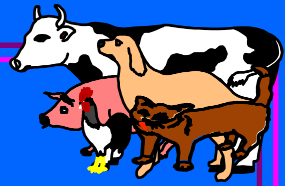


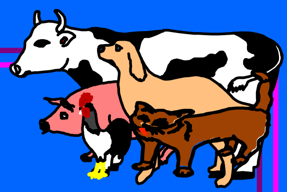
Assessment of Environmental Effects of Airborne Emissions and Waste Effluents from Livestock Production

Jörg Hartung

Institute of Animal Hygiene, Animal Welfare and Behaviour of Farm Animals

University of Veterinary Medicine Hannover,

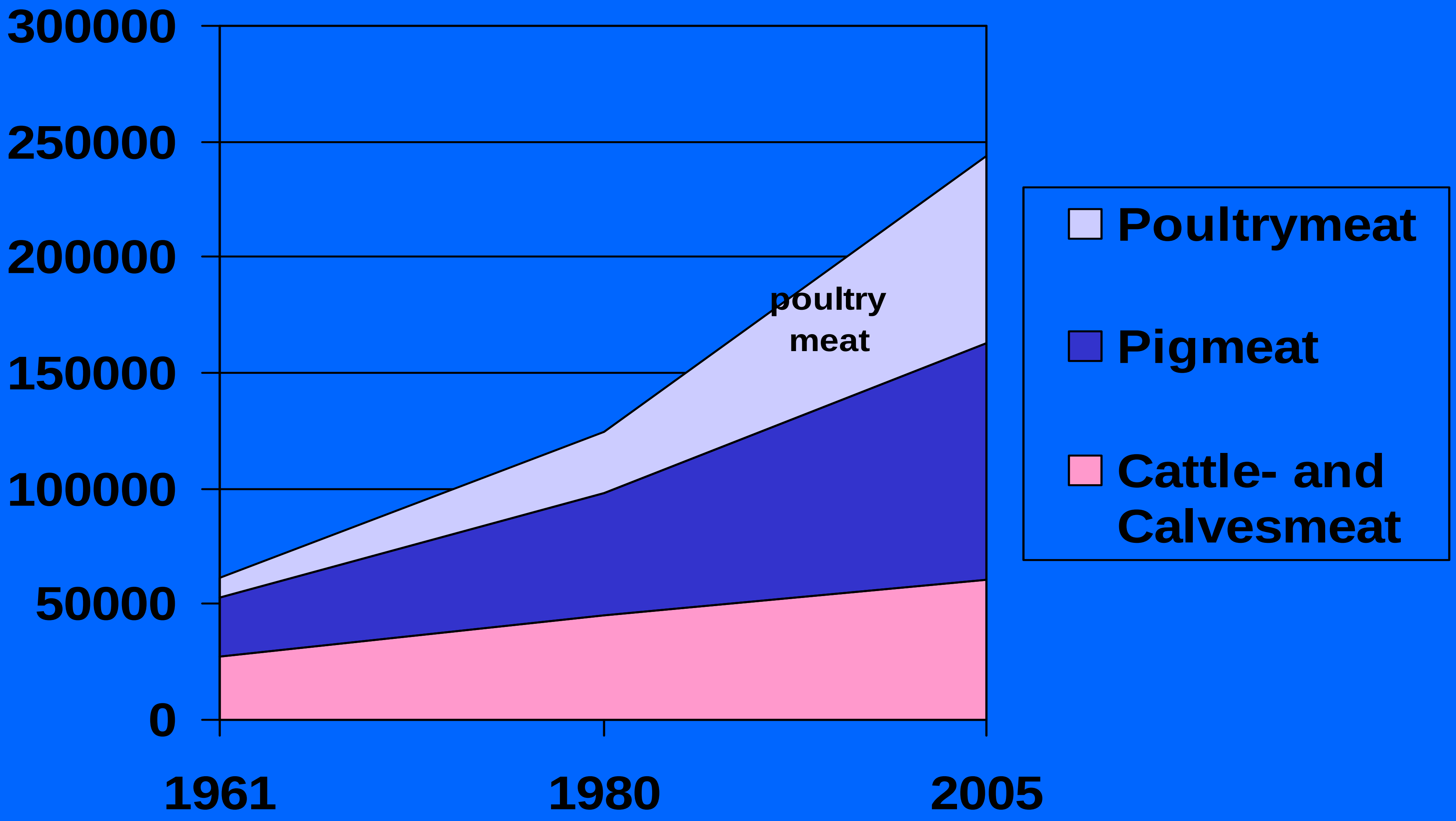
Bünteweg 17p, 30559 Hannover, Germany



Contents:

1. **Introduction: World meat market**
2. **Relationship livestock production and environment and manure amounts**
3. **Type of effluents**
4. **Impact of solid and liquid effluents**
5. **Impact of airborne emissions incl. antibiotic residues**
6. **Brief assessment of environmental pollutants**
7. **Conclusions**
8. **Recommendations**

Development of the world meat market from 1961 to 2005 in 1.000 t and percent of change (%) (Source: FAO 2006)



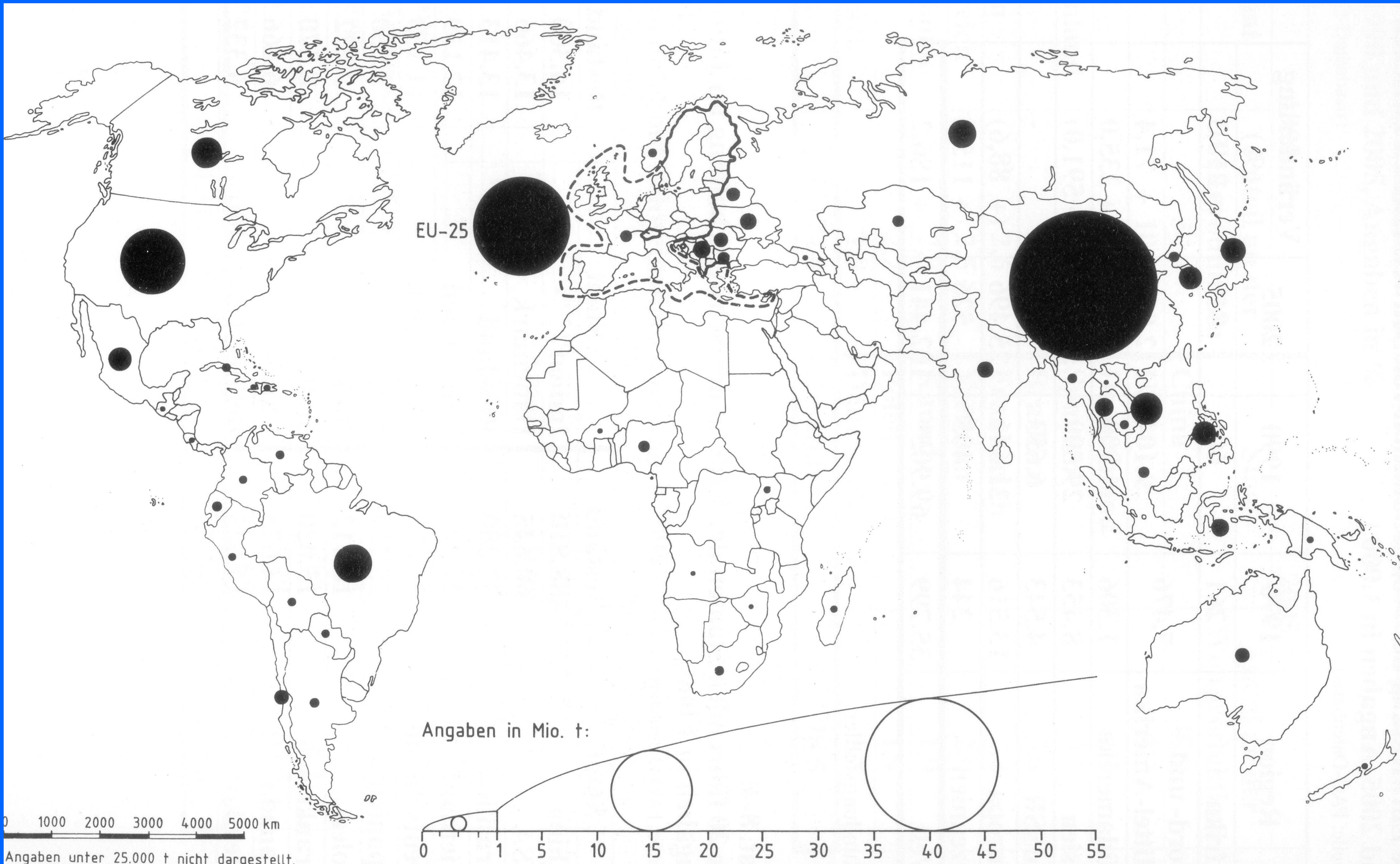
Development of the world meat market from 1961 to 2005 in 1.000 t (Source: FAO 2006)

