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Appendix

Procedure of Iron Testing by Dalta Scientific Company

Photometric Analyzer, Model 260

Test No. 260 - 14-----Iron

The Regents and Accessories requires are as follows:

	R-101	Ammonium Acetate Buffer
	R-39	Hydrochloric Acid, Concentrated
	R-1000	Hydroxylamine Reagent
	R-36	Iron Reagent Powder
	R-102	Phenanthroline, 0.1%
2	103-A	Cylinder, Graduated, 50 ml
2	105-A	Flask, Erlenmeyer, 125 ml
2	107-A	Flask, Volumetric, 50 ml
2	110-A	Pipette, Mohr Measuring, 5 ml in 1/10 ml
	112-A	Scoop

Procedure

This is based on the standard A.P.H.A. method, 12th edition, using Phenenthroline. Where the ample is TREATED TO REMOVE INTERFERING SUBSTANCES. The calibration graph is used.

1. For total Iron, mix the sample throughly and measure 50 ml of mixed sample into a 125 ml Erlenmeyer flask.

2. Simultaneously prepare a reagent by adding 50 ml of sidtilled water toa second 125 ml Erlenmeyer flask.

3. To each Flask, add 2 ml or No R-39 Hydrocholric Acid, Concentrated. And 1 ml of No. R-100 Hydroxylamine Reagent.

4. Heat both flasks to boiling on a hot plate and reduce to volume to approximately 20 ml.

5. Cool to room temperature and transfer each to No.107-A ml Volumetric Flasks.

6. To each, add 10 ml of No.R-101 Ammonium Acatate Buffer and 3 ml of No.R-102 Phenanthroline, 0.1%

7. Dilute each flask to volume with distilled water, and mix. Let stand for five minutes.

8. Turn on the Analyzer and rotate filter selector to No.520.

9. Fill one No.260-T Square 26 mm Test Cell with untreated filtered sample.

10. Insert the test cell containing the blank into the Analyzer, making certain that one of the frosted sides faces to the front. Adjust the meter needle to 100.

11. Replace the blank with the test cell containing the treated sample, and read the meter.

12. Refer to the graph for Iron to convert the meter reading to ppm Iron (Fe)

13. The Model 260 Water Analyzer.

Table 1 Characteristics of Influent and Effluent Ground Water Sample.

Test No I A

Loading	0.42	1/min
Energy used	20	Watts
Conductivity	3.43	micro-mho

	Raw sample	Treated sample
pH	6.35	6.6
Temperature	28°C	48°C
Iron	1.7 ppm	0.0125 ppm
Hardness As $CaCO_3$	380 ppm	330 ppm
Alkalinity	480 ppm	-
Dissolved O_2	2.8 ppm	1 ppm

Percent Iron Removal = 99.26 %

Table 2 Characteristics of Influent and Effluent Ground Water Sample.

Test No I B

Loading	1.50	1/min
Energy	20	Watts
Conductivity	3.43	micro-mho

	Raw sample	Treated sample
pH	6.35	6.5
Temperature	28°C	43°C
Iron	1.7 ppm	0.025 ppm
Hardness As $CaCO_3$	380 ppm	370 ppm
Alkalinity	480 ppm	-
Dissolved O_2	2.8 ppm	2 ppm

Percent Iron Removal = 98.55 %

Table 3 Characteristics of Influent and Effluent Ground Water

Test No I C

Loading	2.31	1/min
Energy	20	Watts
Conductivity	3.43	micro-mho

	Raw sample	Treated sample
pH	6.35	6.55
Temperature	28°C	40°C
Iron	1.7 ppm	0.0625 ppm
Hardness	380 ppm	330 ppm
Alkalinity	450 ppm	-
Dissolved O_2	2.8 ppm	2.6 ppm

Percent Iron Removal = 96.32 %

Table 4 Characteristics of Influent and Effluent Ground Water.

Test No I D

Loading	2.85	1/min
Energy used	20	Watts
Conductivity	3.43	micro-mho

	Raw sample	Treated sample
pH	6.35	6.55
Temperature	28°C	32°C
Iron	1.7 ppm	0.14 ppm
Hardness	380 ppm	380 ppm
Alkalinity	450 ppm	-
Dissolved O_2	2.6 ppm	-

Percent Iron Removal = 91.76 %

Table 5 Characteristics of Influent and Effluent Ground Water Sample.

Test No I E

Loading	3.18	1/min
Energy used	20	Watts
Conductivity	3.43	micro-mho

	Raw sample	Treated sample
pH	6.35	6.45
Temperature	28°C	30°C
Iron	1.7 ppm	0.235 ppm
Hardness	380 ppm	-
Alkalinity	450 ppm	-
Dissolved O_2	2.6 ppm	-

Percent Iron Removal = 85.88 %

Table 6 Characteristics of Influent and Effluent Ground Water Sample.

