The Swedish sewage sludge controversy
issues, actors, interpretations

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This extended abstract reports an on-going study. A full paper is under preparation and will be available upon request.

Introduction

Sewage sludge is the residue that remains when municipal wastewater has been cleaned in treatment plants. In that sense, it is a waste that the treatment plants need to dispose of. Since the construction of wastewater treatment systems, which took place mainly in the 1950's and 1960's, a large proportion of the sludge has been spread on farmland, not only as a way of disposal, but also in order to make use of its content of nutrients and other soil improving substances. The use of sludge has reduced the farmers' need for artificial fertilisers and helped improving the soil structure. In many cases, the farmers have received the sludge at no cost, often also including the costs for spreading, so in their view the use of sludge has been economically attractive. However, the existence of harmful and potentially hazardous substances in sewage sludge has led to opposition against its agricultural use.

With varying degrees of intensity, the debate on whether sludge use in agriculture should be allowed or not has been going on for more than thirty years by now. Some actors are tired of the issue and what seems to be an endless struggle. "Sludge has become such a f-word", said a research colleague of ours working with the food production sector.

Despite the difficulties of getting acceptance, sludge is still an issue for several reasons:

- The economic benefits for both municipalities and farmers,
- The governments' emphasis on the recycling of nutrients as part of a sustainable development,
- The shortcomings of alternative solutions, apart from higher costs.

The term actor is frequently used in this paper. We use that term both for individuals and for organizations, which have an official position on sludge use in agriculture.

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Purpose

Our study of the sludge controversy covers both the interpretations, arguments and policy positions of different actors, and the social process and changes that have taken place over time. The present paper deals mainly with the former aspect. A strict separation of the two aspects is, of course, not possible; it is more a matter of emphasis. The intention of this part of the study is to analyse the structural properties of the different arguments and policy positions. We hope that the results of such an analysis will help us suggesting ways in which the structure of the controversy may be better understood and addressed.

Of central interest to our study is the relation between facts and values. What do the actors agree on? Are the differences in positions due to disagreement over factual information or over the interpretations made of that information? To what degree do the actors seem to think that factual information can resolve the issue?

Another set of questions that we wish to explore deals with the actors' perceived roles and interests. How do they define their own role and responsibility in relation to the other actors? Can the different goals and interests of the actors explain their differing positions, or is the controversy also due to more fundamental value differences?

In our study, we focus on the national sludge debate. This means that most of our empirical material is related to national actors, such as national federations, associations and authorities. In this paper we use some quotations to illustrate ideas and ways of thinking employed by the actors; these are translations that we have done from the Swedish original texts.

Background

Recent events

In October 1999, the Federation of Swedish Farmers (*LRF*) broke the sludge agreement that had been in place since 1994. *LRF* recommended its members not to use sludge any more. The reason given was reports about increasing concentrations of brominated flame-retardants in sludge. These findings had also been given attention by the media. The decision to leave the agreement was, however, also influenced by earlier reports on risks of rapid accumulation of silver in soils where sludge was spread, and reports on hygienic risks related to wastewater from hospitals. The other parties of the sludge agreement were the Water and Wastewater Association (*VAV*[1]) and the Environmental Protection Agency (*NV*). As a result of *LRFs* recommendation, the use of sludge in agriculture dropped significantly.

This new situation caused problems for the municipalities, especially since the government was just about to introduce a tax on organic waste brought to landfills. The purpose of the tax was to create incitements for recycling of nutrients and it went into practice in 2000. Furthermore, it had been announced that the tax would be replaced by a ban on landfilling of organic waste in 2005. Threatened by this development, and with no chance of being able to comply with the national ambitions

[1] VAV is the old acronym for the Water and Wastewater Association. From 1st January 2002 they are called *Svenskt Vatten.* For simplicity, we use the old acronym throughout this paper.

to increase the recycling of nutrients, the municipalities, through *VAV*, demanded clearer guidelines from the responsible authorities.

As a result of the demands from *VAV*, in the spring of 2001 *NV* was commissioned to investigate the policies on sludge and recycling of phosphorus. The investigation would compile best available knowledge in the field and, in co-operation with the relevant actors and other authorities, develop an action plan with time-set goals and target levels.

