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18 - Ozonation – What is the potential? Application of ozone as an alternative to traditional fumigants

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Abstract

Ozonation, the process in which stored products are exposed to a mixture of ozone gas and air in order to terminate unwanted biologic activity is presented as potential method to control pest infestation.

Following a historical resumée of the scientific research on ozonation, the s shown that in at least some cases Ozonation seems to be very effective against infestation. A brief summary on some of the studies relating to the effects on the crops treated with Ozone is given. It is shown that the reported effects in most cases are not causing any harm to the crops.

How are laboratory test results transferred to full scale storage facilities? A number of considerations are discussed; and results from field trials are discussed. It is shown that the amount of Ozone generated is critical, and that the distribution in larger facilities is also critical.

What are the advantages of Ozonation? The potential advantages of the use of Ozone are discussed in relation to the following: effectiveness as a 100% killer, immunity, environment, safety and economical issues.

A brief look to the future of Ozonation is attempted.

Introduction

Research on ozone as a fumigant

- More than 100 scientific articles have been published on the subject.
- Several scientific studies have demonstrated that low ozone contents in air - like 50 ppm - are sufficient to kill insects, mites, molds, bacteria and other organisms.

Ozone as a strong oxidizer is traditionally used for sterilization of water. It eliminates flavour and color and can also purify air.

Results of initial tests on effects of ozone mixtures (50 ppm ozone in air) on *Aspergillus flavus* and maize germination showed:

- 66 % reduction in survival of surface conidia
- Complete inhibition of Hyphal growth and sporulation
- 97% reduction of aflatoxin production
- No reduction of maize germination
  (Ref.: Linda Mason et al, Perdue University)

Tab. 1 Studies at Perdue University on some of the key features of crops that are not affected by Ozone

Grain	Quality Tests
Rice	Adhesiveness test
Popcorn	Popping-volume test
Soybean	Grain composition Amino acid & fatty acid profiles
Corn	Grain composition Amino acid & fatty acid profiles Dry and Wet Milling
Soft and Hard Wheat	Grain composition Amino acid and fatty acid profiles Milling Bread making properties

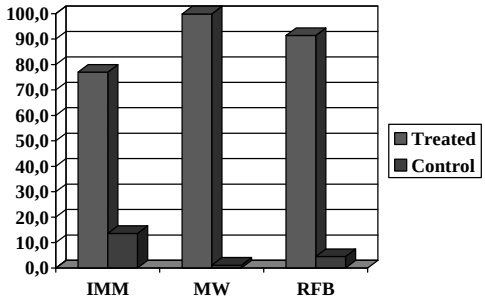

Fig. 1 Lethal effect of 25 ppm ozone in air for 5 days on the red flour beetle *Tribolium castaneum*, the Indian meal moth *Plodia interpunctella* and the meal worm *Tenebrio molitor* (Ref.: Journal of Stored Products Research Volume 37, Issue 4, October 2001, Pages 371-382)

Tab. 2 Effect of 5 ppm ozone in air on micro fungi (Ref.: Mason L Perdue University)

Fungi		**Ozone 5 ppm**	**Control**
Aspergillus flavus	Conidiation (Conidia/plate)	0	1.0x109
	Aflatoxin (ug/plate)	32	1000
Fusarium verticillioides	Conidiation (Conidia/plate)	0	1.0x108

Ozonation works in the laboratory. How can it be applied in silos in practice and and satisfy the industrial needs to disinfest large quantities of grain in big silos with a sufficiently high degree of efficiency. The challenge consists in building ozone generating machines that are able to supply sufficient amount of gas to treat large quantities of grain in industrial complexes with up to 500.000 metric tons and single silos with up to 30.000 metric tons.

Ozonation of stored corn in a 300 ton pilot bin

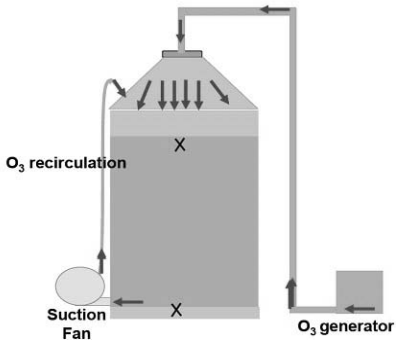

Fig. 2 Ozonation treatment with recirculation and sampling points (X) at the top and bottom of the grain mass (Ref.: Kells, S et al. Journal of Stored Products Research 2001, 7, 371-382)

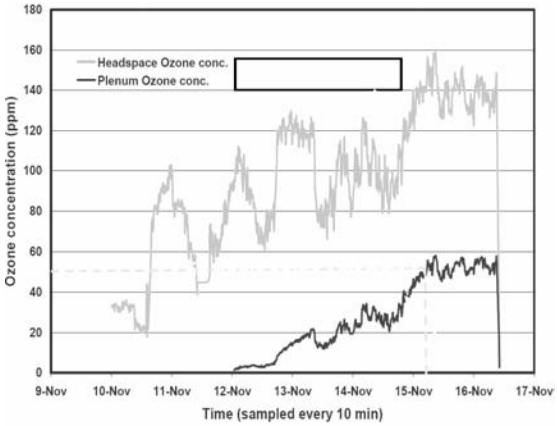

Fig. 3 Ozone contents in air during a field application of maize in the US (ref. Dirk Meier, Perdue University)

Figures 4-6 show some pictures of transportable ozone generators for field application.

Fig. 4-6 Ozone generating machines for field application

The ozonation process in practice

- Applying the existing aeration system
- Sealing off the silo
- When is the ozonation finished?
- Safety procedures

Fig. 7 picture of two ozone generators in action at a treatment of a large elevator Treating an entire structure is difficult; an alternative is to focus on the outlet silo semi continuous treatment.

