Hygiene-Institut des Ruhrgebiets
Institut für Umwelthygiene und Toxikologie
Direktor: Prof. Dr.rer.nat. Lothar Dunemann
Träger: Verein zur Bekämpfung der Volkskrankheiten im Ruhrkohlengebiet e.V.

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Unser Zeichen: A-251791-14-Bi
Ansprechpartner: Herr Bien

Gelsenkirchen, den 19.12.2014

Bonpet fire-extinguishing liquid
here: content of fluorosurfactants

Your order 2014-0052 from 01.10.2014 and our offer A-248765-14-Bi from 30.09.2014

With the above mentioned letter you have authorized us to test the submitted fire-extinguishing medium **"Bonpet fire extinguishing liquid"** regarding the content of fluorosurfactants. The identified results are sent in tabular form on the enclosed attachment.

As a result is to determine that the fluorosurfactants are unverifiable in the tested fire-extinguishing medium.

Best regards
The Director of the Institute
p.p.

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

Dipl.-Umweltwiss. Sebastian Bien
Sachgebietsleiter
Ökotoxikologie

Attachment

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-13042-02-00

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Results of the examination according to DIN 38407, Part 42

Parameter / Probe			"Bonpet fire-extinguishing liquid"
Perfluorobutanat	PFBA	mg/l	< 10
Perfluoropentanoat	PFPA	mg/l	< 10
Perfluorohexanoat	PFHxA	mg/l	< 10
Perfluoroheptanoat	PFHpA	mg/l	< 10
Perfluorooctanoat	PFOA	mg/l	< 10
Perfluorononaoat	PFNA	mg/l	< 10
Perfluorodecanoat	PFDA	mg/l	< 10
Perfluorobutylsulfonat	PFBS	mg/l	< 10
Perfluorohexylsulfonat	PFHxS	mg/l	< 10
Perfluorooctylsulfonat	PFOS	mg/l	< 10

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Ansprechpartner: Herr Bien

Gelsenkirchen, den 19.12.2014

Bonpet fire-extinguishing liquid
here: Skin and Eye irritancy

Your order 2014-0052 from 01.10.2014 and our offer A-248765-14-Bi from 30.09.2014

Within the scope of the afore mentioned letter you commissioned us to conduct tests regarding skin and eye irritancy of the fire extinguishing agent **"Bonpet fire-extinguishing liquid"** we received on October 10th 2014.

1. Skin irritancy

1.1 Method

The determination of the skin irritancy was done using three albino rabbits. For the so-called Patch-Test 2,5 ml of the extinguishing agent **"Bonpet fire-extinguishing liquid"** was applied to a 20 x 20 mm area of shorn skin. The condition of the skin of each rabbit was monitored regularly over the following days. The assessment of the result was done in accordance with the guideline of the Commission 92/69/EEC along the following scale:

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Development of Erythema and Scab	Value
No erythema	0
Very slight erythema (hardly detectable)	1
Clearly localised erythema	2
Moderate to severe erythema	3
Severe erythema (intense redness) to slight scab formation (deep damages)	4

Development of Oedema	
No oedema	0
Very slight formation of oedema (hardly detectable)	1
Slight, but clearly localised oedema (edges are clearly visible due to a significant swelling)	2
Moderate oedema (swelling of approx. 1 mm)	3
Severe oedema (swelling of more than 1 mm and beyond the edges of the exposure area)	4

1.2 Test results

1.2.1 Individual results of the skin observation

"Bonpet fire-extinguishing liquid"

Animal-No.	Skin Irritancy	Observation Period (Days)					
		1	2	3	4	5	6
1	erythema and scab	1	0	0	0	0	0
	formation of oedema	0	0	0	0	0	0
2	erythema and scab	1	0	0	0	0	0
	formation of oedema	0	0	0	0	0	0
3	erythema and scab	1	0	0	0	0	0
	formation of oedema	0	0	0	0	0	0

1.2.2 Summary of the individual results

"Bonpet fire-extinguishing liquid"

	Score *
erythema and scab:	1
formation of oedema:	0

* Score = arithmetic mean of the maximum points of all three animals

This amounts to a total score of **1** for the extinguishing agent **"Bonpet fire-extinguishing liquid"**. According to the hazardous substance law this product can be classified as **non-irritating towards skin**.

2. Eye Irritancy

2.1 Method

The eye irritancy determination was conducted on three albino rabbits (each weighing approx. 2 kg).

0,1 ml of the fire extinguishing agent **"Bonpet fire-extinguishing liquid"** was applied to the conjunctival sac of the right eye (test side). After the addition of the product the eye was held shut by hand for about five seconds.

