
Compilation of a Countermeasures Compendium for Food Production Systems and Inhabited Areas

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ABSTRACT: The STRATEGY project (Sustainable Restoration and Long-Term Management of Contaminated Rural, Urban and Industrial Ecosystems) has established a holistic framework for the selection of optimal remediation strategies for long-term sustainable management of contaminated areas in Western Europe. A fundamental requirement of this framework was the development of databases containing state-of-the-art information on individual countermeasures that might be applicable to food production systems and inhabited areas. A datasheet template was designed taking into account all of the criteria that decision-makers might wish to consider when evaluating different countermeasures. These included a short description of the option, its key attributes, constraints, effectiveness, feasibility, waste generated, doses incurred, costs, side effects, stakeholder opinion and practical experience. A compendium, comprising datasheets for 101 countermeasures was produced based on existing information and new data. The compendium underwent extensive peer review. For some criteria, the inclusion of more detailed guidance was made possible by adopting a CDROM format with hyperlinks to underlying documents, where relevant. The countermeasures compendium has been well received by national and international bodies and plans are currently being made for its further development under the direction of the IAEA/FAO and the EC.

1 INTRODUCTION

Following a large-scale release of radioactivity into the environment, food production systems and inhabited areas may be contaminated for many years. Accident response throughout Europe has tended to focus on management of the early phase, addressing issues such as evacuation, sheltering, restrictions on food and drinking water and provision of stable iodine tablets. Currently, there is little systematic consideration of the long-term management to ensure the sustainability of these areas. To sustain acceptable living and working conditions in contaminated areas we need to construct practicable restoration strategies that address the many different types of environment, land use and ways of life.

The STRATEGY project (Sustainable Restoration and Long-Term Management of Contaminated Rural, Urban and Industrial Ecosystems) was launched in 2000, with part funding from the European Commission, under its 5th Framework Programme. The overall objective of the project is to establish a holistic framework for the selection of optimal remediation strategies for long-term sustainable management of contaminated areas in Western Europe. A fundamental requirement of such a framework is the development of databases containing state-of-the-art information on individual countermeasures that might be applicable to food production systems and inhabited areas.

Many individual countermeasures have been developed since the accident at the Chernobyl Nuclear Power Plant, Ukraine in 1986. Much of the information on these countermeasures was initially based on their effectiveness in terms of dose reduction and cost. However, it is now acknowledged that the costs of the countermeasures may be both social and economic, and there may be benefits other than dose reduction. This paper describes the work carried out under the STRATEGY project on the compilation of a state-of-the-art compendium of countermeasures that considers a wide range of criteria.

2 COMPILATION OF INFORMATION

2.1 Selection of countermeasures

A large number of potential countermeasures were identified from the literature and critically evaluated with regard to their applicability in Europe. The final selection of countermeasures is given in Table 1. It comprises 29 agricultural countermeasures, 12 rural waste disposal options, 10 countermeasures for use in aquatic and forest ecosystems and 36 methods for urban/industrial environments. In addition, 15 non-technical 'social' options were identified that could help society or individuals deal with the contamination at a more local level. There were additional countermeasures described in the literature that were not considered further because of their ineffectiveness (e.g. bioremediation, administration of clay minerals to soil, leaching of soil), inappropriateness for application in the medium to long-term (e.g. administration of stable iodine to livestock) or a lack of relevant information (e.g. administration of alginates to animal feed, selection of different crop variety or species).

2.2 Development of a datasheet template with selected criteria

As the volume of information on individual countermeasures grows, there is a requirement to systematically record data in a standardised format to facilitate comparison between options. A datasheet template was designed for this purpose, taking into account all of the criteria that decision-makers might wish to consider when evaluating different countermeasures (Table 2). These include a short description of the option, its key attributes, constraints, effectiveness, feasibility, waste generated, doses incurred, costs, side effects, stakeholder opinion and practical experience. Datasheets containing information on these criteria were produced for all 101 countermeasures. They were then circulated for internal comment within the project before being sent to international experts and end-users for peer review. The datasheets for urban and industrial countermeasures have already been published [1 and 2], whilst those applicable to food production systems are in press [3].

Table 1 Countermeasures, and waste disposal options contained within the compendium

