Health risks for dairy cows drinking surface water contaminated by sewerage overflows*

Gerwin A.L. Meijer[1], J. de Bree[2], J.A. Wagenaar[3], S.F. Spoelstra[1]

DLO - Institute for Animal Science and Health, [1] Department of Ruminant Nutrition, [2] Department of Immunology, Pathobiology and Epidemiology, [3] Department of Bacteriology; PO Box 65, 8200 AB Lelystad, The Netherlands

Introduction

Approximately 50% of the dairy farmers in the Netherlands use surface water as the main source of drinking water for their cows, especially during the grazing season. With increasing population density, the quality of surface water may be affected by sewage effluents, particularly from sewerage overflows that discharge untreated sewage into surface water. These overflows are designed to discharge approximately 7 times per year when supply of sewage is larger than the storage and transport capacity of the sewerage. Overflows occur mainly during heavy rainfalls in the grazing season, and may have a dramatic effect on the quality of the surface water, especially when these are small ditches with a low water flow (de Zwart & Luttik, 1989). After discharge of a sewerage overflow, surface water may have increased concentrations of nutrients, heavy metals, chemical compounds like PAC's, organochloric compounds, detergents, mineral oil, and micro-organisms including pathogens like Cryptosporidium and Giardia (de Zwart & Luttik, 1989; Medema & Ketelaars, 1995). Also, increased concentrations of endocrine disrupting compounds may be expected, such as: natural hormones (estradiol and estrone), ethinylestradiol from anticonceptives, and chemicals as PCB's, ftalates, and alkylphenols. All these compounds may affect health and fertility of animals drinking this water (WHO, 1989). The exposure of dairy cattle to endocrine disrupting compounds is not known. Physiological responses of dairy cattle to endocrine disrupting compounds have been reported at exposures of 300 to 3000 µgeq/d (Groot, pers. communication; Nwannenna et al, 1994).

Approximately 12,000 sewerage overflows exist in the Netherlands and the cows of 1 of every 20 dairy farmers may be at risk (Kuipers, 1996). However, it is not known to what extent the health of cows drinking surface water in direct contact with sewerage overflows is affected. Also it is not known what the potential contributions of different compounds in surface water are to the health risks of dairy cows. The objectives of this study were to assess the risk of impaired production and fertility of dairy cattle due to their drinking surface water in direct contact with a sewerage overflow, and to estimate the possible contributions of different contaminations to this risk. For the current presentation, the latter part is focussed on the risks associated with endocrine disrupting compounds.

Material and methods

Production and fertility data of heifers and cows exposed or not exposed to surface water in contact with a sewerage overflow were compared using a one-sided student-t-test for the hypothesis that the exposure to water that has direct contact with a sewerage overflow impairs production and fertility. P-values < 0.10 were considered statistically significant. Data for the comparison were obtained from two different sources. Data about the type of water used as drinking water for the cows, and whether this water was in direct contact with a sewerage overflow or not, were taken from the 1995 annual inquiry on grassland utilisation (Kuipers, 1996). From the data of 1783 respondents, we first selected farms with lactating dairy cows (n = 1274). Further, we selected farms where surface water (n = 294), or a combination of surface water and ground- or tap water (n = 344) was used. From this group (n = 638), we selected the farms of farmers who knew whether the surface water was, or was not, in direct contact with a sewerage overflow (n = 508). The postal codes of these farms were then used to select production and fertility data of the cows on these farms from the Royal Dutch Cattle Syndicate (NRS).

Using the NRS data about individual milk production, dates of birth, inseminations, calving and death of individual cows, standardised parameters of production and fertility were calculated in relationship to the exposure during the grazing season of 1995.
Content and potency of endocrine disruptive compounds in water and feed were obtained from literature and used to calculate their equivalence with estradiol in µg/l or µg/kg according to Safe (1995). Exposure to estrogen equivalents was calculated for a worst-case scenario. This represented a dairy cow with an intake of 100 l/d of surface water in direct contact with a sewerage overflow and an intake of 25 kg/d of a dairy ration containing 5% of soybeans and 10% of white clover.

