COMPARISONS OF WATER ANALYSIS KITS[1]

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Abstract: Hellige Water Testing Outfits and a La Motte TRL-05 Water Testing Kit were evaluated by comparison with standard analytical methods. The testing outfits and kit often gave values for variables which were 80-120 percent of values obtained by standard methods. However, for some variables, and especially for total ammonia nitrogen, the testing outfits and kit did not provide reliable data for all concentrations. Results of the present study and earlier studies are summarized in tabular form to provide an assessment of the reliability of seven water testing systems.

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Water analysis kits are frequently used in fisheries management. Boyd (1976, 1977, and 1980) has evaluated the precision and accuracy of several popular water testing kits. The objectives of the present study were to evaluate two other water testing systems, a La Motte TRL-05 Water Testing Kit (La Motte Chemical Products Company, Box 329, Chestertown, Maryland) and several Hellige Water Testing Outfits (Hellige Inc., Garden City, New York) and to compare the reliability of all analytical systems evaluated in the present and earlier studies.

METHODS

Analytical Procedures

The La Motte kit is fully portable and all reagents and apparatus needed for tests are included in the kit. Reagents are either liquids dispensed from dropper bottles or powders dispensed with scoops. Titration volumes are measured with calibrated syringes. The kit contains a pH meter, conductivity meter, and colorimeter of small-scale construction. The Hellige outfits are not packaged in kits, so they are not as convenient for field use. However, all reagents and equipment are provided for each determination so that a laboratory is not required. Burets are used for titrations, liquid reagents are added with pipets, and solid reagents are dispensed with scoops. Sophisticated color comparators with precalibrated color standards are used for colorimetry. Sulfate and turbidity determinations require a Hellige optical turbidimeter.

New Hellige outfits and La Motte kit were used in accordance with manufacturer's instructions. Values obtained with Hellige and La Motte systems were compared with measurements made by standard analytical procedures (APHA 1971, 1975). The standard procedures relied on the same chemical principles used for the kit and outfits.

Water Samples and Comparisons

Samples were obtained from ponds and wells at the Fisheries Research Unit, Auburn University, Auburn, Alabama. Although these samples represented a wide range of water quality, it was occasionally necessary to spike aliquots of samples with small amounts of substances to be measured to provide desired concentration ranges. For each variable, 4 or more samples (low to high concentrations) were analyzed by the standard method, the

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Hellige outfits, and the La Motte kit. Seven replicate determinations were made on each sample by all 3 methods (U.S. Environmental Protection Agency 1972). The standard deviation was taken as a measure of precision of each method of analysis. An F-test was used to determine if variances for the standard method and the method for comparison were homogeneous. Differences between means obtained for standard methods and for Hellige outfits and the La Motte kit were tested for statistical significance by *t*-tests. For obvious reasons, the standard method was always considered the best estimate of concentration. To provide a simple comparison, means obtained for Hellige outfits and the La Motte kit were expressed as percentages of corresponding means obtained for the standard methods.

Results and Discussion

Means of data obtained with the Hellige outfits and the La Motte kit were usually significantly different from those obtained with the standard methods (Table 1). All procedures were precise and seven replicate determinations were made, so many differences that were not great enough to matter in practice were statistically significant. Therefore, a more practical way of comparing the procedures was to express the means of the Hellige outfits and the La Motte kit as percentages of the values obtained with standard methods (Table 1).

The degree of accuracy required for a particular analysis is ultimately the choice of the analyst. However, for most fisheries management decisions, it is not necessary to have highly accurate data. For example, a measured total alkalinity value of 15 mg/liter for a sample with a true value of 18 mg/liter would not result in an erronous judgement in management. Neither would biases of 0.5 mg/liter in dissolved oxygen measurements or 0.5 units in pH determinations result in faulty management recommendations. For most purposes, a method which gives values that are 80-120 percent of the standard method is as suitable as a more accurate procedure.

The Hellige outfits compared favorably (80-120% of standard methods) for all concentrations of total alkalinity, total hardness, dissolved oxygen, and turbidity, for medium and high concentrations of calcium hardness, chloride, nitrate, nitrite, and total chlorine, for low and medium concentrations of color, and for pH values of 4.05 and above. The Hellige outfits gave variable results for sulfate and greatly over-estimated total ammonia nitrogen concentrations. The La Motte kit was reliable for calcium hardness, dissolved oxygen, pH (both by glass electrode and colorimeter), total hardness, all but the lowest specific conductance level, medium and high concentrations of carbon dioxide, chloride, and nitrate, and high concentrations of total chlorine. The La Motte kit gave generally poor results for nitrite, phosphorus, sulfate, total alkalinity, total ammonia nitrogen, and turbidity.

Precision, as estimated from standard deviations, was generally high for Hellige outfits and the La Motte kit. However, the standard methods were often more precise than either of the other analytical systems.

