Environment Canada

Water Science and Technology Directorate

Direction générale des sciences et de la technologie, eau

Environnement Canada

What is Sustainable Remediation?

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D0-99

ABSTRACT

This article serves as a preface to a special issue containing papers from a special symposium on Bioremediation of NAPL-Contaminated Aquifers, organized by the authors at the Fifth Chemical Congress of North America (Cancun, Mexico, 1997), in which the guiding question for the participants to respond to was: Is what is technologically possible also economically feasible? This article attempts to define the concept of sustainable remediation. The concept of relative risk is introduced, comparing the North American context to that of Israel, as an example of a country where groundwater resources are limited. It is a synthesis of the forum discussions that occurred at the symposium and a reflection on the part of the organizers.

MANAGEMENT PERSPECTIVE

This article serves as a preface to a special issue containing papers from a special symposium on Bioremediation of NAPL-Contaminated Aquifers, organized by the authors at the Fifth Chemical Congress of North America (Cancun, Mexico, 1997), in which the guiding question for the participants to respond to was: Is what is technologically possible also economically feasible? It is a synthesis of the forum discussions that occurred at the symposium and a reflection on the part of the organizers. While it addresses the deficiencies of the current management system for contaminated sites, it is not intended to blame any specific government programs or action, but rather is a call to scientists to develop green remediation technologies and a plea towards the education of the public on the need for the conservation of natural resources.

RÉSUMÉ

Cet article sert de préface à un numéro spécial rassemblant les présentations faites à un symposium sur le bioassainissement des aquifères contaminés par des liquides non aqueux, organisé par les auteurs du Cinquième congrès de chimie de l'Amérique du Nord (Fifth Chemical Congress of North America, Cancun, Mexique, 1997), au cours duquel la question thème posée aux participants était : « Ce qui est technologiquement possible est-il économiquement réalisable? ».Cet article tente de définir la notion de l'assainissement durable. On présente aussi la notion du risque relatif en comparant le contexte de l'Amérique du Nord à celui d'Israël, exemple caractéristique de pays à ressources en eau souterraine limitées. Il s'agit d'une synthèse des discussions du symposium, assortie de réflexions des organisateurs.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Cet article sert de préface à un numéro spécial rassemblant les présentations faites à un symposium sur le bioassainissement des aquifères contaminés par des liquides non aqueux, organisé par les auteurs du Cinquième congrès de chimie de l'Amérique du Nord (Fifth Chemical Congress of North America, Cancun, Mexique, 1997), au cours duquel la question thème posée aux participants était : « Ce qui est technologiquement possible est-il économiquement réalisable? ». Bien qu'il porte sur les lacunes du système actuel de gestion des sites contaminés, il n'est pas destiné à critiquer tel ou tel programme ou mesure gouvernementale, mais il s'agit plutôt d'un appel adressé aux chercheurs pour le développement de technologies d'assainissement non polluantes et d'un plaidoyer tentant de sensibiliser le public à la nécessité de conserver les ressources naturelles.

J. ENVIRON. SCI. HEALTH, A36(8), vii–xiii (2001)

FOREWORD

WHAT IS SUSTAINABLE REMEDIATION?

This special issue evolved from the special symposium on sustainable remediation of NAPL-Contaminated Aquifers, organized by the authors at the Fifth Chemical Congress of North America (Cancun, Mexico), in which the guiding question for the participants to respond to was: *Is What Is Technologically Possible Also Economically Feasible?*

In their presentations, the Symposium participants dealt with the following three related questions: (1) Is the cure (i.e., remediation) worth the cost? (2) What is the claim? Namely how do we conceptualize the problems involved in remediation of contaminated aquifers? and (3) Where are we heading as far as large-scale remediation of NAPL – contaminated aquifers and groundwater are concerned? The participants' responses converged into the emerging concept of Sustainable Remediation which, so we believe, should be developed and applied within the current policy of sustainable development, worldwide.

The concept of sustainable development, which was initiated by the Brundtland Commission in 1987 is now well known, if not well understood, within the environmental, governmental or non-governmental organisations (NGOs) of the world. However, the concept of sustainable remediation is seldom invoked in the discussions of contaminated aquifers or particular site remediation. Seeing the two words *sustainable* and *remediation*, combined into a concept, in the same sentence may even seem a contradiction to many. Indeed, the very fact that some form of action is required, implies that the principle of sustainability has been violated. However, even if the principle of sustainability has been violated in the past, in the future we should at least ensure the sustainability of the remedial action.

What is the difference, then, between simple remediation and sustainable remediation? In order to answer this question, it is necessary to examine further the concept of sustainability. What does sustainable development really mean? Initially the idea of sustainability with respect to the environment was based on three requirements: the maintenance of life-support systems, preservation of biological (genetic, species and habitat) diversity (i.e., biodiversity) and the sustainable use of natural resources (1). The first and last are particularly pertinent to remediation; they imply, right from the outset, an active participation of people in the management of their own environment which, in turn, implies a proactive approach to the environment. The word sustainable has been thus applied to a use of natural resources that does not endanger the long-term survival of the environment containing these resources. In practise, this means that any sustainable development plan should balance the immediate economic and life quality benefits that stem from their exploitation with the long-term effects on their availability, feasibility, supply and safe use. Also, it implies regeneration and pacing the exploitation of the resources. The process can be, metaphorically, likened to a marathon runner, who has to save some of his/her energy, at the expense of speed, to be able to arrive, still breathing well and alive, at the finish line. The winner is one who achieves the appropriate balance, which best optimizes the contradicting short-term demands for high speed with the long-term required saving of energy.

