Water Quality of Impoundments on Surface-Mined Sites

J. E. Gilley, G. W. Gee and Armand Bauer

Water quality determinations were made on samples collected from impoundments on a strip mined area and from surface water sites located outside the mine complex. Concentrations of dissolved constituents were determined on two dates for recently established impoundments and for impoundments present for over 25 years. The suitability of the water was evaluated for livestock and irrigation uses.

Expanded utilization of energy reserves in the United States has caused increased concern for the environmental effects of surface mining. Of particular interest is the impact of strip mining on surface and ground water supplies. McWhorter (2) reports that the most significant water pollution potential of coal strip mines in Colorado results from the soluble salt content of the overburden materials. Little detailed information is available on the quality of water originating from surface mined areas.

Runoff from most surface mines in the northern Great Plains remains on the mine site. Impoundments located within the mine complex are generally not part of off-site watersheds. Runoff entering the impoundments is usually lost only through seepage or evaporation.

The anticipated land use following mining for much of the energy impact region of the Northern Great Plains is grazing. If the water meets quality standards, the impoundments would be ideally located to serve as water supplies for the surrounding grazing areas. The ponds could also serve as supplemental irrigation supplies during the critical period of grass establishment, again if quality standards are met. A typical surface mine impoundment is shown in Figure 1.

Gilley was research associate, Department of Agricultural Engineering; Dr. Gee was research scientist and Dr. Bauer was professor, Department of Soils.

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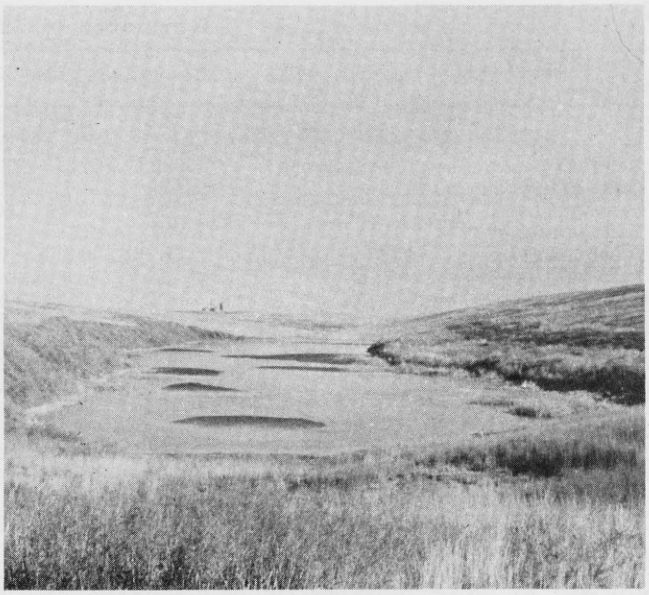

A typical mined-site water impoundment.

The purpose of this study was to (a) determine the amount and type of water soluble constituents present in the water of surface-mined impoundments, (b) compare the water quality of recently established impoundments with those present for more than 25 years, (c) evaluate changes in water quality with time, and (d) determine the suitability of water in the impoundments for livestock and irrigation uses.

Procedure

Water samples were collected from impoundments at the North American Coal Corporation Indian Head mine near Zap, North Dakota. Samples were taken near the shore from seven impoundments; four of these had been in existence four years or less, and three were present for more than 25 years. Water samples were taken also from two stock ponds in the Zap vicinity; from Spring creek at Zap and from the Missouri river at Washburn. Samples collected on November 14, 1975, represented conditions at near minimum pond elevation and the May 13, 1976, sampling date represented conditions following snow-melt. Chemical analyses were conducted by Agri-Science Laboratories of West Los Angeles, California.

Results and Discussion

Results of chemical determinations on samples collected November 14, 1975, and May 13, 1976, are presented in Tables 1 and 3, respectively. Table 2 lists information on heavy metal concentrations in water of two of the impoundments and Spring creek on November 14, 1975. Impoundments designated A, B, C and D were in existence for less than four years, and impoundments E, F and G were present for over 25 years.

Table 1. Surface water quality — November 14, 1975.

