RESEARCH BULLETIN 675 OCTOBER, 1958

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

J. H. LONGWELL, *Director*

Some Quality Factors of Pond Water in Selected Areas of Missouri

T. O. HODGES AND M. D. SHANKLIN

(Publication authorized October 17, 1958)

COLUMBIA, MISSOURI

SUMMARY AND CONCLUSIONS

1. Twenty-nine of the 47 ponds tested had average turbidities higher than 25 turbidity units and would require some kind of treatment, such as flocculation, before filtration for domestic use.
2. It is frequently considered desirable and economical to soften water for domestic use when the hardness is about 70 or greater p.p.m. Using 70 p.p.m. as a breaking point, 19 of the 47 ponds had water that would need softening. The hardness would increase if gypsum were used to clear pond water, resulting in increasing the number of ponds needing softening.
3. Sulfates, alkalinity, chlorides, and pH were well within desirable limits for all ponds tested.
4. Large seasonal variations in pond water turbidity occurred. Special care should be exercised in filtering pond water, particularly during the heavy spring rains.
5. Average turbidity decreased as pond size increased. Turbidities of ponds with surface areas greater than 5 acres were significantly lower than those with less than ½ acre.
6. Pond water in area 4 was significantly more turbid than that in area 1, while values of pH in area 1 were significantly higher than in area 4, perhaps due to soil type or to regional climatic differences.
7. The turbidity of pond water is generally less for waters with higher hardness. Most of the hardness is due to calcium and magnesium, which flocculate suspended material in the water.
8. In general, turbidities were lower for waters with higher conductivities.

The work reported in this bulletin was done under Department of Agricultural Engineering Research Project 155, "Farm Water Supplies." This project is a part of North Central Regional Project NC-9 on Farm Housing Research and is partially financed by funds authorized by Section 9b3, Title I, of the Research and Marketing Act of 1946.

TABLE OF CONTENTS

Fig. 1—The general area where the tested ponds are located is shown by the shaded portion of the map. Figure 2 is an enlargement of this region.

Some Quality Factors of Pond Water In Selected Areas of Missouri

INTRODUCTION

In many rural areas of Missouri and other states pond water is used for domestic purposes. Surface waters require treatment, usually filtration and chlorination, to meet health standards for human consumption. The quality of a water before treatment determines how effectively the water can be treated on the farm.