On the day of treatment and the following five days the condition of the right eye was compared to the left eye (control side) and the maximum irritant effect was rated pursuant to the guideline of the Commission 92/69/EEC using the following points system:

Classification of Ocular Changes

Cornea

Opacity: Turbidity level (for the evaluation the densest area was used)

No ulceration or opacity 0
Scattered or diffuse opacity areas: (except for a slight turbidity
of the normal lustre), details of the iris clearly visible 1
Easily discernable translucent area,
details of the iris partly shadowed 2
Nacreous areas, no details of the iris visible,
size of the pupil hardly identifiable 3
Opaque cornea, because of the opacity iris not visible 4

Iris

Normal 0
Distinctly deepened wrinkles, congestion, swelling, slight circumcorneal hyperaemia or injection;
one of these symptoms or a combination of different symptoms;
the Iris still reacts to light (slow reaction is positive) 1
No reaction to light, haemorrhage, severe damage
(all or different symptoms) 2

Conjunctiva

Redness: Lids and/ or nictitating membrane

Blood vessels normal 0
Some blood vessels show a distinct hyperaemia (injection) 1
Diffuse, crimson colour, individual vessels hardly detectable 2
Diffuse vibrant red 3

Chemosis: Lids and/ or nictitating membrane

No swelling 0
Every swelling above normal (including nictitating membrane) 1
Distinct swelling with partial eversion of the lids 2
Swelling with approx. half-closed lids 3
Swelling with more than half-closed lids 4

2.2 Test results

2.2.1 Individual results of the eye observation

Animal No.	Eye Lesions	Observation Period (Days)											
		1		2		3		4		5		6	
		T	C	T	C	T	C	T	C	T	C	T	C
1	Cornea	0	0	0	0	0	0	0	0	0	0	0	0
	Iris	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival redness	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival chemosis	0	0	0	0	0	0	0	0	0	0	0	0
2	Cornea	0	0	0	0	0	0	0	0	0	0	0	0
	Iris	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival redness	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival chemosis	0	0	0	0	0	0	0	0	0	0	0	0
3	Cornea	0	0	0	0	0	0	0	0	0	0	0	0
	Iris	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival redness	1	0	0	0	0	0	0	0	0	0	0	0
	Conjunctival chemosis	0	0	0	0	0	0	0	0	0	0	0	0

T = test side
C = control side

2.2.2 Summary of the individual results

	Score
Cornea:	0
Iris:	1
Conjunctiva:	1

The afore mentioned results for the extinguishing agent **"Bonpet fire-extinguishing liquid"** amount to eye-irritancy level **1**. According to the hazardous substance law this product can be classified as **non-irritating towards eyes.**

Best regards
The Director of the Institute
p.p.

Dipl.-Ing. Michael Sauerwald
Leiter der Abteilung
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Dipl.-Umweltwiss. Sebastian Bien
Sachgebietsleiter
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Ansprechpartner: Herr Bien

Gelsenkirchen, den 07.01.2015

Bonpet fire-extinguishing liquid
here: Biological soil testing and evaluation

Your order 2014-0052 from 01.10.2014 and our offer A-248765-14-Bi from 30.09.2014

In the framework of the aforementioned order the fire extinguishing agent "**Bonpet fire-extinguishing liquid**" designed by your company was examined regarding its effects on seed germination and growth of higher plants as well as the behaviour of earthworms.

Analytical work was carried out analogous to the DIN ISO regulations 11269-2 (2013) and 11268-1 (2010). The examination results will be described below shortly outlining the applied examination procedures and the chosen test conditions.

The corresponding examinations on our premises have been made in all cases with the concentrate of the extinguishing agent.

1. Determination of the effects on soil organisms

1.1 Investigation of the inhibition of germination and growth of plants

The investigation of inhibitive effects on plant growth was carried out analogous to DIN/ISO 11269-2 with the test plants barley (*Avena sativa L.*), cress (*Lepidium sativum L.*) and radish (*Raphanus sativus L.*).

Homogenized artificial soil "Null" (zero) from the Balster Einheitserdenwerk GmbH, D-58730 Fröndenberg was used as mixing component and comparative substratum. The sample was mechanically blended with the substratum in different proportions of an equal testing quantity of 1000 grs. (referring to oven-dry soil). For each stage of concentration two replicates were prepared. Once the seedbeds had been filled, 50 ml of a liquid compound fertilizer were added to each of them. Then, 10 seeds were evenly distributed over the substratum of each of the replicates and grown in a climatized plant growing room at (20 degrees C. ± 2 degrees C.) and permanent illumination (intensity of exposure at least 7000 Lux). During the 14 day test duration the soil was regularly wetted with water. A test preparation without any addition of the sample served for control purposes.

After the termination of the test the cress and barley germs were cut directly above the substratum's surface. For the test with the radish, the whole plant was taken out of the substratum. The evaluation was carried out on the basis of the plants' weight.

The results of the plant growth inhibition tests carried out by us in this case with respect to the comparative substrates without extinguishing agent "**Bonpet fire-extinguishing liquid**" can be seen in the following summary.