Results

Standardised milk production was 0.9 L/d lower on farms that used surface water in direct contact with a sewerage overflow (Table 1). There were no differences in the number of cells in milk, indicating that health of the mammary gland was not influenced.
Age at first and at successful insemination was on average 11 days greater for heifers drinking surface water in contact with a sewerage overflow than in other heifers, though this difference was not significant (Table 1). The number of inseminations required for pregnancy was equal in both groups. Heifers in the exposed group that calved in the first half year after the grazing period were significantly older at first calving ($P < 0.01$; Table 1). The difference was almost three weeks. The age at first insemination and number of inseminations were the same in both groups, suggesting that exposure to surface water in direct contact with a sewerage overflow lengthened the pregnancy period of heifers, possibly by slowing growth of the foetus.
There was no difference between exposed and control cows in the interval of calving to first insemination, the interval of calving to successful insemination, number of inseminations required for pregnancy and percentage of abortions (Table 1).

Table 1. Farm averages of production and fertility parameters of heifers and dairy cows as affected by exposure to surface water in direct contact with a sewerage overflow.

Parameter	Water in contact with Sewerage Overflow yes	no	Difference	*P*	95% confidence limit
Number of farms†	50-60	287-397			
Heifers:					
Age at first insemination (d)	523	512	11	0.12	> -5
Age at successful insemination (d)	543	532	11	0.13	> -5
Number of inseminations	1.61	1.65	0.04	0.62	> -0.23
Age at first calving (d)	804	784	20	< 0.01	> 6
Cows:					
Standardised milk production (L/d)	35.9	36.8	-0.9	0.09	< 0.2
Standardised cell numbers in milk	1.18	1.15	0.03	0.37	> -0.14
Calving to first insemination (d)	89	93	-4	0.79	> -11
Calving to successful insemination (d)	128	124	4	0.14	> -2
Number of inseminations	1.80	1.79	0.01	0.41	> -0.09
Abortions (%)	8.3	7.1	1.2	0.12	> -0.47

† Exact number depends on the parameter analysed.

Estimated intake of endocrine disrupting compounds from water was lower than intake of phyto-estrogens from feed (Figure 1). In contaminated water, glucuronidated estradiols and ethinyl-estradiol represented a higher risk than chemical compounds. This result is based on the assumption that rumen microorganisms can reactivate the glucuronidated estradiols. Total exposure to endocrine disrupting compounds through water and feed may equal 500

µgeq/cow.day. However, there is much uncertainty as to the metabolism and potency of endocrine disrupting compounds in ruminants. The potency could easily be under- or overestimated by a factor 10.

