OXYGEN UPTAKE RATE (OUR)
SPECIFIC OXYGEN UPTAKE RATE (SOUR) TESTING

INTRODUCTION

- DAN LEAVITT
- SUPERINTENDENT
- CITY OF LONDON
- WASTEWATER TREATMENT PLANT
- 740-852-0279

AGENDA

- SOUR / OUR TEST
- SOUR / OUR PROCEDURE
- SAMPLING PROCEDURE
- APPLICATIONS OF SOUR / OUR
- SOUR EXPERIENCE
- QUESTIONS

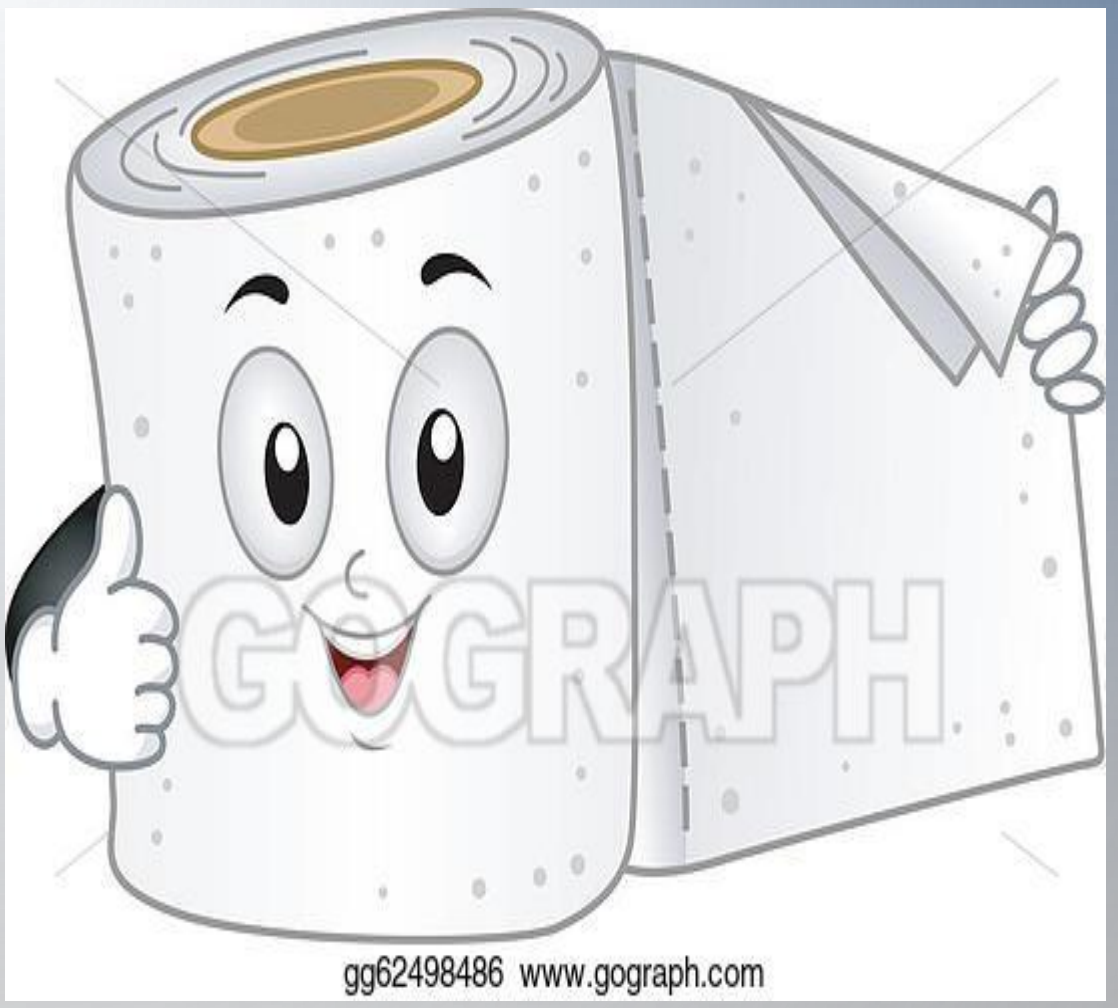
WHAT IS OUR / SOUR TEST

- MICRO-ORGANISMS USE OXYGEN TO CONSUME ORGANIC MATTER
- HIGHER THE OXYGEN UPTAKE – HIGHER ORGANIC CONTENT

DID YOU KNOW?