Test No II A

Loading	2.4	1/min
Energy used	40	Watts
Conductivity	3.96	micro-mho

	Raw sample	Treated sample
pH	7.1	7.3
Temperature	28°C	36.5°C
Iron	1.5 ppm	0.15 ppm
Hardness As $CaCO_3$	405 ppm	-
Alkalinity	380 ppm	180 ppm
Dissolved O_2	2.6 ppm	1.4 ppm

Percent Iron Removal = 90 %

Table 7 Characteristics of Influent and Effluent Ground Water Sample.

Test No II B

Loading	3.12	1/min
Energy used	40	Watts
Conductivity	3.96	micro-mho

	Raw sample	Treated sample
pH	7.1	7.2
Temperature	28°C	35°C
Iron	1.5 ppm	0.46 ppm
Hardness As $CaCO_3$	405 ppm	340 ppm
Alkalinity	380 ppm	180 ppm
Dissolved O_2	2.6 ppm	-

Percent Iron Removal = 69.33 %

Table 8 Characteristics of Influent and Effluent Ground Water Sample.

Test No II D

Loading	4.8	1/min
Energy used	40	Watts
Conductivity	3.96	micro-mho

	Raw sample		Treated sample	
pH	7.1		7.1	
Temperature	28°C		33°C	
Iron	1.5	ppm	0.57	ppm
Hardness As $CaCO_3$	405	ppm	395	ppm
Alkalinity	380	ppm	260	ppm
Dissolved O_2	2.6	ppm	-	

Percent Iron Removal = 62 %

Table 9 Characteristics of Influent and Effluent Ground Water Sample.

Test No III A

Loading	5.04	l/min
Energy used	60	Watts
Conductivity	3.96	micro-mho

	Raw sample		Treated sample	
pH	7.1		7.2	
Temperature	27°C		36.5°C	
Iron	1.5	ppm	0.55	ppm
Hardness As $CaCO_3$	405	ppm	-	
Alkalinity	380	ppm	230	ppm
Dissolved O_2	2.6	ppm	2	ppm

Percent Iron Removal = 63.33 %

Table 10 Characteristics of Influent and Effluent Ground Water Sample.

Test No III B

Loading	2.7	1/min
Energy used	60	Watts
Conductivity	3.96	micro-mho

	Raw sample		Treated sample	
pH	7.1		7.05	
Temperature	27°C		38°C	
Iron	1.5	ppm	0.025	ppm
Hardness	405	ppm	340	ppm
Alkalinity	380	ppm	140	ppm
Dissolved O_2	2.6	ppm	-	

Percent Iron Removal * 98.33 %

Table 11 Characteristics of Influent and Effluent Ground Water Sample.

Test No III C

Loading	4.2	l/min
Energy used	60	Watts
Conductivity	3.96	micro-mho

	Raw sample		Treated sample	
pH	7.1		6.8	
Temperature	27°C		37.5°C	
Iron	1.5	ppm	0.52	ppm
Hardness As $CaCO_3$	405	ppm	360	ppm
Alkalinity	380	ppm	180	ppm
Dissolved O_2	2.6	ppm	-	

Percent Iron Removal = 65.33 %

Table 12 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV A

Loading	0.698	1/min
Energy used	80	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		7.2	
Temperature	27°C		27°C	
Alkalinity	106.6	ppm	103.3	ppm
Hardness	45	ppm	35	ppm
Iron	2.4	ppm	0.12	ppm

Percent Iron Removal = 95.0 %

Table 13 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV B

Loading	0.698	l/min
Energy used	80	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		7.25	
Temperature	27°C		27°C	
Alkalinity	106.6	ppm	81.6	ppm
Hardness	45	ppm	35	ppm
Iron	2.4	ppm	0.1	ppm

Percent Iron Removal = 95.85 %

Table 14 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV C

Loading	0.698	1/min
Energy used	100	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		7.1	
Temperature	27°C		27.5°C	
Alkalinity	106.6	ppm	91.75	ppm
Hardness	45	ppm	40	ppm
Iron	2.4	ppm	0.1	ppm

Percent Iron Removal = 95.83 %

Table 15 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV D

Loading	0.698	1/min
Energy used	160	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		6.9	
Temperature	27°C		27.5°C	
Alkalinity	106.6	ppm	91.75	ppm
Hardness	45	ppm	42.5	ppm
Iron	2.4	ppm	0.032	ppm

Percent Iron Removal = 98.6 %

Table 16 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV E

Loading	0.698	1/min
Energy used	160	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		6.9	
Temperature	27°C		28°C	
Alkalinity	106.6	ppm	82.5	ppm
Hardness	45	ppm	40.0	ppm
Iron	2.4	ppm	0.05	ppm

