THE POTENTIAL BENEFITS OF APPLYING HACCP TO ORGANIC RESIDUALS RECYCLING PROCESSES.

T. D. Evans, PhD, FCIWEM
TIM EVANS ENVIRONMENT, Stonecroft, Park Lane, Ashtead, Surrey, KT21 1EU, England
tel/fax; + 44 1 372 272 172 email: tim@timevansenvironment.com

ABSTRACT
HACCP (Hazard Analysis and Critical Control Point) has many benefits for those who wish to recycle organic residuals (biosolids, treated biowastes etc.) sustainably. This paper will explore these benefits from the perspective of somebody who has in the past developed and managed world-class biosolids recycling operations and who has helped others to apply HACCP.
Frequently the response of people from a regulated industry is to ask what regulations they have to comply with. That might be appropriate for a passive receptor, such as a river into which recovered water is to be discharged, but is it appropriate when preparing organic residuals for recycling, which by definition relies on creating demand in voluntary receptors? Relying on regulation also presupposes that they are able to anticipate all of the risks for every type of residual – producer responsibility and due diligence can be more powerful.
HACCP provides a structured approach to looking at all of the hazards that might "challenge" the sustainability of a "product" (as defined in terms of properties and uses by the producer) and managing the risks to acceptable levels. A producer that considers all of the hazards is much less vulnerable to surprises. The producer that also understands HACCP is able to focus resources where they will have maximum cost effectiveness. HACCP provides traceability and assurance of consistent quality in the final product but with reduced expenditure on testing. It demonstrates due diligence and requires producers to decide on corrective actions that will bring the product back into specification (if something should go wrong). Finally it is a procedure that has the confidence of the food industry, which is one of the major stakeholders, because it is the heart of their product assurance too. This paper will be based on practical experience, not just theory, but will not break confidences.

KEYWORDS
Due diligence, HACCP, Process design, Product assurance, Recycling, Risk management,

INTRODUCTION
Two of the fundamentals of sustainable recycling are compliance with legal and other obligations, and public trust. Quality Assurance is the way to assure that a process is performed the same way every time. But how do you design a process to ensure that all of the hazards have been considered and that their risks are going to be managed to levels that are acceptable? NASA (National Aeronautics & Space Administration) faced the same question regarding the safety of food for astronauts. If you rely on testing the food then you know about the sample you tested, but you don't know about the food you have not tested, and it is the food that has not been tested that [by definition] will be going into space. That is just the same as relying on periodic tests of the organic residuals that are going to be recycled. If the results are constant over time then it is a reasonably safe assumption that the material you have not tested is the same as the little sample you tested. But you don't know. NASA commissioned the Pillsbury Company to come up with something better than end-of-pipe testing. The result was Hazard Analysis and Critical Control Point (HACCP) (pronounced hassup).

HACCP has been adopted by the World Health Organization (FAO, 1997), the European Union and most national governments. It is the basis of producing safe food and drink. The water

industry in the UK was introduced to HACCP during its discussions with the food industry about the sustainability of using wastewater biosolids on farmland to complete nutrient cycles and conserve organic matter. The water industry agreed voluntarily to change to biosolids treatment based on the principles of HACCP and with independently audited quality assurance (Water UK, 1998). The UK regulations (Anon, 1989 and DETR, 1996), which implement the EU sludge directive (CEC, 1986), are being revised to recognize this paradigm shift in the way that the biosolids process is designed and managed. In October 2002, the largest supermarket chain in the UK asked a grower of organic salad crops for a HACCP plan for the compost (from greenwaste) that they use (priv. comm.).

QUALITY ASSURANCE

Applying the principle of quality assurance is an important component of achieving sustainable and reliable solutions for the use or disposal of organic residuals. But this is equally true for any business. The definition of sustainability that I think is appropriate is "Actions today that do not compromise the freedom of action of future generations". Like all other definitions of sustainability this one is open to debate but sustainable development does not mean no-change. Human activity has changed the landscape over millennia. Some of the landscape features that we treasure today are entirely the product of human intervention and activity.