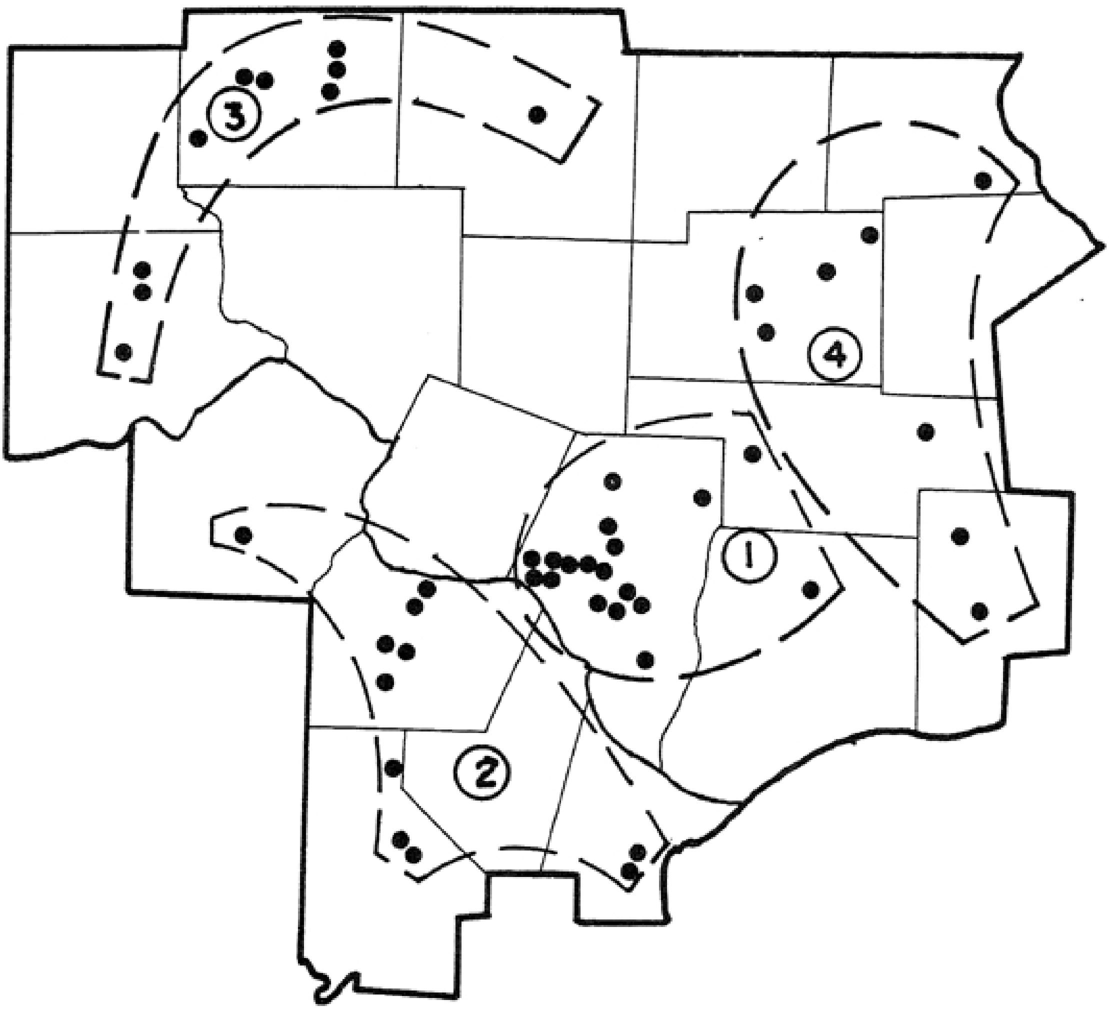


Fig. 2—Black dots indicate the approximate location of the ponds within four sub-areas.

A study was carried out to determine certain pond water quality factors and their variability during the season and between selected areas in the state. Samples of water were collected and analyzed monthly from 47 ponds during the period from August, 1956, to May, 1958. This publication reports the results of these collections and analyses.

SCOPE OF THE STUDY

The 47 ponds were selected randomly within the general area shown in Fig. 1. Ponds ranged in surface area from 0.15 acres to 45 acres. Thirty-two of them had grassed watersheds and 15 had cultivated watersheds. They ranged in age from about 3 to 20 years. Only three of the ponds (2-8, 3-5 and 4-5) had drainage from watersheds with high concentrations of animals.

Fig. 2 shows the locations of the individual ponds included in the study. The area is divided into four smaller areas, numbered 1, 2, 3 and 4. Areas 1, 2, 3 and 4 had 18, 11, 10 and 8 ponds, respectively. Each pond was assigned an identification number according to the area in which it was located. For example, ponds in area 1 were identified by 1-1, 1-2, ---, 1-15, etc.

A sample of water was collected once each month from each pond and analyzed for turbidity, conductivity, pH, chlorides, sulfates, total hardness, and alkalinity.

METHODS OF COLLECTING AND TESTING WATER SAMPLES

Samples of pond water were collected by plunging pint-size polyethelene bottles directly into the ponds. The bottles of water were taken to the laboratory for all determinations. Standard methods which were used for the analyses can be found in the references listed below:

Turbidity determinations were made by measuring the percent transmittance of light rays of a certain wave length with an electronic colorimeter which was calibrated against a standard Jackson Candle Turbidimeter (4, pg. 51; 5, pg. 207).

Conductivity determinations were made with a standard conductivity cell, and *pH* measurements were made with a battery operated pH meter which utilizes a glass electrode in combination with a saturated calomel electrode (5, pgs. 89 and 161).

Chloride determinations were made by titration using the mercuric nitrate method (5, pg. 61).

Methyl Orange (total) alkalinity, as p.p.m. calcium carbonate, was determined by titration methods (3, pg. 2).

Sulfates were determined by titration with standard barium perchlorate in conjunction with an indicator (3, pg. 14).

