University of California San Diego in La Jolla, for a standardized approach to sustainable remediation. The analogue for such an approach was the international standard on the assessment of impact from soil contaminated with petroleum hydrocarbons (ISO 11504:2012) (ISO, 2012a).

2. On Remediation

Remediation follows on from a risk assessment that has deemed risk elimination or reduction to be necessary. Remediation begins with an options appraisal that short lists strategies that could deliver the required reduction in risk. A short listed remediation strategy comprises one or more remediation technologies that will deliver the safe and timely elimination and/or control of unacceptable risks. Such technologies have been classified in a variety of ways over the past three decades (e.g., in situ treatment and ex situ treatment; conventional and process-based treatment; physical, chemical, biological, and thermal treatment).

A decision support focused classification has been promulgated recently that considers technologies in terms of: pre-treatment, treatment, and post treatment. Pre-treatment includes heating the ground to increase contaminant mobility; sparging to transfer contaminants from liquid (aqueous or organic) to vapor phase, and hydraulic fracturing to improve access to contaminants. Treatment breaks the source-pathway-receptor linkage – the risk is eliminated or reduced. Treatment includes soil vapor extraction, excavation, in situ biostimulation, and monitored natural attenuation. Post-treatment deals with wastes arising from the treatment and includes: disposal of excavated materials, filtering process gases through activated carbon, and biopiles.

A conceptual site model focused typology of remediation strategies would see strategies as dealing with the source, pathway, or the receptor. Such a typology is useful when ensuring a complex or even mega site that may require a suite of remediation technologies is being remediated efficiently.

3. Standards

In *Alice through the looking glass* Lewis Caroll (1889) wrote "'When **I** use a word,' Humpty Dumpty said, in rather a scornful tone, 'it means just what I choose it to mean — neither more nor less.'". Science fiction author, Douglas Adams, conceived the Babel fish that is inserted in the listener's ear to enable them to understand anything they hear, for *The Hitchhikers Guide to the Galaxy,* first broadcast on BBC Radio 4 in 1978. An ISO Standard avoids the need for the Babel Fish and renders Humpty speechless.

A standard represents an agreed way of making, doing, using, or communicating. It ensures interoperability, reduces misunderstanding, and facilitates shared understanding and cooperation. Standards published under the auspices of the International Organization for Standardization (ISO) to help disseminate good practice rapidly and deliver a degree of consistency in practice and terminology worldwide.

National Standards Bodies (NSBs), such as the British Standards Institution (BSI), American National Standards Institute (ANSI), formerly the American Standards Association (ASA), and Germany's Deutsches Institut für Normung (DIN) publish national standards to ensure consistency within their countries. The European Committee for Standardization (CEN) does so for 34 European countries (in 2017) and its CEN standards are automatically adopted as national standards in those countries.

4. The ISO Process

The process of developing an International Standard is exacting, time consuming, and painstaking (ISO undated). It begins with a proposal for a new work item which, if approved, results in establishing a working group. The nominated expert members of the working group adhere to a code of conduct (ISO, 2016a) to develop a Committee Draft (CD) which is sent out for consultation and then voted on by those NSBs that are members of the parent technical committee. If the CD is approved, then the Working Group considers any comments that may have been made and updates the text to prepare a Draft International Standard (DIS). This is then formatted according to ISO rules and translated into other languages – in the case of ISO/DIS 18504 into French. The DIS is then subject to another 12-weeks consultation period at the end of which the NSBs vote again on whether or not to issue the DIS as FDIS (Final Draft International Standardf) or directly as an International Standard.

ISO documents use precise terminology to differentiate actions that are required (shall); recommended (should); permitted (may); or possible (can).

The ISO work on standards development is performed by approximately 300 technical committees (TCs). Technical committees deal, inter alia, with particle characterization including sieving (TC 24), terminology and other language and content resources (TC 37), mining (TC 82), quality management and quality assurance (TC 176), geotechnics (TC 182), environmental management (TC 207), geosynthetics (TC 221), nanotechnologies (TC 229), sustainability criteria for bioenergy (TC 248), risk management (TC 262), carbon dioxide capture, transportation, and geological storage (TC 265), and sustainable development in communities (TC 268).

Soil quality is considered under ISO's TC 190. TC 190 comprises seven subcommittees and each subcommittee has working groups. The work to develop ISO/DIS 18504 has been carried out under Working Group 12 of Sub Committee 7 of TC 190. The working group sought to develop what is currently ISO/DIS 18504 is WG 12: Risk based remediation measures (ISO/TC 190/SC 7, 2016b).