The phosphorus chain network

Figure 1 shows an overview of the different activities and actors involved in the recycling of phosphorus if sludge is used in agriculture. Sorting and fractioning technologies lead to similar networks.

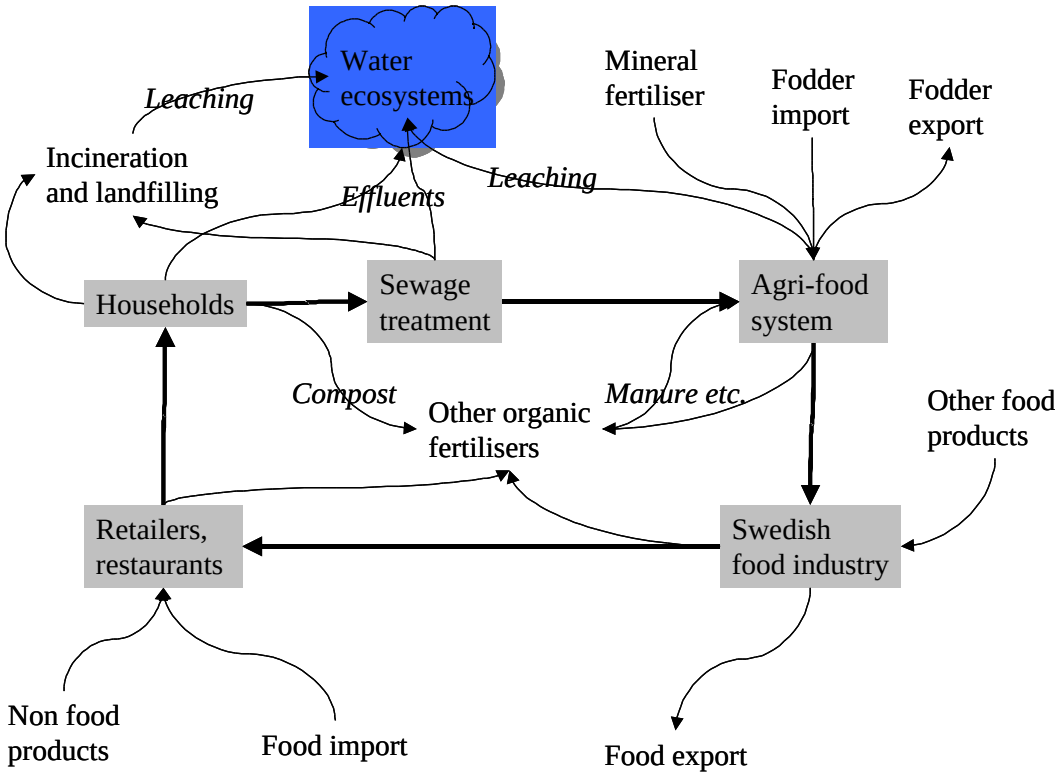

Figure 1. Activities and actors involved in the flow of phosphorus with recycling in place.

The actors

The purpose of this part of the text is to briefly introduce the main actors in the controversy and their positions on sludge use.

The political system and the authorities

The Environmental Protection Agency (*NV*) is responsible authority for sludge related issues and also for resource conservation. They have issued regulations on under what conditions sludge may be used on farmland. These regulations were the basis for the agreement that was broken in 1999. Even though *LRF* has left the agreement, the

regulations are still valid, and as long as they are followed, the spreading of sludge is legal.

The wastewater sector

Almost all treatment facilities in Sweden are publicly owned. In most municipalities a separate department operates the treatment plants, while in some cases this task is carried out by publicly owned companies. Private companies have entered the scene in the last few years, but they are not common. All municipalities are members of the Swedish Water and Wastewater Association (*VAV*). Compared to other countries, the organisation of the Swedish water and wastewater sector is very distributed, meaning that many decisions concerning these systems are made at the municipal level. Since the majority of the municipalities are too small to be able to employ specialists in, for example, sludge treatment technologies, there is a great need for co-operation between municipalities and dissemination of knowledge from the large municipalities to the smaller ones. Some of this co-operation is channelled through *VAV*. There is also a relatively big market for technical consultants to assist the municipalities. The sector is highly regulated; national legislation and directives from provincial governments have had a huge impact on the development of the sector.