Inhibition of germination with plants:

Preparation	Inhibitive effect on plant germination (%)		
	Barley	Cress	Radish
100 mg "**Bonpet fire-extinguishing liquid**" / kg soil	0	23,5	0
1000 mg "**Bonpet fire-extinguishing liquid**"/ kg soil	0	47,1	12,5
10000 mg "**Bonpet fire-extinguishing liquid**"/ kg soil	50	52,9	18,8

Inhibition of growth with plants:

Preparation	Inhibitive effect on plant germination (%)		
	Barley	Cress	Radish
100 mg "**Bonpet fire-extinguishing liquid**"/ kg soil	0	46,1	14,2
1000 mg "**Bonpet fire-extinguishing liquid**"/ kg soil	40,7	68,4	14,5
10000 mg "**Bonpet fire-extinguishing liquid**"/ kg soil	60,5	71,0	23,0

On basis of the nominal formation concentration and the present test results a comparison with the control samples the following effective doses (medium effect concentralion –EC–) with an inhibition of 50% can be estimated. Regarding the determination of the "Lowest Observed Effect Concentration" –LOEC– and the "No Observed Effect Concentration – NOEC– we assume a significant limitation of germ growth and growth behaviour if the difference to the control samples is larger than 10 %.

Germination (14 days):

EC–50	(barlay; 14 days)	=	10000mg **"Bonpet fire-extinguishing liquid"**/kg soil
EC–50	(cress; 14 days)	=	5000mg **"Bonpet fire-extinguishing liquid"**/kg soil
EC–50	(radish; 14 days)	=	>10000mg **"Bonpet fire-extinguishing liquid"**/kg soil
LOEC (barlay)			10000mg **"Bonpet fire-extinguishing liquid"**/kg soil
NOEC (barlay)			1000mg **"Bonpet fire-extinguishing liquid"**/kg soil
LOEC (cress)			100mg **"Bonpet fire-extinguishing liquid"**/kg soil
NOEC (cress)			<100mg **"Bonpet fire-extinguishing liquid"**/kg soil
LOEC (radish)			1000mg **"Bonpet fire-extinguishing liquid"**/kg soil
NOEC (radish)			100mg **"Bonpet fire-extinguishing liquid"**/kg soil

Growth (14 days):

EC – 50	(barlay; 14 days)	=	5000mg **"Bonpet fire-extinguishing liquid"**/kg soil
EC – 50	(cress; 14 days)	=	200mg **"Bonpet fire-extinguishing liquid"**/kg soil
EC – 50	(radish; 14 days)	=	>10000mg **"Bonpet fire-extinguishing liquid"**/kg soil

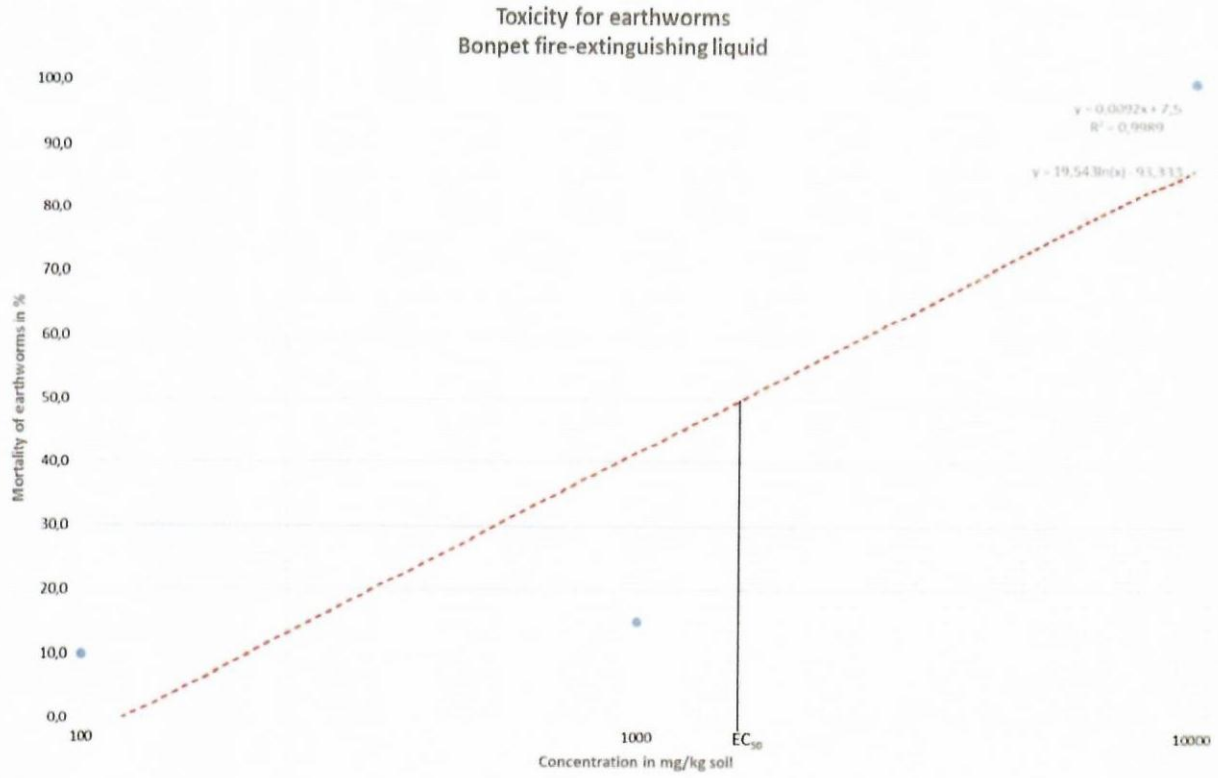
LOEC (barlay)	1000mg **"Bonpet fire-extinguishing liquid"**/kg soil
NOEC (barlay)	100mg **"Bonpet fire-extinguishing liquid"**/kg soil
LOEC (cress)	100mg **"Bonpet fire-extinguishing liquid"**/kg soil
NOEC (cress)	<100mg **"Bonpet fire-extinguishing liquid"**/kg soil
LOEC (radish)	100mg **"Bonpet fire-extinguishing liquid"** /kg soil
NOEC (radish)	<100mg **"Bonpet fire-extinguishing liquid"** /kg soil