Meat	1961	1980	2005	Factor
Cattle- and Calf meat	27,685	45,551	60,191	2.2
Pig meat	24,748	52,683	102,441	4.1
Poultry meat	8,953	25,962	81,436	9.1
Meat total	71,343	136,678	265,429	3.7

Ten leading pig producing countries in 1990 and 2005 (%)

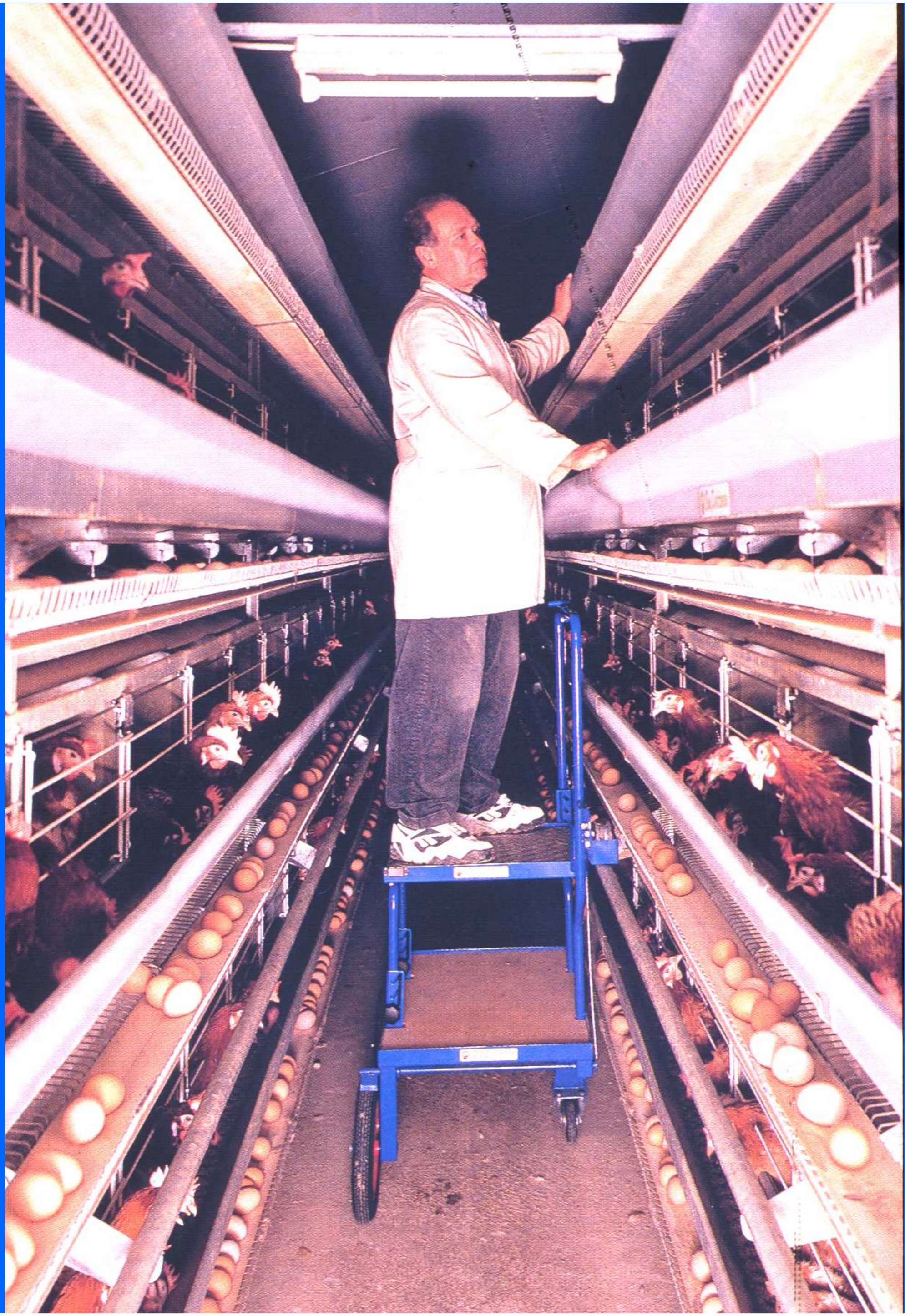
1990		2005	
Country	Percentage in world production	Country	Percentage in world production
China	**34,4**	**China**	**48,9**
USA	**10,0**	**USA**	**9,2**
Russia/UdSSR	**9,5**	**Russia**	**4,4**
Germany	**6,4**	**Germany**	**3,2**
Poland	**2,6**	**Poland**	**3,0**
Spain	**2,6**	**Spain**	**2,2**
France	**2,5**	**France**	**2,0**
Netherlands	**2,3**	**Netherlands**	**1,9**
Italy	**2,2**	**Italy**	**1,9**
Denmark	**1,9**	**Denmark**	**1,8**
total	**74,4**	**total**	**78,5**

Leading pig producing regions in the world



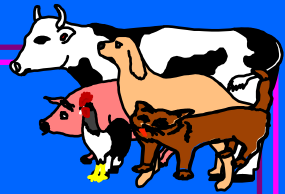
Europe from the sky

Battery cages for laying hens -
4 tiers
daily control



specialised farms…
concentration in regions…

Institute for Animal Hygiene, Welfare and Behaviour



Relationship Livestock Farming - Environment

Gases, Dust,
Micro-organisms,
Toxins, Allergens

Air

Feed

Water

Germany
Livestock in mio. animals

Cattle in total	13
dairy cows	4.1
Pigs in total	27
sows	2.5
Broiler	77
Laying hens	43
Sheep	2
Horses	1
Total no. of Animals:	163
Total in mio. LU:	19.2

Products

Meat: 6 mio. t/a
Milk: 29 mio. t/a
Eggs: 0.8 mio. t/a

Feces, Urine

app. 200 mio. t/a

LU: Livestock Unit
= 500 kg live weight

Source: bft online (2006)

Liquid and solid manure production of animal farming in Germany for 2006 in mio. t (calculated)

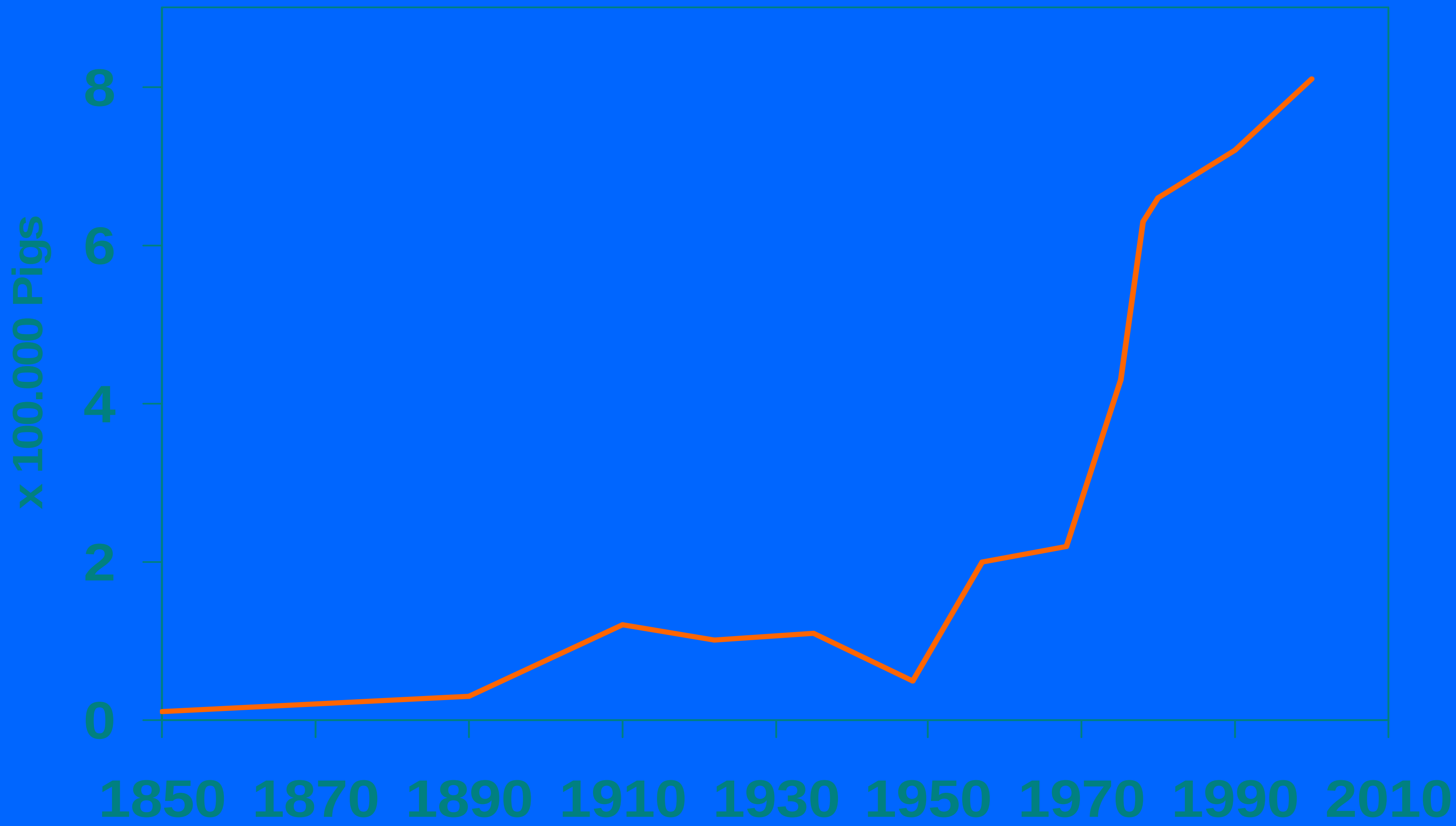
Manure type / Type of animal	liquid	liquid manure amount	solid	solid manure amount
Dairy cow Beef cattle, calf	60 l/d 25 l/d	44 mio m^3/a 38 mio m^3/a	10 t/a 3 t/a	21 mio t/a 13 mio t/a
Fattening pig Sow	6 l/d 15 l/d	47 mio m^3/a 12 mio m^3/a	0.8 t/a 2 t/a	2 mio t/a 0.5 mio t/a
TOTAL		141 mio t/a		36.5 mio t/a
Horse: 10 mio t/a, Sheep: 2 mio t/a				

