TOPIC: WATER REMEDIATION APPROACHES FOR DRINKING WATER SUPPLIES

SUB-TOPIC:
PART B: SELECTION METHODOLOGIES FOR THE REMEDIATION OF DRINKING WATER

Supporting Transcript

PRESENTED BY: George Wilson, The University of Manchester
CONTENT COORDINATOR: Dr. Laura Richards, The University of Manchester (Department of Earth and Environmental Sciences)

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SLIDE 1

This next lecture on remediation approaches focuses on some of the selection methodologies that can be used to decide on an approach for the remediation of drinking water supplies

SLIDE 2

I'll be talking through how technical, socio-economic and regulatory factors come into play into the selection of remediation of drinking water supplies. We'll be looking two techniques which can be used to determine how appropriate a remediation approach might be in a given setting, in terms of their effect on the environment and the project cost versus the benefits. We'll then move onto some of the methodologies that have been used to select remediation approaches.

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When it comes to the selection of a remediation strategy, there are numerous methods that are used to do this, and it's very important to understand that there is no 'one size fits all' strategy. Every site can be unique in many different ways, from the geochemical composition of water, to infrastructure availability, to socio-economic setting and to the regulatory and governance structures in place. And therefore we must consider the site requirements, the regulation as well as socio-economics in order to select a strategy. Appropriate selection and management is crucial to successful implementation of remediation at a particular site.

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The objectives are to explore the factors which need to be considered in the selection of an appropriate remediation strategy for water quality problems and to become familiar with some examples of remediation selection methodologies that are used in the real world.

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So let's talk about the early stages of selection first and how technical, socio-economic and regulatory factors come into play here.

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And so let's consider each one individually. From the technical side of things, the designs need to be suitable and effective on the site, or else the remediation goals may not be achieved. For example, the effectiveness and requirements of arsenic remediation depends also on other geochemical conditions such as concentrations of iron and manganese, as well as the speciation of arsenic. This is very important to consider. The complexity of the project must reflect the infrastructure and skills available to the particular area. A project that requires skilled operators to maintain the process may not be suitable for an area with an unskilled workforce or limited resources. We can also think about the technology in terms of how mature or tested for the purpose this is.

In terms of socio-economic factors, we need to consider the education and awareness of the local population and what people may perceive as acceptable or unacceptable. A good example to consider is the chlorination of public drinking water – chlorine is commonly used as a disinfectant to increase protection against waterborne diseases however in some areas people do not like the taste of chlorine and thus may perceive the treated water not to be acceptable according to their preferences. Willingness to Pay or Willingness to Work surveys can be very useful tools in determining what financial or labour investments people might be willing to make for access to a safer drinking water supply. And then the regulatory context can override other factors that come into, like what the required water standards are, and then the project may need to comply with an environmental impact assessment to ensure there are no unacceptable risks to the environment, what monitoring and compliance structures are in place, and then things like potential financial incentives or penalties for the successful remediation selection and management.

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'Technology Readiness Level' is one way to compare various types of technologies (independent of the other factors). The Technology Readiness Level scale was developed by NASA scientists in the 1970s. A technology readiness assessment is carried out to determine how advanced the technology is for use and is given a level between 1 and 9, where 9 is the most demonstrated technology and available on at a commercial scale, whilst 1 is more of a concept and has not been through many stages of development. This scale can be used as a tool to assess one aspect of risk management of the project and to provide common understanding of the technology status. Generally speaking, a higher technology readiness level has a lower associated risk to it, whilst one which is in the research and development stages, may not be appropriate to use for where a reliable, consistent solution is required.

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And there may be some clear barriers to improving the water quality or to successful implementation of remediation strategies. Firstly, there may be lack of communication and awareness for the need to improve water quality or knowledge on the available treatment systems available, particularly to decision makers. There may be more significant challenges or projects that take priority over a water quality issue. And overall, there may be a reluctance to bring about change, which could come down to the underpinning socio-economic or regulatory context. The costs could simply be too high in relation to the benefits. Let's take at a method of actually comparing these costs versus the benefits, in what's called a cost-benefit analysis.

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So when we come up with a cost-benefit analysis, there are generally four things to consider. The first of which is the construction costs, and these are normally paid in the first few years of the project for things like land acquisition and building materials. Then we have any operational costs which are incurred as the project runs, so things like salaries, any maintenance or any repairs need to be costed and put down. Now every project must have a lifespan – no project can run forever, and the project must be safely and considerately decommissioned at the end of this. This may involve the removal of equipment, for example. Then there are any benefits to the project, for example economic benefits brought about by an increase in visitors to the local area. If the project is related to metal recovery, then selling the metal is a benefit also, although this is unlikely to be a major incentive for most water remediation projects.

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We can use modelling to estimate the valuation of a project, using fixed costs, operational cost (including monitoring) and an annual discount rate, which takes into account bank interest rates. These costs will not always be completely as expected, so we may use a range of values for each cost parameter and a way of simulating hundreds of combinations of values that lie between these ranges, to work out the probability of the project being profitable. This is known as Monte Carlo simulation – we will complete one of these in the learning exercise in the next lecture series and there I'll explain a bit more about how we can use a graph the one on the right as a decision support tool.