Quality Assurance (QA) brought a revolution to manufacturing industry in terms of increasing product reliability. In general those that did not apply QA found themselves at a competitive disadvantage because customers wanted the greater reliability that QA enabled. The exceptions were those who created a cachet attached to their products which meant that people were prepared to tolerate a lack of reliability for the prestige of owning one of their products. However customers still prefer greater reliability and longevity even from these up-market products. Creating a brand image that makes people overlook, or tolerate, certain imperfections is the product of good marketing and/or good luck. But it is not likely to apply to biosolids.

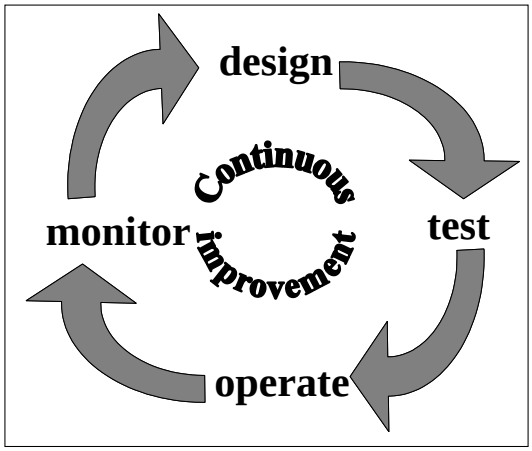

Figure 1 The Quality Assurance cycle

The principle of QA is to harmonize the way that each step in a process is performed in order that it is performed the same way throughout the coverage of the program and by every individual, be they experienced or a new recruit to the job. A part of QA would be adequate training for the new recruit another would be that relevant information is recorded systematically so that there is less reliance on memory of individuals. Figure 1 illustrates the QA cycle. After deciding the Scope of the scheme, a Procedure is designed for each step in the process; it is then tested to check that it is practicable before it is put into operation. Performance is monitored and if weaknesses or areas for improvement are found the Procedure is re-designed and the cycle starts again. One of the features

of QA is that actions are recorded so that they can be verified and traced. Some criticize QA for being cumbersome and generating paperwork.

I was introduce to QA in fall 1989 when I was running a biosolids (treated sewage sludge) recycling program for about 2.5 million population equivalent. The company adopted this as the business model for the whole of Thames Water's biosolids program and it increased to 6.5 million p.e. It operates in the southeast of England, around London, which is the most populous area of the country; it has been expanded to other parts of the UK and has doubled in size.

In 1989 everybody in the team thought they were doing the job properly and were complying with all of the legal obligations, but when we examined it, people were doing things differently. As examples we all knew that we should leave an untreated margin around private wells, explain to farmers what they could grow on treated fields and find out if there were any pre-existing crop or veterinary problems. However when we examined activities it was seldom possible to prove that every one of the necessary things had been done. This obviously meant that the company was vulnerable. The company could have suffered financial liability and/or damage to the reputation of the biosolids program. By early 1993 we had QA accreditation for our biosolids program and were receiving biosolids from treatment processes that were also quality assured. We built to a position of consistently achieving 100% compliance measured by an independent team.

The last thing that I wanted when I was running such a large operation was that somebody else would claim to have found an adverse effect of which I had no prior knowledge. Due diligence studies into the effects of using biosolids was therefore part of the program. If there was an adverse effect of which we had been unaware I considered it better to know about it as soon as possible in order that corrective action could be taken if that were possible, or the strategy could be changed before damage was done if that was necessary. We found no emerging issues that gave us cause to contemplate changing our strategy radically. Continuous improvement became part of the culture.

THE HACCP PROCESS

The second HACCP step (the first is getting the company's commitment and assembling the HACCP team) is to describe the product and its intended use. This is not as silly as it might at first appear. It is useful to address the question "What are you trying to make and how do you expect it to be used?". If you are composting material and intend that the finished product will be the basis of growing media that will be sold through garden centers, there would be some considerations that would not apply if you are making soil improver that will be used on farmland growing cereal crops.

The next step is to construct a flow diagram of the process to which your intend to apply HACCP, and then conduct a reality check to confirm the flow diagram on site. Sometimes this is not quite the same as the managers' recall. Then it is time to list the hazards (the potential to do harm) that could be associated with the final product. Just three examples from the case of the garden center product are injury from a sharp contaminant when a customer is handling the product, cross contamination and infection from using the product to re-pot plants in the kitchen, and odor from the product especially if used for house plants.