1.2 Determination of toxicity for earthworms

The determination of the toxicity for earthworms was carried out analogous to the regulation DIN/ISO 11268-1. To this end, earthworms (*Eisenia fetida*) with a fresh mass between 300 and 600 mg were kept for 14 days under defined conditions (20 degrees C. ± 2 degrees C.; illumination ~ 700 Lux, bright/dark change: approx. 12 h : 12 h) in a test substratum wetted with demineralized water (approx. 60 % of the total water retention value), consisting of 10 % of fine-milled Sphagnum peat, 20 % of kaolin, 70 % of industrial silica sand and approx. 1 % of calcium carbonate, with different proportions of the sample (here: extinguishing agent **"Bonpet fire-extinguishing liquid"**. Per concentration stage three replicates were used with 10 worms being introduced in each test container. The mortality of the earthworms was determined after 7 and 14 days. Four test preparations with 20 worms each without addition of the sample served for control purposes.

The results of the earthworm toxicity test are indicated below:

Concentration "**Bonpet fire-extinguishing liquid**"in mg/ kg soil	100	1000	10000
Mortality of earthworms in %	10	15	100



From the aforementioned test results the following effective dose (medium lethal concentration – LC) with a mortality rate of 50 percent, the extinguishing agent "**Bonpet fire-extinguishing liquid**" can be assessed:

LC – 50 (earthworms; 14 days) = 1600 mg "**Bonpet fire-extinguishing liquid**" / kg soil
LOEC (earthworms): 100 mg "**Bonpet fire-extinguishing liquid**" / kg soil
NOEC (earthworms): < 100 mg "**Bonpet fire-extinguishing liquid**" / kg soil

Summary

Regarding the use of the product "**Bonpet fire-extinguishing liquid**" as an extinguishing agent outside of closed spaces it can be noted that based on the established test results there are no objections against the usage of the product if the quantities used/ the concentration of the extinguishing solution is chosen so that the amount of extinguishing agent in the soil is well below the mass concentration of 100 mg "**Bonpet fire-extinguishing liquid**"-concentrate/ kg soil and that it can be assumed that there is no significant interference with plant growth the life cycle of soil organisms.

Based on the maximum non-effective dose ("No Observed Effect Concentration" (NOEC)) a scale of 100 mg "**Bonpet fire-extinguishing liquid**" solution / kg soil should not be exceeded.

Additionally it should also be noted that from a water hygienic point of view, waters that contain "**Bonpet fire-extinguishing liquid**" and are biologically untreated should not be drained into the outlet channel because the determined aquatic toxicity (see our letter A-251836-14-Bi from 07.01.2015) would have adverse effects on water quality.

Best regards
The Director of the Institute
p.p.

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Unser Zeichen: A-251836-14-Bi
Ansprechpartner: Herr Bien

Gelsenkirchen, den 07.01.2015

Bonpet fire-extinguishing liquid
Here: Waste water examination and evaluation

Your order 2014-0052 from 01.10.2014 and our offer A-248765-14-Bi from 30.09.2014

In the framework of the before mentioned order the fire extinguishing agent **"Bonpet fire-extinguishing liquid"** designed by your company has been examined regarding its biodegradability and its impact on higher and lower aquatic organisms.The mentioned product is an aqueous solution based on organic substances which is meant to be used for the extinguishing of fires.

Analytical work was carried out according to the standardized OECD Test Guidelines, as well as the regulations laid down in the German Standard Procedures for examinations of water, waste water and sludge. The examination results will be described below shortly outlining the applied examination procedures and the chosen test conditions. The corresponding examinations have been made in all cases with the concentrate of the fire extinguishing agent.