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In order to make optimal selections for remediation out of the possible choices, we need some sort of robust, easy to use methodology that can be adapted and applied in a variety of situations. And so we'll look at two attempts to achieve this. The first is a system abbreviated as DESYRE, which means decision support system for rehabilitation of contaminated sites. It is a form of decision support software designed to assist the decision maker for the remediation of contaminated sites, designed to consider a number of variables involved, in a way which is reproducible and transparent. It is split up into characterization of the site, which includes a conceptual model and states any contaminant transport through the site as well. Then there is a block on the socio-economic analysis which indicates what the best use of the land is. The remediation technologies comparison and risk analysis modules are combined to produce an effective framework for the selection of clean-up techniques. The final step refers to the decision making on the selection. Technological, environmental, and socio-economic factors are described numerically so that each alternative can be compared and a best-off decision be made.

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And the second example of a decision support tool or a selection methodology is multicriteria decision analysis, or MCDA. Multicriteria decision analysis involves three concepts: firstly, defining an objective to the model, so explicitly defining what decision is being made, secondly, the potential options that need to be ranked or scored and last a set of criteria to rank them against. The criteria are grouped into four categories – environmental, social, technical and economic. The specific criteria are determined from the literature. Once this is set up, different mathematical models can be used to rank the potential options against each other, and this helps the inform the decision maker on what the best strategy for this scenario will be. Most approaches will have advantages and disadvantages and so optimal choices are context dependent.

The UK Environment Agency employs the multicriteria decision analysis criteria method, alongside a cost-benefit analysis to inform decisions on project development.

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This shows an example of a multicriteria decision analysis from Schuwirth's 2018 paper. In this case both an assessment of water quality and the modelling of potential consequences of the projects are fed into the decision support framework, in order to choose the best decisions for water quality. So modelling and assessment are the preliminary steps that are used in the support methodology, which is used to improve the decision-making. Don't worry about the individual steps that are shown in this example, but do appreciate that the model input data may be very complex and often is based on the outcome of modelling.

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What are some of the limitations to using decision support tools like the ones mentioned? Well, the success of any model depends on the quality of the input data. This data needs to accurately represent the site, otherwise we are not making realistic predictions. This is extremely hard to get right. And specifically to the MCDA, there is no reflection of the uncertainty in this input, we can't put a range of likely values into the model.

And when it comes to the selection criteria for these projects, often the criteria is only suited to a small number of stakeholders, such as the landowners or government agencies, and though we may consider other users of the land in the criteria, they may not necessarily get any decision-making powers, and so can feel left out. Similar to this, we also need to think of a scenario where the data is misrepresented or not presented in a transparent way, and this could happen to serve a company that wants to develop its project despite the environmental consequences, so that it can make more capital gains, for example. We need to think out who is carrying out the analysis and if they have any financial interest in the decision's outcome.

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And so lets think about the limitations of a cost-benefit analysis as well. Again, the accuracy of any input data is crucial to the successfulness of the modelling. For a cost-benefit analysis, we *can* use a range of input values although this does not necessarily mean the cost or benefit will lie within this range. And a cost-benefit analysis is purely a tool to predict whether the project will make money or not. This means that the cost-benefit analysis has a hard time putting a value on things like the enjoyment of an area before and after remediation takes place, or the protection of a rare species, and these fall into the category of social and environmental costs and benefits. Some have indeed attempted to put values on these, but these values will ultimately be difficult to adapt to a specific site and will always be subjective.

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To summarize, we can say that technology, socio-economics and the regulatory context are important factors to be considered in the initial selection of a remediation strategy. A cost-benefit analysis, which must outline costs and benefits for construction, operation and decommissioning phases, is one tool which can help determine whether the project will likely make profit or loss. It's important to remember that there is no "one size fits all" solution to effective remediation, and appropriate selection is highly site-specific. Although these tools can be useful for considering options, they can be limited by appropriate input data or concepts – so a site-specific evaluation is always recommended. And for this we can use remediation selection methodologies as decision support tools for water quality remediation, as they provide a method that can be used in any setting, to decide the best strategy to go about remediation. Although, they certainly aren't perfect tools by any means.

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And now if you'd like to do the following for the learning exercise. Firstly, list 5 factors which need to be considered in the selection of a remediation strategy and for each, explain why. Next, I want you to think of a scenarios where a developer wants to solely use a cost-benefit analysis to select a remediation strategy for water quality improvements. Can you think of the advantages and disadvantages of doing this? Lastly, can you find any other examples of remediation selection methodologies, other than DESYRE and MCDA + cost-benefit analysis? There are definitely a lot more out there than those few. You might also want to think about the strengths and weaknesses of each methodology.

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Here is a list of the references used for the slides.

SLIDE 24

I refer you to this tutorial on how to produce a simple cost-benefit analysis flowsheet, although we will return to this in the mining mini-series.

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