There are many hazards associated with recycling organic residuals, just as there are with any activity. That does not mean that we should be scared of doing it, just that we should manage the risks. There are hazards associated with driving a car, riding a bicycle, walking beside a road or playing contact sports but we do them when we think the risks are acceptable. Table 1 illustrates the risks of some normal activities.

Table 1 Examples of risks involved in normal activities (from FWR, 2002)

ACTIVITY	RISK OF	CASES PER MILLION
Travel 1000 miles by air	Fatal accident	3
Travel 1000 miles by car	Fatal accident	20
Travel 1000 miles by motorcycle	Fatal accident	400
Working 10 years in a factory	Fatal accident	300
1 glass wine per day for 10 years	Cirrhosis	1000
1 cigarette per day for 10 years	Heart attack or lung cancer	2500
Living 1 year at age 30	Death from all causes	1000
Living 1 year at age 55	Death from all causes	10000

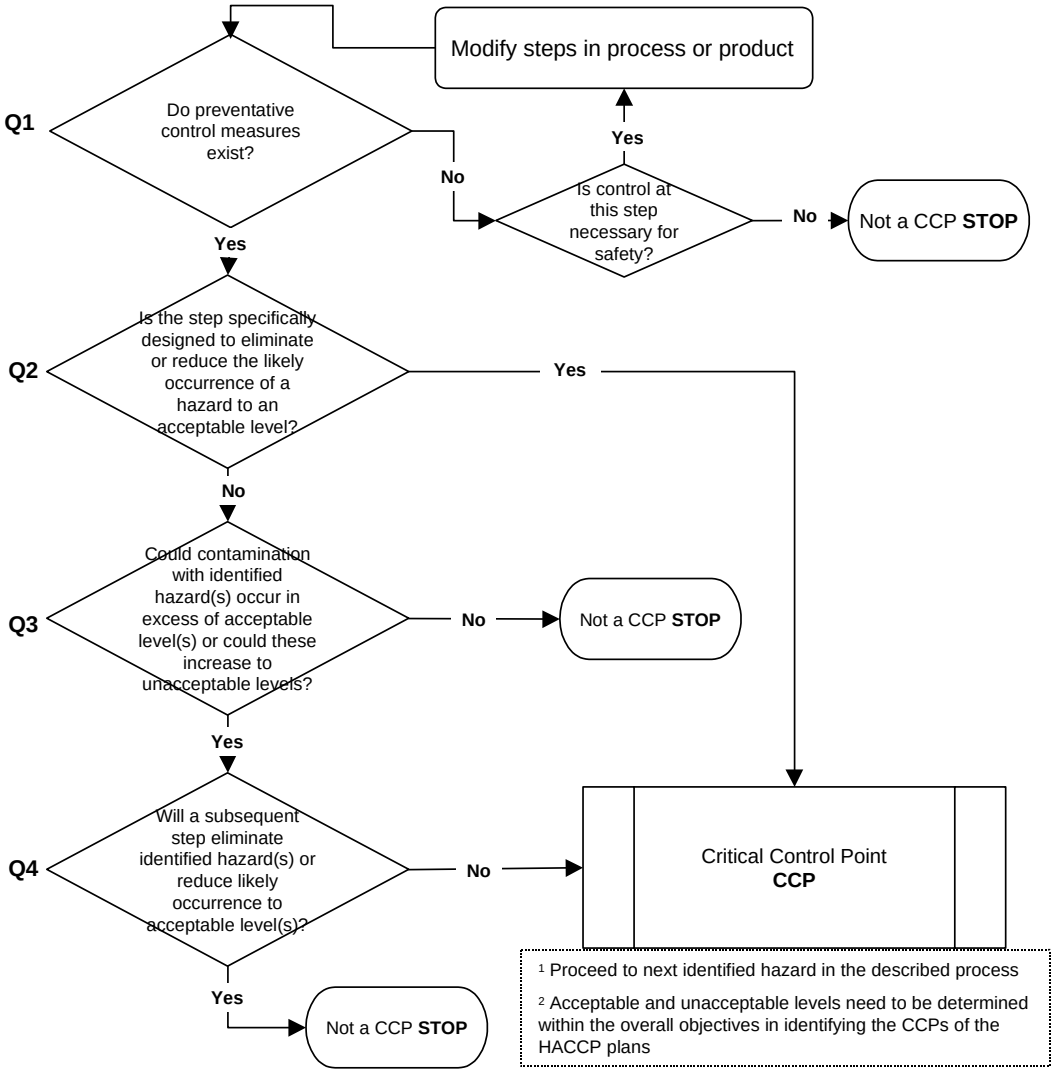

Figure 2 HACCP decision tree

The seventh step in HACCP is to consider each step in the process and to see which, if any, of the hazards that step is able to control. This is systematically accessed using a decision tree such as that illustrated in Figure 2.