- FIRST USE OF TOILET PAPER DATED BACK TO 6TH CENTURY AD IN EARLY MEDIEVAL CHINA

- THE TOILET PAPER ROLL WAS INVENTED IN 1890 BY THE SCOTT BROTHERS

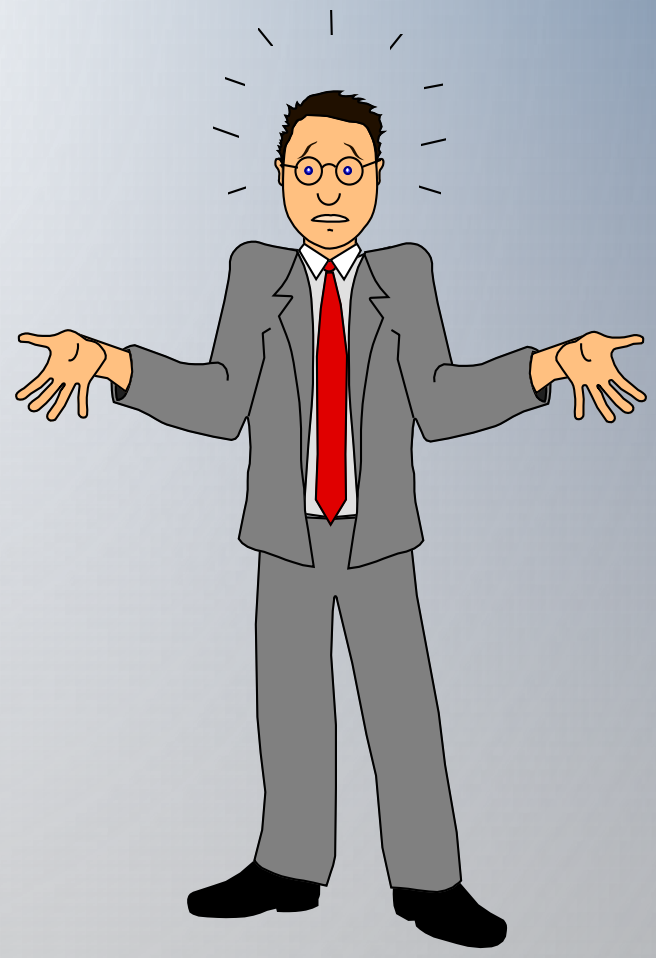


SPECIFIC OXYGEN UPTAKE RATE

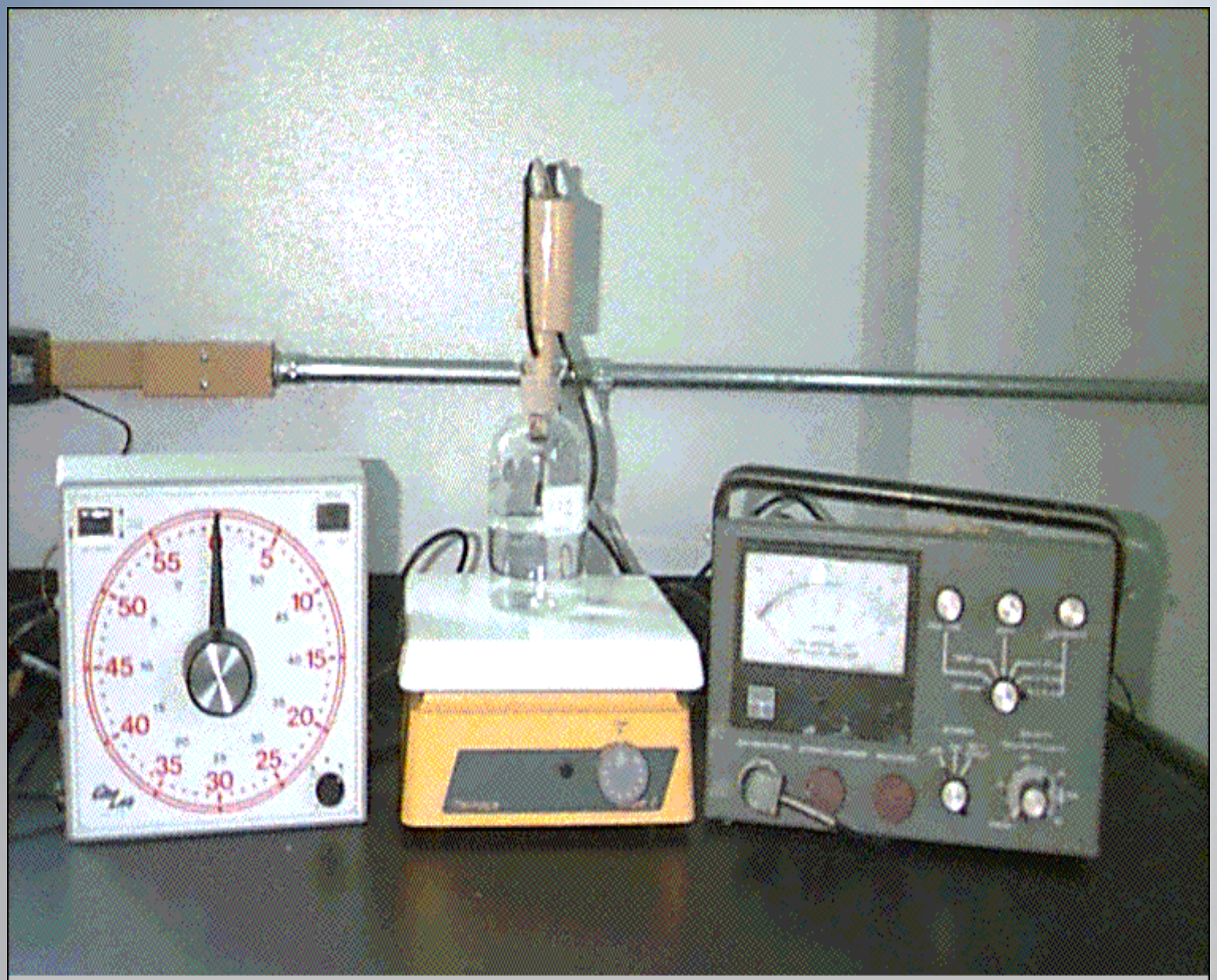
- Milligrams of Oxygen Consumed
- Per Hour
- Per Gram of Volatile Suspended Solids (dry weight)
- 503 Reg. Use Total Solids (dry weight) Per Gram
- At 20 C (503)
- Temp Correction for 10-30 C (503)
- OUR = Oxygen Uptake Rate mg/L/hr

TOP TEN LIST ON WHY DO THE SOUR TEST

- 10 - NOTHING TO DO ALL DAY !!!
- 9 - BECAUSE MY BOSS SAID SO!!!
- 8 - I LIKE TO WATCH THE STIR BAR GO AROUND!!!
- 7 - TO DO THE SHAKE!!!



