A REVIEW OF ESTABLISHED EUROPEAN PRACTICE IN RELATION TO BIOHAZARDS ASSOCIATED WITH WASTE AND WASTE RELATED BIOFUELS

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A greater understanding of biohazards has now emerged and technical and organisational measures are being developed to reduce the associated risks for the reuse of biotreated waste. This paper presents a review of the current knowledge base of implementing the Directive on biological agents in the waste related sector. Appropriate solutions can be accommodated into the design and operation of waste processing facilities to improve safe operation and meet regulatory objectives by using a systematic approach to design and operation. Such an approach has been established for a number of years as normal practice in the process related industries, such as chemical and pharmaceutical, with regard to chemical and biological agent compliance.

THE LEGISLATION

Historically mechanically biotreated or biotreated waste was simply collected and either landfilled or land spread. Increasingly this material is now being recycled or processed to derive a fuel value. However, the biological risks associated with this waste processing are often ignored or underestimated in the design phase. While it is known that there is a significant association between exposure to bioaerosols and health effects, such as bronchitis, it is not nearly as defined or understood as that for exposure to chemical agents. However, such exposure is regulated by the Directive on the protection of workers from risks related to biological agents (2000/54/EC).

Waste related technologies are at their most advanced stage in a number of Central European countries, where landfilling of waste was phased out several years ago.

Directive 2000/54/EC on the protection of workers from risks related to exposure to biological agents defines Biological Agents in Article 2 of the Directive as micro-organisms, including those which have been genetically modified, cell cultures and human endoparasites, which may be able to provoke any infection, allergy or toxicity. Biological agents are classified into four risk groups, according to their level of risk of infection:

1. Group 1 biological agent means one that is unlikely to cause human disease.
2. Group 2 biological agent means one that can cause human disease and might be a hazard to workers; it is unlikely to spread to the community; there is usually effective prophylaxis or treatment available.
3. Group 3 biological agent means one that can cause severe human disease and present a serious hazard to workers; it may present a risk of spreading to the community, but there is usually effective prophylaxis or treatment available.
4. Group 4 biological agent means one that causes severe human disease and is a serious hazard to workers; it may present a high risk of spreading to the community; there is usually no effective prophlaxis or treatment available.

Article 16 of the Directive and Annex VI specify the protective measures that must be taken for industrial processes using Group 2, 3 or 4 biological agents. These are based on a risk assessment to select and combine the containment requirements. For Group 1 biological agents the principles of good occupational safety and hygiene should be observed. Article 8 defines hygiene and individual protection.

While this legislation relates to 2000, there is little doubt that its implementation is less well developed and understood than the equivalent legislation on chemical agents. However, biological agents can present an equivalent, if not greater hazard, to both the workers and the surrounding population from chemical agents.

WASTE AND BIOFUELS

According to Eurostat in March 2010:

- "In the EU27, 524 kg of municipal waste was generated per person in 2008. 40% of this municipal waste was landfilled, 20% incinerated, 23% recycled and 17% composted. The average amount of waste generated in the EU27 was virtually unchanged from 2007 (525 kg per person)".

According to the Management Plan for 2010 from DG Environment, European Commission:

- "Exploiting the resource potential of waste streams, an action plan for eco-innovation and reviewing the Environment Technology Action Plan, the Thematic Strategy on Natural Resources and the Waste Thematic Strategy will be part of the contribution from environment policy to improve resource efficiency".

Traditionally waste would have gone in a sealed truck to a landfill or in more developed western cities to a municipal incinerator. Now a variety of processing techniques are being utilised to recover fractions of the waste and with regard to disposal of the residual fraction, to maximise its energy recovery potential and minimise the impacts of disposal. This is leading to both an increased potential for generation and release of biological agents and to an increased interaction of human receptors with these biological agents.

Of particular relevance in this regard are waste processing steps associated with the reception and stockpiling of waste, the manual sorting of waste, the biological decay of waste, such as by composting or anaerobic digestion, and the handling of waste by-products.