As described above, sludge handling is a serious problem for almost all municipalities at present. They seek cheap, reliable, environmentally benign solutions that can solve the problem of sludge disposal at least for the next few years. Some of them view agricultural use of sludge as a good and feasible option; others believe that alternative solutions must be found. At the national level, however, *VAV* work to promote the use of sludge in agriculture as the priority option.

The farmers

The farmers are a diverse group with very different opinions on the use of sludge. However, in this paper we deal mainly with the national actor representing the farmers: the Federation of Swedish Farmers (*LRF*). About 80 percent of the farmers are members of the federation. Apart from being the farmers' co-operation and lobbying organisation, *LRF* also owns the Swedish Agriculture Cooperatives, which includes a large part of the Swedish food industry. The farmers and the food industry are thus closely linked, not only by a seller–buyer relationship but also through a co-operative ownership. As mentioned above, *LRF* has previously supported the use of sludge, but do not recommend this practice any more. Since not all farmers are members of the federation, and since it is only a recommendation, sludge is still being spread in some regions. Most of the products from those farms are exported as fodder.

The food industry

Many food companies have accepted the use of sludge in the past, but since *LRF* left the sludge agreement in 1999 the situation has changed. Today, almost no companies are willing to buy crops or other food products from farmers who use sludge. Accepting sludge would only give a negligible economic advantage to the food industry, and it would entail an economic risk since new alarm reports about unwanted substances in sludge may reduce consumers' confidence in their products.

The consumers

Surveys have shown that many consumers do not have a clear opinion on whether sludge use in agriculture is acceptable or not; in general, the issue seems not to be of high priority.

At the national level, consumers are represented by consumer organisations. Two such organisations are active in the sludge debate: the Swedish Consumer Coalition (*SKiS*) and the Swedish Consumers' Association (*SKR*). Unlike some other countries, the consumer movement in Sweden is not very visible in the public debate, and therefore not well known to the general public. Traditionally, the authorities have been regarded as the most important protectors of consumers' health. *SKiS* is the more radical of the two organisations and also the one that is the most active on the sludge issue. They are strongly opposing the use of sludge, mainly for health reasons.

The environmental movement

The Swedish Society for Nature Conservation (*SNF*), which is the largest environmental organisation in the country, is also engaged in the debate. Their official position does not, in general, support the use of sludge. However, there has been an intense internal debate within *SNF* on the issue, and, until 1996 they supported the agreement between *NV, VAV* and *LRF*. This disagreement among environmentalists is important, because it indicates that the controversy at hand is not of the traditional 'environmental protection *versus* economic development' type, but is also based on conflicting environmental objectives. Other environmental organisations, such as Greenpeace, are not actively involved in the debate at present.

The issues: debates within the debate

In this part we briefly go through the contested issues. These are both related to the potential risks of spreading sludge on farmland and to the benefits of recycling nutrients. As will be shown later on, even though these "core issues" are of central importance, the controversy is also strongly influenced by other aspects.

Metals

Today, seven metals (Cd, Pb, Cu, Cr, Hg, Ni and Zn) are frequently measured in sludge. For these seven, there are limit values that regulate sludge use in agriculture. Many other metals are, however, also present in sludge. Some of these have attracted attention recently because since the naturally occurring concentrations are very low, the amounts added with sludge cause a rapid increase in concentrations. Some of these metals are known to have negative effects, such as silver, while for others little is known about their behaviour in soil and their biological effects. All actors agree that, in the long run, systematic increases of concentrations of metals are unacceptable. However, they do not agree on safety margins and how urgent the reduction of metals flows to soil is.

Organic pollutants

Organic pollutants are different from metals in two important respects: their number and their degradability. While the metals are a finite number of well-specified

elements, the organic pollutants that may be present in sludge can be counted in tens of thousands. Furthermore, many new chemicals are synthesised and put into circulation in society every year. Many of these chemicals are not harmful and many degrade rapidly into harmless, naturally occurring, substances. Some are, however, persistent and harmful even in low concentrations. Only for a minority of these substances are the biological effects well investigated. The actors do not agree on how great the risks of this group of pollutants are.