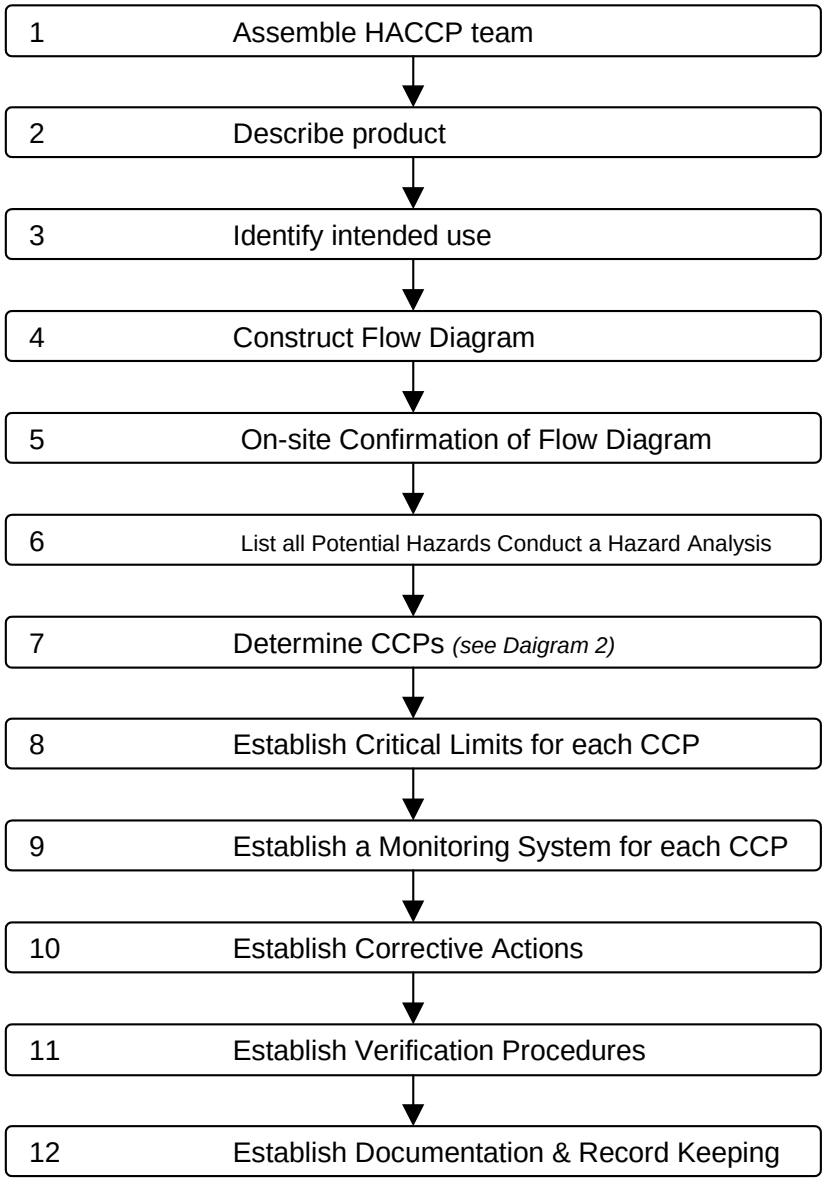

Figure 3 Logic sequence for applying HACCP

Having determined the Critical Control Points (CCPs) it is then necessary to decide their operating conditions and the Critical Limits (CL) outside which the risk will not be controlled, the monitoring system for each CCP, the Corrective Actions that will be taken if a CCP goes outside its CLs. The requirement to define Corrective Actions is a very powerful feature because it forces you to plan for the downside. End-of-pipe testing does have a place in HACCP and that is for Verification that the CCPs are effective and their CLs appropriate. However end-of-pipe testing is not the prime means of control. Finally there must be a system of documentation and record keeping. If the entire product goes through the CCPs, and if there are monitoring records that these have operated within their CLs, we can be confident that the hazards have been managed to acceptable levels of risk. Figure 3 summaries the steps in applying HACCP and a worksheet for conducting a HACCP analysis is shown in Figure 4.