How can this apply to remediation? Sustainable remediation is an action that mitigates risk without compromising the availability, economic feasibility and safety (health-wise) of the resources. At the limit, this idea has been termed "natural" or "intrinsic" remediation. This occurs when nature is capable of taking care of the pollution burden without external intervention, at a pace that is sufficient for the risk to the community not to increase. At the other end of the spectrum, when nature fails to maintain its long-range dynamic equilibrium concerning its biogeochemical cycles, severe pollution in ever-increasing pace occurs. A remedial action must then be taken. The choice of the type of remediation always has long term effects. This can be compared to a person's decision of the amount of the monthly payment in a mortgage. Choosing low payments results in much higher overall costs in the long term. However, if the payments are too high in proportion to the available income, the lifestyle of the payer is compromised. A careful balance in terms of short- and long-term cost-benefits/tradeoffs must be achieved.

Sustainable remediation of contaminated sites, regardless of the location, size or extent of the remediation targets, means the dealing with complex multicomponent systems, in which the life-supporting natural resources and potential health risks, are the major issues of concern. The remediation should not only be economically and technologically feasible, but also it should guarantee the availability, usability, supply and self-renewal capability of the natural resources of the remediated site, while mitigating risk to the ambient receptor. The problem is that, as with any other environmentally-related issue, a conflict may arise between the short-term interests of the individuals or groups who are in control of the site to be remediated and the long-range interests of the public at large: The former will act based on what is likely to provide them and their families with a short-term security (2), whereas the long-term "security" of the latter may be jeopardized, by the particular remediation action taken (or not taken) by the site owner. Similar conflicts may be operating even if the contaminated site is under national/governmental control (e.g. regional aquifers).

How does sustainable remediation differ from any other form of remediation? Whenever a site is considered for restoration, several technological options are considered, which inevitably will differ in terms of efficacy, capital investment and long-term maintenance costs and impact. It is often interesting to examine on what basis the treatments are selected. Unlike what some might think, it is not always the cheapest or the most effective, in terms of contaminants removal, that is selected. Often it appears to be the option that offers the least amount of risk to the decision-maker that is chosen.

Why is that? Going back to the initial reason as to why a site is being considered for remediation, the answer then becomes obvious: one of the major driver for remedial action is to remove risk for either the current or the future users of the remediated site. It is not surprising then, that those tasked with remediation will not want to add to the risk burden and will select their action on what constitutes the least risk to potential human users, not withstanding the potential for legal recourse against them, if the chosen course of action is not in accord with the expectations. The result of this situation is that the decision for remediation is based on at least four factors: perceived risk, feasibility, responsibility and the ability of the parties involved to pay. In view of the fact that, ultimately, most environmental problems in our modern socio–economic–political context "boil down" to: who pays what and how much, in what order of priorities, it may be safe to conclude that, to the first approximation, sustainable remediation is characterized by its meeting simultaneously both criteria of economic feasibility and post-treatment safety of the remediated site (e.g., drinking water pumped from a remediated water supply well).

This brings us first to the problem of risk assessment. It is generally agreed that the use of this methodology provides the best practical approach for ecosystem protection (3). In theory, the risk posed by a given situation is the same everywhere. Let consider, as an example, a leaking underground storage tank. It is now common knowledge that if the gasoline, or other type of light non-aqueous phase liquid (LNAPL) that is spilled, reaches the groundwater, the most soluble components will rapidly dissolve and contaminate the water. Since gasoline floats, it will partially volatilize in the unsaturated zone where the contamination is transported within the gas phase of the system. It may, thus, cause explosion hazards in the basements of houses. Those risks are very real in some situations, but not in all. However, often government regulations will require the same remedial action everywhere for a given problem, even if, as shown in the above example, the impact of the situation may vary widely from one case to another. The problem of gas vapours entering the basements through the drain can only occur where houses have basements and drains to a sewer or sumps. This type of construction is very prevalent in the northern part or North America, but not so much elsewhere in the world. Similarly, the need to protect ground water as a resource may apply only if this source of groundwater is being used for a water supply. In Canada, for example, that is currently true for approximately a third of the total population. In the province of Prince Edward Island all the residents rely on groundwater, but quantity is generally not a problem. In contrast, the situation in Israel concerning the availability of groundwater resources and the population dependability on them, is totally different. What does this mean? It means that risks assessment must take the reality of the local environment into consideration, but without loosing sight of the relevant short- and long-term global perspectives.

