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Gelsenkirchen, 08.12.2008

## **Biological soil test and assessment**

**Reference:** Fire extinguishing agent "FireAde 2000 - Fire Fighting Agent"

Letters dated 19.06.2008, 18.08.2008 and 05.09.2008 and telecom. dated 01.08.2008

In the context of the above-mentioned contract award, the fire extinguishing agent "FireAde 2000 - Fire Fighting Agent" produced by the company Fire Service Plus, Inc., 180 Etowah Trace, Fayetteville, GA 30214, USA, was analysed with respect to its effects on emergence and growth of higher plants as well as its behaviour towards earthworms. The product discussed is an aqueous solution designed on a surfactant basis, which is to be employed in an application concentration of 0,5 % for use in extinguishing forest fires..

The analytical studies were performed according to DIN ISO procedures 11269-2 (1995) and 11268-1 (1997). The examination results are described below along with a short outline of the examination method used in each case and the test conditions selected.

Taking into consideration that according to the product information approx. 10 litres of an aqueous 0,5 % "FireAde 2000 - Fire Fighting Agent" solution are used for a surface of 1 m<sup>2</sup> for extinguishing forest fires, it can be assumed that one kilogramme of soil of the upper vegetation zone (depth: 0 – 10 cm) with an average density of 2 g/cm<sup>3</sup> is, in the most unfavourable case (so-called "worst-case scenario"), affected by approx. 50 grammes of the 0,5 % fire extinguishing agent solution.

The corresponding examinations tests in our Institute were in all cases performed with the 0,5 % aqueous solution of the fire extinguishing agent.

## **1. Determination of the effects on soil organisms**

### **1.1 Determination of emergence and growth inhibition in plants**

The inhibiting effects on plant growth were examined analogously to DIN/ISO 11268-1 with the test plants barley (*Avena sativa* L.), cress (*Lepidium sativum* L.) and radish (*Raphanus sativus* L.).

Universal soil type "zero" of Balster Einheitserdenwerk GmbH, D-58730 Fröndenberg was used as a blending component and as a comparative substrate.

The sample was mechanically mixed in varying proportions with the substrate to give a respective test sample of 1000 g (based on oven-dry soil). Two identical samples were produced for every concentration stage. After filling all cultivation containers, 50 ml of a liquid compound fertiliser were added in each case. 10 seeds were then evenly distributed on the substrate of each identical sample and cultivated at 20 ± 2 °C and under permanent illumination (light intensity of at least 7000 lux) in an air-conditioned cultivating room. During the 14-day test period the soil was moistened regularly. The control was a test batch without addition of the sample.

At the end of the test the cress and barley seedlings were cut off directly above the substrate surface. For the tests with radish the entire plant was removed from the substrate. Evaluation was by means of plant weight.

The results of the plant growth inhibition tests performed by us in the present case based on the control substrate without fire extinguishing agent "FireAde 2000 - Fire Fighting Agent" can be gathered from the following compilation.

**Inhibition of germination in plants:**

| <b>Preparation</b>                              | <b>Inhibiting effect<br/>on plant<br/>germination (%)</b> |              |               |
|---|---|--------------|---------------|
|   | <b>Barley</b>   | <b>Cress</b> | <b>Radish</b> |
| 25g 0,5% fire extinguishing solution/ kg soil   | < 10  | < 10         | < 10          |
| 50g 0,5% fire extinguishing solution / kg soil  | < 10  | < 10         | < 10          |
| 100g 0,5% fire extinguishing solution / kg soil | < 10  | < 10         | < 10          |

### Growth inhibition in plants:

| Preparation                                    | Inhibiting effect<br>on plant growth<br>(%) |       |        |
|--|---|-------|--------|
|  | Barley                                      | Cress | Radish |
| 25g 0,5% fire extinguishing solution/ kg soil  | 14  | - 22  | -9     |
| 50g 0,5% fire extinguishing solution/ kg soil  | 24  | 34    | 5      |
| 100g 0,5% fire extinguishing solution/ kg soil | 29  | 38    | 27     |

\* In comparison to the control plants, promotion of plant growth by 30 % was determined.

Based on the nominal batch concentrations and the present test results the following effective doses (average effective concentration – EC– ) can be estimated in the case of 50 % inhibition when compared with the control samples. When determining the "Lowest Observed Effect Concentration" – LOEC – and the "No Observed Effect Concentration" – NOEC – we assume a significant inhibition in germination and growth behaviour if the difference to the control samples is greater than 10 %.