Describe Product

Diagram Process Flow

Process step	Hazard(s)	Control Measures	CCP Question 1 2 3 4 CCP	Critical Limit	Monitoring Procedures	Corrective Actions	Records	Verification *Comment*

Figure 4 Example of a HACCP worksheet

HACCP is complementary to QA; it is not an alternative. HACCP comes first because it is the tool to design the process; QA standardizes the operating procedures. People coming from a tradition of regulation often (wrongly) resist defining CCPs because they think of them as points of regulation whereas they should regard CCPs as a defense because they demonstrate that the producer has undertaken due diligence. It takes some time (and help) to get into the HACCP way of thinking; to get full value the facilitator should have some understanding of the residuals business. HACCP enables innovation. It is proactive, verifiable, and focuses resources where they are needed. It creates solutions that are appropriate to each individual situation. This is in marked contrast to prescriptive regulation, which is very unlikely to anticipate every possible local variation and peculiarity.

If I were running a biosolids program today, I would welcome HACCP with its systematic approach to hazard identification and risk control, because it is a better way to design the process. Of course, HACCP can't help to control hazards that you don't identify so it is important to be honest and dispassionate. The last thing a residuals recycling program needs is a hostile front-page news story.

HACCP can be applied to the whole residuals process, from control of pollutants at the source through residuals treatment to land-application. It can increase the confidence of producers, users, and stakeholders, and thus help to assure longevity to a residuals program.

EXPERIENCES OF IMPLEMENTING HACCP

I have assisted several clients to implement HACCP; their representatives have generally agreed that the following hazards should be considered:-

- <u>insufficient pathogen control</u> possibly resulting in:-
  - action for non-compliance
  - infection of customers' animals or crops
  - infection of client's or contractors' personnel
  - infection of third parties
  - civil action for damage to receptors of infection
  - damage to reputation and loss of customers
  - loss of the confidence of the BRC[1] and termination of the agreement
- <u>unacceptable chemical contamination</u> possibly resulting in:-

[1] BRC – British Retail Consortium, the trade association of the supermarkets and other retailers

- action for non-compliance
- unnecessarily rapid exhaustion of landbank
- damage to reputation and loss of customers
- adverse media coverage
- civil action for damage to value of land and crops
- loss of the confidence of the BRC and termination of the agreement locally

- pollution of groundwater or surface water, or damage to property because of lateral movement of biosolids across land or through drains possibly resulting in:-
  - cost of remedial action
  - prosecution
  - damage to reputation
- creation of odor nuisance when delivering or applying biosolids possibly resulting in:-
  - public complaints, damage to reputation, and adverse media coverage
  - loss of customers not prepared to accept the public hostility
  - issuance by EHO of Abatement Notice
  - loss of the confidence of the BRC and termination of the agreement locally
- aesthetic contaminants in/on the biosolids and/or the treated land resulting in damage to reputation and loss of customers
- inconsistent product quality resulting in damage to reputation and loss of customers

The HACCP methodology can be applied to manage the risk of all of these hazards if we consider the whole of the process – as illustrated in Figure 5. We all know that the work that has been done to control pollutants at source has been a triumph that has meant that “heavy metals", the traditional scare, has now been relegated to history and that as far as day-to-day operations are concerned we are restricted by nutrient application. But sometimes those who work on Module 1 do not have much contact with the biosolids team. Some sites receive wastes by truck as well as via the sewer and there is sometimes a degree of friction between the truck side and the operations side of the site. And yet fundamentally the majority of people want job satisfaction, we want to know that we are doing the right thing. The application of HACCP to the whole process has meant that each of the component parts of the process has become more transparent to all of the other parts. We have been able to design procedures that give everybody an understanding of the importance of their part of the process to the overall risk management, confidence in the other activities in the process and a better understanding of the whole process.