The *theoretical hardness* of a water is the sum of the concentrations of all metallic cations other than cations of the alkali metals, expressed as equivalent calcium carbonate concentration. The hydrogen ion, being non-metallic, is excluded from the definition. As used in this publication, *hardness* shall mean total hardness, as determined by a variation of the EDTA (ethylenediaminetetraacetic acid and its sodium salts) titration method, and reported as parts per million (p.p.m.) calcium carbonate equivalent (3, pg. 5).

SIGNIFICANCE OF THE TESTS

An exact limit on the permissible turbidity of water for human consumption is not defined, but it is felt by some authorities that the upper limit should be about 10 turbidity units when determined by the "Jackson Candle Method."

Definite upper limits for many factors have been established by the U. S. Public Health Department (1) for drinking water. The upper limits for factors considered in this study are:

a. chlorides, 250 mg. per liter.*
b. sulfates, 250 mg. per liter.
c. pH, about 10.6 at 25° C due to the limitations of phenolphthalein alkalinity as $CaCO_3$, to 15 mg. per liter plus 0.4 times the total alkalinity.
d. total alkalinity. mg, per liter as $CaCO_3$, 400 at pH of 8.0 to 160 at pH, of 10.6 at a temperature of 25° C.
e. pH, about 10.6 due to alkalinity considerations in (d) above.

Specific conductance measurements give an indication of the total concentration of the ionized constituents of a natural water.

RESULTS

Seasonal variations of turbidity, conductivity, and total hardness are shown in Fig. 3. The plotted points represent the monthly average values for all 47 ponds. During the period from August 1956 to about March of 1957, pond water levels and turbidities were generally quite low with conductivities and hardnesses being relatively high. Spring rains in 1957 caused the average turbidity for the 47 ponds to rise to 142 turbidity units in May; at the same time conductivity and total hardness decreased to about 50 mhos per cubic centimeter and 64 p.p.m., respectively. From June, 1957, to May, 1958, fluctuations of all three factors were less, with the ranges being (1) 48 to 83 turbidity units, (2) 54 to 65 p.p.m. hardness, and (3) 25 to 126 mhos per cubic centimeter conductivity. For both years, the lowest turbidities occurred during January and the highest during April or May.

Comparison of Water Quality in Four Locations of the State

Table 1 shows the 22-month averages and standard deviations of water quality factors for individual ponds grouped by areas within the state. Ponds 1-12, 2-10, 3-5, and 4-5 are not included in the data comparisons because of poor management practices, such as permitting hogs and other livestock to have direct access to the water.

Turbidity. The arithmetic average turbidity for 17 ponds in area 1 was 29.3; for 10 ponds in area 2, 51.5; for 9 ponds in area 3, 49.5; and for 7 ponds in area 4, 71.8 turbidity units. The differences between the means in comparing areas 1 with 2, 1 with 3, 2 with 3, 2 with 4, and 3 with 4 were not significant. The difference between the means of areas 1 and 4 was significant at the 2 percent level.

