Scenarios for zinc and copper: a strong sustainability and weak sustainability approach

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SUMMARY

Problems related to heavy metals have decreased over the last decades. However, if no additional action is taken, these problems are bound to increase again in the future due to present stock-building in society. This report specifies two policy scenarios that address the problems related to copper and zinc in the Netherlands. One scenario is based on a strong sustainability approach and the other on a weak sustainability approach. The strong sustainability scenario is defined as the set of measures to conform to the environmental standards with the lowest possible costs. The weak sustainability scenario is defined as the set of measures where costs and benefits are optimally balanced.

For the analysis of this problem a combination of analytical tools is used, namely Substance Flow Analysis (SFA), Life Cycle Assessment of products (LCA) and Cost Benefit Analysis (CBA).

An inventory is made of the possible measures and their costs based on present available technology to reduce copper and zinc emissions. The environmental effects of these measures are estimated using SFA models, i.e. FLUX and DYNABOX. The effects are expressed in Risk Ratios: the predicted concentrations divided by the environmental targets. The measures in both scenarios are taken in order of cost-effectiveness. For measures that affect more then one substance emission a distinction is made between non-allocated costs and allocated costs of a measure. In the later a part of the total cost of a measure is attributed to a specific substance emission based on the level of reduction and the severity of the emission, using LCA impact assessment factors. Next a selection of measures for the strong sustainability scenario is made based on cumulative cost effect curves. The selection of the measures for the weak sustainability scenario is based on marginal cost benefit curves. Finally an indication is given of some possible side effects of the measures, distinguished in side effects from substitution of products, technical measures and volume measures in agriculture.

Effective measures in both scenarios are immobilisation of landfill, reduction of copper and zinc additions to fodder and a reduction of the number of livestock. To comply with ambient environmental standards appears to be costly, but there appear to be large environmental benefits as well. The outcome of the weak sustainability scenario depends highly on some methodological choices, especially on which benefits to include. The two approaches can be regarded as complementary: strong sustainability is a long-term view of how it should be, while weak sustainability is better suited for the short term – in the present situation, with many problems and a limited amount of money, what should we do first? To be really policy relevant, the steady state type of analysis therefore should be supplemented with dynamic analysis, showing the consequences of certain policy measures over the years.

CONTENT

1. INTRODUCTION

1.1 The metal problem

Environmental problems related to heavy metals have a long history. Certain events in the past have induced governments to address these problems in their environmental policy. As a result, the emissions from point sources have been reduced significantly over the past decades in many countries. Some therefore may regard the metals' problem to be solved. However, the inflow of freshly mined metals into the world economy has remained at a high level. The question then is, if the metals no longer are emitted, what then is their fate? This question was the starting point of an interdisciplinary research program, the Metals program, financed by the Dutch National Science Foundation (NWO). It was found that the past reduction of emissions of the investigated metals to water and air has gone in hand with an increase of the accumulation of these metals in stocks of materials, products and landfilled waste. As a result, a future rise in emissions to the environment will take place if no action is taken. On the long run, this will lead to a surpassing of water and soil standards for ecosystem health and of standards for human exposure through the different environmental media. Thus the present day use of the four metals cannot be regarded as sustainable (Guinée et al., 1999; Van der Voet et al. (eds.), 2000).

In order to solve problems related to heavy metals, measures will be required, like the immobilisation of metals in solid waste flows and a complete phase-out of many applications, including non-functional ones. Although there is ample time for the implementation, the question is whether such measures are feasible at all in view of the many other environmental problems, which must be addressed as well.

1.2 Definition of the scenarios

The question how these measures should be regarded in a broader perspective is the subject of this paper. Two approaches are elaborated:
(1) a strong sustainability approach: provided that the environmental standards must be met, what is the most cost-effective package of measures to reach these standards?
(2) a weak sustainability approach: if environmental costs as well as benefits are included, which measures have a positive cost-benefit balance and would environmental standards be met as a result of a package containing only such measures?

First the analytical tools and framework are introduced used to calculate the results of the two approaches and indicate the basic drawbacks of the analysis. Then an inventory is made of measures to reduce the heavy metal load to the environment. In this paper the measures are focussed on problems concerning copper (Cu) and zinc (Zn). For each of these measures the effectiveness and costs are summarised. The cost-effectiveness and costs-benefits of the measures are derived and the results of the strong sustainability scenario and weak sustainability scenarios are given in terms of effects and costs. Besides effects on the copper and zinc load to the environment the measures might also have other effects on the environment, the possible side – effects. In chapter 9 some attention is given to the possible side-effects of the measures. Finally the results of the two scenarios are compared and discussed.