The work on ISO/DIS 18504 began with a proposal from the BSI committee EH4 Soil Quality (BSI EH4 2012) that mirrors the work of TC 190 (Soil Quality). This led to a formal ISO New Work Item Proposal (ISO, 2012b) that was circulated to members of TC 190 for consideration and voting on whether or not to accept it. The BSI proposal was accepted by the members of TC 190 by an overwhelming majority of 15 countries' NSBs in favor, none against, and seven abstentions (four countries did not cast their vote) (ISO, 2012c). NSBs had the chance to comment with their vote. Comments often listed the names of their nominated experts to join the working group but some include observations on the proposal:

> "A standard on "sustainable remediation" is highly welcomed, for several reasons. This is a rather new topic, worked on by a variety of experts in many countries. In this early stage of development of tools, goals etc. for sustainable remediation, efficient communication between experts, which often represents dissimilar of points of view, are utterly important. In such a situation an appropriate terminology with globally accepted definitions would be of great importance in order to avoid misunderstandings and to fix the limits for the concept(s) behind sustainable remediation."
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> "Sustainable remediation is being discussed at a different level in a number of (European) groups. It is important to have uniform understanding of sustainable remediation."
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> "The development of a single document is the right approach." "This is consistent with our national policy for managing contaminated sites and soils and is in line with our sustainable development goals."
>
> "Sustainable remediation is one of [the] important issues in [our] remediation market."

A working group, TC 190/SC 7/WG 12, was subsequently established and those national standards bodies that are members of TC 190 were asked to nominate experts to participate in the working group. Despite being innovators in the field of sustainable remediation, experts from the USA and Canada were not eligible to join the working group as their NSBs are not members of TC 190. However, an early draft text that informed the discussions of the ISO working group comprised sections written by many experts from around the world, including substantial contributions from the USA, Canada, and Australia. The working group's active members met online using the collaborative work environment of Citrix's gotomeeting. Those members lived in countries spanning only 12 time zones so meetings could be held during the normal day rather than requiring some to be up in the middle of the night. This meant several meetings, lasting up to two hours, could be held with minimal disturbance to normal work and at no cost to members. Ad hoc face-to-face conversations were held at various conferences around the world: AquaConsoil (Europe); Battelle and US Environmental Protection Agency (US EPA) Brownfields (North America); and CleanUp (Australia).

A CD text was produced and circulated to NSB members of TC 190/SC 7 in 2014 (ISO 2014a). The CD carries a warning that "*This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.*" Holders of pre-existing intellectual property rights and others are able to comment on the CD. Indeed, "*Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.*" Following the 2-month voting period, the CD was approved by an overwhelming majority of countries' NSBs, with 15 countries in favor, none against, and five abstentions (ISO, 2014b). Comments were received from eight countries (many of which covered similar ground – much to the working group's relief). Comments included suggestions to: resolve typographical errors, expand the scope of the document, either delete or add to the existing text, help make the text clearer to readers, add specific documents to the list of references, encourage consistency with terminology in other (non-ISO) documents, and give primacy to SI units over imperial units of measurement.

One suggestion was that a sustainability assessment may show that remediation would have a net adverse effect or that legal requirements could not be met and, therefore, remediation should not be undertaken at all. The working group rejected this suggestion as being contrary to the principles of risk-based land management. Legal requirements that cannot be met should be identified before, or perhaps shortly after, entering the options appraisal process and certainly well before comparing viable alternative remediation strategies to discern which one would be the most sustainable.

The comments on the CD were considered during a series of online meetings in 2014 and 2015 by the Working Group. The responses to each were documented. Many were accepted and a revised text was submitted as a DIS. The DIS has fewer than ten requirements but makes over 20 recommendations. It serves both a normative and an informative role. The DIS was issued in both English and French to the NSB members of TC 190/SC 7 for 3- month voting period which ended in February 2016. The DIS was approved for publication as a full Standard subject to consideration of any suggestions for improvements.

Having established the need and appetite for a standard on sustainable remediation and having summarised the process of getting to the DIS stage, what follows is commentary on the developing understanding of the challenges of applying the principles of sustainable development to the process of contaminated land remediation.

5. Avoiding the Unsustainable

The concept of sustainable development and the term sustainability have been heavily criticized as vague, subjective, relative, and meaningless. There are of course legitimate questions over the extent to which inter-generational matters should be taken into account. There are also limits to economic growth imposed by the finite nature of Earth's non-renewable resources (Meadows et al., 1972). However, history shows that technological and material transitions do not happen due to the exhaustion of a material but rather by it being supplanted by something better. The valve gave way to the transistor and that in turn to the electronic chip.