Characteristics of Modern Animal Production

Increase in:

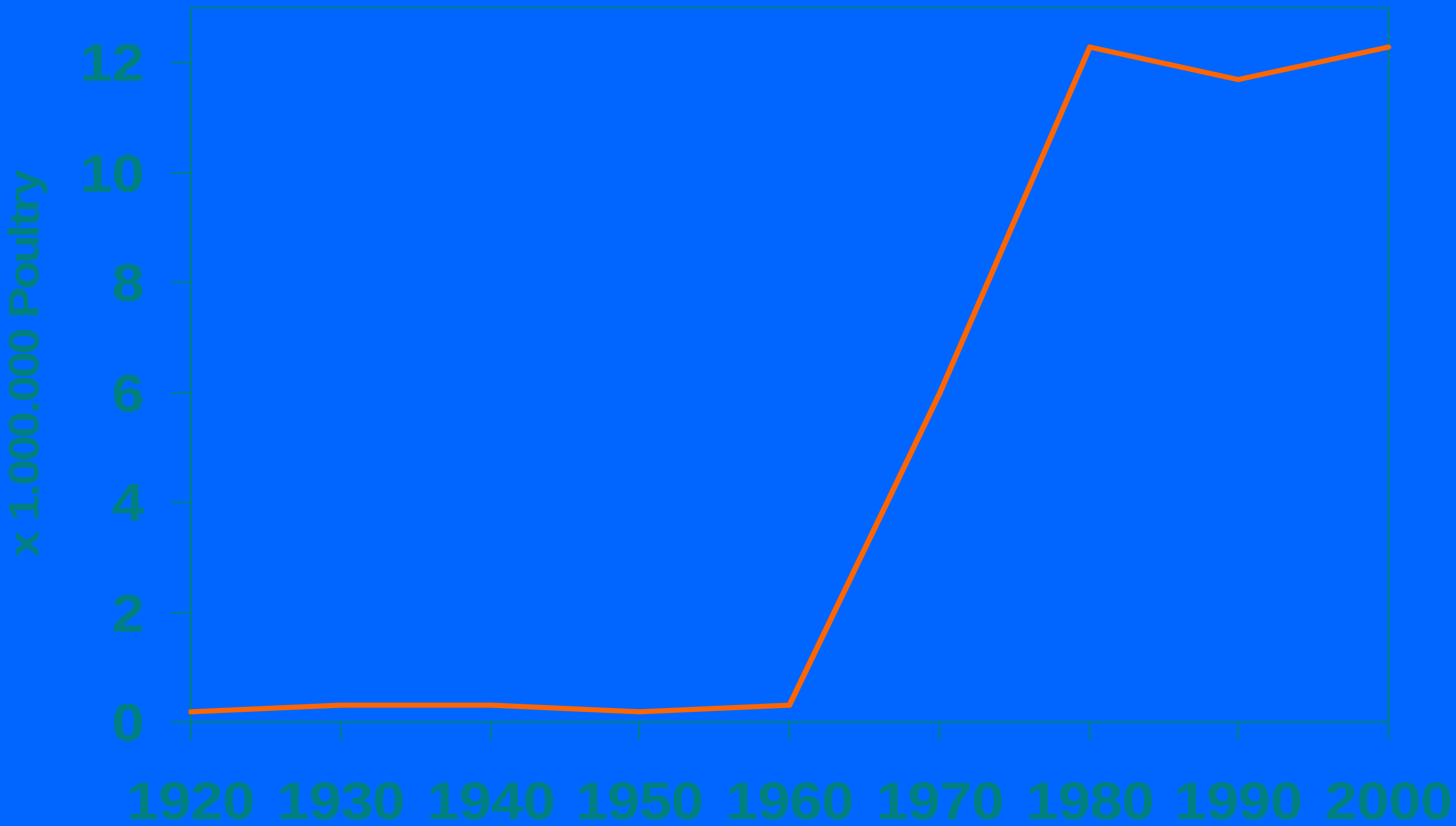
- **Intensification** of housing and management
- **Specialisation** in one species, large numbers
- **Concentration** of production in certain regions

Development of PIG production in the District of Vechta, Northwest Germany, since 1852 (area ~800 km²)



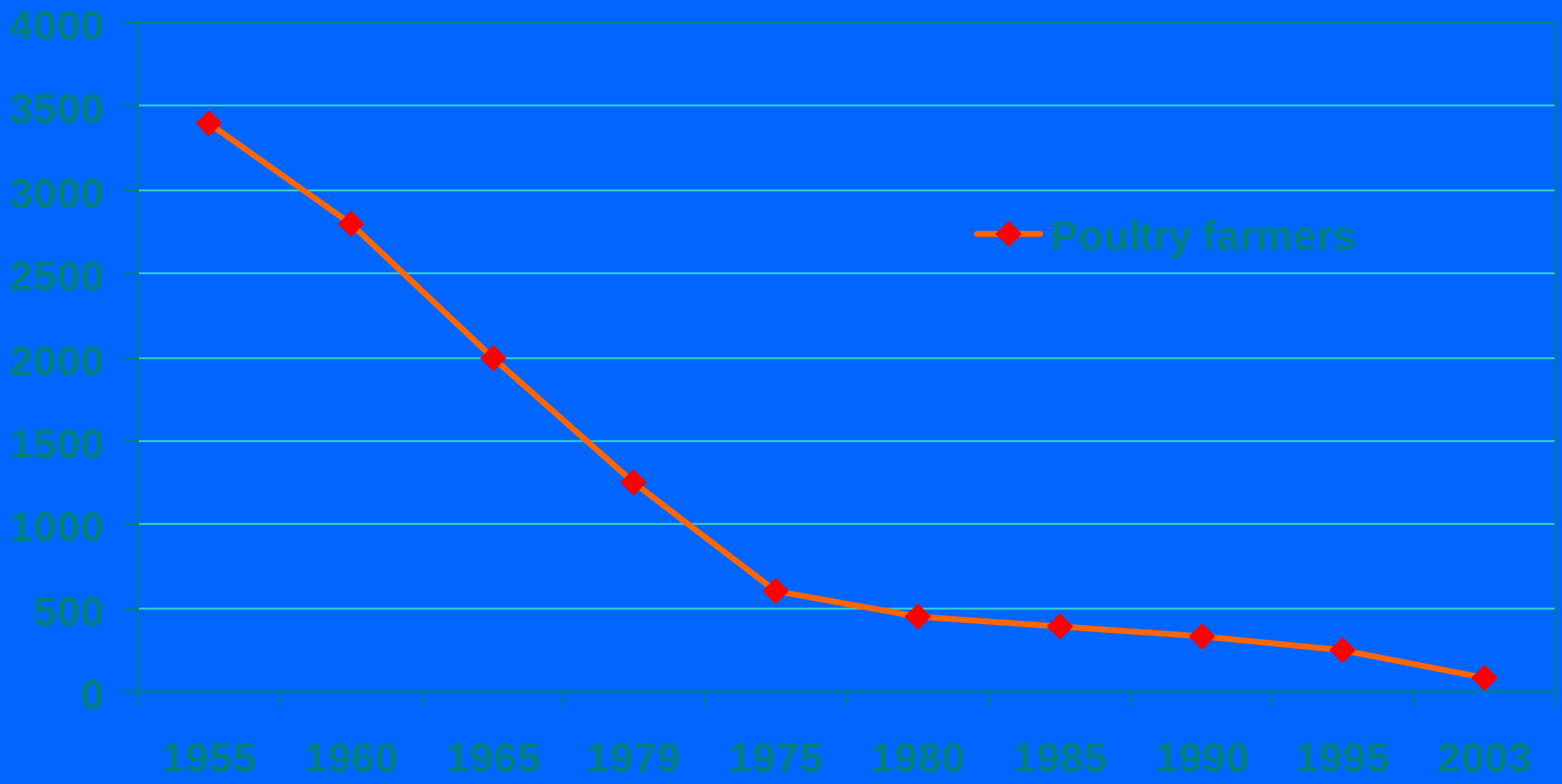
(Windhorst, 2006)

Development of POULTRY production in the District of Vechta, Northwest Germany, since 1920 (area ~800 km²)



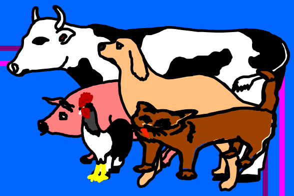
(Windhorst, 2006)

Number of POULTRY farmers in 1000 from 1955 to 2003 in Germany



(Burdick et al., 1999; Windhorst, 2005)

Institut für Tierhygiene, Tierschutz und Nutztierethologie



What are the consequences?