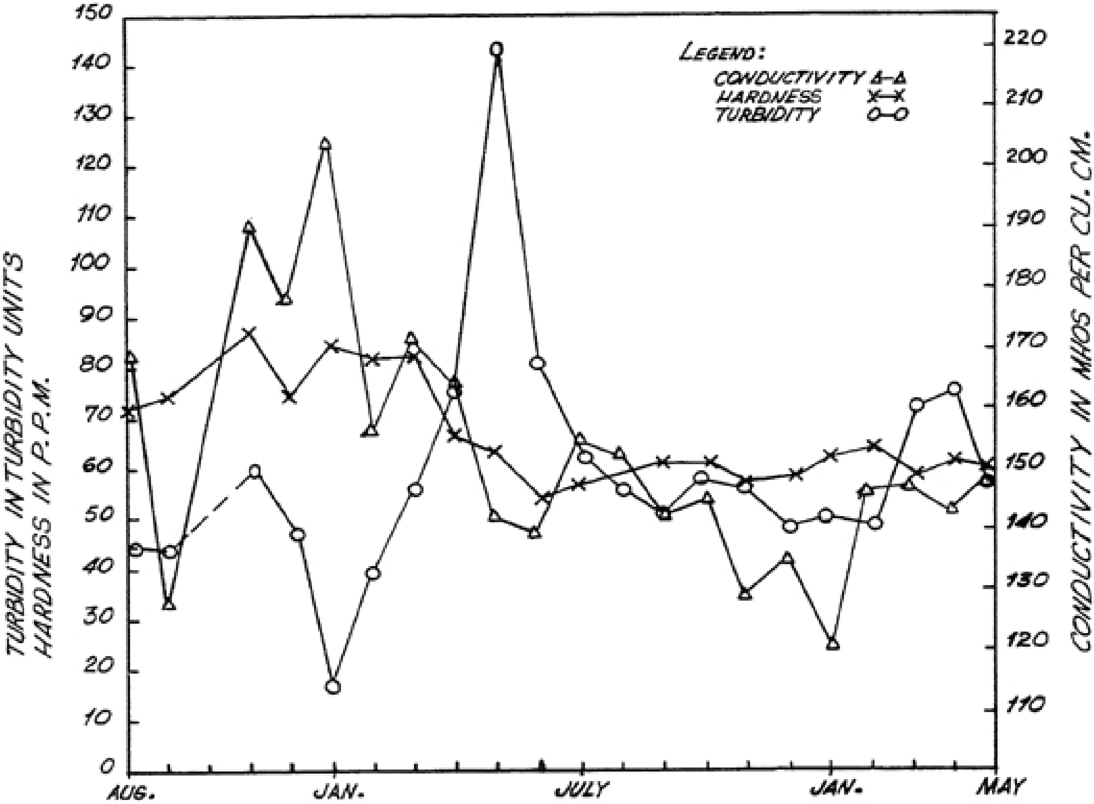
Conductivity. The arithmetic average conductivity for 17 ponds in area 1 was 156.8; for 10 ponds in area 2, 144.0; for 9 ponds in area 3, 155.5; and for 7

*Mg. per liter is approximately equivalent to parts per millions (p.p.m.) as used in this publication.

Fig. 3

SEASONAL VARIATION OF TURBIDITY, CONDUCTIVITY AND TOTAL HARDNESS

(Average of 47 ponds by months from August, 1956 to May, 1958)



ponds in area 4, 169.6 mhos per cubic centimeter. The difference between means when comparing conductivities of water for any two areas was not significant.

Total Hardness. The arithmetic average hardness for 17 ponds in area 1 was 67.3; for 10 ponds in area 2, 66.3; for 9 ponds in area 3, 66.3; and for 7 ponds in area 4, 66.4 p. p. m. There were no significant differences between the hardnesses of water for the four locations.

Sulfates. The arithmetic average sulfates for the 17 ponds in area 1 was 20.1; for 10 ponds in area 2, 15.6; for 9 ponds in area 3, 16.2; and for 7 ponds in area 4, 23.0 p.p.m. The difference between the means of sulfates for area 1 and 2 was significant at the 5 percent level. Comparisons between other locations were not significant.