However, while recognizing that what we are pursuing may be seen by critics as unattainable, it is important to consider whether the opposite situation – that of remediation that is too costly, has too great an adverse effect on the environment, or is socially unpalatable – can be avoided.

Another form of unsustainable remediation is remediation where the socio-economic-environmental investment delivers a trivial risk reduction and, therefore, that investment cannot be justified. Examples of unnecessary remediation are where the contamination is deep, so people are not exposed or where the groundwater is unlikely to be polluted as it is protected from overlying contamination by a thick layer of low permeability clay (i.e., there is no source-pathway-receptor linkage in either case).

6. Absolute versus Relative Sustainability

Absolute sustainability – in the sense of the plain English meaning of being "capable of enduring" – is not a helpful concept in the context of a remediation project. A project has temporal and spatial boundaries. Given that remediation has been deemed necessary by a risk assessment carried out under a specific legal context, the issue becomes one of how to choose what form that remediation should take.

Remediation begins with an options appraisal that short lists several technically valid strategies that could deliver the required reduction in risk. The question is what criteria (speed, cost, disturbance to neighbors, environmental impact, etc.) are used to choose between these alternatives. The emerging ISO standard is intended to help identify the most sustainable among the shortlisted valid alternative remediation strategies. It is therefore a form of relative sustainability assessment.

7. Partial or Total Assessment

Remediation that meets the definition in ISO/DIS 18504 may rightly be considered to be sustainable remediation. However, when the project involves more than just remediation activities, then it is the overall project that ought to seek to be sustainable and not just the subset of activities dealing with soil and water contamination.

This matters because if only part of the project is tested on the anvil of sustainable development, then there is a risk that there will be unnecessary overall environmental impact, societal concern, or economic expenditure.

This paper and the ISO standard only focus on remediation breaking the source-pathway-receptor relationship (referred to as a contaminant linkage in the UK). The broader challenge of ensuring brownfield redevelopment is sustainable redevelopment or that technology trains exploit synergies between remediation and say energy extraction or material recovery have been considered by others (e.g., Holland et al., 2013).

8. Can sustainable remediation be green, and vice versa?

The long lasting stand-off between the proponents of sustainable remediation and of green remediation seems to have been partially resolved with a realization that the trajectory of the two concepts has led them to different places on the spectrum of risk-based land management rather than them being synonyms or alternatives.

The options appraisal process helps identify the most sustainable of shortlisted remediation strategies, any of which could achieve the technical remediation objectives. Once the remediation strategy is chosen, its environmental impact can be optimized by applying the principles of green remediation and associated toolkits.

Sustainable remediation may also be shown to be green, and vice versa. However, the terms are not synonymous and it is recommended that assessors make it very clear which framework they are adopting.

9. Sustainable Remediation

Words matter and if, in a technical context, are used loosely, incorrectly, or inconsistently they cease to be useful conduits of meaning, intent, and desire. In fact false, unreasonable, or unverified claims of 'sustainability' could be seen as misrepresentation of the goods or services being offered by a contractor or consultant respectively.

Several organizations had used or proposed various definitions of sustainable remediation at the time work on the ISO Standard got underway. Some had proposed more than one definition. There was a need to adopt or adapt a set of words for a standardized definition.

During its 2014 annual meeting in Berlin, ISO/TC 190/SC 7 refined the definition of sustainable remediation that had been suggested in the committee draft CD (ISO, 2014a) to read: "elimination and/or control of unacceptable risks in a safe and timely manner whilst optimising the environmental, social and economic value of the work" (ISO 2015). The challenge therefore was to help decision-makers select remediation strategies that would reduce those risks deemed unacceptable but that would do so in a way that considered the overall value of the works.

10. On choosing indicators and metrics

An indicator is "single characteristic that represents a sustainability effect, whether benefit or negative impact, which may be compared across alternative remediation strategies, comprising one or more remediation techniques and/or institutional controls, to evaluate their relative performance" (ISO, 2015). Indicators should be independent, uncorrelated, and non-overlapping; orthogonal as mathematicians would put it.

The two defining functions of an indicator are that it has to be useful in differentiating candidate alternative remediation strategies and it has to represent an aspect or component of one or other of the three dimensions of sustainable development (social, economic, and environmental). To be clear, a characteristic that is shared by all or many of the candidate strategies does not help in preferring one strategy over another. If the total energy use of several candidate strategies is more or less the same or all pose the same negligible risk to worker safety or all create approximately the same number of jobs, then these are not useful indicators as they do not differentiate between remediation options. Similarly, while the color of the above ground infrastructure may differ among candidate strategies, it is unlikely to be a relevant factor in preferring one strategy over another.