Growing concerns about:

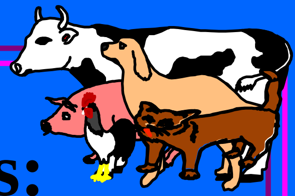
the well-being of the animals in these "*animal factories*" (animal health and welfare)

Large amounts of manure are applied to limited available agricultural land

High concentrations of aerial pollutants in these intensively operated animal houses (occupational and animal health)

High emissions of gases, dust and micro-organisms into the atmosphere of rural areas

Institute for Animal Hygiene, Welfare and Behaviour



AERIAL POLLUTANTS General Concerns:

Aerial pollutants in and from animal houses give cause for concern for several reasons. They contribute resp. can compromise:

• the respiratory health of animals indoors (pigs, poultry, horses)

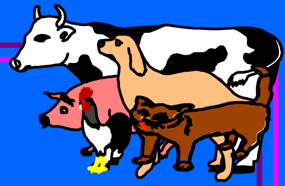
• the health of farmers working regularly in the atmosphere

• **the health of residents in the vicinity of farms by emissions**

• **to soil acidification and global warming (NH_3, CH_4, N_2O)**

• **little is known about PM 10 particles in and around livestock houses and the discharge to the atmosphere**

Institut für Tierhygiene, Tierschutz und Nutztierethologie



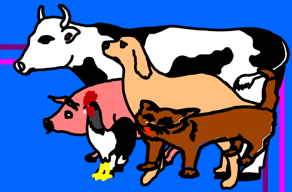
What are the Air Pollutants in and from animal housing?

Gases Ammonia, hydrogen sulfide, carbon dioxide, methane, nitrous oxide, 136 trace gases, osmogens

Bacteria 100 to 1000 CFU per litre of air
80 % Staphylococcaceae/Streptococcaceae

Dust e.g. 10 mg/m³ total dust (poultry houses)
organic components up to 90 %, *antibiotics*

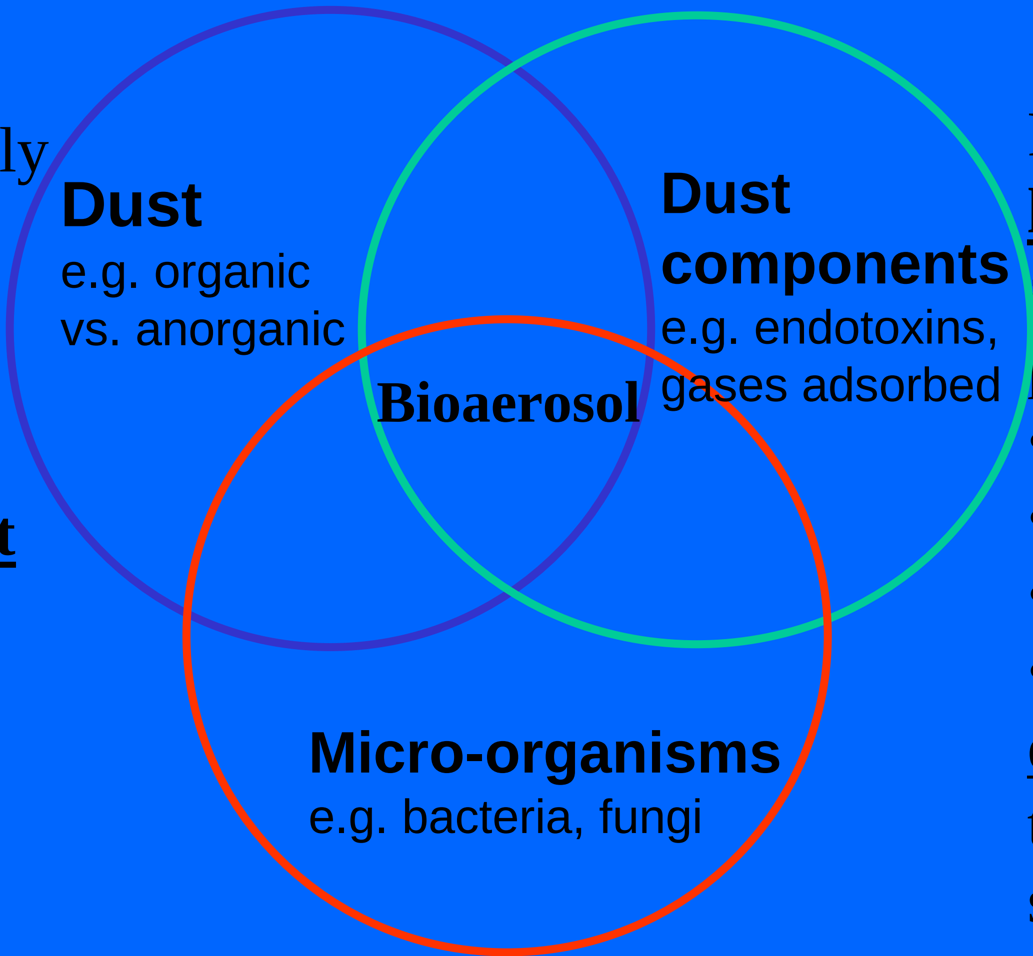
Endotoxins e.g. 5 µg/m³ (poultry houses)



Definition of Bioaerosols

Aerosol

Material finely divided and suspended in **air** or other **gaseous environment**



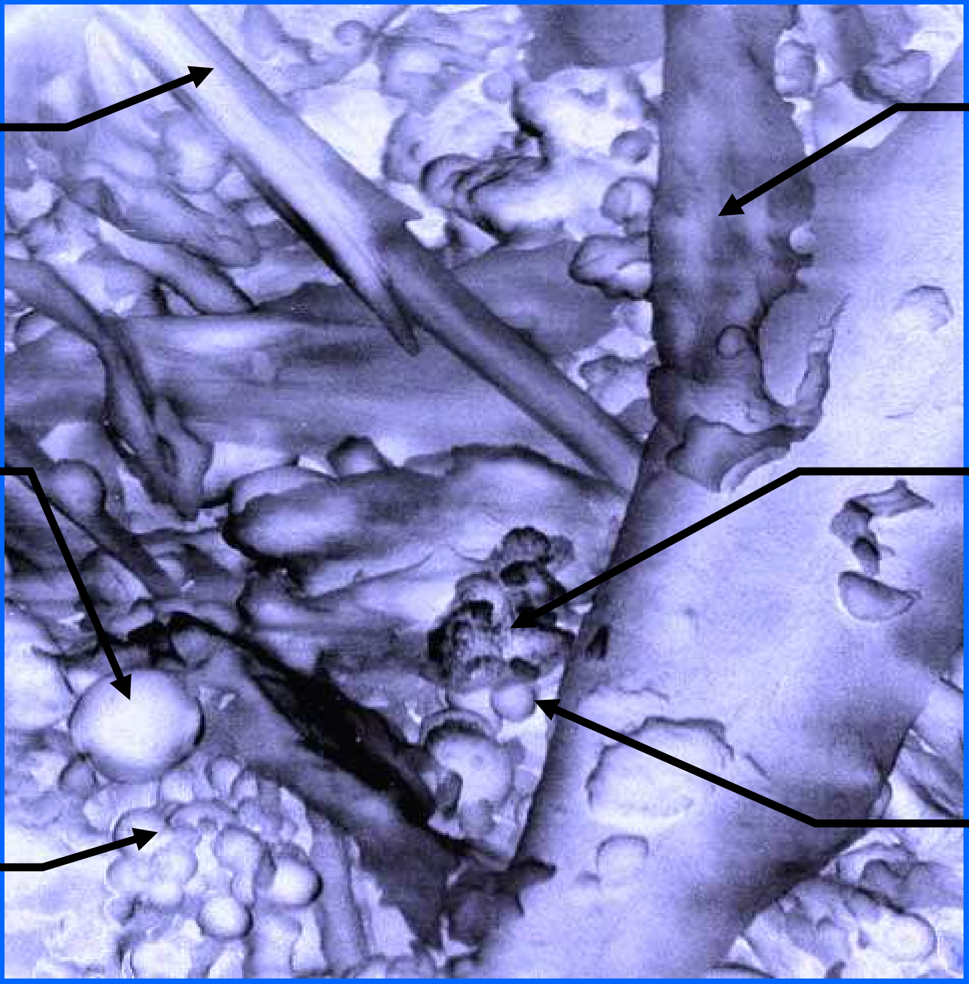
Bioaerosol

Particles of **biological origin** or activity with the potential of

- infectivity
- allergenicity
- toxicity
- pharmacological effects on living things. Particle size: 0.5-100 µm

(after Hirst 1995)

The ‚nature' of livestock dust



Dust particle from the air of a poultry barn with bacteria.
Fluorescence microscopic technique.