THE HEALTH RELATED IMPACTS ASSOCIATED WITH WASTE PROCESSING

Municipal waste contains on average 55% of biogenic and 45% of non-biogenic materials. A considerable fraction of the biogenic component is food related while the ligno-cellulose fraction derived from trees, grasses, etc, is also significant. Moulds and mildew are fungi that grow on the surface or pores of materials, such as wood, food residues or textiles.

When the fungi, their spores and/or other fungal components are inhaled they can induce irritating symptoms of the mucous membranes and/or allergic reactions. In addition, unspecified complaints like headache and fatigue are often attributed to mould exposures by affected persons. Symptoms of allergic disorders are mainly similar to hay fever or asthma bronchiale with dyspnoea and cough. These health effects are well known, it is not only workers in waste related facilities, which are exposed to these levels, but the general public who are resident in poorer quality housing stock in which these moulds and mildew occur. However, the situation is much more pronounced in the biological processing of waste in that the growth of these moulds and mildews is being deliberately promoted. From a health perspective severe toxic effects (Organic Dust Toxic Syndrome (ODTS)) can be observed in the case of very high mould concentrations (10^6 to 10^9 cfu[(1)]/m^3) or bacteria at 1–2 μg/m^3, which can occur in such workplaces.

It is accepted that fundamentally all moulds and mildews are in the position, after in-breathing of the spores and other fungi related fractions, to trigger allergic reactions. Medical studies in Germany have shown that about 5% of the population demonstrate a sensitising reaction to moulds and mildew. The presence of this sensitisation raises the risk for the development of allergic symptoms and/or further sensitisation. According to the Merck on-line medical library, the fungus *Aspergillus fumigatus* flourishes in soil, decaying vegetation, foods, dusts, and water. Other fungi, including *Penicillium*, *Candida*, *Curvularia*, and *Helminthosporium*, can cause an identical illness. In some people, the effects of the allergic reaction combine with the effects of the fungus to damage the airways and lungs. The fungus colonizes the mucus in the airways of people with asthma or cystic fibrosis (both of whom tend to have increased amounts of mucus) and causes recurrent allergic inflammation in the lung. The tiny air sacs of the lungs (alveoli) become packed primarily with eosinophils. Increased numbers of mucus-producing cells may also appear. If the disease has caused extensive damage, inflammation may cause the central airways to widen permanently, a condition called bronchiectasis, essentially the lungs are likely to become scarred.

Other forms of aspergillosis can occur. *Aspergillus* can invade the lungs and cause serious pneumonia in people with an impaired immune system. This condition is an infection, not an allergic reaction. *Aspergillus* can also form fungus balls (aspergillomas) in cavities and cysts of lungs damaged by another disease, such as tuberculosis; severe bleeding may result. Hypersensitivity pneumonitis (also called extrinsic allergic alveolitis, EAA) is an inflammation of the alveoli within the lung caused by hypersensitivity to inhaled organic dusts. It is a recognised occupational illness (BK 4201) in Germany. When it is triggered by exposure to moulds, such as is found in hay, it is often called by its common name; Farmer's Lung. It nearly always occurs with repeated exposure to very high concentrations of spores (10^6 to 10^{10} cfu/m^3).

The irritating and toxic effects of moulds and mildew are primarily related to their metabolic products (e.g. mycotoxin), cell wall components (glucans), as well as the immunological reaction through the release of interleukins or inflammation mediators. Mucous Membrane Irritation (MMI) can occur with medium concentrations of spores of moulds and mildew ($>10^3$ cfu/m^3) and is thus common to both the indoor environment and the workplace. Moulds and mildews also produce volatile organic compounds, the so called Microbial Volatile Organic Compounds (MVOCs), which are the cause of the typical mildew odour. The odour threshold for MVOCs is significantly below the level of their toxic effects.