Pathogens

Bacteria, viruses, fungi and parasites may be present in sludge. Through sludge treatment, most of these can be eliminated, but their complete absence requires advanced treatment and only under special conditions can this be fully guaranteed. As for metals and organic pollutants, there is no agreement among the actors whether pathogens may cause problems if sludge is used in agriculture.

Nutrients

Phosphorus is a vital element for biological production. Since the easily accessible and relatively unpolluted deposits of phosphorus-rich minerals are limited, and since the demand for phosphorus as fertiliser will remain high, or even increase, society needs to be careful with available phosphorus. Therefore, the Swedish parliament has set high targets on recycling phosphorus from organic waste. Phosphorus is the nutrient that is the most emphasised in the sludge debate, but some actors, both farmers and others, also talk about the need for recycling nitrogen, potassium, sulphur and other elements.

While all actors in the controversy agree that, in the long run, the recycling of phosphorus and other nutrients is a priority target, there are different opinions on how urgent this recycling is and to what degree the benefits of it can compensate for the risks of spreading sludge on farmland.

Present options

The resistance against sludge has caused municipalities to look for other options. To help the reader better understand the discussion, we briefly describe the main alternatives considered at present.

1. Landfilling. Has been widely used as a complement to spreading, for polluted sludge and in areas where there has been no demand for sludge in agriculture. Not allowed from 2005.
2. Soil production. The use of sludge for other purposes than agriculture: parks, flower plantations, embankments for noise reduction, golf courses. Has grown in recent years.
3. Forest fertilisation. Both in coniferous forests and Salix plantations.
4. Incineration. The ashes are not organic waste and may thus be brought to landfill.
5. Sludge fractioning. Makes the phosphorus available for recycling. The technology is still under development.
6. Fractioning of ashes after incineration. Makes the phosphorus available for recycling. The technology is still under development.
7. Super critical water oxidation. Makes the phosphorus available for recycling. The technology is still under development.

8. Urine sorting. Makes a large portion of the nutrients available for recycling. Requires the installation of special WCs and separate piping for collection.
9. Separate black-water system. Water from WCs handled separate from other streams of liquid waste. Requires special installations and separate piping.

Apart from sludge use in agriculture, only options 5 through 9 in the list above fulfil the government's long-term goals to recycle phosphorus to agriculture. All three fractioning technologies (5, 6 and 7) need further testing in full scale before they can be a considered a realistic option. The sorting alternatives (8 and 9) cannot be implemented in the short run, but require major reconstruction.

As can be understood, in the present situation, the municipalities require both short-term ways to take care of the sludge and robust directives for their long-term planning.

Analysis

In our analysis of the controversy, we try to identify some factors that make it difficult to find solutions that can be widely accepted. We focus mainly on the situation of today, but in order to understand what the situation would be like if sludge would be accepted for use in agriculture again, we also to some extent deal with the situation as it was before the sludge agreement was broken.

Facts, values and interpretations

The role of science and facts

One of the issues that have been discussed the most and the longest in the sludge controversy is the health effects of metals, most notably cadmium. Even though the issue has been on the agenda for more than thirty years, the actors view available scientific information in very different ways as illustrated by the following two quotations. The first one is taken from *VAVs* official comment on a draft version of a report written by *NV*: "Products without hazards" (*Varor utan faror*).

> Scientific investigations come to the unambiguous conclusion that bringing nutrients back to farmland through the spreading of sludge does not entail any problems in the short or medium term, while the accumulation of heavy metals may become a problem in the long term…

The second quotation is from a recent report on metals in sludge written by the consumer organization *SKiS*.

> The amount of cadmium in the soil is today so high that further increases must be prevented, even if this requires large sacrifices. Increasing concentrations in soil lead to higher concentrations in food products and in people's kidneys. Today, the concentrations are on a level where kidney specialists say that there are no margins left; risk groups are already believed to have damaged kidneys.