Health effects of bioaerosols

- **Dust particles** → **respiratory tract, eyes, skin e.g. lung clearance impaired**
- **Dust < 5 µm** → **lung affected, e.g. alveoli**
- **Microorganisms** → **infections by specific pathogens**
- **Endotoxins** → **inflammation of the airways, allergic reactions**

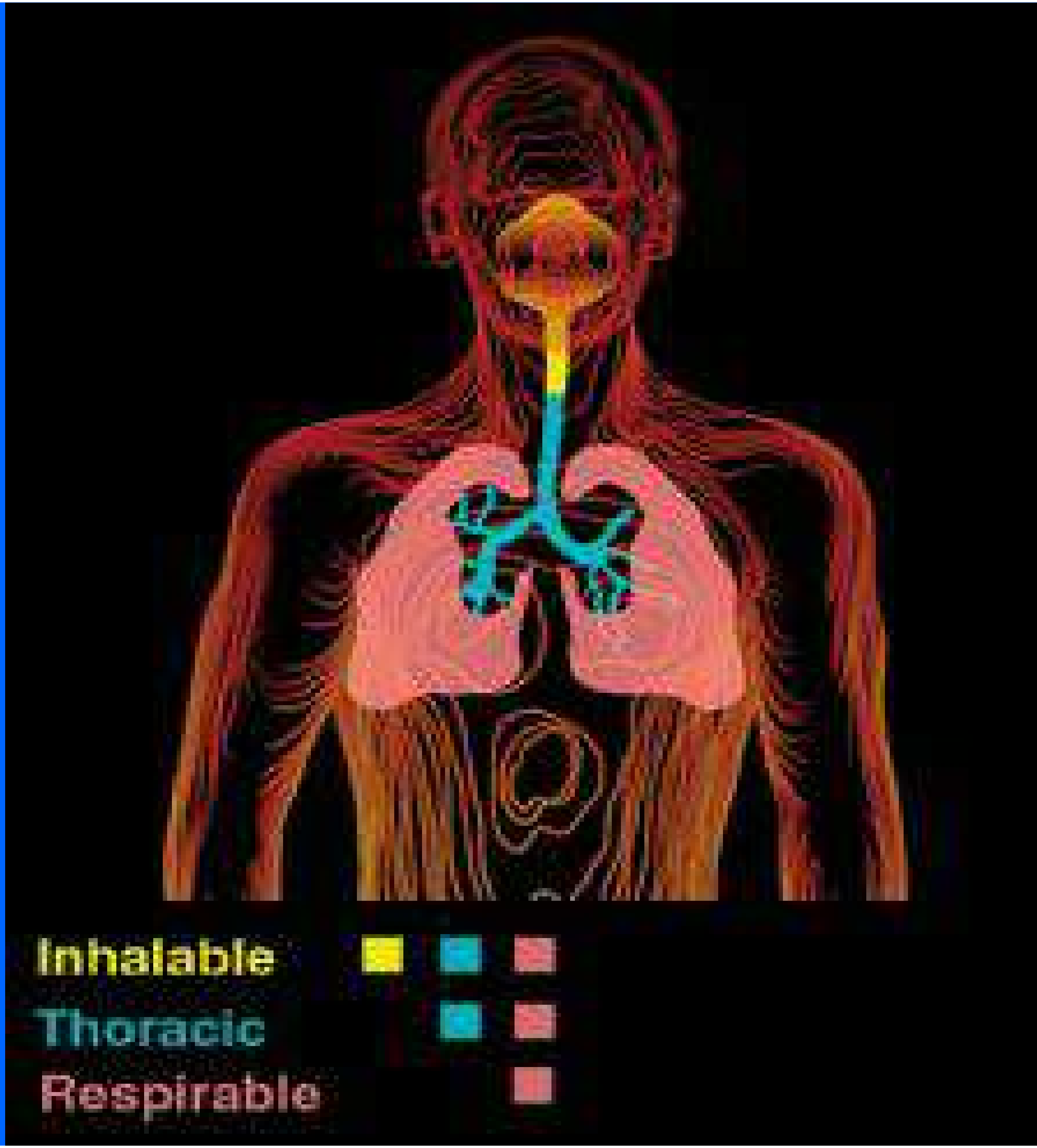
Quantitative data…

Bioaerosol Concentrations in Livestock Buildings

		Cattle	Pig	Chicken
Inhalable Dust	mg m^{-3}	**0.38**	**2.19**	**3.60**
Respirable Dust	mg m^{-3}	**0.07**	**0.23**	**0.45**
Total Bacteria	log CFU m^{-3}	**4.4**	**5.2**	**5.8**
Total Fungi	log CFU m^{-3}	**3.8**	**3.8**	**4.1**
Inhalable ETOX	ng m^{-3}	**23.2**	**118.9**	**660.4**
Respirable ETOX	ng m^{-3}	**2.6**	**12.0**	**47.5**

ETOX: Endotoxin, 1 ng equals approx. 10 EU (endotoxin units)
CFU: Colony forming units

(Seedorf et al. 1998, Takai et al. 1998; modified)


Inhalable
Thoracic
Respirable

Man can protect himself,
the animals cannot.

Air borne transmitted micro-organisms and virus in pig and poultry houses (Wathes 1994)

Bacteria

Bordetella bronchiseptica
Brucella suis
Corynebacterium equi
Erysipelothrix rhusiopathiae
Escheria coli
Haemophilus gallinarus
Haemophilus parasuis
Haemophilus pleuropneumoniae
Listeria monocytogenes
Leptospira pomona

Macobacterium tuberculosis
Mycoplasma gallispeticum
Mycoplasma hyorhinus
Mycoplasma suipneumoniae
Pasteurella multocida
Pasteurella pseudotuberculosis
Salmonella pullorum
Salmonella typhimurium
Staphylococcus aureus
Streptococcus suis type II