The World Health Organisation (WHO) Regional Office for Europe, 2009, "WHO guidelines for indoor air quality; dampness and mould" has published extensive evidence for the association between moulds/dampness in the indoor environment and asthma, particular complaints of the respiratory tract and respiratory infections. The WHO concluded that the presence of dampness and/or mould in the indoor environment is to be perceived as a potential health hazard. However, the missing dose – effect relationship from epidemiological studies shows that there is no individual indicative parameter that can be measured, which is so specific or sensitive, in order to conclude an associated exposure to dampness.

This conclusion of environmental medicine does not apply to occupational medicine, where according to the German Federal Environmental Agency's (UBA), 2004, Minutes of their conference on "Micro-organisms in the surroundings of biowaste processing plants", a dose effect relationship can be demonstrated between the concentration of moulds and mildew in the air and the occurrence of toxic related symptoms. As non-cultivatable mildews can cause these symptoms, the microscopic capture of the total concentration of all mildews present is important.

Of significance therefore is how waste processing facilities contribute to an increase in the concentration of micro-organisms in their surroundings. It must not be for-

[1]cfu: Colony Forming Units – This is a measure of the viable fungal or bacterial numbers.

gotten that moulds and mildew are an essential part of the living nature. They can breakdown many varieties of materials, such as wood, and are therefore an essential contributor to the carbon cycle. There is always a presence of mould and mildew spores in the outdoor air, such that concentrations in the presence of waste processing facilities do not necessarily originate there. There is some data on the concentrations of mould fungi in outdoor air in the literature, but the available data on bacteria concentrations is much more limited and on endotoxin concentrations virtually non-existent. The BGIA, the Institute for Occupational Safety and Health of the German Social Accident Insurance Institute, 2009, in their paper; "Microbiological background values in outside air – evaluation of the BGIA exposure databank MEGA", analysed mould, fungi, bacteria and endotoxin concentrations in Germany with a total of 1,172 results over a period of eight years.

For biological agents, unlike chemical agents, there are no legal limit values with which measurement results can be compared with. However, there is a need to compare measurements at the workplace with a reference value. When taking measurements the natural background value of the biological agents is of course highly relevant and this varies based on climatic and seasonal conditions. The largest amount of data collected by the BGIA study was for mould and mildew concentrations (665 results). The concentrations measured varied from 1 cfu/m^3 measured in September to 28,571 cfu/m^3 measured in May. This reflects the findings of other authors and that in the vegetation period, concentrations of more than 10^4 cfu/m^3 are not uncommon. The usual concentrations in Germany lie for the summer and autumn in the range 1×10^3 to 4×10^3 cfu/m^3 and in winter a ten fold reduction to the range 2×10^2 to 8×10^2 cfu/m^3. For the bacterial concentration 265 measurements were taken. The usual bacterial concentration in Germany ranged between100 to 800 cfu/m^3. The number of endotoxin measurements taken amounted to 191. The arithmetic medium values per month varied between 1.99 and 17.22 Endotoxin Units (EU) per m^3.

The above clearly demonstrates that the evaluation of mould and mildew concentration in the air can not be deduced from a single measurement and requires expert assistance. Note: Relevant standards have been developed, such as EN 13098, VDI 4300 part 10, VDI 4252 part 2 and the ISO 16000 series (particularly ISO 16000-17). *Aspergillus fumigatus* and thermopile Actinomycetes are often proposed as indicators of micro-organism emissions from composting plants, as this type of micro-organism arises regularly in high concentrations in the composting process and otherwise only in low concentrations in outside air. The UBA study recommends that a background value of 20 cfu/m^3 of *Aspergillus fumigatus* can be accepted for 'unpolluted' outside air and as a rule for rural areas a concentration of <10 cfu/m^3 is to be expected. Measurements at six composting plants (delivery, sorting, transfer, treatment of fines) demonstrated concentrations ranging from 10^3 to 10^8 cfu/m^3.