1. Bacterial toxicity test

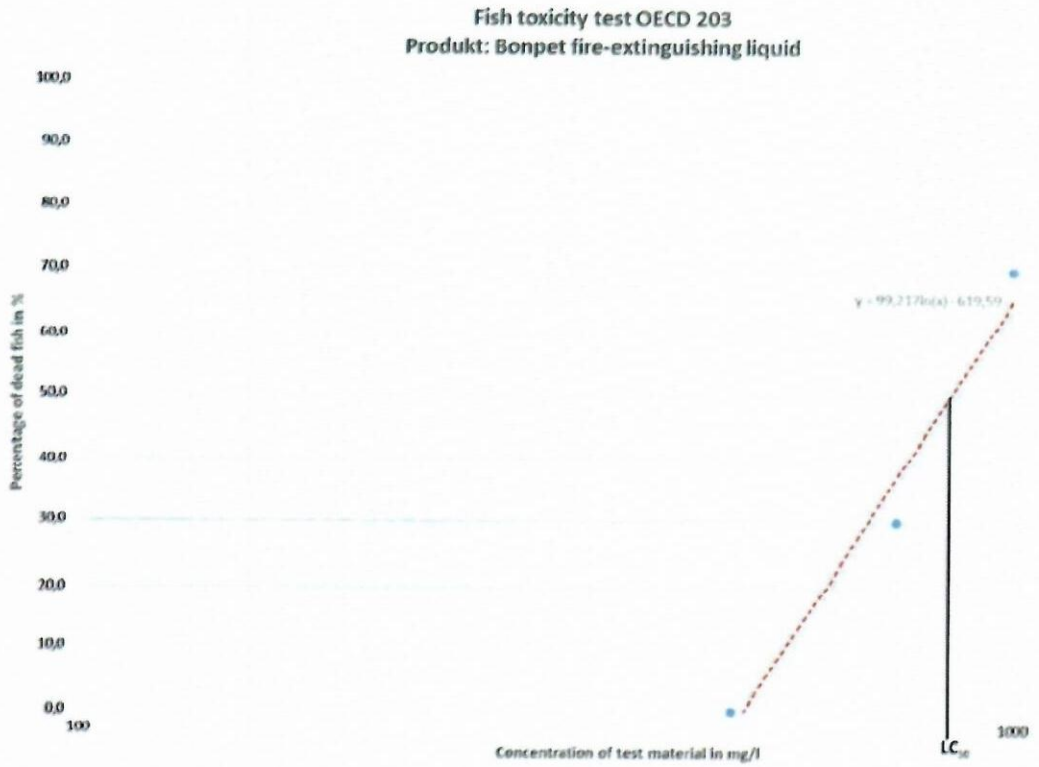
A TTC-test has been carried out in order to be able to make practical statements regarding a possible toxicity of the product **"Bonpet fire-extinguishing liquid"** to be examined with respect to lower aquatic organisms. The method is based on the dehydrogenases of the living cells (activated sludge) reducing 2,3,5- triphenyl tetrazolium chloride (TTC) to red formazan in quantitative dependence on the corresponding active cells. Thus, by means of a quantitative determination of the formed formazan a direct statement can be made about the toxicity of a substance introduced into a defined activated sludge/ TTC suspension on comparing the results with those of a parallel sample which does not contain the substance.

As is made clear by the semi-logarithmic graphical illustration (Annex 1), the formation of formazan expressed in absolute values initially lies above the blank value. The further course of the curve proves that a decrease of the formazan formation takes place with the percentage of **"Bonpet fire-extinguishing liquid"** being increased which reaches the blank value at a concentration of approx. 0,1 ml/10 ml (= 10 ml/l) of the total solution.

2. Fish toxicity test

The examination of the product **"Bonpet fire-extinguishing liquid"** regarding its fish-toxic properties has been carried out with the help of the procedure (fish test) described OECD Directive 203 ("Fish Acute Toxicity Test"). According to this, 1 to 3 cm long Zebra-fish (*Danio rerio*) were introduced into test solutions prepared with the before mentioned product and diluting water and the animals' behaviour monitored for 96 hours. During the duration of the test, the temperature of the aired test water was maintained at 23 ± 2 degrees Celsius. The results have been summarized in the following table:

Concentration of test material in mg/l	100	250	500	750	1000
Percentage of dead fish in %	0	0	0	30	70



From the before mentioned data the following LC-50 value can be determined:

LC-0	:	500mg **"Bonpet fire-extinguishing liquid"**/l
LC-50*	:	850mg **"Bonpet fire-extinguishing liquid"**/l
LC-100	:	>1000mg **"Bonpet fire-extinguishing liquid"**/l

3. Daphnia toxicity test

Daphnia toxicity has been determined according to the procedure described in OECD Directive 202 ("Acute Immobilisation Test") with the test organism "Daphnia magna STRAUS". The indication of the dilution level of the test substance, in which a certain percentage of daphnia

* LC 50 = the concentration of the test material to be examined, determined by graphical methods or calculation, with 50 % of the introduced fish dying during the 48-hour-test.

remains buoyant after 48 hours of testing (temperature: 20 degrees C. ± 1 degree C.; no illumination), serves as a measure for the effect of water ingredients.