Percent Iron Removal = 97.9 %

Table 17 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV G

Loading	0.698	1/min
Energy	200	Watts
Conductivity	4.5	micro-mho

	Synthetic sample	Treated sample
pH	7.1	6.95
Alkalinity	106.6 ppm	90.0 ppm
Hardness	45 ppm	40 ppm
Iron	2.4 ppm	0.025 ppm
Temperature	27°C	28°C

Percent Iron Removal = 98.9 %

Table 18 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV H

Loading	0.698	1/min
Energy used	200	Watts
Conductivity	4.5	micro-mho

	Synthetic sample	Treated sample
pH	7.1	6.8
Alkalinity	106.6 ppm	77.5 ppm
Hardness	45 ppm	42.5 ppm
Iron	2.4 ppm	0.0125 ppm
Temperature	27°C	28°C

Percent Iron Removal = 99.4 %

Table 19 Characteristics of Influent and Effluent Synthetic Water Sample.

Test No IV I

Loading	0.698	l/min
Energy used	240	Watts
Conductivity	4.5	micro-mho

	Synthetic sample		Treated sample	
pH	7.1		6.8	
Alkalinity	106.6	ppm	86.0	ppm
Hardness	45	ppm	42.5	ppm
Iron	2.4	ppm	0.01	ppm
Temperature	27°C		28°C	

Percent Iron Removal = 99.5 %

Cost Estimated

For Iron Removal by Electrical Means.

1. Natural Water

Flow rate 2.7	1/min	= 162	1/hr.
Energy used 60	Watts	= 60	W-hr.
percent of iron removal		98.33	%
Alkalinity		380	ppm
a unit of electrical energy is		0.75	฿
Cost of electrical energy per cu.m. is = 0.06 0.75/0.162		= 0.77	฿
approximatty		= 0.30	฿/cu.m.

2. For a Synthetin Water

Flow rate 0.698	1/min	= 41.88	1/hr.
Energy used 160	Watts	= 160	W-hr.
Percent of iron remove		98.6	%
Alkalinity		106.6	ppm
41.88 1/min energy used		= 0.16	k-W
cost of electrical energy per cu.m. = 0.75 0.16/0.04188		= 2.926	฿
approximetty		3.00	฿/cu.m.

Note. The lower the alkalinity, the higher the energy cost.

For Iron Removal by Spaulding Precipitator by R.H.BABCOCK (1949)

Percentage of Iron renoval		95	%
Alum used	=	2.5	gpg
Lime used	=	2.5	gpg
For one cu.m. of water used	= 2.5 1,000/3.787g.		
	=	0.66	g.
cost of alum	=	.20	฿/cu.m.
cost of lime	=	.05	฿/cu.m.
total	=	.25	฿/cu.m.

Table 20 Estimated cost at various flew rate

Flew rate l/min	40 Watts		60 Watts	
	Cost ฿/cm.	% Fe removal	Cost ฿/cm.	% Fe removal
2.0	0.249	97	-	-
2.5	0.199	88	0.300	99
3.0	0.166	75	0.249	95.25
3.5	0.142	66.25	0.217	81
4.0	-	-	0.187	68

Table 21 Estimated cost at various percentage of iron removal.

% Fe removal	40 Watts		60 Watts	
	Cost ฿/cm.	Flowrate l/min	Cost ฿/cm.	Flowrate l/min
95	.23	2.15	.243	3.05
90	.204	2.40	.230	3.25
85	.192	2.60	.220	3.40
80	.178	2.80	.212	3.55
75	.166	3.0	.202	3.70

Table VI Summary of Result

	Flow Rate l/min.	Energy watts.	Alk. ppm.	Hardness ppm.	Iron ppm.	%Removal	pH	Tem. °C
Natural Row Sample No I	-	-	480	380	1.7[illegible].7	-	6.35	28
	0.42	20	-	330	0.0125	99.26	6.6	48
	1.50	20	-	370	0.025	98.55	6.5	43
	2.31	20	-	330	0.0625	96.32	6.55	40
	2.85	20	-	380	0.14	91.76	6.55	32
	3.13	20	-	-	0.235	85.88	6.45	30
Natural Raw Sample No II	-	-	380	495	1.5	-	7.1	28
	2.[illegible]	[illegible]0	[illegible]80	-				
	2.4	40	180	-	0.15	90	7.3	36.5
	3.12	40	180	340	0.46	69.33	7.2	35
	4.8	40	260	395	0.57	62	7.1	33
	2.7	60	140	340	0.025	98.33	7.05	38
	4.2	60	180	360	0.52	65.33	6.8	37.5
	5.04	60	230	-	0.55	63.33	7.2	36.5
Synthic Sample.	-	-	106.6	45	2.4	-	7.1	27
	0.689	80	103.3	35	0.12	95	7.2	27
	0.689	100	91.75	40	0.10	95.85	7.1	27.5
	0.689	160	82.50	40	0.05	47.90	6.9	28
	0.689	200	77.5	42.5	0.0125	99.4	6.8	28.5

VITA

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