Parameter	Impoundment A	B	C	D	E	F	G	Pond A	B	Spring creek	Missouri river
pH	8.3	9.0	8.3	8.3	8.0	8.2	7.7	7.6	8.2	7.7	8.0
Sodium adsorption ratio	12.2	12.0	8.1	5.5	8.1	5.1	6.6	1.0	1.3	0.4	1.3
Specific conductance, umhos/cm	1390	1320	1610	3300	2640	2450	2560	385	1520	1430	594
Total dissolved solids, mg/1	1420	2490	1800	3840	2730	3270	2640	554	1390	1290	505
Total hardness, mg/1	86	84	200	850	450	580	520	130	450	650	200
Bicarbonate, mg/1	282	429	423	146	425	888	351	144	509	292	157
Boron, mg/1	0.2	0.2	0.4	1.0	0.2	0.4	1.0	0.4	0.4	0.8	0.2
Calcium, mg/1	24	21	45	160	110	100	200	32	94	180	54
Chloride, mg/1	6.0	11	5.0	14	17	16	14	4.0	14	7.1	12
Fluoride, mg/1	0.7	0.7	0.7	1.0	0.7	0.7	0.6	0.2	0.5	0.5	0.6
Iron, mg/1	2.3	0.6	0.2	0.1	0.1	0.1	0.1	0.8	0.2	0.1	0.2
Magnesium, mg/1	6	8	21	110	45	79	4	12	52	49	17
Manganese, mg/1	0.030	0.005	0.005	0.010	0.015	0.035	0.005	0.005	0.020	0.005	0.005
Nitrate, mg/1	3.3	1.0	1.0	1.0	1.0	1.0	3.3	1.0	1.0	1.0	1.0
Potassium, mg/1	19	16	23	24	18	26	15	8	11	8	4
Sodium, mg/1	260	260	260	360	400	280	350	26	130	26	42
Sulfate, mg/1	450	300	440	1460	920	460	950	70	320	450	150

Chemical Constituents

Considerable variation in measured concentrations appeared between sampling locations. Large variations in many chemical measurements appeared on each of the sampling dates between impoundment D and the other recently leveled sites. Water was of more questionable quality at site D than at the remaining six impoundment locations.

Table 2. Heavy metal determinations — November 14, 1976

Parameter	Impoundment D	F	Spring creek
Aluminum, mg/1	1.8	.80	.70
Arsenic, mg/1	0.01	0.01	0.01
Barium, mg/1	0.4	0.9	0.1
Beryllium, mg/1	0.03	0.01	0.01
Cadmium, mg/1	0.01	0.01	0.01
Chromium, mg/1	0.002	0.002	0.010
Chromium, (Hexavalent), mg/1	0.005	0.005	0.005
Cobalt, mg/1	0.039	0.011	0.024
Copper, mg/1	0.004	0.012	0.006
Lead, mg/1	0.01	0.03	0.02
Lithium, mg/1	0.22	0.14	0.10
Mercury, mg/1	0.0006	0.0006	0.0005
Nickel, mg/1	0.004	0.046	0.018
Selenium, mg/1	0.002	0.002	0.002
Silver, mg/1	0.011	0.008	0.008
Vanadium, mg/1	0.42	0.08	0.10
Zinc, mg/1	0.02	0.03	0.02

Measurements of some parameters were larger on samples collected from the most recently established sites while concentrations of other constituents were greater on samples obtained from the older impoundments. Runoff entering the impoundments passes over spoil materials removed from varying overburden depths, often with different chemical and physical characteristics. The chemical properties of the spoil materials dictate surface water quality. The quality of water located outside the mine complex was superior in some regards and inferior in others, depending on the parameter examined.

Variations in Water Quality With Time

Concentrations of some constituents were larger on November 14, 1975, with greater concentrations of other parameters measured on May 13, 1976. Significant variations in concentrations of total dissolved solids (TDS) appeared between the two sampling dates on samples from the most recently established impoundments; variation in TDS was generally smaller at the other seven sites. Measurements of total hardness, calcium and chloride were usually greater on samples collected November 14, 1975. Higher values of sodium adsorption ratio, potassium and sodium normally appeared on May 13, 1976.

Table 3. Surface water quality — May 13, 1976.

Parameter	Impoundment A	B	C	D	E	F	G	Pond A	B	Spring creek	Missouri river
Sodium adsorption ratio	13.1	14.8	6.8	21.1	13.0	14.7	8.7	1.1	4.9	1.4	1.7
Total dissolved solids mg/1	1170	3440	1190	4260	2730	3220	2310	270	1440	930	520
Total hardness, mg/1	87	73	150	430	400	510	460	87	410	270	210
Aluminum, mg/1	1.6	1.8	0.66	0.66	0.67	0.89	0.89	1.3	0.67	0.67	0.44
Calcium, mg/1	20	15	28	83	81	83	88	21	82	86	48
Chloride, mg/1	3.6	3.6	3.6	14	11	12	8.9	3.6	7.1	7.1	11
Iron, mg/1	1.9	1.5	1.7	0.4	0.1	0.1	0.1	1.3	0.1	0.1	0.4
Magnesium, mg/1	9	8	13	55	49	73	59	8	51	37	22
Potassium, mg/1	19	17	19	50	21	26	17	18	16	12	8
Sodium, mg/1	280	290	190	1010	600	760	430	23	230	62	55
Sulfate, mg/1	410	330	260	1170	1310	1410	1120	50	460	310	160

Water Quality Standards

Recommended livestock, irrigation and U. S. drinking water standards are presented in Table 4.

