Microbial load of tributaries to drinking-water reservoirs stemming from different catchment areas

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1. Introduction

Surface water reservoirs are the main sources of drinking-water supply in some regions of Germany. However, those reservoirs may easily be affected by microbial contamination.
The occurrence of pathogenic micro-organisms in drinking water is of significant hygienic interest. Especially some parasites have been an important cause of waterborne diseases worldwide during the last decades due to their resistance against disinfection and environmental distress. There is still a lack of knowledge concerning possible ways of contamination of surface water with pathogens and their persistence in watercourses.
The State Ministry of Environment of Nordrhein-Westfalen instructed the Institute of Hygiene of the University of Bonn to carry out an investigation of three tributaries to drinking water reservoirs, which have different landuse patterns in their catchment areas.
Besides the quantative determination of bacteria and parasites one of the main goals was to work out the geoecological aspects of the different catchment areas and their implication on microbial contamination of surface water.

2. Methods

In total **155** water samples were regularly collected from 16 points within 13 months (1/1997 to 1/1998). In addition to the regular monitoring **32** samples were also taken during heavy rain fall. The sampling includes the outflow of 2 sewage plants as well (s. tab. 1).

All water samples were analyzed for physico-chemical, bacteriological and parasitological parameters. Besides the faecal indicator bacteria of water quality ***(E. coli, coliform bacteria, faecal streptococci, clostridia)*** pathogens were also examined, which could cause infectious diseases when they are present in drinking water (WHO 1993) like pathogenic ***Salmonella spp., Yersinia spp., Campylobacter spp., E. coli O 157:H7*** and the parasites ***Giardia lamblia*** **and** ***Cryptosporidium parvum.***

Table 1 Selected investigation areas and places of water samples

No. (P-)	Place of water sample	Catchment area
P-1	Nauholzbach water gauge	Obernau reservoir
P-2	Kall water gauge	Kall reservoir
P-3	Entenpfuhl	Kall reservoir
P-4	Hoscheit	Kall reservoir
P-5	Bruchgraben	Kall reservoir
P-6	Fischbach	Kall reservoir
P-7	Kall in front of Paustenbach	Kall reservoir
P-8	Paustenbach	Kall reservoir
P-9	rain overflow basin Rollesbroich	Kall reservoir
P-10	Roßbach	Kall reservoir
P-11	Domäne Drainage	Kall reservoir
P-12	Keltzerbach left tributary	Kall reservoir
P-13	Keltzerbach	Kall reservoir
P-14	Wahnbach water gauge	Wahnbach reservoir
P-15	sewage plant "Hillesheim"	Wahnbach reservoir
P-16	sewage plant "Niederkassel"	(river Rhine)