Fungi

Aspergillus flavus
Aspergillus fumigatus
Aspergillus nidulans
Aspergillus niger

Coccidioides immitis
Cryptococcus neoformans
Histoplasma farcinorum

Rickettsia

Coxiella burnetii

Protozoa

Toxoplasma gondii

Virus

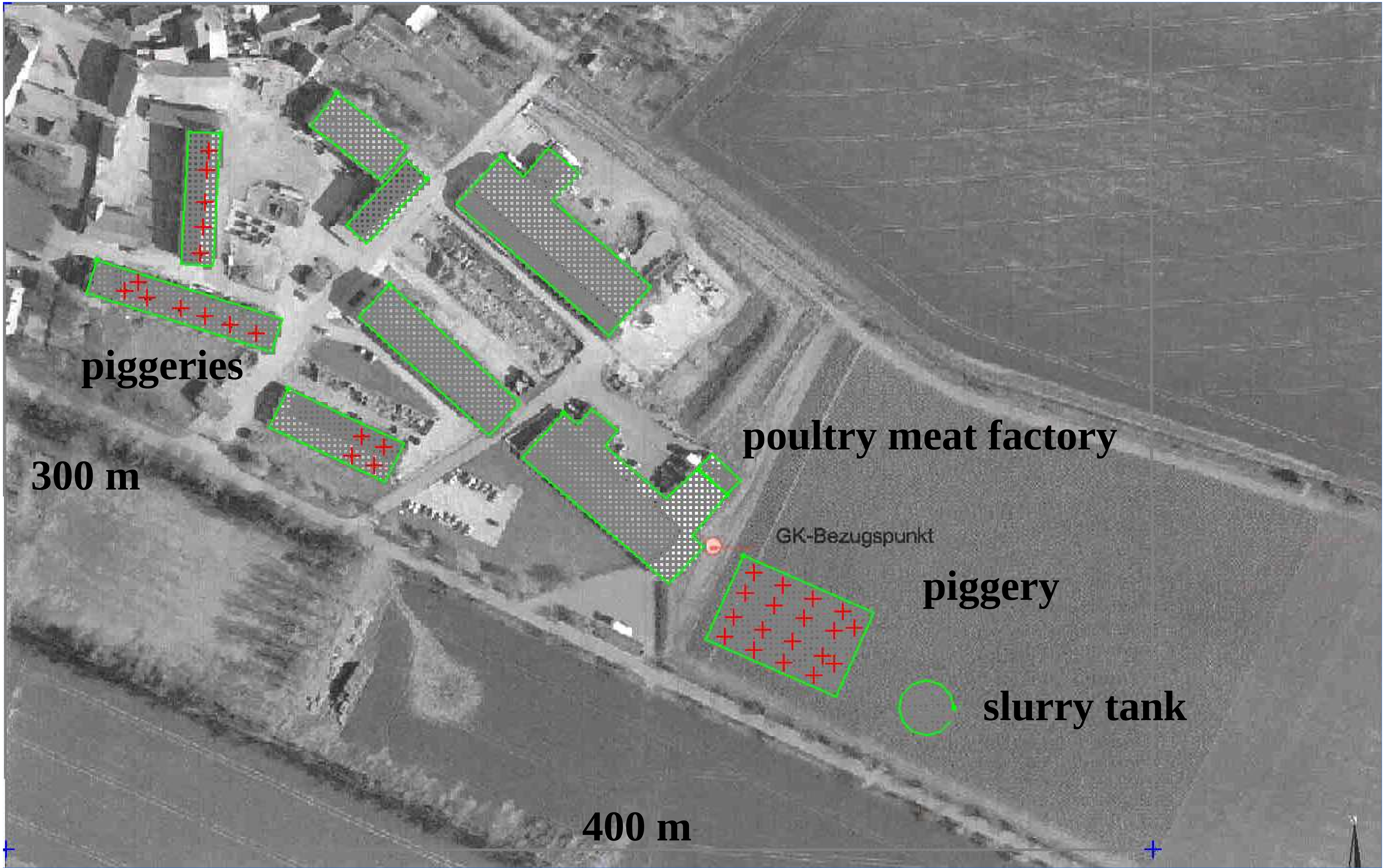
African swine fever
Avian encephalomeyelites
Avian leucosis
Foot-and-mouth disease
Fowl plague
Hog cholera
Inclusion body rhinitis
Infectious bronchitis of fowls
Infectious laryngotracheitis of fowls

Infectious nephrosis of fowls
Infectious procine encephalomyelitis
Marek's disease
Newcastle disease
Ornithosis
Porcine enterovirus
Swine influenza
Transmissible gastroenteritis of swine

An example of a „safe distance“ between a piggery and a poultry meat processing plant

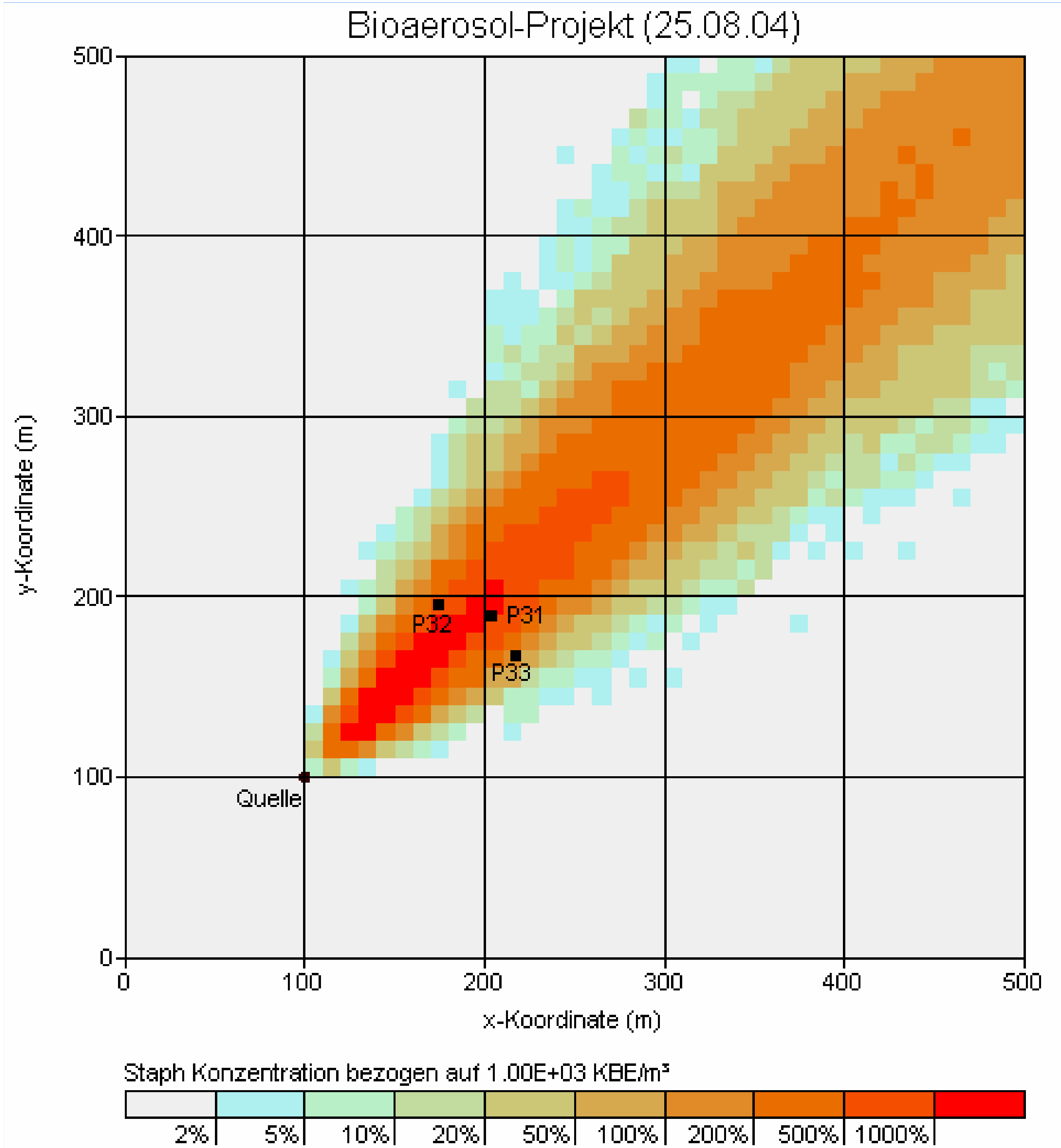
Assessment of the risk of transmission of risk bacteria e.g.

Bacillus cereus
Staph. aureus
Salmonella spp.


piggeries
poultry meat factory
300 m
GK-Bezugspunkt
piggery
slurry tank
400 m

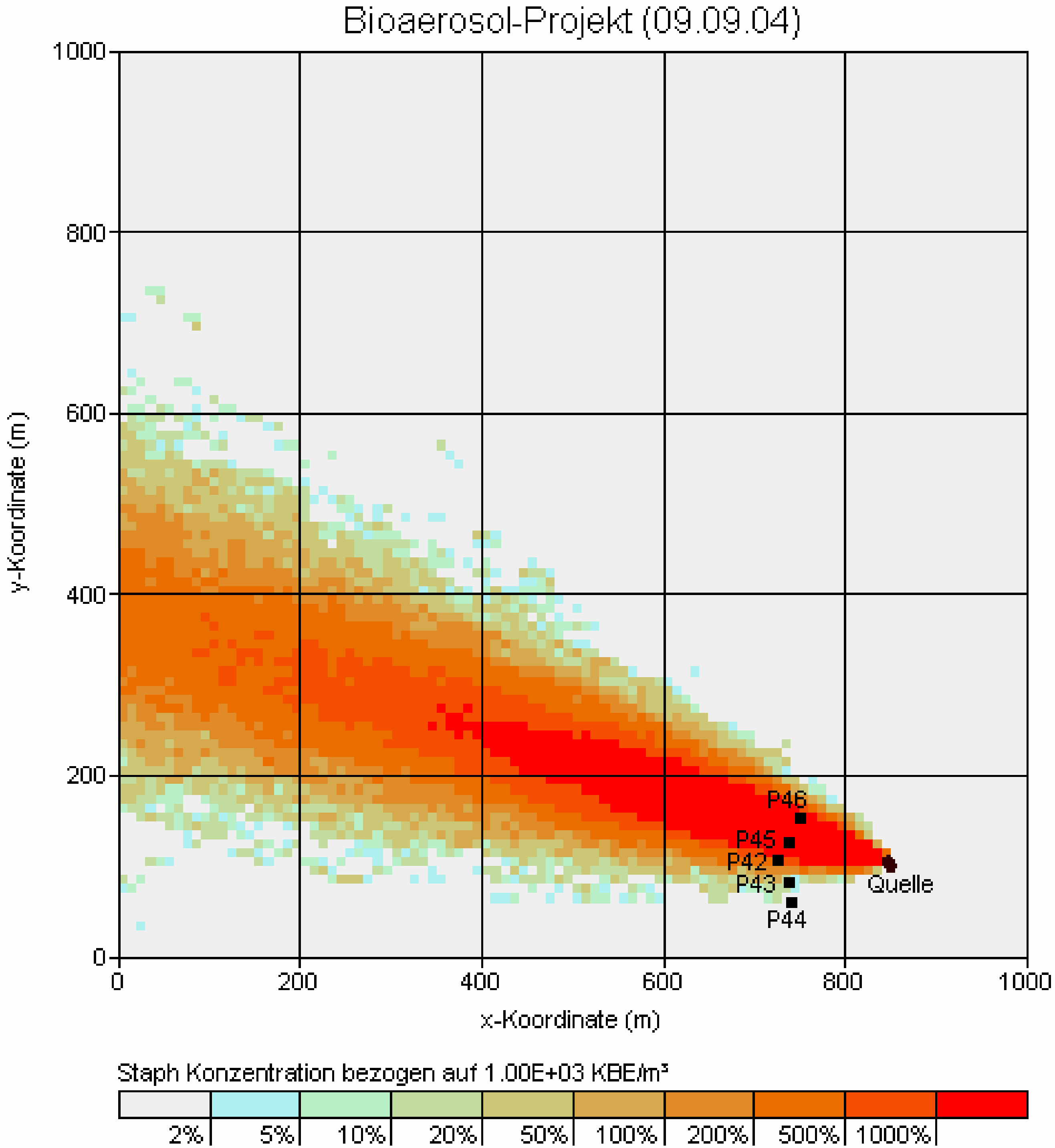
Survival times in air of some micro-organisms (nach Müller u. Wieser 1987)