The conclusions about what is known about effects of metals are radically different, even though these two actors probably base their conclusions on more or less the

same body of scientific articles and reports. The different views notwithstanding, both actors have a strong confidence that decisions made about the handling of sludge can be based on scientific knowledge. As illustrated by the following two quotations, they are both frustrated over what they think is a biased debate. The first one is taken from a letter sent from *VAV* to the Minister of the Environment.

> The sludge issue has been subject to many beliefs, most of which lack factual grounding and are based on feelings. We think it is absolutely necessary that a long-term sustainable strategy be based on science.

The view of *VAV* may be compared with what *SKiS* write on their website:

> In order to get a sufficient amount of unbiased facts, something that is not easy in a society where research is dependent on the state and the industry, we have… --- …been able to uncover truths that otherwise would have been hidden from us, and an impressive amount of facts, that will for sure be scrutinised and refuted by those who have things to lose from the exposure of unpleasant truths.

Both actors want to be seen as the guardian of truth who fights against ignorance and subjectivity, and they both say they would like to see a facts-based debate. However, they do not seem to have much confidence in each other's truth claims.

The policy instrument that has been used to regulate the use of sludge is mainly a set of limit values decided by the authority *NV*. It is interesting to note that both *VAV* and *SKiS* criticise these values for not being science-based. *SKiS* wrote as follows in an official comment on a draft version of the report "Products without hazards" (*Varor utan faror*):

> The limit values mentioned in the draft are based on pragmatic considerations and on the existing levels in sludge, and have hardly anything to do with environmental protection, health or sustainable agriculture. Those values have been decided in order to enable the spreading of sludge.

VAV is also critical against the limit values. In a letter to the Ministry of the Environment, they wrote that these values were:

> … a negotiation product, against which many objections may me raised on scientific grounds.

Even though *SKiS* and *VAV* agree that the limit values are not sufficiently based on scientific results, that come to opposite conclusions as to how the values ought to be adjusted.

What qualifies as a problem?

The actors in the debate have different views on what kinds of findings are needed to indicate that there is or may be a problem. For example, *SKiS* are of the opinion that increasing concentrations of metals or organic pollutants are an indication that there may be problems. Earlier, we also mentioned that it was increasing concentrations of brominated flame-retardants that caused *LRF* to change their recommendation on

sludge. These actors both represent a ‘precautionary’ frame illustrated by the following quote from a summary of a recent report published by *SKiS*:

> No element may be left out beforehand; all increases in concentrations should be viewed as potentially dangerous, since we cannot remove the metals afterwards or foresee their fate in soil.

In contrast, *VAV* represents a ‘proofs first’ frame, illustrated by the following quotation from a letter from *VAV* to the Minister of the Environment:

> To demand, for ethical reasons, that the concentrations of unwanted substances should be on background levels may render sludge fertilisation impossible, even though there are no real risks to the environment or to human health.

What information qualifies as an indication of a problem to these two actors? Clearly, they have different ideas about that, and, since they do not agree on that level, they have problems convincing each other with factual arguments, or what they view as facts.

Interpretations of results from flow models

In the on-going investigation by the Environmental Protection Agency, flow models with a life-cycle perspective have been used for comparing treatment options. The technical potential for recycling nutrients have been analysed in these studies, as well as associated costs, energy consumption and emissions. In these models, the basis for comparison is the flow of phosphorus, so costs and energy consumption are expressed per kilogram of recycled phosphorus. This way of evaluating the systems makes sense to the agency and to the wastewater sector. However, the Federation of Swedish Farmers think that these studies are a comparison of “apples and bananas”, since they do not take the differences in quality of the nutrient flows into account. While some alternatives will result in more or less pure phosphorus being brought to farmland, other options will produce nutrients that are, to varying degrees, polluted. Furthermore, the studied systems do not only differ with respect to contamination but also to the capacity to recycle other nutrients than phosphorus: nitrogen, potassium and sulphur. A comparison focused solely on the recycling capacity for phosphorus does not take these differences into account, something pointed out both by the farmers and the wastewater sector.