TABLE 1--POND SIZES, WATERSHED DESCRIPTION, AND 22-MONTH AVERAGE VALUES AND STANDARD DEVIATIONS OF FACTORS TESTED.*

Pond No.	Surface Area (Acres)	Water Shed	Age, 1958 Years	Turbidity		Conductivity		pH	
				Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
1-1	0.41	Grass	--	14.4	10.6	159.1	110.5	8.1	.74
1-2	0.75	Grass	4	13.1	10.9	207.1	55.3	8.1	.71
1-3	0.70	Grass	--	7.6	3.65	169.9	39.1	8.1	.73
1-4	0.39	Grass	4	21.5	17.3	165.0	34.3	8.0	.74
1-5	1.20	Cult.	4	78.2	73.0	169.5	53.2	7.1	.33
1-6	0.25	Grass	4	69.9	39.4	80.5	24.6	7.1	.53
1-7	1.26	Grass	9	26.9	22.7	195.1	32.9	7.5	.58
1-8	1.56	Grass	5	12.9	7.9	208.9	21.4	7.6	.24
1-9	2.13	Grass	5	43.8	36.3	222.4	30.5	7.7	.24
1-10	0.79	Grass	15	30.2	16.1	119.8	27.2	7.4	.53
1-11	5.0	Grass	5	18.5	11.4	146.7	23.6	7.8	.78
1-12**	5.8	Cult.	3	193.9	159	98.2	44.7	7.1	.33
1-13	1.41	Grass	--	18.6	15.5	94.3	17.6	7.7	.78
1-14	1.60	Grass	--	12.1	20.8	203.2	55.5	8.2	.78
1-15	1.25	Grass	12	21.8	10.63	134.8	24.2	7.5	.74
1-16	1.50	Grass	3	68.1	43.0	92.7	27.3	7.1	.42
1-17	15.0	Cult.	16	20.0	15.15	147.1	14.8	7.4	.24
1-18	1.20	Cult.	--	9.6	5.4	156.9	15.7	7.5	.47
2-1	5.15	Grass	--	22.0	12.9	148.6	16.9	7.8	.73
2-2	3.76	Grass	--	15.4	8.6	170.1	20.8	7.6	.35
2-3	0.51	Cult.	7	53.8	36.2	197.4	48.0	7.6	.67
2-4	0.57	Grass	4	21.3	19.0	273.8	49.4	7.7	.33
2-5	0.57	Grass	3	11.3	6.0	223.0	46.4	8.4	.62
2-6	0.59	Cult.	3	44.3	36.1	68.0	9.8	7.2	.53
2-7	0.42	Grass	5	67.7	68.8	109.1	28.0	7.4	.97
2-8	0.68	Grass	11	61.5	38.6	95.8	14.5	7.1	.33
2-9	1.51	Cult.	5	107.9	113.4	68.9	20.0	7.0	.33
2-10**	0.84	Grass	8	293.4	236.6	83.6	12.9	6.8	.33
2-11	0.41	Grass	4	93.9	78.8	87.2	20.8	7.1	.47
3-1	0.47	Grass	12	56.6	61.7	169.6	32.0	7.7	.77
3-2	2.08	Cult.	8	29.6	17.75	136.0	26.0	7.6	.64
3-3	10.3	Grass	20	48.2	41.8	222.2	47.5	7.7	.48
3-4	2.41	Grass	--	50.1	31.9	76.0	21.6	7.1	.11
3-5**	0.27	Cult.	4	179.3	123.2	88.5	12.8	7.3	.25
3-6	0.29	Cult.	5	26.9	20.3	151.2	57.9	7.9	1.03
3-7	0.23	Grass	3	34.1	44.2	154.6	49.3	7.6	.34
3-8	0.17	Grass	10	81.4	51.3	215.7	32.3	7.5	.69
3-9	0.50	Cult.	12	91.5	81.2	106.7	21.3	6.9	.54
3-10	0.47	Grass	--	14.5	10.4	167.4	53.7	7.9	.83
4-1	1.50	Cult.	3	64.1	65.2	185.3	57.8	7.2	.24
4-2	0.50	Grass	13	101.0	92.0	192.7	74.5	7.2	.33
4-3	45.0	Cult.	--	35.5	29.6	128.1	17.75	7.2	.24
4-4	0.29	Cult.	--	103.8	35.25	240.0	46.2	7.7	.82
4-5**	0.67	Grass	3	288.9	285.6	200.5	77.0	7.1	.33
4-6	0.15	Cult.	6	37.9	17.6	92.6	36.9	7.0	.24
4-7	15.0	Grass	--	39.2	50.1	222.9	25.9	7.4	.78
4-8	0.29	Grass	4	106.3	78.3	116.1	17.6	7.4	.18

* Turbidity in turbidity units. Conductivity in mhos per cubic centimeter. Total hardness, alkalinity and chlorides in p.p.m.