Species	rel. humidity %	Air temp. °C	Half-life time min
P. multocida	87	21-24	28.69
P. multocida	87	28-34	5.34
P. multocida	70	21-34	30.74
P. multocida	70-87	40	1.72
E. coli (0:78)	55	22	70.32
E. coli (0:78)	15-40	22	27.98
E. coli (0:78)	30-40	28-34	40.95
S. newbrunswick	30	10	8.68
S. newbrunswick	70	21	34.72



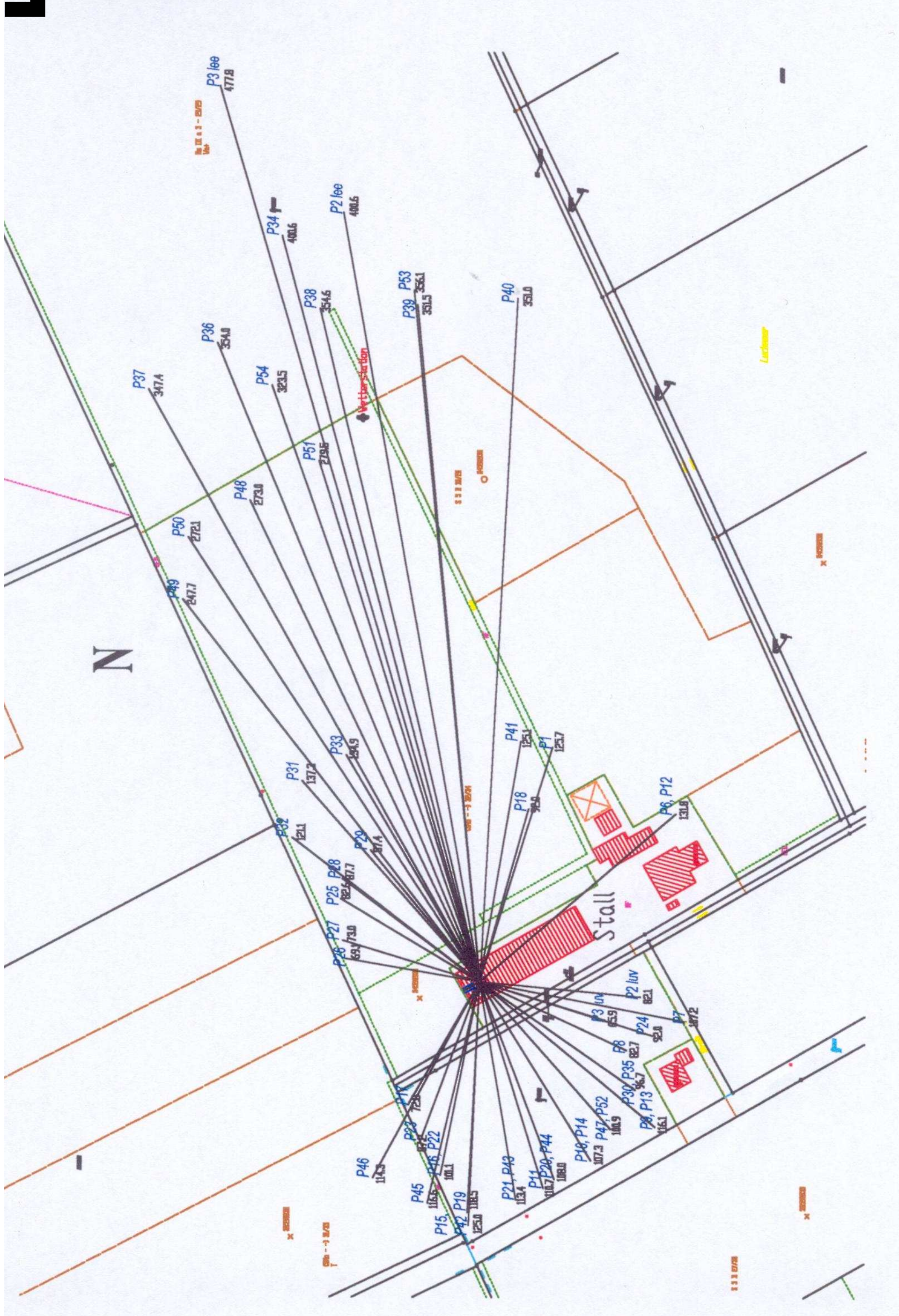
Emission and dispersion of *Staphylococcae* around a broiler farm (single source model) in main wind direction. Monitoring points P31, P32 and P33, 1,5 m above ground. Wind: 226 °, 6,3 m/s; Dispersion class: 3.1.

(4000 cfu/m³ of air in 500 m)



Emission and dispersion of *Staphylococcae* around a broiler farm (single source model) in main wind direction. Monitoring points P42, to P46, 1,5 m above ground. Wind: 108 °, 2,8 m/s; Dispersion class: 3.1.


Stall 2


N
Stall

Fine dust

EU Guideline on Air Quality 96/62/EG and amendments 99/30/EC, 2000/69/EC, 2002/3/EC define thresholds for PM 10.

	mean for	threshold µg/m³	max. no. of trespass.	Valid from
PM 10	24 h	50	35 d per y	01.01.2005
	cal. year	40	0	
	24 h	30	7	evaluation level
	24 h	50	7	01.01.2010
	cal. year	20	0	

Dust concentration close to a broiler barn (red line) and 250 m away from the barn (blue line)

