

**Microbiological Quality of Surface Drainage Water From Three Small
Irrigated Watersheds in Southern Idaho**

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ABSTRACT

The irrigation waters applied to and the surface drainage waters leaving three small watersheds in southern Idaho were analyzed for coliforms and other microorganisms and for biochemical oxygen demand (BOD). Numbers of coliforms and fecal coliforms tended to be greater in the drainage than in the irrigation water, but the differences were generally within the confidence limits for Most Probable Numbers analyses. Fecal streptococci numbers were higher in the drainage than in the irrigation water on two of the three small watersheds. The numbers of fecal streptococci and microorganisms incubated at 20C were higher in the drainage than the irrigation water; otherwise, the bacteriological quality of the irrigation water was not significantly changed by irrigation use. BOD in the drainage water samples averaged 4 mg/liter oxygen demand compared with 2 mg/liter oxygen demand in the irrigation water.

Additional Index Words: coliforms, fecal coliforms, fecal streptococci, surface runoff.

Many claims have been made that agriculture is polluting lakes and streams with chemicals, organic wastes, and microorganisms. Of course, some microorganisms are found in almost all water. Wadleigh (7) suggested that we need information on the extent to which infectious agents in irrigation water are coming from agricultural sources. Water diverted from the Snake River in southern Idaho for irrigating agricultural land is contaminated with coliforms and other microorganisms normally associated with fecal pollution (6). Coliform bacteria may be from various origins ranging from soil to animal pollution, but much of this contamination of the water originated from sewage outfalls and food processing wastes upriver. Approximately 50% of the irrigation water used on the Twin Falls Irrigation District infiltrates the soil and emerges from natural and artificial subsurface drains (2). Smith, Douglas, and Bondurant (5) evaluated the microbiological quality of the subsurface drainage and found that soil filtration decreased the bacteria numbers in the water and improved the quality to, or almost to, domestic quality.

The influence of irrigation on bacteriological water quality can be determined by measuring changes in bacterial numbers in the water before and after passage across the surface of the soil. A few experiments have been conducted in the humid areas of the United States to determine agricultural impact on water quality using rainfall as the immediate source of water. Kunkle (3) determined base levels of coliform contamination in water from a grazed pasture and a hay field in Vermont. He reported that fecal coliforms were better indicators of animal pollution than total coliforms, that these microorganisms were greatly influenced by rainfall, and that a storm event increased the coliform numbers. Weidner et al. (8) reported runoff studies from Coshocton, Ohio watersheds and presented sediment loads and coliform counts as-

sociated with runoff. Melaney et al. (4) reported that the bacteriological quality of farm ponds in Ohio that were supplied with water from agricultural runoff was surprisingly good. The water could be used for animal watering and domestic purposes with relatively minor purification. We found no reports of bacterial water quality changes resulting from irrigation use. The research reported here was conducted to determine the influence of surface irrigation on bacteriological quality of the surface runoff water.

MATERIALS AND METHODS

Three small watersheds near Twin Falls, Idaho were selected for this study. The first was located on the Jerome-Minidoka County line approximately 0.6 km (1 mile) north of the Snake River. It received water from the Unit A main canal of the A and B Irrigation Company. The waste water flowed into a central receiving pond from the 482-ha watershed and was pumped back into the main canal below the diversion point. Approximately 0.9 m³ of water per m² of land was delivered to the project during each irrigation season. Four families resided on the watershed and two families kept livestock. Water samples were obtained at the waste water pumping station. The second watershed contained approximately 446 ha of land that received water from the Twin Falls canal, and was occupied by two residences and a few beef cattle part of the time. The land was located near the town of Hansen, and comprised parts of sections 25 and 30. The third watershed received water from a secondary irrigation lateral east of Kimberly, Idaho adjacent to U. S. Highway 30. The watershed comprised parts of sections 21, 22, 27, and 28, with an area of approximately 625 ha. The outflow sampling site was located north of Kimberly near U. S. Highway 30. Sixteen families resided on the watershed and three of these kept livestock. Approximately a 2 m depth of water was delivered to Hansen and Kimberly watersheds during each irrigation season. These sites were selected because they were each irrigated from a single canal source and had a single drainage point. Crops grown were sugarbeets (*Beta vulgaris* L.), dry edible beans (*Phaseolus vulgaris* L.), alfalfa (*Medicago sativum* L.), wheat (*Triticum aestivum* L.), mixed feed grain and peas (*Pisum sativum* L.). A few acres of potatoes (*Solanum tuberosum* L.) were grown on the A canal site. Water samples were obtained from the inlet and outlet of each watershed at 2-week intervals from the beginning of irrigation until harvest during the growing seasons of 1969 and 1970.