Agricultural Countermeasures	
Administration of AFCF boil to ruminants Administration of clay minerals to feed Application of K fertilisers to arable soils/grassland Application of lime to arable soils/grassland Clean feeding Change of hunting season Dilution Decontamination techniques for milk Distribution of saltlicks containing AFCF Distribution of concentrates with AFCF Distribution of concentrates with added calcium Deep ploughing Early removal of crops Feeding animals with crops/milk > Intervention levels Food bans	Live monitoring Manipulation of slaughter time Ploughing, fertilising and reseeded of unimproved pastures Processing of milk for human consumption Processing of crops for consumption Salting of meat for consumption Selective grazing regime Select edible crop that can be processed Select alternative land use Slaughtering dairy cows Shallow ploughing Skim and burial ploughing Suppression of lactation before slaughter Topsoil removal
Rural waste disposal options	
Biological treatment (digestion) of crops Biological treatment (digestion) of milk Burning of carcasses Burial of carcasses Composting Disposal of contaminated milk to sea	Incineration Landfill Landspreading of milk and slurry Ploughing in of standing crops Processing and storage of milk for disposal Rendering
Aquatic and Forest	
Addition of lime to lakes or catchments Addition of potassium to lakes Bans on drinking water consumption Construction of dykes or barriers Purification of drinking water at water treatment plants	Regulation of contaminated water flow through reservoirs Switching or blending of drinking water supplies Forest soil treatment with fertilisers Modification in tree felling time Restriction on the use of wood
Industrial	
Application of detachable polymer paste on metal surfaces Chemical cleaning of contaminated metal surfaces Cleaning of contaminated ventilation systems Cleaning of contaminated plastic and coating surfaces	Electrochemical cleaning of metal surfaces Filter removal from industrial areas Physical cleaning of metal surfaces Ultrasound treatment + chemical decontamination
Urban	
Ammonium treatment of walls Application of clean sand or soil around dwellings Change of roof Deep ploughing (park areas) Fire hosing of roads and walkways Garden digging High pressure washing of dwellings High pressure washing of roofs Intensive indoor surface cleaning Lawn mowing Mechanical abrasion of wooden walls Pruning or removal of trees and shrubs Re-surfacing frequently occupied areas Road planing	Roof cleaning by cleaning device Roof cleaning with pressurised hot water trolley Sandblasting of walls Shallow ploughing (park areas) Skim and burial ploughing (park areas) Snow removal Topsoil removal and applying lignin coating Topsoil removal by machines Topsoil removal manually Triple digging Turf harvesting Turning flagstones Vacuum sweeping roads and walkways
Social Countermeasures	
Advice on use of fire ash Compensation scheme Dialogue and Consultation: Citizen's Jury Dietary advice Do nothing Education programme in schools Evacuation/sheltering Food labelling	Information/Advice Bureau Medical check-up Provision of counting/monitoring equipment Raising intervention limits Relocation Restrictions on gathering of free food Restrictions on the use of recreational areas

Table 2 Criteria used to describe countermeasures

Criteria	Issues
Key attributes	Objective Other benefits Countermeasure description Target Target radionuclides Scale of application Contamination pathway Exposure pathway pre intervention Time of application
Constraints	Legal Social Environmental Communication
Effectiveness	Countermeasure effectiveness Factors influencing effectiveness of procedure (Technical) Factors influencing effectiveness of procedure (Social)
Feasibility	Required specific equipment Required ancillary equipment Required utilities and infrastructure Required consumables Required skills Required safety precautions Other limitations
Waste	Amount and type Possible transport, treatment and storage routes. Factors influencing waste issues
Doses	Incremental averted doses Factors influencing incremental averted dose
Intervention Costs:	Equipment Consumables Operator time Factors influencing costs Communication costs Compensation costs Waste costs Assumptions
Side effect evaluation	Ethical considerations Environmental impact Agricultural impact Social impact Other side effects
Stakeholder opinion	
Practical experience	
Key references	
Comments	

2.3 Inclusion of ‘second layer’ documents on CDROM

The datasheets are both comprehensive and concise and intended to be generally applicable across Western Europe. Nevertheless, for some criteria (e.g. legal, social and communication constraints, ethical considerations, cost-effectiveness, wastes, additional doses and stakeholder opinion) the inclusion of more detailed guidance was considered appropriate. Presentation of this additional information was achieved using a CDROM format [4] whereby hyperlinks were created between particular criteria in the datasheets and relevant ‘second layer’ documents. A brief summary of what is contained in the second layer documents is given below.

2.3.1 Legal, social and communication constraints

The feasibility of individual countermeasures will not only depend on technical constraints but also on a variety of legal, social and communication issues. Legal constraints are discussed in terms of environmental legislation (e.g. for nature conservation, freshwater resources, atmosphere, marine, waste), maximum permitted levels of radionuclides in foodstuffs, protection of cultural heritage, declarations on human rights, conventions on workers rights, ownership and access to property, and liability for possible damage to property. Social and communication constraints (e.g. acceptability of countermeasures on animal welfare grounds, rationales for choosing a particular countermeasure) unlike technical or legislative constraints are shown to be less rigid and insurmountable.