The effect of the mass concentration of the examined fire extinguishing agent "**Bonpet fire-extinguishing liquid**" on the buoyancy of the small aquatic crustaceans Daphnia magna has been compiled in the following table:

Concentration of test substance in mg/l	5	7,5	10	25	50
Percentage of daphnia incapable of swimming in %	0	0	0	0	0

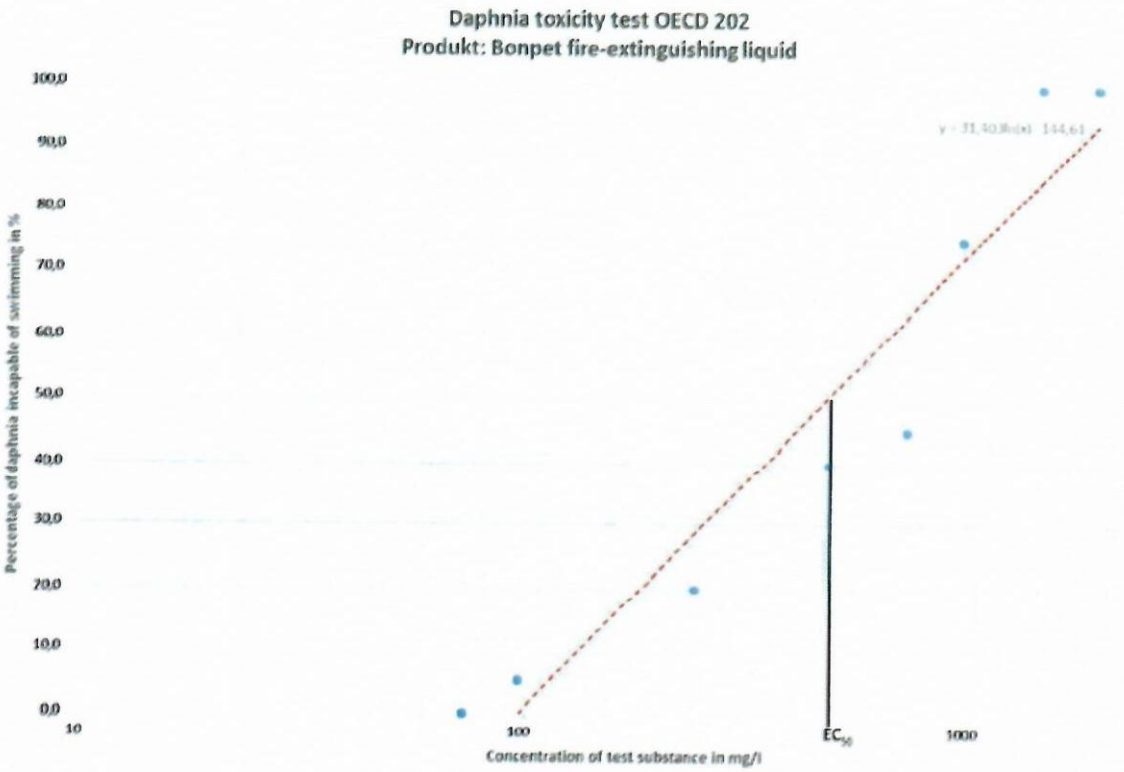
Concentration of test substance in mg/l	75	100	250	500	750
Percentage of daphnia incapable of swimming in %	0	5	20	40	45

Concentration of test substance in mg/l	1000	1500	2000
Percentage of daphnia incapable of swimming in %	75	100	100

Based on the before mentioned test results the following effect concentrations (EC values) for the fire extinguishing agent "**Bonpet fire-extinguishing liquid**" can be determined:

EC - 0 (48 hs) = 75 mg /l
EC - 50** (48 hs) = 500 mg /l
EC - 100 (48 hs) = 1500 mg /l

** EC 50 = the concentration of the test material to be examined, determined by graphical methods or calculation, with 50 % of the introduced daphnia are incapable of swimming during the 48-hour-test.



4. Algae toxicity test

The determination of the inhibitation of cell reproduction with green algae was carried out according to OECD Directive 201 ("Growth Inhibition Test"). Under this standard the green algae *Scenedesmus subspicatus* are cultivated in a nutrient medium for 72 hours and under defined conditions (23 degrees C. ± 2 degrees C.; permanent illumination at 8000 lux) and at different sample concentrations; at certain times (24 hs, 48 hs and 72 hs) the toxicity of the test substance is to be checked by the determination of the number of cell count.

The results of the cell reproduction inhibition test are listed below:

5. Biodegradation pattern

The biodegradability of the fire-extinguishing agent **"Bonpet fire-extinguishing liquid"** was specified using manometry to determine the biochemical oxygen demand based on OECD-Guideline 301 f (Manometric Respirometry Test). This method does not only state a measurement for the microbiological-oxidative degradation of organic ingredients, but also allows for assessments regarding the kinetics of the degradation. The reference value for the degradation rate is the chemical oxygen demand that is determined experimentally using the dichromate-method. The COD can be seen as a measurement for the complete mineralisation of the organic substance of the test solution.

Because Ammoniumcarbonate and Armoniumhydrogencarbonate are a part of the formulation of the Bonpet fire extinguishing liquid it was necessary to suppress a potential nitrification during the degradation-test, so the nitrification inhibitor N-allylthiourea (ATH) was added to the sample.