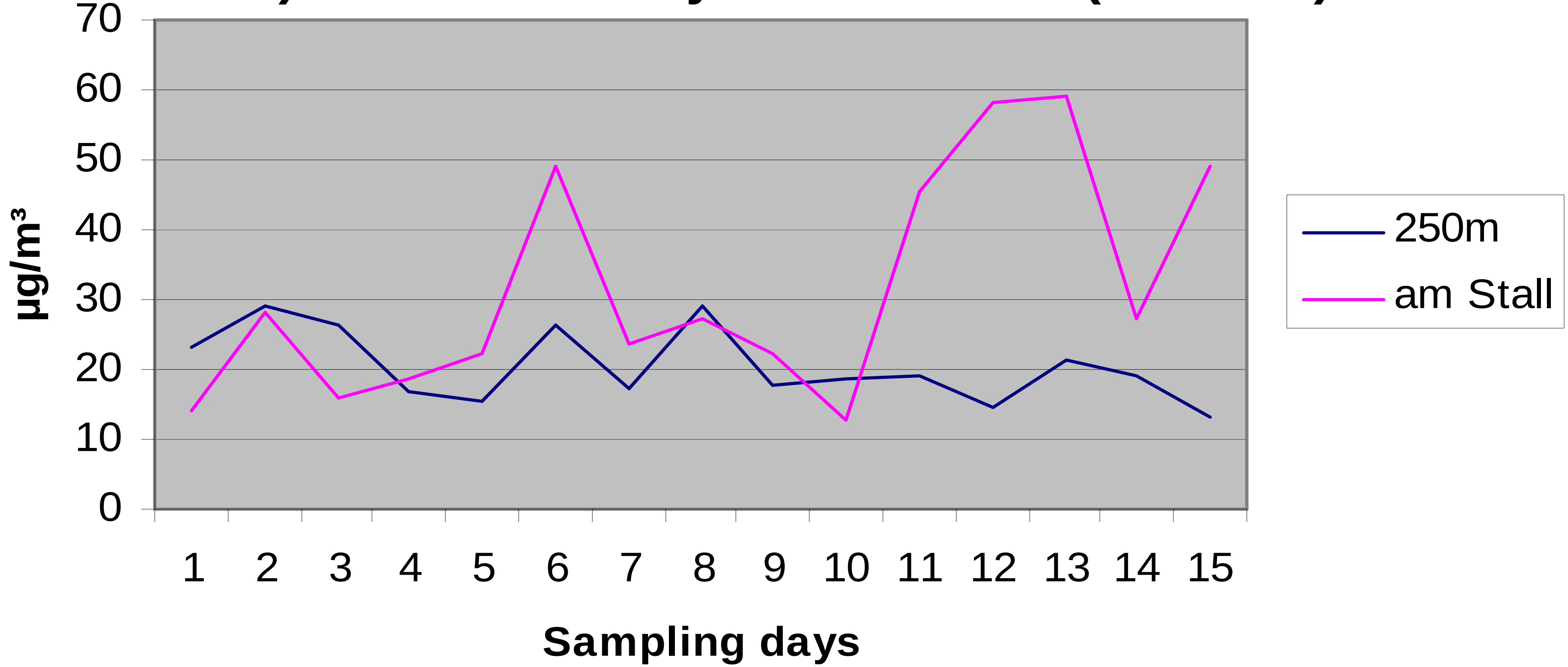


Table. 2: **Antibiotic residues in pig house dust. The values (mg/kg dust) represent the means of 2 samples, which have been corrected for mean recovery investigated in the concentration range of 0.2–1.0 mg/kg (103 ± 21% for oxytetracycline (OTC), 89 ± 21% for tetracycline (TC), 94 ± 21% for chlortetracycline (CTC), 27% ± 8% for tylosin (TYL) and 49 ± 16% for sulfamethazine (SMZ). Calculations for chloramphenicol (CAP) were based on the method of standard addition as described in Methods. Sulfamethazine was the only sulfonamide which could be detected; all other compounds were not detectable (--) in any sample and therefore not shown in the table.**

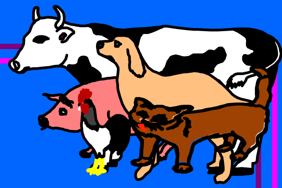
Sampling year	OTC [mg/kg]	TC* [mg/kg]	CTC* [mg/kg]	TYL [mg/kg]	CAP [mg/kg]	SMZ [mg/kg]	Sum [mg/kg]
1981	1.10	--	--	0.42	--	1.85	3.37
1982	0.18	--	--	0.09	--	0.06	0.33
1983	--	0.19	2.12	5.65	--	2.90	10.86
1984	--	--	--	--	--	--	--
1985	--	--	--	--	--	--	--
1986	--	--	--	12.18	--	0.32	12.50
1987	--	--	--	8.72	--	0.39	9.11

(from Hamscher et al. 2003 in Environ Health Perspectives)

A few remarks

on *green house gases* and animal production

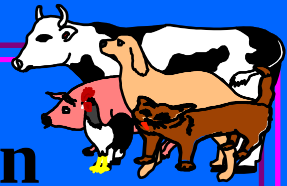
Institut für Tierhygiene, Tierschutz und Nutztierethologie



Some gas concentrations in the atmosphere

Substance/Compound	CO_2	CH_4	N_2O
Pre-indust. conc.	280 ppm	700 ppb	270 ppb
Conc. in 1998	365 ppm	1745 ppb	314 ppb
Rate of change/yr.	1.5 ppm	7.0 ppb	0.8 ppb
Atmosph. lifetime yr.	5 - 200	12	114

Source: McBean et al. (2001)



Amount of ammonia emission (estimated in million tons)

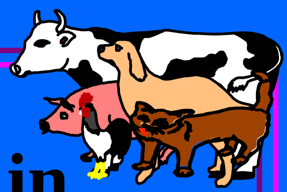
Ammonia: 23 - 88 Mt global

20 - 61 Mt livestock

Cattle	ca. 60 %
Pig	ca. 25 %
Poultry	ca. 10 %

Stall/Storage: 35 %, Storage: 10 %, Grazing: 15 %

Application: 40 % ***($C0_2$ equivalent: 3.1)***



Amount of Methane emission (estimated in million tons)

Methane: **535 Mt global** **(swamps <237 Mt yr^{-1}, rice, mining, oil-, gas exploitation, others)**

Burning 923 kt (28%)
Wastes 794 kt (24%)

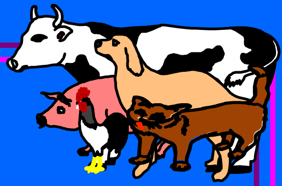
103 Mt animal husbandry (animals, feces)

Cattle	**130 - 290 g/LU d^{-1}**	**1.6 Mt yr^{-1} (D)**
Pig	**10 - 20 g/LU d^{-1}**	**0.18 Mt yr^{-1} (D)**
Poultry	**10 g/LU d^{-1}**	**0.35 Mt yr^{-1} (D)**

Depending on nutrition and keeping system

($C0_2$ equivalent: 21)

Institut für Tierhygiene, Tierschutz und Nutztierethologie



Amount of nitrous oxide (estimated in million tons, Mt; LU=Livestock Unit; pl. = place)

Distickstoffoxid: **17.7 Mt global (natural up to 10 Mt yr $^{-1}$, microbial processes in soil)**

In D (1999): Agric. 83 kt (59%)
Traffic 18 kt (13%)
Industry 12 kt (9%)
Burning 12 kt (9%)

8.0 Mt anthropogen

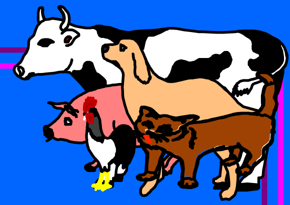
6.2 Mt from animal husbandry

Cattle		**0.8- 2.0 g/LU d $^{-1}$**	**0.01 Mt yr $^{-1}$ (D)**
Pig	**0.02-3.7 kg/pl. yr $^{-1}$**	**(0.4-73 g/LU d $^{-1}$)**	**0.65 Mt yr $^{-1}$ (D)**
Poultry	**0.042 kg/pl. yr $^{-1}$**	**(29 g/LU d $^{-1}$)**	**0.99 Mt yr $^{-1}$ (D)**
Total			**1.65 Mt yr $^{-1}$ (D)**

(C0 $_2$ equivalent: 310)

Assessment of some compounds emitted from animal farming

Compound	environmental impact					
	local	regio	globa	low	med	high
GASES						
CO_2	-	-	-	x	-	-
NH_3	xxx	xx	x	-	xx	-
CH_4	-	-	xxx	-	-	xxx
N_2O	-	-	xxx	-	-	xxx
NUTRIENTS						
Nitrate	x	x	(x)	-	xx	-
Phosphate	x	x	(x)	-	xx	-
Cu/Zink	xx	xx	(x)	-	x	xx
BACTERIA	xxx	x	(x)	-	x	x?
Dust	xx	x	(x)	-	x	-
Fine dust	xx	xx	xx		x	xx?
DRUGS	xx?	xx?	x?	-	x?	x?



Conclusions

1. **Modern animal production is expanding worldwide, pig and poultry production in particular.**
2. **At the same time it faces increasing consumer concerns in view of the welfare of the animals and <u>environmental pollution.</u>**
3. **Effluents with high concentrations of substances such as nitrate, phosphate, heavy metals and possibly antibiotics in manure are mounting in certain regions in the world.**
4. **Air pollutants such as gases, dusts, micro-oganisms and endotoxins pose a risk for the health and well-being of the animals and the farmers indoors and are the reason for complains in residential areas.**
5. **Dust emission contributes to the PM 10 budget of the atmosphere in rural areas. CH4 and N2O contribute to global warming.**

Future needs

1. The development of animal friendly and low emission housing systems should be encouraged including mitigation techniques, eg. strict housing hygiene, end of pipe techniques such as biofilters, bioscrubbers, covered manure pits and shallow manure application or the new opportunities for biogas.
2. There is an urgent need to create an understanding of “safe distances” between farms and to residential areas to prevent transmission of infectious agents and harmful substances. This should become an essential part of local and regional planning.
3. Adequate and efficient feeding regimes and the use of manure are required with minimal wastage of nitrogen and phosphorous.

Future needs

5. The environmental risk analysis should be further improved including new emerging compounds, not only in Europe but in different regions in the world, contributing to environmental standards for animal production.

6. For the realization of these aims the cooperation of farmers, agricultural engineers, veterinarians and governmental agencies is necessary.

Because:

The story is not yet finished. New compounds are waiting for our Close (and caring) attention

fine dust, fate of drug residues and nanoparticles.

Hygieia

Environmental hygiene

Hygieia by Gustav Klimmt

HYGIEIA is not only a beautiful girl, it teaches us also to maintain the environment which contains all the elements such as air water and soil which are essential for our and our animal`s life. That may be difficult sometimes, but I am sure she will help us with her long standing experience – when we listen to her.

Thank you
for
your attention

Sustainable Animal Production

Welfare and protection

Animal & Man

Product safety and quality

Consumer demands

Protection Ecology

Environment

Economy

Thank you for your attention