SPECIFIC GUIDANCE FOR WASTE PROCESSING SECTOR

With regard to guidance issued by the authorities in relating to biological hazards associated with waste processing, this hazard has been recognised for some time, such as the Swiss Environment Agency (SAEFL), 2009, was stating in their "Non-Polluting Municipal Waste Incineration: Myth or Reality?" with regard to Mechanical/Biological Treatment (MBT) systems:

- "The problem is that the fractions obtained are generally of poor quality which makes their recycling somewhat difficult. The compost, for instance can often not be used for agricultural production. The combustible fraction is rarely of good quality. Its incineration in cement works or industrial boilers is, therefore, rarely possible. In addition, working conditions on sorting lines (industrial sorting can never become totally automatic) presents **health and ethical** problems. Finally, however well the sorting is carried out, there always remains a fraction (or residue), frequently highly polluted, which needs to be incinerated or landfill".

There are no MBT systems in Switzerland, but they have gained in popularity in other jurisdictions, particularly in Germany and Italy, often promoted by a 'Green' agenda, which sees them as an alternative to incineration, which they are not, as MBT is only a pre-treatment step. Composting of biowaste is also becoming increasingly popular, in Germany it is estimated that each citizen is separating about 100 kg of biological and green waste, which amounts to over 8 million tonnes per year. This material is then composted in either domestic or centralised facilities, or with increasing frequency broken down in anaerobic processes to generate biogas, which leads to a more positive environmental balance and a revenue stream from the biogas. There is therefore increasing interaction between the workforce and the surrounding population with the biological agents inherent in these processes. The German Federal Agency for Worker Protection and Occupational Medicine (BAuA) has published a set of technical regulations on biological agents (TRBA). While these are only available in German, the ones which are relevant to waste processing facilities include:

- TRBA 405: Use of measurement processes and technical control values for airborne biological agents.
- TRBA 214: Waste processing facilities including sorting plants in the waste sector.
- TRBA 220: Safety and health with activities occurring with biological agents in waste water plants.
- TRBA 212: Thermal waste handling: Protective measures.
- TRBA 230: Protective measures for activities involving biological agents in agriculture and forestry and comparable activities (available in both English and German).

The Committee for Biological Agents (ABAS), which is responsible for developing the technical regulations

(TRBA), made it clear in their decision of March 2003, that as a rule in thermal waste handling plants, biological agents of Groups 1 and 2 occur. In particular areas, such as in the waste bunker, infectious material can be present, which can contain biological agents of risk **Group 3**. For waste water treatment plants, including the handling of sludges, TRBA 220 highlights the relevant biological agents present and recommends that Protection Level 2 according to the Directive on Biological Agents be applied. For waste processing facilities including sorting plants, TRBA 214 states that as a rule biological agents of Group 1 and 2 arise, although there is also a possibility of **Group 3** agents due to the presence of medical related waste or due to the presence of vermin.

The TRBAs specify specific technical and organisation measures that are required to be implemented, which are more comprehensive than the list of protective measures provided in the Annex to the Directive. In general the organisational measures are quite common to all in that a strong emphasis is placed on hygiene and regular cleaning. Not only do surfaces have to be designed such that they are easy to clean, such as the avoidance of crevices and surfaces which are easy to wipe down, but the generation of whirled up dust has to be avoided by the use of suitable vacuum system. Some specific points to note are:

- TRBA 212 requires that cabins and control rooms with a permanent employee presence must be enclosed and mechanically ventilated. The cabin of the waste crane must be held at a slightly positive pressure. Mobile vehicles, which do not have an enclosed cabin with filtered air, can only be used in exceptional cases in areas which have a presence of biological agents and in these circumstances suitable Personal Protective Equipment is required. The delivery area for the waste should be held under negative pressure with the air drawn through the bunker into the furnace system.
- TRBA 214 requires that fundamentally the operation should be constructed that in areas where biological agents occur, such as delivery, material preparation, composting and post composting, etc, no permanent workplaces occur. With occasional work in these areas suitable personal protective equipment is to be worn, such as a half mask with a particle filter of type P2 to EN 143 or FFP2 to EN 149.
- TRBA 214 requires that in plants where household waste is handled, that manual sorting is avoided, such as by the use of machine sorting. If this is not completely possible then the component of manual sorting must be minimised. The areas for delivery, sorting and in-between storage are as much as possible to be installed in separated building areas.
- According to TRBA 214 permanent workplaces, such as in mobile or fixed units are only allowed to be located in cabins and control rooms equipped with air filtration or mechanical ventilation from uncontaminated areas. For sorting cabins, the ventilation stream should come from above over large surface air delivery elements, for example over every occupied sorting place with an area not under 1 m^2, a delivery air flow of about 1,000 m^3 per hour per sorting position is required. The sorting position is to be laid out such that the breathing area of the personnel with all task related movements is covered by the forced ventilation. Surfaces in these areas must be easy to clean and machines and vehicles must be equipped with technical measures to minimise contamination on entry.
- The composting process must be separated from the other parts of the facility in order to avoid, as a minimum to minimise, the contamination of the workforce with the biological agents, which are released during composting. If possible the operation of the composting area is to be done automatically and no permanent workplaces should be present in this area. For open composting the organisational measures are particularly important in order to reduce as far as possible the contact time with biological agents. In particular with the turning of the compost no personnel should be in the area and the procedure should as much as possible take place in still wind conditions.
- TRBA 230 contains a section on the preparation and utilisation of biomass. This highlights that risks arise in particular with the delivery and reception of biomass, such as from the inhalation of aerosols and the presence of biological agents of Group 3 if sick animals are present in the livestock (chlamydia in poultry litter).

Some additional guidance is provided by the Bavarian Environment Agency (BayLFU), July 2009, Biogas Handbook, which states that as a rule biological agents of Group 2 are to be found in biogas plants and the protective measures according to Group 2 should be used.

The Directive on Biological Agents (2000/54/EC) requires for "any activity likely to involve a risk of exposure to biological agents, the nature, degree and duration of worker's exposure must be determined in order to make it possible to assess any risk to the workers' health or safety and to lay down the measures to be taken". Its German implementation (BioStoffV) contains no limit value concept and no measurement obligations for the employer, stating as a rule for the risk assessment the completion of measurements is not necessary, although in individual cases orientated measurements can be necessary to determine the type, extent and length of the exposure.

In this regard the concept of the Technical Control Value (TKW) is established, which is the concentration of the biological agent in the air for a specific occupational activity, or for a particular process or plant type, which can fundamentally be reached with the application of the state of technology. This value is a judgement of the effectiveness of the protective measures and is determined by the ABAS. It can be defined either as a summation or related to a group of micro-organism. However, the TRK delivers no evidence between the correlation between exposure and the thereby connected possible health effects on the employees. This is based on the fact that as a rule no effective threshold for effects can be determined and also by maintenance of the TRK an impact on health cannot be excluded. Therefore ongoing improvements of the technical circumstances and technical protective measures are necessary.

TRBA 405 is a recommendation for the determination of the concentration of bacteria and fungi in the workplace air and the use of TRKs for the testing of the effectiveness of technical protective measures. The evaluation of viruses is not covered by this guidance. TRBA 405 recognises that the variations in exposure concentrations of micro-organism can be very large. There is also the presence of a background concentration, which has to be referenced against suitable measurements of the outside ambient air. The measurement programme has to consider the use of orientation measurements, as the expected concentrations of the bacteria and fungi is often not known. As work activities can lead to spikes in exposure, i.e. short term high concentrations, the investigation of the extent and length of these exposure peaks can be necessary, in order to protect the workers in a focused manner from possible health impacts. The measurement process must deliver representative results related to the exposure of the workforce. The samples should, as far as possible, be completed at breathing height and in the immediate vicinity to the employees. The table in TRBA 405 then provides information on the minimum number of measurements to achieve a measurement result, e.g. for a sample time of less than 5 minutes the number of samples taken should be greater than 12 in order to provide a median value as the measurement result.