2. METHODS

2.1 *Strong and weak sustainability*

The concept of sustainability as introduced by Bruntlandt (1987), taking intergenerational equity as a starting point, is still a very broad one and leaves room for different interpretations. In the ecological economists literature, two schools of thought appear to be emerging, known as "strong sustainability" and "weak sustainability" (Daly and Cobb 1989, pp. 72 and 73). The strong sustainability point of view states that natural capital cannot be exchanged by man-made capital, and that therefore the environmental conditions should be treated as external constraints in economic models. In the weak sustainability framework, man-made and natural capital are considered interchangeable. In this view, trade-off between man-made and natural capital is possible, so that natural capital can be internalised in economic models in one utility function.

A scenario evaluation according to "strong sustainability" ideas can be called a cost-effectiveness approach and can also be seen as an operationalisation of the concept of eco-efficiency. The evaluation asks: 'what is the least-cost package of measures that results in compliance with environmental standards?' For finding least-cost packages one uses optimization models, for example in the various MARKAL models as used at ECN for optimization of energy systems (Gielen & Kram, 1997).

The "weak sustainability" approach asks for cost-benefit analysis (CBA) to evaluate measures. CBA becomes increasingly important in environmental policymaking, at least at the European level: the Single European Act requires that community environmental policy shall take account of the "potential benefits and costs of action or lack of action" (article 130 R). Cost-benefit analyses of environmental policies are usually pervaded with large uncertainties stemming from both lack of empirical data and methodological issues not resolved. Although in recent studies (e.g. the ExternE project of DGXII/US-EPA) advancements have been made in benefit estimations, uncertainties in the assessment of monetarily valued impacts are still expected to be large (orders of magnitude). Nevertheless, such analysis can be very useful in informing about the direction of policy making.

2.2 Analytic tools

The starting point for the present paper is the research on the flows of four heavy metals (copper, zinc, lead and cadmium) in the Dutch society and environment as performed in the Metals program (Van der Voet et al. (eds.), 2000). The study has used Substance Flow Analysis (SFA) as its primary tool. It has included an assessment of the present situation (in this case, 1990) and a model calculation of three scenarios, aimed at the two most problematical metals zinc and copper. The results of this database and modelling are the starting point for the assessment in this paper. SFA results are limited: only the flows of the four metals themselves are considered. Environmental side effects on the one hand and economic impacts on the other hand are ignored.

Life-Cycle Assessment (LCA) is a method to analyse the environmental impacts of cradle-to-grave economic chains. An LCA system contains all processes required to fulfil a specific function, and specifies all emissions to and extractions from the environment, as well as other environmental interventions (ISO, 1999). Two alternatives for the same function thus can be compared on their environmental impacts, including side effects. In the case of metals, substitution of copper or zinc with iron or plastics can be assessed with LCA on the overall environmental impacts. Other measures are more difficult to evaluate with LCA. For example closing down stockbreeding is not a simple case of substitution. Animal products may be replaced with plant products, home produced meat may be replaced by imported meat, and / or the Dutch will find other ways to make a living. All have different environmental impacts. In this paper, we restrict the use of LCA to the simpler cases of substitution of products, materials or processes. LCA is used for the evaluation of the strong sustainability and weak sustainability scenarios on their side effects to other environmental problems. A limited number of existing LCA studies has been used (Senhorst, 1993a and 1993b; de Rijke & Korenromp, 1994) to compare specific zinc and copper applications in building and construction with alternative materials (plastics, steel and glass fiber).

Cost Benefit Analysis (CBA) is a method to assess the appropriateness of deciding on measures based on an overview of their costs and benefits in monetary terms. CBA strives for comprehensiveness of the aspects taken into account. Also CBA aims to make decision making transparent. Both characteristics require careful scoping of aspects to take into account and to not take into account. In CBA, environmental aspects are included as well. A translation must be made, therefore, from environmental parameters into economic ones. In theory CBA is more encompassing than LCA: not only environmental but also economic costs and benefits are included, and an absolute assessment is possible. In practice the translations of environmental interventions into economic terms is difficult and therefore generally incomplete. Knowledge about environmental cause-effect chains is limited and there are large problems with the valuation of environmental effects in monetary terms.

2.3 System boundaries

Scope

A major element in defining the scope of the evaluation of both the costs and benefits – environmental and economic – of a measure evolves from the question how to attribute costs and benefits associated with the measure. This issue evolves from the possibility that a certain measure to address a specific environmental problem might be beneficial to other environmental problems as well. If so, in an evaluation of such measure, one might consider to either take account of such side effects by reducing the costs in the eventual balance of costs and benefits, or extending the benefits in the balance. What to do depends on the framework of comparison. In a 'strong sustainability' framework, comparing costs with improvements in terms of environmental quality only, one would (have to) reduce the costs, since 'economics' is account for only by the cost item. In a 'weak sustainability' context it would be methodologically more consistent to incorporate all the extra benefits – if monetarily valued – in the benefit side of the balance.