** Not included in comparisons.

TABLE 1--CONTINUED

Pond No.	Total Hardness Avg.	Total Hardness Std. Dev.	Alkalinity Avg.	Alkalinity Std. Dev.	Sulfates Avg.	Sulfates Std. Dev.	Chlorides Avg.	Chlorides Std. Dev.
1-1	68.1	11.3	63.4	19.5	22.0	13.7	4.9	0.93
1-2	64.8	21.4	96.1	26.5	13.9	6.2	2.5	.89
1-3	77.5	22.2	71.7	12.1	23.2	8.0	3.0	.74
1-4	49.9	17.7	63.8	16.7	21.8	4.6	2.6	.47
1-5	63.3	24.84	27.0	10.5	43.6	17.6	3.4	.74
1-6	37.9	10.7	40.4	18.9	20.4	6.9	2.2	.73
1-7	83.4	15.5	87.3	19.9	13.5	5.1	5.7	1.06
1-8	103.0	11.7	94.4	16.5	15.7	4.3	3.5	.53
1-9	104.4	15.7	110.2	73.35	23.1	3.8	3.0	.57
1-10	54.4	11.7	58.3	13.0	16.5	4.3	2.9	1.17
1-11	67.3	15.4	59.2	9.7	18.5	4.3	3.1	.57
1-12**	39.7	15.0	26.7	13.2	21.8	7.7	4.6	3.0
1-13	44.6	9.7	40.8	6.7	18.8	11.6	1.9	0.40
1-14	87.7	27.1	86.4	20.2	16.5	7.5	5.2	1.11
1-15	62.1	16.0	49.3	17.7	16.5	4.7	4.9	1.08
1-16	41.4	9.6	47.1	14.3	15.8	7.3	1.7	.42
1-17	62.0	9.8	57.8	11.7	27.7	7.0	5.7	0.61
1-18	73.5	15.0	68.2	21.2	14.5	3.5	3.7	1.03
2-1	60.5	10.4	49.5	19.4	14.3	4.7	7.8	.85
2-2	79.5	8.8	77.0	14.45	17.0	3.7	2.6	1.02
2-3	72.2	20.0	76.1	15.6	13.2	4.0	7.9	1.73
2-4	139.9	32.8	119.1	40.6	17.3	6.8	5.3	1.81
2-5	124.9	28.1	96.7	25.1	19.1	7.7	4.8	1.21
2-6	33.3	9.5	31.0	9.3	16.4	5.0	3.2	0.83
2-7	42.6	12.6	41.7	8.2	15.0	5.9	5.9	3.02
2-8	44.7	8.7	41.4	14.1	14.5	3.5	3.4	0.91
2-9	31.7	10.0	22.9	9.9	14.5	3.5	2.5	0.66
2-10**	40.7	8.6	33.9	12.0	16.8	4.0	3.8	1.18
2-11	33.6	8.8	39.1	16.0	15.0	3.16	1.4	0.42
3-1	81.6	13.8	76.3	20.4	14.1	4.4	4.4	0.65
3-2	59.5	14.8	65.1	12.2	11.8	4.0	2.6	0.59
3-3	94.4	27.1	88.4	15.2	16.8	4.0	5.7	1.19
3-4	35.7	11.6	38.1	7.6	12.7	4.1	1.8	0.48
3-5**	40.5	10.8	32.5	7.1	14.1	3.8	1.8	0.45
3-6	52.2	21.4	42.8	9.3	20.5	4.2	3.3	1.25
3-7	75.8	19.1	70.5	16.3	16.8	3.4	1.5	0.43
3-8	80.5	15.4	77.6	25.9	18.2	6.4	13.4	2.0
3-9	40.2	11.0	36.8	15.4	17.3	4.7	5.7	2.35
3-10	77.1	26.0	68.5	16.2	15.0	2.2	3.2	0.46
4-1	84.4	22.8	78.7	23.3	29.6	9.2	4.3	0.51
4-2	72.1	26.0	71.3	16.8	21.5	8.7	8.8	1.05
4-3	61.2	14.0	58.5	7.2	17.3	3.9	3.3	0.61
4-4	81.6	17.0	91.9	18.7	12.3	5.2	19.7	3.02
4-5**	70.3	21.2	74.5	23.1	15.8	5.7	10.5	6.71
4-6	31.9	14.3	38.9	9.0	19.2	6.1	2.5	0.85
4-7	92.2	77.3	58.5	23.2	40.2	7.6	10.1	1.84
4-8	41.8	6.2	60.0	17.5	20.4	4.3	2.6	0.61

Chlorides. The arithmetic average chlorides for 17 ponds in area 1 was 4.3; for 10 ponds in area 2, 5.3; for 9 ponds in area 3, 5.3; and for 7 ponds in area 4, 7.9 p.p.m. There were no significant differences between the means for different locations.