Presumptive, confirmed, and completed coliform counts were made using three sets of five lactose broth fermentation tubes per sample, followed by inoculation of the positive cultures on brilliant green bile broth, and then on EMB agar according to Standard Methods (1). Most Probable Numbers (MPN) were calculated from the tables using numbers of cultures and numbers of positive cultures in each category. The 95% probability limits of MPN counts are given in the MPN tables (1). Fecal coliform counts were made by MPN analyses according to Standard Methods (1). Fecal streptococci were determined by micropore filtration. Starch hydrolyzers were grown on starch agar as described previously (5). Dissolved oxygen was measured with a gold-silver electrode and BOD₅ (5-day 20C biochemical oxygen demand) was determined. Water temperatures were measured at each site at sampling with a glass thermometer calibrated to 0.1C.

RESULTS AND DISCUSSION

All the water used for irrigating the three small watersheds was diverted from the Snake River. The runoff

¹Contribution from the Northwest Branch, Agricultural Research Service, USDA; Idaho Agr. Exp. Sta. cooperating. Received May 10, 1972.

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water from the watersheds was principally surface runoff with no known subsurface seepage contributing. All of the runoff water from the A canal watershed was collected in a pond and pumped back into the canal below the diversion point. The microbial population of this pond may have been subject to some dieoff as in a treatment lagoon. The other two watersheds had no retention structures and the water was collected as it left the watersheds. Microorganism populations in the water leaving the watersheds were the product of the populations of the diverted irrigation water, dieoff, and pickup of microorganisms from the soil as the water moved across the fields. Numbers increased or decreased depending upon which factor was dominant, microorganism dieoff or pickup.

The maximum, minimum, and median numbers of coliform organisms in irrigation and drainage water samples are given in Table 1. Median values indicate the relative distribution of organism counts in each series of samples for a sampling site. The wide variations in coliform counts reflected considerable variability in quality of the irrigation water. No seasonal or annual trends were found in any of the bacterial numbers.

The A canal water was pumped into the canal and the other two sites received water diverted by gravity flow. Coliform counts in most cases tended to be higher in the drainage water than in the irrigation water but the differences observed were within the 95% confidence limits for MPN analyses.

The fecal coliform numbers in the A canal irrigation and drainage water were not different (Table 1). In the Hansen canal and the Kimberly lateral, fecal coliform organism numbers were greater in the drainage than in the irrigation water. Fecal streptococci numbers based on maximum and median values were approximately two to six times greater in the drainage than in the irrigation water.

Fecal coliform/fecal streptococci ratios were calculated for all of the water samples. Of the 86 samples, 27% of

the irrigation water and 10% of the drainage water samples had ratios greater than 2.5. This indicates that the respective percentages of the irrigation and drainage water samples were contaminated with fecal pollution (7). The decrease in these ratios from the irrigation water to the drainage appears to be the result of a greater increase in fecal streptococci than fecal coliforms in these field situations. In one case on the Kimberly drainage, the fecal coliforms increased sharply over the irrigation water indicating probable contamination from human sources.

There are no clearcut trends apparent in numbers of starch hydrolyzers as reported in Table 1. Both increase and some decrease in numbers were observed between the irrigation and drainage samples but none exceeded the 95% probability limits for MPN analyses.

Plate counts of microorganisms incubated at 20C were of the same order of magnitude in the irrigation and drainage water from the A canal and drain samples (Table 2). In the other two watersheds, the drainage water contained severalfold more microorganisms than the irrigation water in most of the samples.

The water samples were all taken between 9:00 and 11:00 am local time, and the temperatures were measured at sampling. Temperatures of the canal water samples averaged 19.5C in 1969 and 19.3C in 1970.

BOD₅ measurements were made on all the water samples. The irrigation water averaged 2 mg/liter oxygen demand, and the drainage water averaged 4 mg/liter oxygen demand, indicating low concentrations of readily oxidizable organic material in the water.

CONCLUSION

The irrigation water samples were polluted with microorganisms associated with human and animal wastes, as indicated by numbers of coliforms and by fecal coliform/fecal streptococci ratios. There was a trend toward increasing numbers of coliforms and fecal coliforms in the drainage water compared to the irrigation water, but the differences were generally within the confidence limits for MPN analyses. On two of the three watersheds, microorganisms incubated on plating agar at 20C had higher counts in the drainage than in the irrigation water. Fecal streptococci numbers were significantly higher in the drainage than in the irrigation water on two of the three small watersheds. Because drainage from the A canal watershed was contained for a time in a pond before being pumped back to the canal, dieoff of bacteria could have taken place in the pond, thus producing lower numbers than were found in the other two systems that did not have ponds.