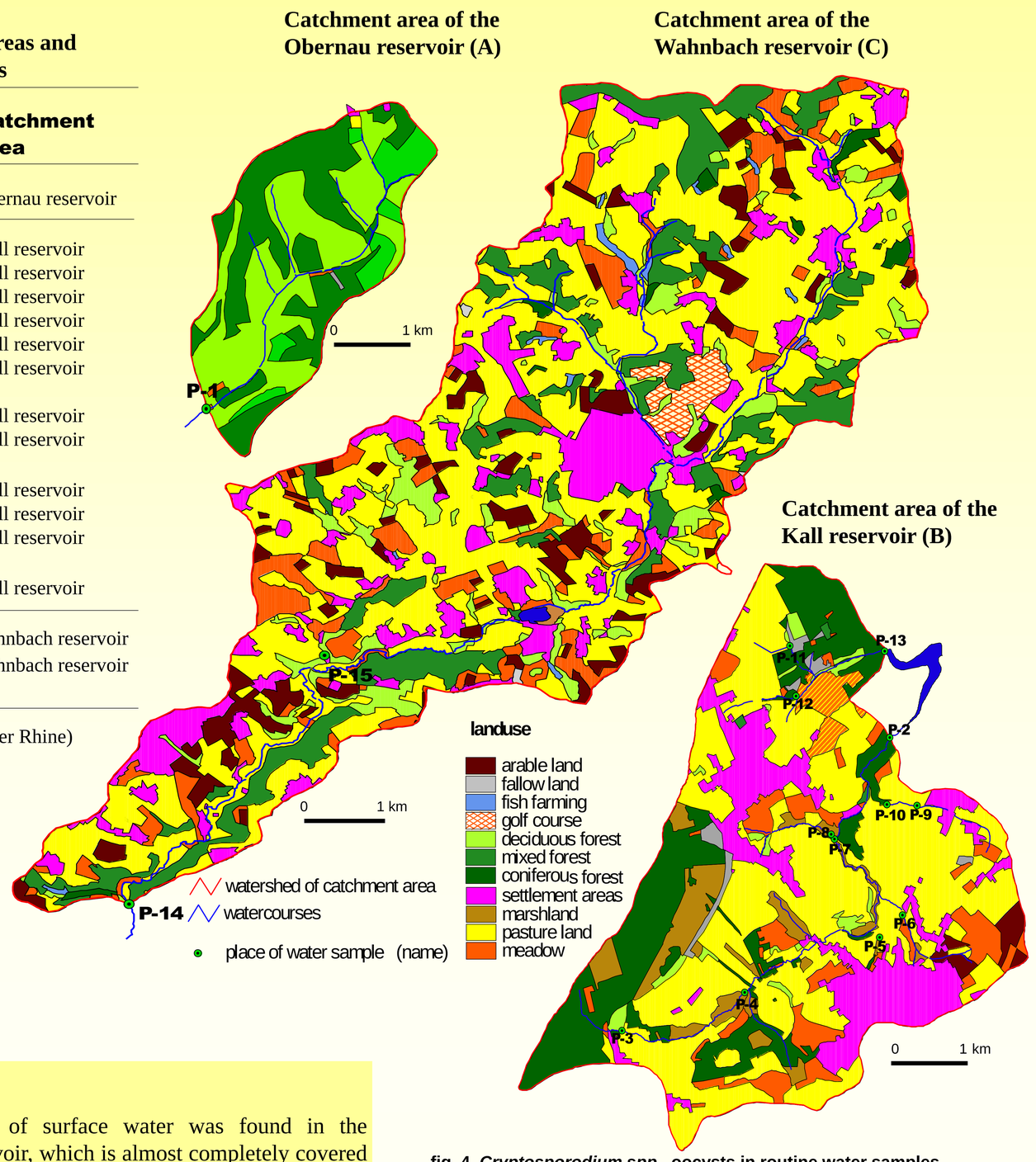


fig. 1 *E. coli* in routine water samples

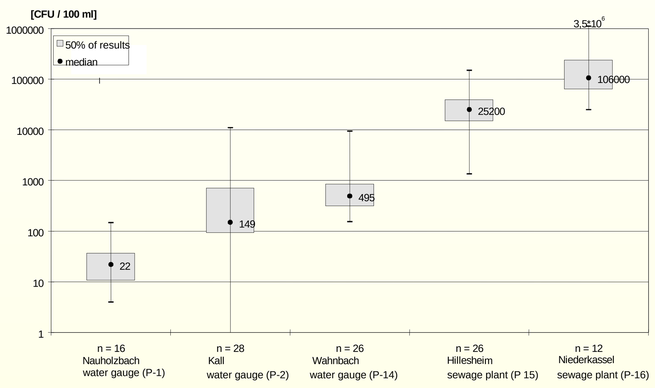


fig. 2 Coliform bacteria in routine water samples

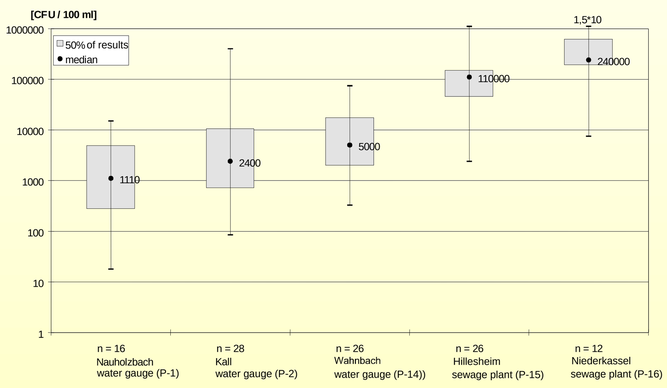
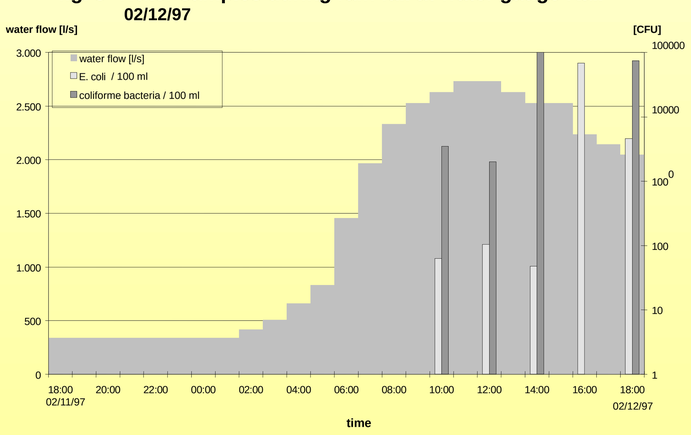