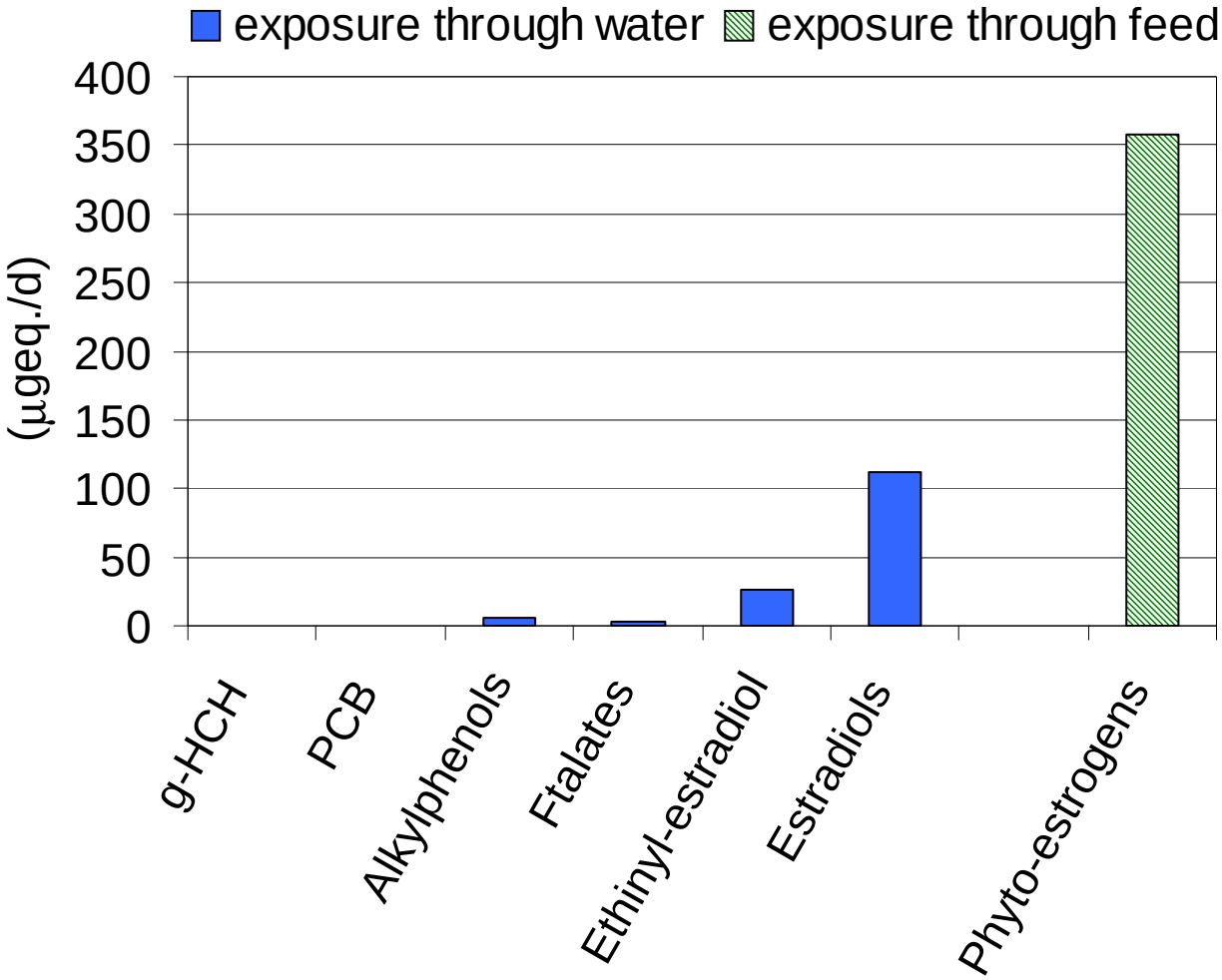

Figure 1. Estimated exposure of dairy cows to endocrine disrupting compounds from surface water contaminated by a sewerage overflow and from feed.

Discussion

Our study showed impaired milk production and fertility of cows on farms where surface water in direct contact with a sewerage overflow was used as the main source of drinking water for the cows. This finding is in line with recent findings in small wildlife rodents in the Netherlands that showed more histological abnormalities in reproductive organs when they were exposed to contaminated water (Bosveld, 1998, unpublished).

Currently, it is not known which factors are the underlying causes for these effects. The causes for impaired production are probably different from the ones causing the fertility problems. In a more extended study (Meijer et al. 1997) we identified endocrine disrupting compounds as one of the most likely causative agents in sewerage, together with sulphur and nitrogen compounds, and pathogens like *Vibrio cholera*, Giardia and Cryptosporidium.

Our estimates showed that exposure of dairy cattle to endocrine disrupting compounds from the environment might more or less equal the exposure through feed. This level of exposure to endocrine disrupting compounds may be expected to affect fertility in dairy cattle.

However, many uncertainties about endocrine disrupting compounds remain to be solved. These include uncertainties about their concentrations in small surface waters as well as

about their origin, about their metabolism in the rumen and their potency in dairy cattle. Impaired fertility is one of the major problems of dairy farming systems. Therefore, a co-operative, multi-disciplinary approach is needed to elucidate the role of endocrine disrupting compounds on reproductive health of farm animals.

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