2.3.2 Ethical considerations

A number of ethical criteria are important in the evaluation of countermeasures. In this context, decision-makers need to ask questions on whether:

- (i) The distribution of cost and benefits is equitable. Countermeasures that reduce collective dose (e.g. by banning foodstuffs) often change the distribution of dose, from consumers/farmers to workers/consumers/populations around waste facilities.
- (ii) The risks are imposed or voluntary. Voluntary countermeasures (e.g. provision of counting equipment, dietary advice and self help measures for farmers) that are carried out by affected individuals, or that increase personal understanding or control over the situation, respect the fundamental ethical values of autonomy, liberty and dignity. Imposed countermeasures (e.g. bans on amenity use, radical changes in farming practice) are highly disruptive and infringe upon liberty.
- (iii) The action carries a risk of serious environmental damage. Countermeasures that change or interfere with ecosystems may have uncertain or unpredictable consequences for the environment. Environmental risk raises a variety of ethical issues including consequences for future generations, sustainability and balancing harms to the environment/animals against benefits to humans.

General information is provided on the ethical criteria against which each individual countermeasure can be evaluated.

2.3.3 Cost effectiveness

Calculating cost-effectiveness (i.e. the direct monetary cost of reducing a unit collective dose (euros/person Sv) is a useful tool in a decision-making. It gives the least costly method of achieving a specified reduction in dose, or it can predict the maximum reduction in dose for a fixed cost. A cost-effectiveness analysis may be an important first step in excluding some countermeasures. A methodology is described for calculating cost-effectiveness for all of the countermeasures contained in the compendium that lead to an averted collective dose. Actual cost-effectiveness is both scenario and site specific.

2.3.4 Wastes

The generation of waste as a result of implementing a countermeasure is frequently overlooked in assessing practicability. However, the volumes of waste produced can be considerable (e.g. following food bans, topsoil removal, processing or decontamination of milk, fire hosing of roads and walkways). Therefore, careful consideration must be given to the management of waste before selecting a countermeasure. Twelve options for the management of rural wastes have been identified (Table 1), ranging from relatively simple *in situ* disposal methods to off-site commercial treatment facilities. Few of these options have been previously considered in the context of restoration strategies. They are described in individual datasheets and form part of the countermeasures compendium. A separate second layer document describes 15 management options for wastes arising from countermeasures directed at urban or industrial areas. These range from techniques for the disposal of contaminated soil and vegetation to sophisticated methods for volume reduction.

2.3.5 Additional doses

The implementation of most types of countermeasures will lead to additional doses to those implementing them, and to those affected by the wastes generated. The additional dose is an incremental dose that specifically excludes doses from contamination already present in the environment. A series of calculations to specifically calculate the additional doses incurred by operatives (e.g. farmers and factory personnel) from the implementation of agricultural countermeasures is described. All of the major relevant pathways, external irradiation, inhalation of resuspended material and inadvertent ingestion of contaminated material were considered. A complementary approach is described for estimating doses in various representative locations inside and outside selected urban and industrial environments.

2.3.6 Side effect evaluation

The implementation of countermeasures leads to direct costs (e.g. manpower, compensation) which can be easily quantified and side effect (or indirect) costs (e.g. 'non use' values such as loss of biodiversity, deterioration in animal welfare, and 'use' values such as restrictions in hunting, fishing, swimming), for which it is more difficult to ascribe a monetary value. A more holistic approach to decision making needs to take into account the indirect effects of countermeasures. Five methods to value the indirect effects of countermeasures are described: choice modelling (preferred technique), contingent valuation, travel cost, hedonic pricing and production function approaches.

2.3.7 Stakeholder Opinion

Stakeholder participation is an important mechanism to explore the benefits or disadvantages of individual countermeasures, and is an essential step in developing a decision framework. Close liaison with the FARMING stakeholder network [5] facilitated evaluation of the datasheets for agricultural countermeasures and rural waste disposal options from stakeholder perspectives in the UK, Finland, Belgium, Greece and France. Opinion from the UK node of the FARMING network was included in the datasheets. The divergence of opinion between national groups is discussed further in a linked document ([6] which attributes these differences to variations in geomorphology, climate, land

management, infrastructure, consumer confidence and culture. Stakeholders were consulted in small groups or individually for feedback on the other categories of countermeasures. Their comments have been incorporated into the datasheets.

3 FUTURE DEVELOPMENTS AND APPLICATIONS

The countermeasures compendium has been well received by national and international bodies and plans are currently being made for its further development. For example, the datasheets for agricultural countermeasures and rural waste disposal options are being taken forward by the FAO/IAEA joint division for adaptation to other climate types. They may also be used to update IAEA Handbook 363 [7]. Furthermore, plans to expand the compendium in a new Integrated Project (EURANOS) are being negotiated under the auspices of the EC Framework Six Programme. Countermeasures applicable to the pre-release and early phase will be identified and new datasheets compiled. Existing datasheets will be extended to cover radionuclides of importance in the early phase, as well as those from potential terrorist devices. Updated versions of the CDROM, for both food production systems and inhabited areas, are expected by the end of 2005. These revised countermeasures compendia will form the main input to recovery handbooks being developed in collaboration with stakeholders for future use in Europe.

4 REFERENCES

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