With regard to waste processing plants including sorting plants, TRBA 214 requires the employer to regularly test the functionality and effectiveness of the technical protective measures. In the permanent work locations in sorting cabins, cabins and control locations, this testing should follow independently of the time of residence by means of the determination of the concentration of the biological agent. Note: The TRK does not serve for operational situation and areas in which process and technology related the required breathing air quality can not be maintained, such as the delivery areas and the intensive composting. The TRK has been determined as 5×10^4 cfu/m^3 of breathing air as a summation value for mesophilic moulds and mildew. If the results of the testing are over 1×10^5 cfu/m^3 the employer is required to repeat his risk assessment. If the assessment shows that the protective measures do not suffice, then these are to be adjusted without delay to the state of technology and their effectiveness to be tested anew.

While the above provides specific guidance in relation to worker protection, the health related impacts on population in the vicinity of such facilities must also be considered. Various measurement results are available from the vicinity of composting plants (UBA), these show wide variations from one as high as 10^6 cfu/m^3, to much lower concentrations that impact on sensitised persons (10^2 cfu/m^3) and with regard to Mucous Membrane Irritation (10^3 cfu/m^3). The key aspect is the design of the composting system. With enclosed composting systems micro-organism concentrations elevated above background levels are to be observed out to 200 m, which is extended to 500 m when open composting is used.

The decisive factor therefore is the design of the composting system and the process activities, e.g. the turning of compost in open or semi-open composting system leads to higher concentrations in the surroundings. The lowest impact is to be found with enclosed processing connected to a well functioning biofilter. Biofilters demonstrate very different performance levels in their ability to lower compost specific micro-organism emissions, if they are badly maintained they can actually become an emission source rather than a reduction system. While such composting plants are also associated with odours, which can have an indirect impact on health due to physiological stresses, there is no direct correlation established between the presence of odours and the health impacts of biological agents. However, the technical controls to reduce the impact of both are often similar.

The German Federal Ministry of Environment's (BMU), 2002, technical instructions on air pollution control (TA Luft), require in Section 5.4.8.5 that composting plants of more than 3,000 t per year should be as far as possible operated in an enclosed manner. Plants with a throughput of more than 10,000 t/a must be operated as a closed system. This had to be implemented by the end of 2007.

With regard to other Member States the guidance available is less comprehensive. For instance the UK Health and Safety Executive's, 2008, Research Report RR609 on "Collecting, Transfer, Treatment on Processing Household Waste and Recyclables", has an Annex (F3) on microbial hazards guidance, which is quite general in content. An earlier report Health and Safety Executive, 2003, Research Report 130 on "Occupational and Environmental Exposure to Bioaerosols from Compost and Potential Health Effects – A Review of Published Data", identified that workers are at risk from concentrations which are 10 to 1,000 times greater than found in ambient air. It concluded that further research needed to be done particularly in relation to worker protection although in general such facilities do not present an endangerment to the surrounding public.

Health and Safety Executive, 2010, Research Report (786) on "Bioaerosol emissions from waste composting and the potential for workers' exposure", monitored bioaerosol emissions in the vicinity of composting plants. Like the monitoring work described previously (UBA) significantly elevated concentrations of bioaersols were found in the vicinity of the composting plants, which decreased with distance downwind. It was concluded that "there was little evidence therefore that the composting operations studied made a major contribution to the overall bioaerosol burden by a distance of 250 m from activities". This confirms the position of the UK Environment Agency, 2007, Policy 405-07 in that they will take into account the potential effects of bioaersols on human health when authorising new waste composting facilities or changes to existing facilities. To do this applicants will have to provide the Environment Agency with site specific bioaersol risk assessment if there is a workplace or dwelling within 250 m of the composting site boundary. The Environment Agency, 2009, has also published a guide SC004021/SR3 on "Review of methods to measures bioaerosols from composting sites" and "Guidance on the evaluation of bioaerosol risk assessments for composting facilities".