After the initial wariness about identifying CCPs clients have frequently realized that they have more CCPs than they had thought about and that they are operating effectively, but they had just not thought about them that way.

In order to gain economies of scale water companies have concentrated on one or two mega-labs operating 24/7 with high capacity expensive automated equipment. A recurrent reaction from clients has been to want to revert to “the good old days” of on-site laboratories and process sampling. When we have discussed this we have concluded that this expenditure is unnecessary because the CCPs have been shown to achieve the properties that process sampling would be looking for. For example, if the trend in gas production from an anaerobic digester is consistent and the feed volumes and temperatures are in range you can be more confident in the effectiveness of treatment than waiting for chemical analysis of pH, VFA, etc.

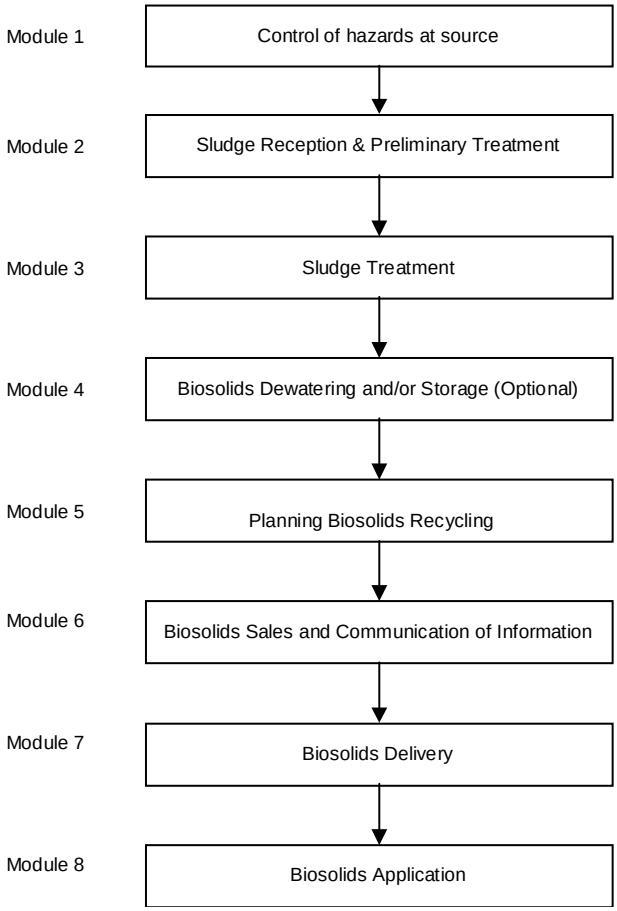

Figure 5 The biosolids process

Odor has been a crunch question. Everybody knows that if they spread stinking biosolids there are likely to be complaints. They know that this is the factor that is most likely to create public hostility and which could get the regulatory agencies involved. But sometimes they have put their heads in the sand and hoped the problem would go away or that they could persuade people to accept the odor. It is not yet a regulated parameter but it is the source of greatest vulnerability for residual recycling. I was amazed when the members of one HACCP team were unanimous and adamant that a type of treatment, which the client was deploying widely, did not control odor. They said it just changed the odor from one foul character to a different foul character, however the process could achieve the pathogen reduction numbers! If a residuals program creates odor nuisance it is not sustainable. HACCP gives a tool to address this issue.

Whilst working on one of the HACCP programs I stayed at a farm bed & breakfast and took the opportunity to ask the farmer what he thought of the local biosolids program. He replied enthusiastically that it seemed very good and efficient "they sampled my farm but said I did not need any". I replied that this was good news because it meant that the available phosphate content of his soil (P-index) was so high that he could save the cost of P-fertilizer until the P-index comes down to where he could benefit from biosolids. However the client had not closed the loop so the farmer did not really appreciate why he did not need biosolids and that he had reserves of soil-P that he could afford to exploit. He would have been lost to the program forever and his land would have been a source of eutrophying phosphate. Avoidance of excessive nutrients was part of the hazard analysis so we bolted complete communication into the process.