This requires introducing the concept of relative risk. Whether we think it is fair or not, the economic realities of the population depending on groundwater as the major source of water supply will often dictate the course of action to be taken. In fact, this is the realism of constraints and, in turn, relationships within which we are operating whenever the scarcity of the resource at point is the determining factor. Thus, in many areas of the world, water quantity considerations far overshadow the water quality criteria. It brings to light the harsh differences of what is acceptable, between developing countries and the advanced, western economies of the world. The increased risk of one more case of cancer in a million is the criteria used for the permitted levels of carcinogenic chemicals in drinking water in most developed countries, where the average life expectancy exceeds 80 years. Does it make sense to apply the same standard level to areas where the average person may hope to survive noy much more than half as long? More important though, is the decision as to how the money available should be used given the "state of pollution," the need for remediation, the scarcity of the resources and the wish to ensure sustainability. If the decision is between installing an expensive treatment system, planting a crop, or use more water to increase production (and profit), the latter will prevail.

If so, what should (or would) be the decision, say in Israel, concerning the use of secondary treated wastewater for unlimited agricultural irrigation? Should (or would) the decision – with respect to the same issue – be the same, say, in the U.S.? This is a real issue on the current agenda of the first country national water policy. Whatever the final decision, the potential long-range consequences can be predicted.

Does this mean that we should be given free reign to pollute and not clean up in developing countries because they either economically cannot afford it, or are not as likely to have strict environmental laws? It does seem to be happening. However it is not inevitable. Mitigating risk can be done by using very rapid and expensive remediation methods, or by using, sometimes less rapid, but much cheaper alternatives. This is what sustainable remediation and economic feasibility are all about: it is developing methods that do not require extraordinary resources, or resources better used elsewhere. It is working with nature, by using supporting natural processes technologies, rather than against it. It is achieving a balance between risk mitigation and the expenditures required to achieve it, through optimization based on well-defined criteria.

The development of feasible, sustainable remediation technologies is therefore, the challenge to the scientists, engineers and practitioners throughout the world. To begin with, the cost of a technology is seldom considered at the onset of a research program. Cost considerations are more present when a particular site-specific remediation is considered. Generally, remediation methods are primarily based on scientific principles and on choosing a method that will give the best possible results, usually in the shortest time possible. One should remember, however, that scientific research is rather costly and thus may, in extreme cases, to negatively affect attempts of balancing budgets (4). Time is money, and long term liabilities and maintenance of properties do not look good on the balance sheet of any corporation. Those involved in developing and applying remediation technologies are also looking for profit, in the short term. This is a necessity for a company to survive. In recent times, the environmental remediation sector has been suffering (5), because the investors are not seeing profits for their investments. Obviously, in such a context, sustainable remediation is a loosing argument, except, perhaps, if prevention starts to play a more decisive role. Can we hope that things will change? Well, things will have to change, because taxpayers are starting to ask questions concerning the results obtained with their tax money. Remediation is now competing with health, education, transport and welfare. The concept of the polluter pays has not produced the expected results. When the burden of remediations have started to tip the balance of the financial statements into the red, companies have resorted to bankruptcy. The ultimate result is that we collectively must share the cost of either remediation or of the consequences of pollution, such as finding alternate sources of water or moving residents entirely out of an area to protect the health of the community. In such a scenario, the concept of sustainability is starting to gain ground.

Sustainable environmental education within the framework of the development of students' higher-order cognitive skills (i.e., question asking, decision-making, problem-solving and system critical thinking) is the key for facilitating the necessary paradigm shift, from corrective to preventive, concerning all major aspects of environmental contamination issues worldwide (6, 7). As was agreed upon by all the Cancun special symposium on Sustainable Remediation of NAPL Contaminated Aquifers, education is the key for sustainable behaviour of people (i.e. less consumption and prevention) who, collectively, will demand sustainability from their governments. It is also through public support that large scale sustainable remediation will be made possible.

The fact that sustainability is adhered to in principle, however, does not automatically foster the development of the appropriate technologies. Some headway is being made by the use of the natural attenuation concept in legislative circles. It is a good first step, and while it will not work in all situations, it will have the merit of bringing forth the concept of relative risk and the urgent need of educating the population. The very reason why programs such as Superfund in the U.S. were put in place, however, is the failure of natural attenuation in mitigating the risks of contamination.

What then? The sites that pose the greatest risk will still have to be remediated. For sustainable remediation to become a reality will require scientists and engineers to change their paradigms and to attack the problems associated with aquifer contamination from variety of angles. Specifically, instead of looking for rapid, effective, but economically taxing methods, they will have to develop more passive, less energy intensive methods of remediation. It will mean helping the remediated systems to achieve sustainability, by integrating the remedial actions undertaken with the natural processes, so that one complements and enhances the other. It will mean favouring "soft" or "green" technologies such as enhanced *in situ* bioremediation over the more "high tech" ones. The methods used may be going at a turtle's pace, but they might just outdo the rabbit in the long run.

But, above all, the intrinsic complexity of the remediation process and the feasibility constraints within which we are operating, are expected to result, slowly but surely, in a paradigm shift – from correction to prevention. In the meantime, the numerous contaminated sites that have been created in the twentieth century should be attacked with sustainable remediation as the guiding principle. This was the intention of the organizers of the symposium and this special issue has been produced using the same guiding perspective.

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