Alkalinity. The arithmetic average alkalinity, as calcium carbonate equivalent, for 17 ponds in area 1 was 64.9; for 10 ponds in area 2, 58.6; for 9 ponds in area 3, 62.7; and for 7 ponds in area 4, 62.6 p.p.m. There were no significant differences between the means of alkalinities for different locations.

pH. The arithmetic average pH for 17 ponds in area 1 was 7.65; for 10 ponds in area 2, 7.49; for 9 ponds in area 3, 7.5; and for 7 ponds in area 4, 7.3. The difference between the means of areas 1 and 4 was significant at the 1 percent level. The differences between the means of other areas were not significant.

In general, there was no obvious trend toward geographical differences in the four groups of ponds studied. The three isolated instances of statistically significant differences between means (see turbidity, pH, and sulfates above) could, perhaps, be attributed to differences in areal soil compositions, stable differences, but could as easily be attributed to areal climatic differences which would disappear in a long-term study.

Comparison of Pond Water Turbidities for Cultivated and Grassed Watersheds

As shown in Table 1, of the 43 ponds included in the discussion of data, 30 had grassed watersheds and 13 had all or partly cultivated watersheds. The mean turbidities were 42.6 turbidity units for the grassed watersheds and 55.7 for the cultivated ones. While the difference between the means was not significant, it is of interest to note that the standard deviations of the means were 5.5 turbidity units for the grassed and 9.9 for the cultivated watersheds. This indicates less fluctuation of turbidity for pond water collected from grassed watersheds.

Comparison of Ponds by Age

The ponds ranged in age from three years to about 20 years. The ages shown in Table 1 are for 1958. No relationships were found between pond age and the quality factors studied.

Comparison of Water Turbidities by Size of Pond

As can be seen in Table 1, the ponds ranged in surface area from 0.15 to 45 acres. The mean turbidity for 13 ponds with watersheds of 0.15 to 0.47 acres was 59.1; for 10 ponds with watersheds of 0.5 to 0.84 acres, 43.5; for 14 ponds with watersheds of 1.2 to 3.76 acres, 40.3; and for 6 ponds with watersheds of 5 to 45 acres, 32.6 turbidity units.

The difference between the means of 59.1 and 32.6 is significant at the 5 percent level. Other comparisons of differences between the means are not significant. In general, the larger ponds tended to have less turbid waters than smaller ponds.

Comparison of Water Turbidities by Hardness

The average hardness of water from the ponds ranged from 31.7 to 139.9 p.p.m. (Table 1). The mean turbidity of 14 ponds with hardnesses of from 31.7 to 52.2 p.p.m. was 64.1 turbidity units; for 14 ponds with hardnesses of from 54.3 to 75.8, 35.1; and for 15 ponds with hardnesses of from 77.0 to 139.9, 38.2. The difference between the means of 35.1 and 38.2 p.p.m. was not significant. The differences between the means of 64.1 and 35.1 and between 64.1 and 38.2 are both significant at the 2 percent level. In general, the harder water (more than 50 p.p.m.) tended to be less turbid than waters having hardnesses of less than 50 p.p.m.

Comparison of Water Turbidities by Conductivity

Table 1 shows that the average conductivities of the pond waters ranged from 68 to 273 mhos per cubic centimeter. The mean turbidity for 13 ponds with conductivities of 68 to 120 mhos per cubic centimeter was 67.6 turbidity units; for 20 ponds with conductivities of 131 to 197, 34.1; and for 10 ponds with conductivities of 203 to 273, 40.0.

The difference between the means of 67.6 and 34.1 was significant at the 1 percent level. Other comparisons of means were not significant.

In general, for the ponds tested, waters with conductivities greater than about 120 mhos per cubic centimeter had turbidities about half as great as waters with conductivities less than about 120 mhos per cubic centimeter.

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