When comparing technical systems, a basis of comparison, describing the main function performed, is needed, but, as seen above, the systems may differ in many respects. Depending on perspectives, actors emphasise the importance of these other aspects of performance differently, and they thus have different views on the relevance of the results of the flow models and what weight these results should have in the process of policy design.

Taking the future into account

As shown, the actors have different ideas on what the situation is like at present, but the evaluation of sludge use in agriculture also involves theories about the future. How will the use of chemicals in society in general change during the decades to come? To what extent are further improvements of the quality of the sludge possible?

The answers to such questions have great importance for how different actors evaluate alternative options. Figure 2 shows different beliefs about how the concentrations of metals in sludge will develop in the future. How this develops is of great importance since the metals may accumulate in soil if sludge is spread. The greater the amounts of metals added to soil in total, the greater the risks of negative effects. If concentrations are believed to drop radically in the future, and if safety margins are believed to be large, sludge use today may not be a problem. On the contrary, if concentrations are believed to remain relatively high, there may be good reasons to introduce other solutions today already.

One reason for allowing the spreading of sludge, often put forward by the wastewater sector, is that this will motivate municipalities to continue their efforts to reduce the inflow of unwanted pollutants to the wastewater systems. If sludge is incinerated, it is believed that the quality of the sludge will not improve as much as if spreading is practiced. Hence, according to this belief, if the incineration alternative is chosen the point in time when sludge can be acceptable for use in agriculture will be even more distant.

The actors' ideas about the future influence how they interpret today's situation and how they evaluate different options. But, in turn, the interpretations and evaluations done by actors today influence actions taken and thereby contribute, both directly and indirectly, to shaping the future situation.

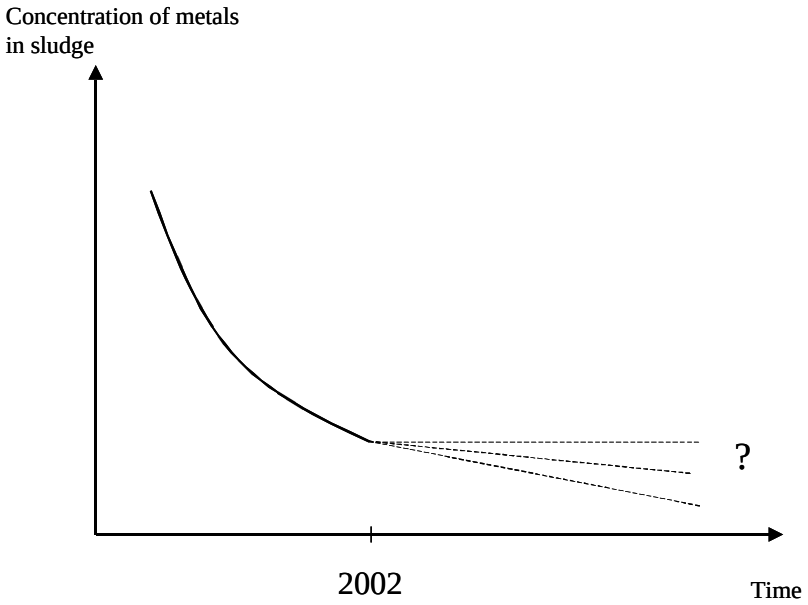

Figure 2. Different ideas about the future quality of sludge.

Actors' roles and relations

Interdependencies in the phosphorus chain network

In the network studied, each actor controls some vital resource, which they may or may not make available to the other actors. In order to understand the relations in the

network, it is important to analyse what resources are involved, how they are made available, to what degree different actors depend on getting access to each other's resources, and what possibilities the actors have to find substitutes for the resources involved.

The farmland is the most vital resource controlled by the farmers. They may make this resource available to the wastewater sector. However, farmland is not the only possible option for sludge disposal, so, if disposal is the only objective, municipalities do not depend on farmers' acceptance. But, if political decisions require recycling of phosphorus, municipalities have no alternative but to find ways of making the farmers accept fertilising products from wastewater systems. The farmers, however, have other sources of nutrients to chose from: mineral fertilisers and organic waste products that do not come from the wastewater systems. They are thus not to the same degree dependent on the municipalities than *vice versa*.