fig. 3 Water samples during rain fall at water gauge Kall 02/12/97



3. Results

The lowest microbial contamination of surface water was found in the investigation area of the Obernau reservoir, which is almost completely covered with forest (98 %) and not affected by settlement areas or agricultural use. The catchment areas of the Kall and Wahnbach reservoir are both characterised by intensive agriculture (pasture lands for dairy farming) and settlement areas. However, the wastewater is mainly piped out of the Kall area (B), whereas in the Wahnbach area (C) the treated wastewater is led into the river before the reservoir. The bacteriological analysis of water samples in these regions resulted in similar concentrations, which does indicate faecal contamination (fig. 1 and 2). *Campylobacter spp.* and *Yersinia spp.* were unfrequently found at all places of water samples, even at Nauholzbach. *E. coli 0 157:H7* could not be quantified in any sample. The outflows of both sewage plants showed higher concentrations of bacterial loads as the watercourses.
Cryptosporidium spp. oocysts were frequently detected in all samples of the different tributaries, *Giardia* cysts less. However, the outflows of the sewage plants showed increased levels of giardia cysts (fig. 4 and 5). Related to the watercourses the concentration of microbial parameters, especially the parasitic load, increased to maximum values during heavy rain fall. Even water samples from areas unaffected by agriculture and settlement showed higher levels of micro-organisms in case of precipitation (fig. 3 and 6).

4. Discussion

The microbial load of the different tributaries to the drinking water reservoirs correlates with the landuse patterns of their catchment areas. We found in all investigated areas faecal pollution of the surface water, which may increase extremely during rain fall. Temporarily the concentration levels exceed the EG-guideline values for surface water intended for bathing (EG-Richtlinie, 76/160/EWG). We also pointed out, that the sewage plants present an important source of microbial contamination to surface water.
We examined, if the guideline criterias turbidity and indicator bacteria correlate with the parasitic loads, but our results did not proof strong correlations between parasitic contamination and microbial indicators or physico-chemical parameters. However, the increased level of *cryptospridium spp.* oocysts can be correlated with agriculture (i. e. cattle), while higher concentrations of *giardia lamblia* cysts are related to human wastewater.
Our conclusion is, that it is of the utmost importance to protect catchment areas of surface drinking water supplies from human activities as a part of the multi-barrier concept which includes the reduction of diffuse and point pollution in catchment areas of water resources intended for human consumption.

fig. 4 *Cryptosporodium spp.* oocysts in routine water samples

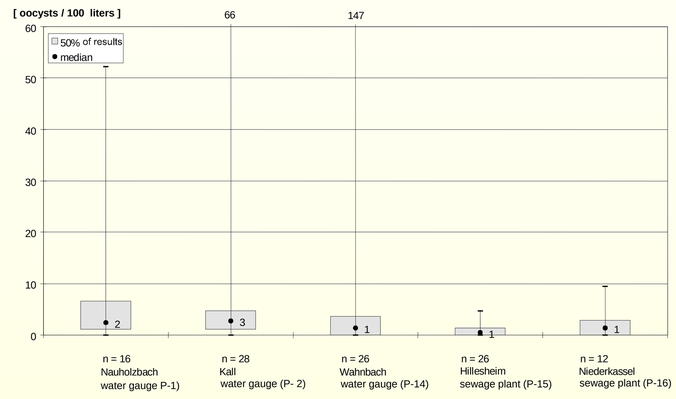


fig. 5 *Giardia lamblia* cysts in routine water samples

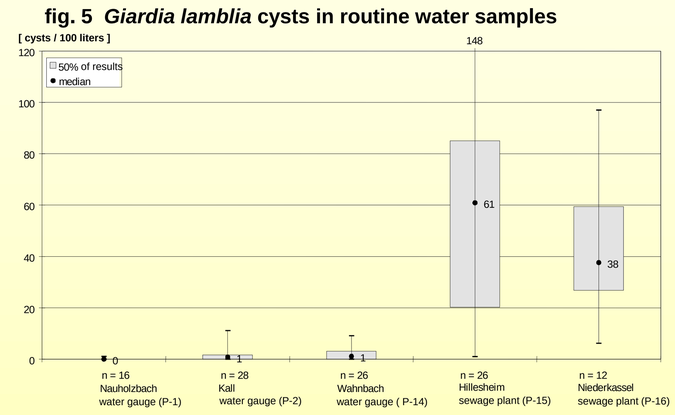
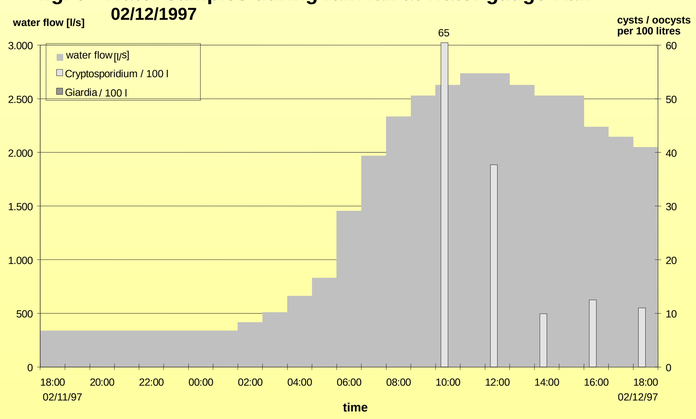


fig. 6 Water samples during rain fall at water gauge Kall 02/12/1997



5. References

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