Table 2 provides a summary of comparisons between 7 different water analysis systems and standard methods. Each comparison is the average of data obtained by making 7 replicate analyses each of several (3 to 8) samples by each method under evaluation. These data may be consulted to determine if a particular water analysis kit is suitable for a given application. Neither the author nor Auburn University endorse any particular analysis kits, but many of the simple analytical systems will provide values that are within 80-120 percent of values that would be obtained by highly reliable standard methods. Therefore, kits appear sufficiently reliable to justify their wide use in fisheries management. Caution must be used to insure that manufacturer's directions are carefully followed, that kits are not abused through improper storage, and that reagents are replaced at least annually.

Table 1. Comparisons of water analyses made by standard methods, Hellige water testing outfits and with a LaMotte water analysis kit. Seven replicate determinations were made on each sample by each technique.

Standard method		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Calcium hardness (mg/liter as $CaCO^3$)				
13.7	0.10	10.7	2.14	78 [a]	15.6	0.54	114 [b]
39.7	0.31	38.0	0.37[1]	100	33.9	0.69[1]	89 [b]
59.4	0.30	58.6	0.90	99	60.3	1.38	102
97.2	0.21	98.5	1.32	101 [a]	106.0	1.50	109 [b]
196.0	0.38	200.0	0.95	102	208.0	4.89	106 [b]
			Carbon dioxide (mg/liter)				
7.2	0.17				4.5	0.41	62 [b]
14.1	0.94				14.0	0.52[1]	99
19.7	1.41				21.6	0.42	110 [a]
34.0	0.96				34.3	1.02[1]	101 [a]
			Chloride (mg/liter)				
10.9	0.10	14.7	0.68	135 [b]	18.2	1.22	167 [b]
46.6	0.06	49.5	0.68	106 [b]	52.1	2.25	112 [b]
81.3	0.09	85.4	1.21	105 [b]	82.5	2.50	101
104.0	0.11	107.0	0.81	103 [b]	106.0	0.96	102 [b]

Table 1. Cont.

Standard Methods		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Color (color units)				
26.2	0.95	24.6	0.534[1]	94 [b]			
68.6	2.44	63.6	1.34[1]	93 [b]			
116.0	5.35	111.0	3.78[1]	96 [b]			
388.0	7.53	278.0	44.90	72 [b]			
			Dissolved oxygen (mg/liter)				
2.7	0.10	2.5	0.22[1]	92	3.0	0.42	113
4.8	0.08	4.4	0.19	92 [b]	4.9	0.36	102
6.8	0.14	6.1	0.20[1]	90 [b]	7.5	0.44	111 [b]
8.9	0.05	9.8	0.38	111 [b]	9.1	0.69	103
10.3	0.08	10.9	0.38	106 [b]	12.0	0.93	117 [b]
			Nitrate (mg/liter)				
0.0	0.00	0.0	0.00	75 [a]			
0.2	0.01	0.1	0.00	53 [b]			
0.2	0.01	0.2	0.02	81 [b]			
0.6	0.03	0.6	0.04[1]	100			
0.8	0.05	0.8	0.21	100			
0.1	0.01				0.1	0.05	77
0.2	0.01				0.2	0.02[1]	110
0.7	0.01				0.7	0.04	100
1.1	0.01				1.1	0.07	93 [a]

Table 1. Cont.

Standard Methods		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Nitrite (mg/liter as N)				
0.0	0.00	0.0	0.00[1]	62 [b]	0.0	0.01	231 [b]
0.0	0.00	0.0	0.00	98	0.0	0.01	93
0.1	0.00	0.7	0.00[1]	79 [b]	0.0	0.02	25 [b]
0.1	0.00	0.1	0.00[1]	95 [b]	0.5	0.16	384 [b]
			pH				
			Colorimetric			Miniature pH meter	
2.2	0.02	3.0	0.14	136 [b]	2.2	0.02[1]	96 [b]
4.0	0.03	4.6	0.03[1]	114 [b]	4.2	0.02[1]	104 [b]
5.2	0.05	5.4	0.06[1]	103 [b]	5.3	0.02[1]	102 [b]
6.9	0.04	7.2	0.10	105 [b]	7.2	0.04[1]	105 [b]
8.9	0.03	9.1	0.20	102 [a]	9.0	0.06[1]	102 [b]
10.1	0.02	9.6	0.24	95 [b]	10.2	0.04[1]	101 [b]
11.0	0.02	10.5	0.06	95 [b]	11.3	0.02[1]	103 [b]
						Colorimetric	
5.8	0.10				5.7	0.02	100
7.2	0.04				6.8	0.05[1]	93 [b]
8.5	0.08				8.4	0.20	99
9.5	0.04				9.3	0.03[1]	99 [b]
			Phosphorus (mg/liter as P)				
0.1	0.01				0.1	6.01[1]	67 [b]
0.2	0.01				0.4	0.02[1]	162 [b]
0.4	0.01				0.6	0.02[1]	151 [b]
0.9	0.02				1.3	0.10	156 [b]

Table 1. Cont.