Livestock Quality Standards

Guidelines listed under livestock quality standards are threshold values, lower concentrations of which are of little or no concern (1). The constituents of greatest potential significance include total dissolved solids and sulfate.

Suggested limiting concentrations of total dissolved solids and sulfates above which animals in lactation or production might show definite adverse effects are 5000 and 1000 mg/liter, respectively (1). Measurements of total dissolved solids for both sampling dates were less than the limiting values. Sulfate concentration of water from four of the impoundments was greater than the limiting concentration on May 13, 1976.

Table 4. Water quality standards.

Parameter	Livestock quality standards[1]	Irrigation water standards[2]
pH		
Sodium adsorption ratio		6.0
Specific conductance, umhos/cm		750
Total dissolved solids, mg/l	2500	500
Total hardness, mg/l		
Bicarbonate	500	
Boron, mg/l		0.75
Calcium, mg/l	500	
Chloride, mg/l	1500	100
Fluoride, mg/l	1	
Iron, mg/l		
Magnesium, mg/l	250	
Manganese, mg/l		2.0
Nitrate, mg/l	200	
Sodium, mg/l	1000	
Sulfate, mg/l	500	200
Aluminum, mg/l		1.0
Arsenic, mg/l	1	1.0
Barium, mg/l		
Beryllium, mg/l		0.5
Cadmium, mg/l	5	0.005
Chromium, mg/l		5.0
Chromium (Hexavalent), mg/l	0.05	
Cobalt, mg/l		0.2
Copper		0.2
Lead, mg/l	0.05	5.0
Lithium, mg/l		5.0
Nickel, mg/l		0.5
Silver, mg/l		
Selenium, mg/l	0.01	0.05
Vanadium, mg/l		10.0
Zinc, mg/l		5.0

[1]*California State Water Quality Control Board, 1963. Guides for Evaluating the Quality of Water Used By Livestock and For Irrigation.*

[2]*Federal Water Pollution Control Administration, 1968. Water Quality Criteria.*

Pond B showed a higher than recommended bicarbonate concentration on November 14, 1975. The other sampling sites located outside the mine complex appeared to have quality factors with less than the established threshold values.

Irrigation Water Standards

The irrigation water standards listed in Table 4 are also threshold values. Water supplies with concentrations below these recommended values should be satisfactory for almost all crops and any arable soils (1). Higher allowable concentrations might be possible for some of the grass species established on the mined sites.

The sodium adsorption ratio of water from the impoundments in general is between the threshold and limiting values suggested for irrigation. Concentrations of total dissolved solids and sulfate were exceeded in water from some of the impoundments on both sampling dates. Samples from Pond B and Spring creek at Zap also had measured values of total dissolved solids and sulfate between the threshold and limiting concentrations.

Complete evaluation of the water quality hydrology of an impoundment would require collection over a period of several years of replicated samples taken from numerous locations of varying depth. While data gathered from this preliminary study may yield useful information on potential trends, the measurements should not be considered as absolute values. The results are tentative and should be reevaluated as more water quality information becomes available.

Summary

Variation in concentrations of water soluble constituents appeared between sampling locations. Values of some chemical parameters were higher on water from the recently established impoundments, while values of other constituents were higher on older sites. Significant changes in surface water quality appeared between November 14, 1975, and May 13, 1976. Water quality factors of potential concern include sodium adsorption ratio, total dissolved solids and sulfate. Determination of the chemical characteristics of an impoundment before it is used as a livestock or irrigation supply is recommended.

References

1. California State Water Quality Control Board. 1963. **Guides for Evaluating the Quality of Water Used for Livestock and for Irrigation.**

2. McWhorter, David B., Rodney K. Skogerboe and Gaylord V. Skogerboe. 1975. **Water Quality Control in Mine Spoils — Upper Colorado River Basin.** Environmental Protection Agency. 670/2-75-048.