Assessing the chemical oxygen demand of the undiluted extinguishing agent **"Bonpet fire-extinguishing liquid"** of 28300 mg O_2/l as the necessary amount of oxygen for the 100 % degradation, the biochemical degradation, expressed as BOD, amounts to 17800 mg O_2/l = 62,9 % after a period of five days.

As can be seen in the chart (Annex 2) regarding the manometrically determined biochemical degradation kinetics, the microbiological degradation of biochemical oxidisable ingredients, under the given test conditions, was completed after a period of approx. 27 to 28 days; it amounts to approx. 83,4 %.

6. Oral mammal toxicity

The limit test in compliance with OECD guideline 420 with a limit concentration of 2000 mg **"Bonpet fire-extinguishing liquid"** per kilogram body weight tested on wistar rats showed no toxic influences on the test animals. The acute oral mammal toxicity can be defined as > 2000 mg per kilogram bodyweight.

Summary

Based on the results of the TTC-test it can be maintained, in view of the disposal of the product through sewage systems to the waste water treatment plants, that no negative effects are to be expected for the biologically operating section of the treatment plant as long as it is made sure that the fire extinguishing agent solution "**Bonpet fire-extinguishing liquid**" is diluted at a ratio of **at least** 1:100 with other waters such as, for instance, domestic waste water.

Furthermore, it must be guaranteed that the sewage treatment plant does not get overloaded with quantities of water containing fire extinguishing agents.

Water containing the product "**Bonpet fire-extinguishing liquid**" should not be disposed of via draining canals as it might lead to adverse changes of the water quality due to its established aquatic toxicity.

Based on the results of the toxicity testing and the determination of biodegradability and in consideration of the regulations on hazardous substances (Commission Regulation (EU) No 286/2011) the "**Bonpet fire-extinguishing liquid**" has not be declared as hazardous to the aquatic environment.

The Director of the Institute
p.p.

Dipl.-Ing. Michael Sauerwald
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Attachments

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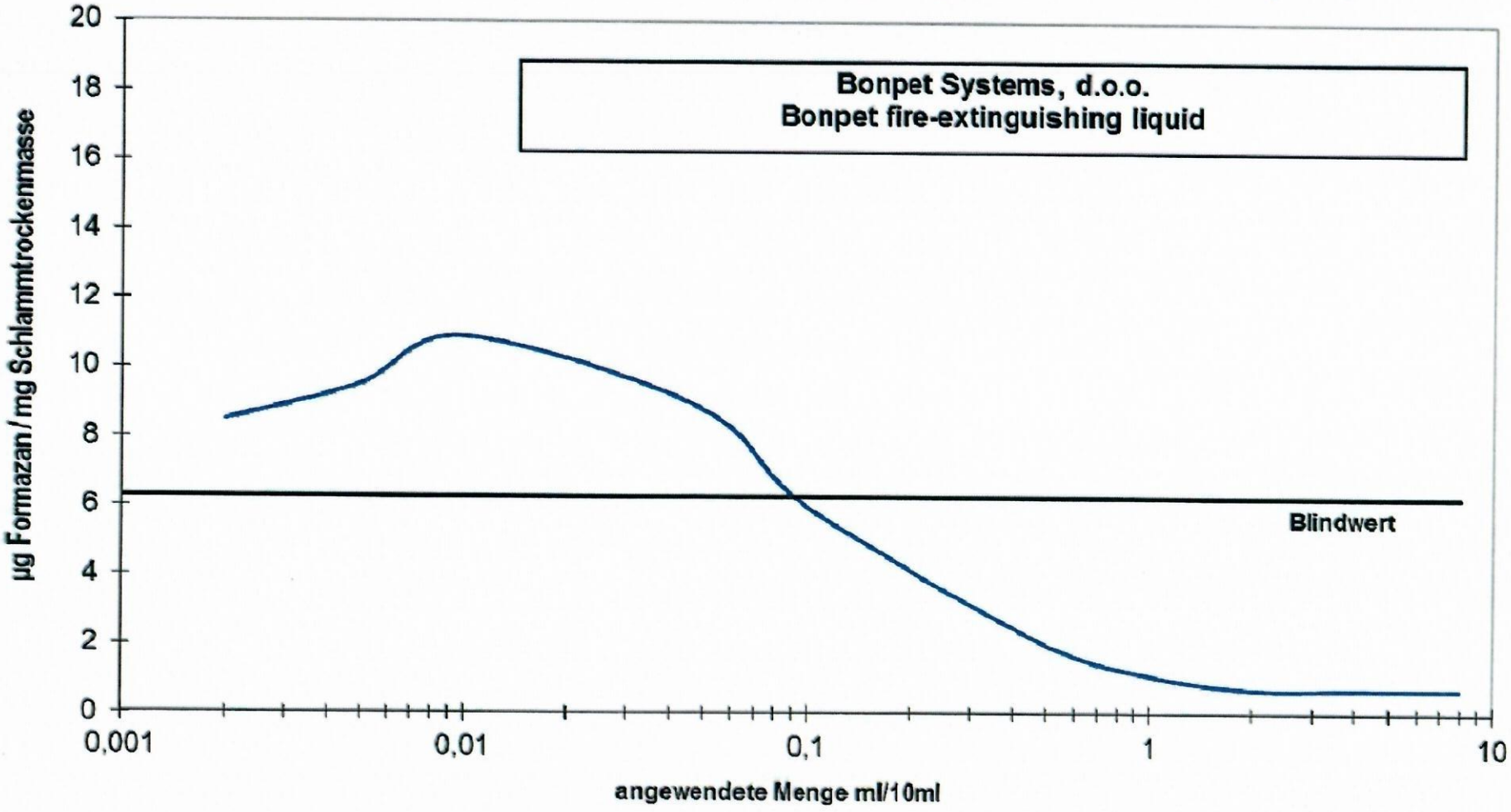
Toxizitätsbestimmung mit 2,3,5-Triphenyltetrazoliumchlorid (TTC)