The evidence to date from the Environment Agency's documentation is that the overwhelming majority of composting facilities in the UK are based on open systems and the HSE Research Report 786 highlighted how high bioaersol concentrations were measured in cabins of vehicles in use on the six sites investigated in the UK. For example in 24% of samples *Aspergillus fumigatus* concentrations exceeded 10^4 cfu/m^3.

In the Netherlands the Exposure Standards Setting Committee (DECOS) proposed setting and endotoxin limit of 200 EU/m^3 as an inhalable dust exposure hazard limit in 2003. DECOS recommend health based occupational exposure limits which serve as a basis in setting legally binding occupational exposure limits set by the Minister of Social Affairs and Employment. DECOS, July 2010, Report on Endotoxins, compiled in conjunction with the *Nordic Expert Group for criteria documentation of health risks from chemicals*, regards an exposure level of 90 EU/m^3 as a No Observed Effect Level (NOEL), which is their **recommended exposure limit** (eight hour time weighted average) for both acute and chronic exposure to endotoxins. This is based on measurement according to EN 14031. As the report stated, to date no occupational exposure limits had been defined previously for airborne endotoxins, either in the Netherlands or elsewhere.

There is no doubt that this new limit is going to present a challenge as the literature contains results of endotoxin measurements at composting facilities and municipal waste facilities, where concentrations of up to 200 EU/m^3 are to be found during general waste handling, see HSE Report 130. This report also references measurements taken at an open composting facility in Finland, where endotoxin levels were very high at about 80 – 3,445 EU/m^3 outside and 0 – 152 EU/m^3 inside vehicle cabs.

CONCLUSIONS

There is no doubt that the micro-organisms associated with waste and biofuels, particularly the production of biogas, are a significant health hazard to both the workers in the processing facilities and potentially the surrounding community. It is therefore critical to design the necessary technical and organisational measures correctly in order to achieve the required levels of protection.

The use of open composting systems and standard agricultural vehicles is not going to provide the necessary minimisation of exposure and as a greater understanding of biohazards evolves, with the associated development in exposure levels which have to be maintained, there will be pressure to upgrade existing facilities. Indeed the legislative framework with regard to the Directive on Biological Agents and the general duty to maintain a safe working environment are already well established. All that was previously lacking was a sufficient understanding of the risks and the appropriate mitigation measures.

The process industries have had a systematic approach to chemical and biological agent compliance for a number of years. This systematic approach is based on the steps of:

- Risk Assessment;
- Design of mitigation measures (both technical and organisational);
- Occupational monitoring and review of the effectiveness of mitigation measures.

In some cases mitigation measures will be related to relatively simple hygiene and housekeeping, such as the avoidance of power hosing to clean surfaces in order to prevent the formation of aerosols. However, the implementation of such measures requires the correct design of equipment surfaces to facilitate alternative cleaning methods. In other cases the necessary mitigation measures will be more complex, such as moving from open to enclosed composting systems. In essence the whole waste and biomass handling system has to be engineered on a step by step basis to reduce the exposure pathways. These skills may not exist within many companies already engaged in this sector and for a gap analysis of their needs they may need to turn to specialists, such as those with the necessary experience already gained in the process industries.

"How safe is safe enough?" is a fundamental question, which society does not have a ready answer to. There is a significant biohazard risk associated with this sector. There is a body of 'hard' law, such as Directives with concepts, which have to be met. There is also an evolving body of 'soft' law, such as technical regulations, scientific reports, etc. There is no 'one size fit all' solution for this processing sector and what is considered 'Best Available Techniques', within the Principle of Proportionality, is only evolving. The first step must be to assess the risk and determine where one stands versus established benchmarks.

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