Standard Methods		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Specific conductance (μmbos/*cm*)				
42.9	0.38				58.6	0.98	137 [b]
140.0	0.79				138.0	0.58[1]	99 [b]
370.0	2.89				393.0	12.50	106 [b]
800.0	5.77				865.0	1.89	108 [b]
1240.0	5.77				1400.0	14.40	113 [b]
1830.0	4.50				2070.0	15.70	113 [b]
2250.0	3.72				2600.0	13.40	116 [b]
			Sulfate (mg/liter)				
2.2	0.11	4.2	0.47	185 [b]	0.0	0.00	0
11.4	0.24	10.8	1.03	95	13.7	0.59	120 [b]
21.7	0.41	30.6	2.14	141 [b]	27.1	0.58[1]	125 [b]
42.2	0.68	37.7	1.30[1]	89 [b]	53.6	1.51[1]	127 [b]
57.7	0.79	58.4	1.99	101	95.0	2.04	165 [b]
			Total alkalinity (mg/liter as $CaCO_3$)				
6.1	0.22	6.8	2.36	113	17.9	10.70	295 [a]
33.2	0.22	34.3	0.53	103 [b]			
74.8	0.23	81.7	1.38	109 [b]			
110.0	0.38	117.0	1.86	106 [b]	90.0	10.00	82 [b]
187.0	0.23	192.0	1.38	103 [b]	154.0	4.76	82 [b]

Table 1. Cont.

Standard Methods		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Total ammonia nitrogen (mg/liter)				
0.1	0.01	0.2	0.04	198 [b]	0.5	0.02	505 [b]
0.2	0.03	0.6	0.03[1]	320 [b]	0.8	0.03[1]	390 [b]
0.6	0.06	2.8	0.14[1]	500 [b]	0.3	0.03[1]	509 [b]
1.1	0.06	4.9	0.70	449 [b]	2.2	0.04	197 [b]
			Total chlorine (mg/liter)				
0.1	0.01	0.1	0.01[1]	129 [b]	0.2	0.06[1]	229 [b]
0.9	0.01	1.0	0.02[1]	109 [b]	1.2	0.02[1]	136 [b]
2.2	0.03	2.2	0.12	100	2.7	0.07	120 [b]
4.1	0.04	4.3	0.22	106 [a]	4.6	0.02[1]	112 [b]
			Total hardness (mg/liter as $CaCO_3$)				
21.9	0.12	21.7	0.32	99	22.6	0.98	103
41.3	0.13	41.5	0.56	100	43.0	1.91	104
77.5	0.17	76.0	0.21[1]	98 [b]	80.3	1.38	104 [b]
108.0	0.44	108.0	0.58[1]	100	106.0	3.31	98

Table 1. Cont.

Standard Methods		Hellige			LaMotte		
Mean	SD	Mean	SD	Percent of standard method	Mean	SD	Percent of standard method
			Turbidity (nephelometer turbidity units, NTU)				
2.0	0.13	1.9	0.20[1]	95			
11.4	0.08	12.8	1.35	112 [a]			
39.1	1.66	36.9	1.68[1]	94 [a]			
59.1	0.58	60.9	4.60	103			
82.2	0.95	89.6	4.43	109 [b]			
104.0	1.12	116.0	4.39	112 [b]			
137.0	2.76	136.0	6.24[1]	99			
4.0	0.63				6.4	4.90	162
19.9	0.74				29.3	5.49	147 [b]
35.8	1.39				64.0	7.66	179 [b]
67.8	3.18				88.0	7.66[1]	130 [b]
131.0	4.02				277.0	9.23[1]	211 [b]
158.0	1.50				299.0	14.50	189 [b]

[1]Variances (s^2) were homogeneous and pooled variances were used in t-tests ($s_1^2 = s_2^2$, df = 12; $s_1^2 = s_1^2 \neq s_2^2$, df = 6).

[a] Significantly different ($P < 0.05$) from standard method.

[b] Significantly different ($P < 0.01$) from standard method.

Table 2. Comparisons[1] between water analysis kits and standard methods. Each entry is based on 7 replicate analyses each of 3 to 8 samples (low to high concentration of each variable).

Determination	Hach kits		Bausch and Lomb SpectroKits	Ecologic kits	CHEMetric kits	Hellige outfits	LaMotte kit
	DR-EL/2 (From Boyd 1976, 1977)	AL-36B	(From Boyd 1980)			(From present study)	
Total hardness	106			96		96	104
Carbon dioxide	106	157	130	131			93
Chloride	141		70	96		112	120
Color	111					89	
Copper	92						
Dissolved oxygen	108	96	112	101	120	98	109
Methyl orange acidity	103						
Nitrate	125		100			82	95
Nitrite	92		87			84	183
Orthophosphate	101		108				134
pH	100	112		110		107	100
Specific conductance	121						113
Sulfate	101		63	104		122	134
Total alkalinity	101	125	114	118		107	153
Total ammonia nitrogen	128		59		76	367	400
Total chlorine	98		96	166		111	152
Total hardness	100	150	112	95		99	102
Total iron	68						
Turbidity	169		77			103	170

[1] $\frac{\text{Concentration by water analysis kits}}{\text{Concentration by standard method}} \times 100$

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