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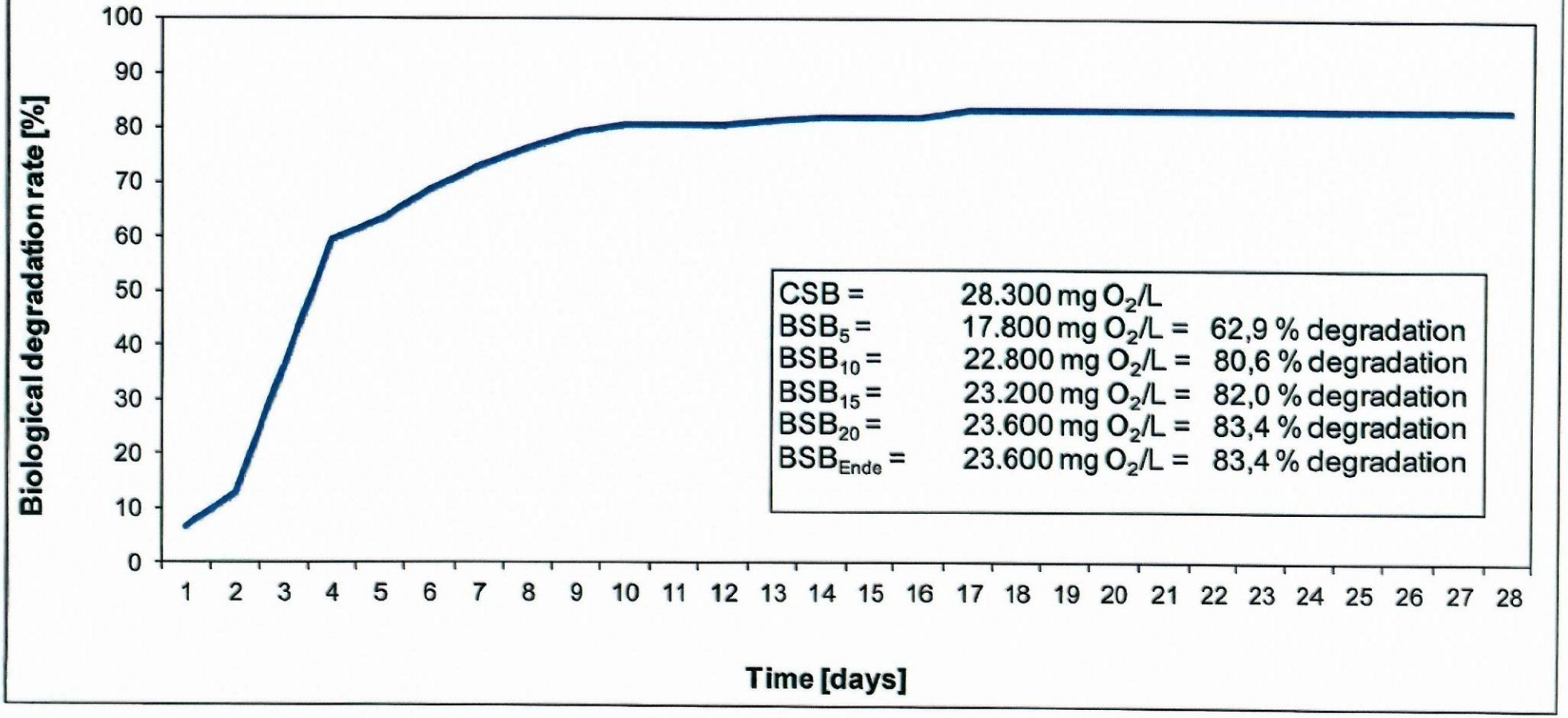
Biochemical degradation kinetics
Produkt: Bonpet fire-extinguishing liquid



Concentration of the original substance	in mg/l	75	100	250	500	1000
Growth rate inhibition	in %	0	0	8,0	27,0	53,6

Concentration of the original substance	in mg/l	2500	5000
Growth rate inhibition	in %	94,9	97,2

This shows the following effective concentrations (IC values) for the product **"Bonpet fire-extinguishing liquid"** in a graphical assessment (see below) at an inhibition of 10 % and 50 %:

IC_{10} (0 to 72 h) = 300 mg/l
IC_{50} (0 to 72 h) = 850 mg/l