The wide probability limits of MPN analyses make it difficult to evaluate these kinds of data with certainty.

Table 1—Coliforms, fecal coliforms, fecal streptococci, and starch hydrolyzers in irrigation and surface drainage water

Type of organisms	MPN organisms per 100 ml water					
	Maximum		Median		Minimum	
	Irrigation†	Drainage	Irrigation	Drainage	Irrigation	Drainage
A Canal						
Total coliforms						
Presumptive	34,500	91,800	14,100	17,200	800	500
Confirmed	34,500	91,800	7,000	17,200	800	200
Completed	3,300	7,000	1,700	1,100	0	0
Fecal coliforms	1,400	1,700	400	400	0	0
Fecal streptococci*	409	2,375	66	115	5	56
Starch hydrolyzers	>321,000	>321,000	11,000	44,000	340	0
Hansen Canal						
Total coliforms						
Presumptive	>160,900	54,200	2,300	34,800	200	7,900
Confirmed	500	54,200	500	34,800	0	3,300
Completed	200	2,600	0	3,300	0	200
Fecal coliforms	700	2,300	0	500	0	0
Fecal streptococci	1,054	2,142	118	508	5	474
Starch hydrolyzers	321,000	321,000	26,000	70,000	220	0
Kimberly Lateral						
Total coliforms						
Presumptive	>160,000	91,800	3,300	54,200	1,300	22,100
Confirmed	1,300	91,800	3,300	22,100	800	9,400
Completed	800	10,900	400	1,700	0	700
Fecal coliforms	700	13,000	200	800	0	0
Fecal streptococci	1,995	4,980	181	1,472	62	0
Starch hydrolyzers	>321,000	>321,000	70,000	184,000	0	0

* Fecal streptococci were determined by micropore filtration and direct counting.
† All sites were sampled 15 times except the Hansen Canal drainage which was sampled 13 times because it was dry on two sampling dates.

Table 2—Plate counts of microorganisms from irrigation and surface drainage water incubated at 20C

	Organisms per ml water			Number of samplings
	Maximum	Minimum	Median	
A canal	230,000	300	12,000	15
A canal drainage	268,000	2,300	60,000	15
Hansen canal	15,000	1,200	3,100	15
Hansen drainage	158,000	54,000	95,000	13
Kimberly lateral	233,000	5,000	10,000	15
Kimberly drainage	272,000	83,000	123,000	15

Nevertheless, even though microorganism counts tend to be higher in drainage than in the irrigation water on these three small watersheds, irrigation use has a minimal deleterious effect on the microbiology of these waters.

LITERATURE CITED

1. American Public Health Association, Inc. 1965. Standard methods for the examination of water and wastewater. 12th ed. New York. 769 p.
2. Carter, D. L., J. A. Bondurant, and C. H. Robbins. 1971. Water soluble $\text{NO}_3\text{-N}$, $\text{PO}_4\text{-P}$, and total salt balances on a large irrigation tract. *Soil Sci. Soc. Amer. Proc.* 35(2):331-335.
3. Kunkel, S. H. 1970. Concentrations and cycles of bacterial indicators in farm surface runoff. p. 49-60. *In* Relationship of agriculture to soil and water pollution. Cornell University Conf. on Agricultural Waste Management, Cornell University.
4. Melaney, G. W., H. H. Weiser, R. O. Turner, and M. Van Horn. 1962. Coliforms, enterococcus, thermotolerants, thermophiles, and psychrophiles in untreated farm pond waters. *J. Appl. Microbiol.* 10:44-51.
5. Smith, J. H., C. L. Douglas, and J. A. Bondurant. 1972. Microbiological quality of subsurface drainage water from irrigated agricultural land. *J. Environ. Quality* 1:308-311.
6. United States Department of the Interior, Federal Water Pollution Control Administration, Northwest Region. 1968. Water quality control and management, Snake River Basin. 72 p.
7. Wadleigh, C. H. 1968. Wastes in relation to agriculture and forestry. *USDA Misc. Publ.* 1065. 112 p.
8. Weidner, R. B., A. G. Christenson, S. R. Weibel, and G. G. Roebeck. 1969. Rural runoff as a factor in stream pollution. *J. Water Pollu. Contr. Fed.* 41(3):377-384.