### Germination (14 days):

EC-50 (barley; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

EC-50 (cress; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

EC-50 (radish; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

LOEC (barley): > 100 g 0,5% fire extinguishing solution/ kg soil

NOEC (barley):  $\geq$  100 g 0,5% fire extinguishing solution/ kg soil

LOEC (cress): > 100 g 0,5% fire extinguishing solution/ kg soil

NOEC (cress):  $\geq$  100 g 0,5% fire extinguishing solution/ kg soil

LOEC (radish): > 100 g 0,5% fire extinguishing solution/ kg soil

NOEC (radish):  $\geq$  100 g 0,5% fire extinguishing solution/ kg soil

Growth (14 days):

EC – 50 (barley; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

EC – 50 (cress; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

EC – 50 (radish; 14 days) = > 100 g 0,5% fire extinguishing solution/ kg soil

LOEC (barley): < 25 g 0,5% fire extinguishing solution/ kg soil

NOEC (barley): < 25 g 0,5% fire extinguishing solution/ kg soil

LOEC (cress): < 50 g 0,5% fire extinguishing solution/ kg soil

NOEC (cress): 25 g 0,5% fire extinguishing solution/ kg soil

LOEC (radish): < 100 g 0,5% fire extinguishing solution/ kg soil

NOEC (radish): < 100 g 0,5% fire extinguishing solution/ kg soil

## 1.2 Determination of toxicity to earthworms

Toxicity to earthworms was determined analogously to the procedure DIN/ISO 11268-1. Here, earthworms (*Eisenia fetida*) with a fresh mass of from 300 to 600 mg were kept for 14 days under defined conditions ( $20 \pm 2$  °C; illumination  $\approx$  700 lux, light/dark change: approx. 12 h : 12 h) in a test substrate moistened with demineralised water (approx. 60 % of the total water-retaining capacity), consisting of 10 % finely ground sphagnum peat, 20 % kaolin, 70 % industrial quartz sand and approx. 1 % calcium carbonate with various proportions of the sample (here: fire extinguishing agent "FireAde 2000 - Fire Fighting Agent"). For every dilution step three identical samples were used in which 10 worms were placed in every test container. The mortality of the earthworms was determined after 7 and 14 days. Four test batches with 10 worms each and without addition of the sample served as controls.

The results of the earthworm toxicity test are presented below:

|   |      |      |       |
|---|------|------|-------|
| Concentration 0,5% fire extinguishing solution/ kg soil | 25 g | 50 g | 100 g |
| Mortality of the earthworms in %                        | < 10 | < 10 | < 10  |

From the above-mentioned test results, the following effective dose (average lethal concentration – LC -) can be estimated at a mortality rate of 50 % for the 0,5 % solution of the fire extinguishing agent "FireAde 2000 - Fire Fighting Agent":

LC – 50 (earthworms; 14 days) = > 100 g 0,5% fire extinguishing solution / kg soil

LOEC (earthworms): > 100 g 0,5% fire extinguishing solution / kg soil

NOEC (earthworms):  $\geq$  100 g 0,5% fire extinguishing solution / kg soil

## Summary

With respect to using the product "FireAde 2000 - Fire Fighting Agent" as a fire extinguishing agent for forest fires, it is to be remarked that based on the above-mentioned test results no objections are to be made to the use of the product if the amount or concentration of the fire extinguishing agent solution used is chosen such that the content of the fire extinguishing agent in the soil is well below the mass concentration of  $< 25 \text{ g}$   $0,5 \text{ \%}$  "FireAde 2000 - Fire Fighting Agent" solution / kg of soil and it can be assumed from this that plant growth and the life cycle of soil organisms is not significantly disturbed.

Based on the maximum "No Observed Effect Concentration" (NOEC), in our opinion an order of magnitude of approx.  $< 25 \text{ g}$  of an  $0,5 \text{ \%}$  aqueous "FireAde 2000 - Fire Fighting Agent" solution/ kg of soil should be maintained.

This concentration step corresponds, for example, to the order of magnitude of a quantity of less than 5 litre of an aqueous  $0,5 \text{ \%}$  "FireAde 2000 - Fire Fighting Agent" solution sprayed onto a surface of  $1 \text{ m}^2$  of soil (based on a vegetation zone of 10 cm).

Furthermore, it is to be noted that with respect to water toxicology, water that contains the product "FireAde 2000 - Fire Fighting Agent" and has not been biologically treated should not be discharged into the receiving water, because, based on the aquatic toxicity determined (cf. our letter initialled: A-170545b-08-WR), it would lead to a disadvantageous change in water quality.

Sincerely

Director of the Institute

p.p.



Dipl.-Ing. Michael Sauerwald  
Leiter der Abteilung  
Abwasser-, Boden- und Lufthygiene



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