In the present research it was possible to assess the extra benefits in environmental terms, drawing from extensive experience with LCA (CML literature). This is since in LCA two major topics are (i) providing environmentally comprehensive insights in environmental effects of (economic) activities and (ii) addressing problems of allocation of effects to activities. This experience has been used in evaluating the costs of measures as to be used in the 'strong-sustainability' approach. In the following this is referred to as 'full costs' and 'allocated costs' approaches. Within the 'weak sustainability' approach it was not possible to monetarily assess the side effects of the measures. These are only included as 'not-accounted-for' items in the balance. In table 2.1 below the included environmental and economic costs and benefits are specified.

Table 2.1 Scope of the evaluation for the strong sustainability and weak sustainability scenarios

	evaluation tools used	environmental benefits	economic benefits	environmental costs	economic costs
strong sustainability scenario	cost-effectiveness: SFA, LCA, cost assessm't	reduction of env. concentrations Cu and Zn in the Netherlands; concurrent reduction of other emissions / extractions	-	increase other extractions / emissions due to substitution	direct costs of measures aimed at Cu and Zn
weak sustainability scenario	cost-benefit: CBA	monetary benefits of reducing Cu and Zn concentrations in the Netherlands		direct costs of measures	

The outcomes of the two scenarios thus are not really comparable. To enable a comparison, the scenarios are also expressed in each others terms: the benefits of the strong sustainability are estimated in economic terms as well, and the environmental concentrations of Cu and Zn that are the result of the weak sustainability scenario are specified. Thus a comparison is possible of the costs, the benefits and the environmental concentrations of Cu and Zn.

Time

The starting point for the analysis was the situation in the Netherlands in 1990. A complete overview of flows of heavy metals was made for this year. For the calculation of the effectiveness of certain measure packages, as well as the two scenarios presented in this paper, a static approach was taken. The scenarios were translated into a technical management regime, implemented in the model as a set of input-output coefficients, and the equilibrium situation of this regime was calculated. The result is an overview of the flows of the metals in a steady state. Such an overview must not be interpreted as a prediction of any future situation, but rather as a caricature of the management regime. It is conceptually equivalent to comparative static modelling in economics, and therefore can be used as a basis of comparison for different alternatives.

Cost-effectiveness calculations as well as CBAs are performed under ceteris paribus conditions. This condition is likely violated by only considering the effects of a measure as they would evolve in an equilibrium situation, since reaching such a state would require hundred of years. We accept this inconsistency in a first comparison of the approaches.

2.3 Allocation of the costs of the measures

In the previous paragraph it is stated that some of the measures may affect the emission of more than one substance. When deriving the cost-effectiveness of a measure then the problem arises how much of the costs of the measure should be attributed to a specific substance.

The cost - effectiveness of a measure m can be defined as:

$$CE_m = \frac{C_m}{E_m}$$

In which C_m is the Cost and E_m is the Effectiveness of a measure m.

If the measure affects more than one substance the formula can be rewritten as:

$$CE_m = \frac{C_m}{E_m} = \frac{C_m}{E_{m,s1} + E_{m,s2} + E_{m,s3} + E_{m,sn}}$$

In which $E_{m,sn}$ is the Effectiveness of measure m on substance n.

In order to make a fair comparison of cost – effectiveness between measures with a narrow effect and measures with a broad effect the costs of a measure can be allocated to the separate substances it affects. The cost effectiveness can be redefined as:

$$CE_m = \frac{C_m}{E_m} = \frac{{}^{a}C_{m,s1}}{E_{m,s1}} + \frac{{}^{a}C_{m,s2}}{E_{m,s2}} + \frac{{}^{a}C_{m,s3}}{E_{m,s3}} + \frac{{}^{a}C_{m,sn}}{E_{m,sn}}$$

In which ${}^{a}C_{m,sn}$ are the allocated costs of a measure m to substance sn.

For the allocation of the costs of a measure allocation factors should be derived. For this purpose the expertise of the methodology of Life Cycle Impact Assessment (LCIA) is used (Guinée et al., 2001; Heijungs et al., 1992; ISO, 1999). In LCIA there is a procedure, consisting of several steps i.e. characterisation, normalisation and weighting, to convert emission in order to make it possible to add up emissions of different substances contributing to different environmental problems.

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LITERATURE

APPENDICES