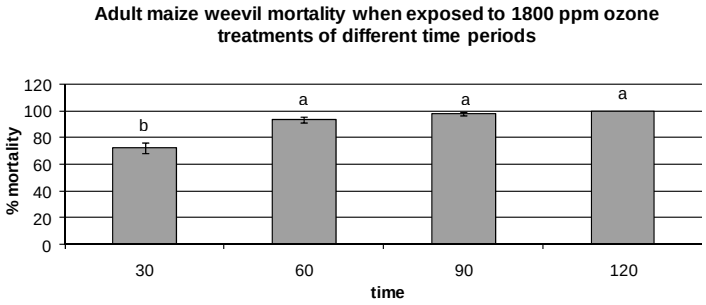

Fig. 8 Mortality of maize weevils when exposed to 1800 ppm ozone in air for different exposure times; 100% mortality after 120 min exposure

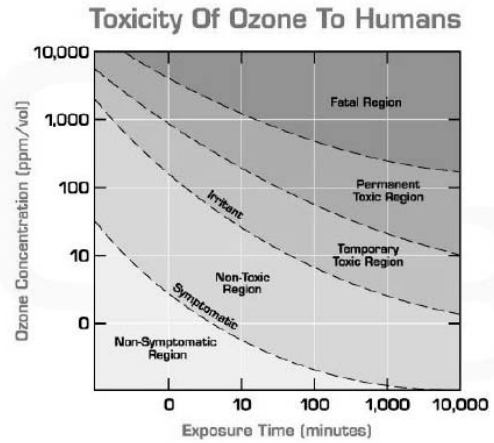

Fig. 9 Toxic side effects of ozone on humans (Langewerf 1963; cited in Dimitriou 1990)

Environmental advantages

- Ozone is a non toxic and non pollutant agent.
- Ozone is most likely less damaging to the crop than other fumigants.
- Ozone can substitute phosphine in certain circumstances and also methyl bromide and other chemicals.
- No transport of toxic gases necessary since the ozone is generated on-site.
- Only electric power is required to generate ozone; this fact is enabling remote areas in developing countries to obtain easy access to an efficient fumigation.

Safety advantages

- Ozone is at low contents in air much less toxic to humans than other fumigants like for instance phoshine etc. can cause lethal accidents when misused.
- Although ozone is toxic, the ozonation process uses so low contents in air that there is no need to use an "expert company" to operate the machine.
- During the ozonation period it is a lot safer to be close to the silo site compared to conventional fumigation. Even an accidental short entrance into the silo is not considered to be dangerous.

Economic advantages

- Ozonation is cheaper than conventional fumigation methods. Depending on the size and shape of the silo, it is estimated that Ozonation is 30 – 50% cheaper.
- Reduced requirement for fan operation.
- When Ozonation is used supplementary to grain chilling, the need to cool is significantly reduced.

Technological advantages

- Ozonation is most likely more efficient than the use of traditional fumigants.
- If the ozonation is performed with the right timing and the right concentration profile, studies have showed that harmful biological organisms will be completely killed.
- And controlled.
- Ozone seems to be a more “broadband” fumigant than other chemicals since it seems to attack cell walls in the organisms in a fundamental way (some refer to this as cell lysing).
- Some consider it most certain that most organisms will not be able to develop immunity towards ozone due to less or none mutations.

Ozone is not recognized for use on stored crops in the eu!

Regulatory status in USA

- FDA and EPA define it as “pure air” – GRAS (Generally Regarded As Safe). This has encouraged practical use.
- It is currently used in many organic applications.
- Major industries are currently implementing applications for:Pathogen reduction in storage of grapes, potatoes and onions.
- The author expects to supply 4 machines capable of treating up to 2000 tons of cereals within 12 months in USA.

19 - The Crop Protection Industry´s View on the Regulatory Situation for SPP Chemical

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Abstract

The regulatory situation regarding products for the protection of stored products in the EU has become increasingly complex in recent years. Since 1991, products for the control of the major storage pests – insects and rodents – were regulated by the Plant Protection Directive 91/414/EEC, one of the world´s most stringent legislations for pesticides. In the course of the EU review program for existing active substances, the number of available plant protection active substances was reduced from around 1000 in 1993 to about 250 to date. Many SPP pesticides were lost in this process already.

A second challenge for industry came with the Biocidal Products Directive 98/8/EC (BPD) in March 1998. Due to insufficient clarification of borderlines and lack of harmonisation, many products are now under the scope of both directives. Additional bureaucratic hurdles are now raised by the new European chemicals legislation REACH, requiring registration for all chemicals, including coformulants.

For many companies, especially SMEs, the costs of several million € for studies, dossier compilation and authorisation fees are not viable for the relatively small storage protection product segment.

For the remaining products, use restrictions due to the high importance of human and environmental safety are increasing, resulting in less availability of products for amateur use. At the same time, the political climate tends against the use of chemicals in general.

Awareness must urgently be raised, both on the political public level, as to the necessity and benefits of chemical storage protection.

Introduction

The Regulatory Environment: Farmers in Europe as producers of food or feed commodities are subject to a whole network of stringent regulations. The “Basic Regulation” on food and feed safety requires zero tolerances to contamination by insect pests, rodents or microorganisms. Therefore, chemical pest control is often inevitable to ensure the requ ired quality of the produce.

The use of chemical pest control agents, in turn, is subject to one of the world´s most stringent legislations. Products must be authorised according to their intended uses. Depending on the area and site of application, one product may, under European law, be subject to several overlapping bodies of legislation at a time. For example, rodent baits or insecticides when used in post-harvest treatment or storage of crops or in processing factories are