Since the farmers sell their products on a market, they can only produce what their customers, the food industry, are willing to buy. They can export some of their products, but this is not possible for all sorts of products and for some products they get less paid on the export market. Farmers who start using sludge are facing an economic risk, which affects their willingness to do so. Many food companies do not accept products from fields where sludge has been spread at some point during a certain period of time. This means that the land may be quarantined for a number of years after sludge has been used. During this time the farmer cannot grow the most suitable and profitable product, but has to choose an alternative.

For the purpose of this analysis of interdependencies, the food industry can be regarded as more or less a channel between the farmers and the customers. In this role they have little to gain from accepting the use of sludge since they realise that the goodwill value of using sludge is very low. Especially so since customer groups that demand environmentally benign products or health food most probably prefer organic food products to sludge-fertilised products.

The consumers are free to buy imported food products or organic products if they lose confidence in the conventional Swedish products. The consumers' main resource is their buying power, and they are not obliged to co-operate in the phosphorus chain network if they feel that those products are not safe.

The government and the authorities can hardly decide that farmers should accept sludge being spread on their land or that the food industry and their customers should accept products from farms where sludge has been used. One factor that confuses the debate is the question of whether sludge should be regarded as a commodity or as a waste or as both. These different ways of describing sludge invoke different logics of control: sludge-as-commodity may be traded freely in the market, and it is the demand that controls production volumes and the buyer who decides what quality is acceptable; sludge-as-waste, on the other hand, is something that should be regulated by the responsible authorities and disposed of in the best way possible. Both ways of looking at it are fully reasonable, but in concrete situations they may lead to conflicting views. The unclear status of the sludge may be one cause of the diverging opinions on how sludge should be managed. The ambiguity seems to be due to the mixing up of different physical streams: nutrients and pollutants.

The actors that can be identified along the physical flows (of nutrients, metals and hazardous organic substances) are not automatically part of a network with shared goals and purposes. Chain management requires that such a network is created and maintained. For the up-stream identification and phase-out of pollutants from society, such networks may become extremely complex and involve many hierarchical levels. The actors realise that they depend on many other actors and factors that lie beyond their control, for example the chemical industry, the electronics industry, the EU legislation on chemicals and the deposition of airborne pollutants. Furthermore, the actors directly involved are not one static network either; different actors will be involved, and to varying degrees, depending on what technical solutions are chosen.

Assessing consumer reactions

All actors recognise that consumers' acceptance is a key factor. However, the actors have different views on to what the consumers may react negatively, and what kinds of reactions are likely. People in the wastewater sector typically say that most consumers do not care about the use of sludge in agriculture, and those who do have concerns will in most cases feel safe if only provided with credible scientific results. In contrast, the consumer movement typically claim that most consumers would be against the use of sludge if only someone would provide them with facts. Both these actor groups seem to believe that facts more or less speak for themselves so that consumers, when provided with the adequate facts, would come to the same conclusion as they have done themselves.

The food industry, on their side, seem to be more concerned with how consumers may react to future environmental alarms related to food products and sewage systems. It is, however, difficult to actually know something about such potential consumer reactions. The beliefs about consumer attitudes held by the wastewater sector and the consumer movement are, at least in principle, easier to test. The food industry's suspicion about potential reactions to future alarms is much trickier to vindicate or refute.

Discussion

As has been shown, the controversy is intertwined with lots of other issues, some of which lie beyond the control of the actors. The widespread use of chemicals and metals in modern society is the most important of those issues. The actors in the sludge network view the risks related to sludge use in agriculture and the difficulties of finding workable solutions as a symptom of something in society that they do not think they have a part in. They feel that they can do little about this underlying problem, but they are the ones who are collectively blamed for not being able to meet the societal goal of "closing the material loops" by organising the recycling of phosphorus. It is not surprising that this feels unfair.

Three tribes?

Based on our analysis, we propose that the controversy may be viewed as a struggle between "tribes", each with their beliefs and preferred treatment alternatives. We have identified three such tribes, and we have chosen to call these: the 'proofs first' tribe, the 'precautionary' tribe and the 'technological fix' tribe. Below, we present highly

condensed and simplified versions of how members of these three tribes may describe the problem of how to handle sludge.