In the absence of a universally agreed inventory of indicators, broad categories of indicators are presented in ISO/DIS 18504 for each of the environmental, social, and economic dimensions. The working group recognized the environmental and economic dimensions as being well understood and able to be characterized by a mature population of indicators. This reflects work on the pricing of remediation and on minimizing the environmental footprint of remediation. However, the social dimension is less well constrained and has been the focus of recent deliberation. Harclerode et al. (2015) conclude that social indicators are more mature and further developed than widely believed but that none of the social impact assessment tools reviewed encompasses the entirety of the social dimension of a project. They champion a simple, comprehensive assessment of all social indicators in conformity with the principle of parsimony known, perhaps not eponymously, as Occam's Razor (Thorburn 1915, 1918) should apply. It is better to be comprehensive in the coverage of social issues than to be sophisticated in the quantification of a few.

Metrics measure indicators. They can be couched terms of a value (i.e., the product of a number and a unit), a semi-quantitative dimensionless score, or a rank (e.g., cheapest; quickest). The effort involved in measuring an indicator increases in going from a rank to a score to a value. Therefore, the simplest metric that allows a characteristic to act as an indicator should be chosen to avoid unnecessary measurement costs.

11. On assigning weightings and combining measures

Once indicators have been chosen, metrics selected, and measurements made, those measurements have to be combined to give an overall rating to allow the preferred remediation strategy to be identified.

The relative importance given to each indicator can affect the outcome. As such, assigning different weightings to different indicators can become a contested exercise. Different stakeholders may have different priorities and these will be reflected in their desire to assign different weights to the same indicator. Therefore, weighting should not be engaged in unless there is a clear desire for it by stakeholders and a clear need for it in identifying a preferred strategy. Where weights are to be assigned then a process that ensures stakeholders have the appropriate influence is needed. The consistency of each stakeholder's priorities then needs to be determined. Then a comparison of the weights assigned to each indicator can identify where conciliation between different stakeholders is needed. Where conciliation is not possible for valid reasons, the evaluation of alternative strategies can proceed using the different weights to see if the outcome is different. This process of negotiation and a focus on the ultimate point of the exercise – to identify the most sustainable of the shortlisted technical feasible remediation strategies – can be quite liberating and avoid long delays, exacerbated contestation, and undue costs.

Even if different weightings are applied to individual indicators, it is recommended to start the assessment by normalizing the total scores within each of the three dimensions of sustainability. That is to say, at least initially, the environmental, social, and economic considerations should be balanced, so that the assessment is not biased towards a single dimension.

An overall rating for alternative remediation strategies is not always needed. Sometimes simple pairwise comparison of alternatives shows that one strategy is clearly preferable to all others (Nathanail, 2011). Sometimes simple rankings for each indicator and compiling a medal table can identify a clearly preferable strategy (Smith & Kerrison, 2013). The move to a fully quantitative form of assessment should be resisted as it results in either ignoring indicators that cannot be assigned a value or in protracted negotiations on how to convert metrics to a common scale. Should this be necessary, then the common scale usually considered is money. A simpler and less contentious alternative is to normalize all the metrics and then carry out a multi-dimensional distance calculation using the Pythagorean theorem to combine orthogonal components (our indicators in this case) to identify the preferred strategy. This can be done simply in a spreadsheet.

12. On claiming remediation to be sustainable remediation

The keepers of the keys to sustainable remediation, the various sustainable remediation fora, have an explicit self-interest and an implicit responsibility to safeguard the value of the concept of sustainable remediation in the face of various definitions and more worryingly claims that cannot be substantiated by evidence.

Given the ISO/DIS 18504 definition it is now incumbent on practitioners presenting case studies that purport to constitute sustainable remediation to clearly show how what they are reporting has met with that definition. Unsubstantiated and unsubstantiatable claims that a specific project constitutes sustainable remediation cannot continue to be made in public fora if the concept of sustainable remediation is to have meaning and value. Similarly, laudable efforts to reduce the environmental impact of remediation should not be seen as equivalent to or synonymous with sustainable remediation.

13. Conclusions

The ISO 18504 standard constitutes the first document with worldwide locus in the domain of sustainable remediation. It allows countries without the capacity to develop their own guidance to benefit from the work done in many countries. It encapsulates the work of various groups around the world, notably of the various sustainable remediation fora that have developed following the pioneering initiation of SURF in the United States. It also allows claims that remediation is sustainable remediation to be benchmarked against a definition with wide acceptance worldwide.

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