One of the great strengths of HACCP is that it gives solutions that are appropriate to place. If a particular facility can demonstrate that it can achieve the desired product quality with a particular

configuration and operating conditions and that the process can be monitored and recorded that is perfectly acceptable within HACCP. Policy makers and regulators only have to specify the ends, they don't have to specify the means. This means that they do not have to try to anticipate every eventuality. It also means that the desired ends are achieved rather than the means – which might not be the same thing. Going back to the example of odor, there is no particular merit in complying with the regulator's process conditions if the product still stinks. HACCP does not involve a bureaucracy to authorize new processes. Instead it creates traceability and places onus on operators to take responsibility for their own products and undertake due diligence. Operators are required to verify their processes by product testing, but the testing frequency can be reduced as confidence in the CCPs grows.

One of the facilities I investigated was having difficulties achieving the microbiological standards, and yet it was in good condition. It had been refurbished recently with considerable investment. It has 2 mesophilic digesters (20 days HRT) and 4 secondary digesters (21 days' capacity each) shown in Figure 6.

Figure 6 Anaerobic digestion - 2 primary mesophilic digesters (above) and 4 secondaries below

The screening, grit removal and control on pre-thickening were all good as was the regime for dumping sediment from the bottom of the digester. Because of this the HRT was maintained and heat-exchangers were protected from blockage. Digester temperatures were maintained at 36±1ºC and there were 2 probes per digester, their temperatures were similar. Gas production was consistent. It looked like a model site but on investigation the secondary digesters were being by-passed because the centrifuge produced drier cake when working on hot sludge. In addition there was a reception point for digested liquid from other works downstream of the digesters; these other works were not HACCP. When batch storage was reinstated and the digested liquid routed before the CCP, the biosolids consistently met the biological limits. This was a no-cost solution consistent with HACCP, auditable and traceable.

Should there be a *de minimus* limit below which HACCP (and QA) is an unwarranted burden? I would answer "most definitely No". The case of Walkerton in rural southern Ontario, Canada demonstrates the error of such a suggestion. Walkerton is a small town with 4900 residents. In

May 2000 it was struck by infection of *E. coli* O157:H7. Seven people died and 2,300 became violently ill. The town water supply comes from 3 wells; the chlorine dosing equipment was poorly maintained. One of the wells was not sealed to the rock around the shaft, and it was downhill from a small, cattle farm. The ground was swampy and the aquifer below was covered by only 2.4 meters of sand, gravel and rock - not enough to filter out bacteria before water reached the well. Another well was artesian and had a very weak overflow flap valve. The laboratory had repeatedly reported bacterial contamination of Walkerton's water. In May 2000 there was heavy rain, which caused run-off from local farmland. Run-off water got into the wells, the chlorine dosing was not working properly [again] the water superintendent put the lab's report of failing water aside [again] thinking he could solve the problem and *E. coli* O157:H7 was pumped into pumped into the town's water supply with disastrous consequences. HACCP and QA would have prevented this tragedy of errors. My local village butcher's shop is required to have HACCP, can there really be a valid argument for exempting a facility producing biosolids for use on land?

CONCLUSIONS

HACCP, coupled with quality assurance, has major advantages for producers of organic residuals who want to manage them sustainably. It is a better way to design processes. It is pragmatic and appropriate to the local situation. It is superior to prescriptive legislation that seeks to define the means rather than the ends.

When a company has undertaken comprehensive HACCP analysis, made the paradigm shift and implemented HACCP, what then? We can expect that it will be in a much stronger position. It will have identified process steps (the CCPs) that control the risk of hazards to acceptable levels, trained personnel, installed monitoring procedures and defined failure mode strategies. It will have looked for, and locked off, routes for cross-contamination and bypasses. It will have defined means of recording that CCPs are operating effectively by instrumentation and/or documentation so that personnel are aware of the operating conditions and so that there is traceability. All of this will mean that the quality of its product is more assured, which will increase customer satisfaction, product differentiation and market share. The company's reputation will be enhanced and the motivation of its teams should be better, it will be less vulnerable to actions, bad publicity, damage to reputation, etc. resulting from a failure of the process. Its process will be more sustainable and it need not have cost a fortune.

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