The 'proofs first' tribe
Society is full of potentially harmful substances. However, we can identify the most hazardous ones and regulate their use. The worst substances should be banned. Through continuous improvements, the quality of the sludge can be assured. By building barriers, we can protect the sewage systems from inflows of unwanted substances, thereby also protecting the quality of the sludge. Such barriers can be either physical or based on increased knowledge among the users. As far as we know, safety margins are large, but quality improvements are needed to avoid problems in the long run. Recycling of phosphorus and other nutrients is an important societal goal, and the spreading of sludge is the cheapest and best option for achieving that goal. Replacing the old systems with sorting ones is very costly and would take more than 50 years.

The 'precautionary' tribe
Society is full of substances that we cannot control. Some of these will be present in sludge and accumulate in soil if sludge is spread. We do not have, and will never have, sufficient knowledge about the behaviour and effects of all those substances. Since the pollution of farmland is irreversible, the soils must be protected. For some substances, there are small or no safety margins left, which means that the use of sludge must be stopped immediately. Furthermore, the shortage of phosphorus is exaggerated. In the short run, mineral fertiliser, which is less polluted than sludge, is a good option. In the long run, sorting systems should be installed so that nutrients from food may be safely brought back to farmland in a natural form, thereby closing the eco-cycles. If we decide that now, the old systems can be replaced within a few decades. In this scenario, the wastewater treatment plants would take care of the polluted liquid waste and generate a toxic sludge that needs to be incinerated and safely deposited.

The 'technological fix' tribe
Since it seems hopeless to reach acceptance for the spreading of sludge in agriculture from all actors involved, we need to find other ways to bring the phosphorus back. Sorting solutions are not an option in the short run, and, for economic reasons, probably not in the long run either. Therefore, we ought to invest in the new fractioning technologies and build full-scale plants, where the alternative solutions can be evaluated and compared. Even though these technologies are somewhat more costly than the spreading of sludge or incineration, they produce pure phosphorus that may be recycled without risk. This is a solution that ought to resolve the dilemma.

We believe that each of these tribes have an interpretative package, a coherent set of ideas, which helps members selecting salient new information and organising that information into the existing package. As we understand the situation, the 'proofs first' tribe and the 'precautionary' tribe are not possible to reconcile. The new technologies tribe seems to be more compatible with the two others, even though it may be resisted because it represents an "engineering" solution that does not bring other nutrients than phosphorus back to the soil. In the view of the two other tribes it represents an artificial solution to the problem and it does not provide any incentives

for phasing out hazardous substances from society, on the contrary, the processes advocated by the 'technological fix' tribe use lots of chemicals.

Fundamental questions

The tribes differ in a number of ways, and we believe that those differences may be made more explicit through questions such as the following:

* If the recycling of phosphorus is an important and urgent societal goal, can we then accept certain risks in order to reach that goal?

* What conclusions should be drawn from the likely existence of unknown hazardous substances and pathogens in sludge, i.e. how should uncertainty and ignorance be taken into account? How safe is safe enough?

* What kind of information qualifies as an indication that there is, or may be, a problem? Increasing concentrations of some substance in sludge? Higher concentrations in crops from fields where sludge has been used than in crops from other places? Observed effects on humans?

* How will short-term choices of sludge treatment alternatives influence the long-term development of sewage systems and sludge quality?

* If the use of sludge is accepted again and a new problem turns up, what would be the consequences? If consumers react negatively, who would lose, and could that loss be compensated? Who would probably be blamed? Who would stand up and take the responsibility?

None of these fundamental questions can be answered by scientific inquiry. This points at the shortcomings of research and analysis in finding solutions to controversies of the kind we have analysed. We believe that the actors need to take more time to identify these kinds of fundamental questions and discuss them explicitly, in addition to the discussion of technical and scientific issues related to sludge. This is not an alternative to scientific investigations, but a crucial complement for better understanding the difficulties faced. Hopefully, discussions on questions like the ones above, can, even if they do not lead to consensus, broaden the actors' perspectives and increase their mutual respect and understanding.