WHY USE THE SOUR TEST

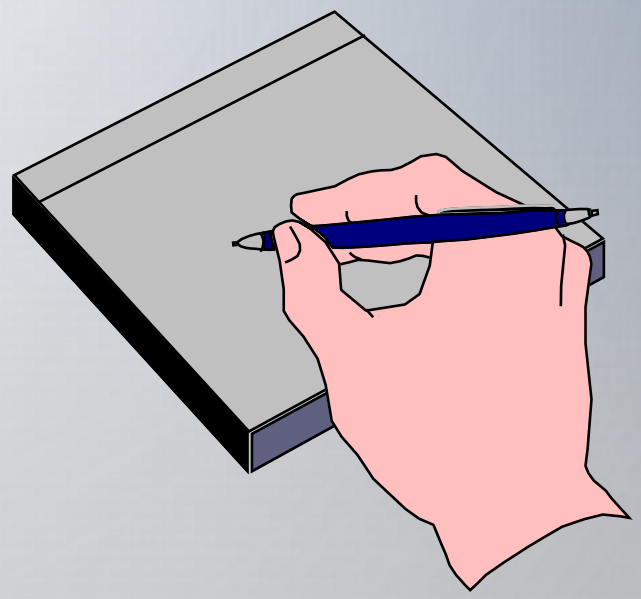


sour1.JPG

- EQUIPMENT
- TIMELY
- EASY

WHY USE THE SOUR TEST

SOUR PROCEDURE



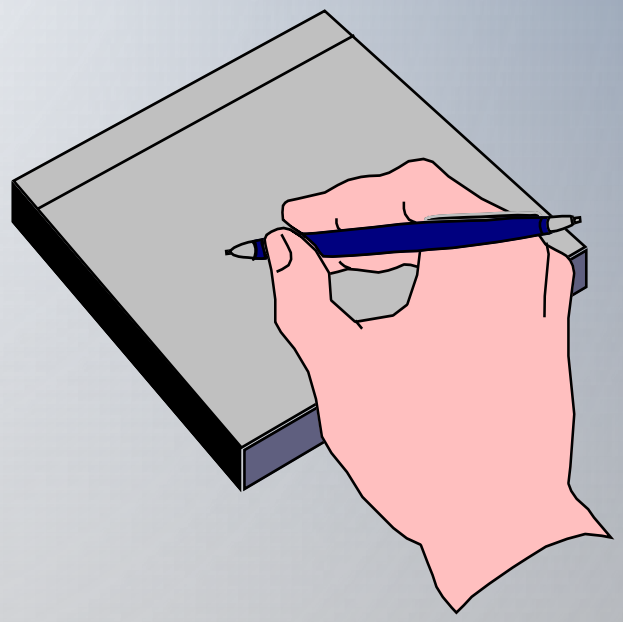
EPA United States Environmental Protection Agency

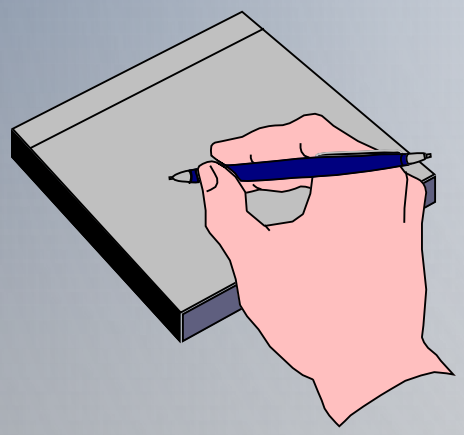
Environmental Regulations and Technology

Control of Pathogens and Vector Attraction in Sewage Sludge

PROCEDURE SOURCE

- OEPA BIOSOLIDS RULES 3745-40-04(4) VAR-4
- STANDARD METHODS 18TH 2710-B
- OEPA WEBSITE - BIOSOLIDS





EPA-821-R-01-014
January 2001

METHOD 1683

Specific Oxygen Uptake Rate in Biosolids

Draft
January 2001

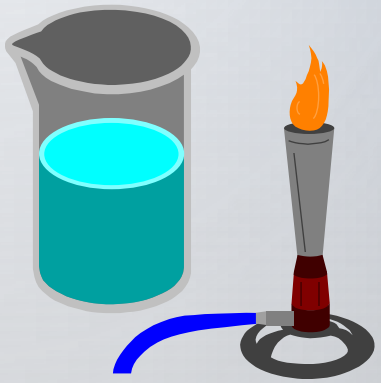
U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Engineering and Analysis Division (4303)
1200 Pennsylvania Ave. NW
Washington, DC 20460

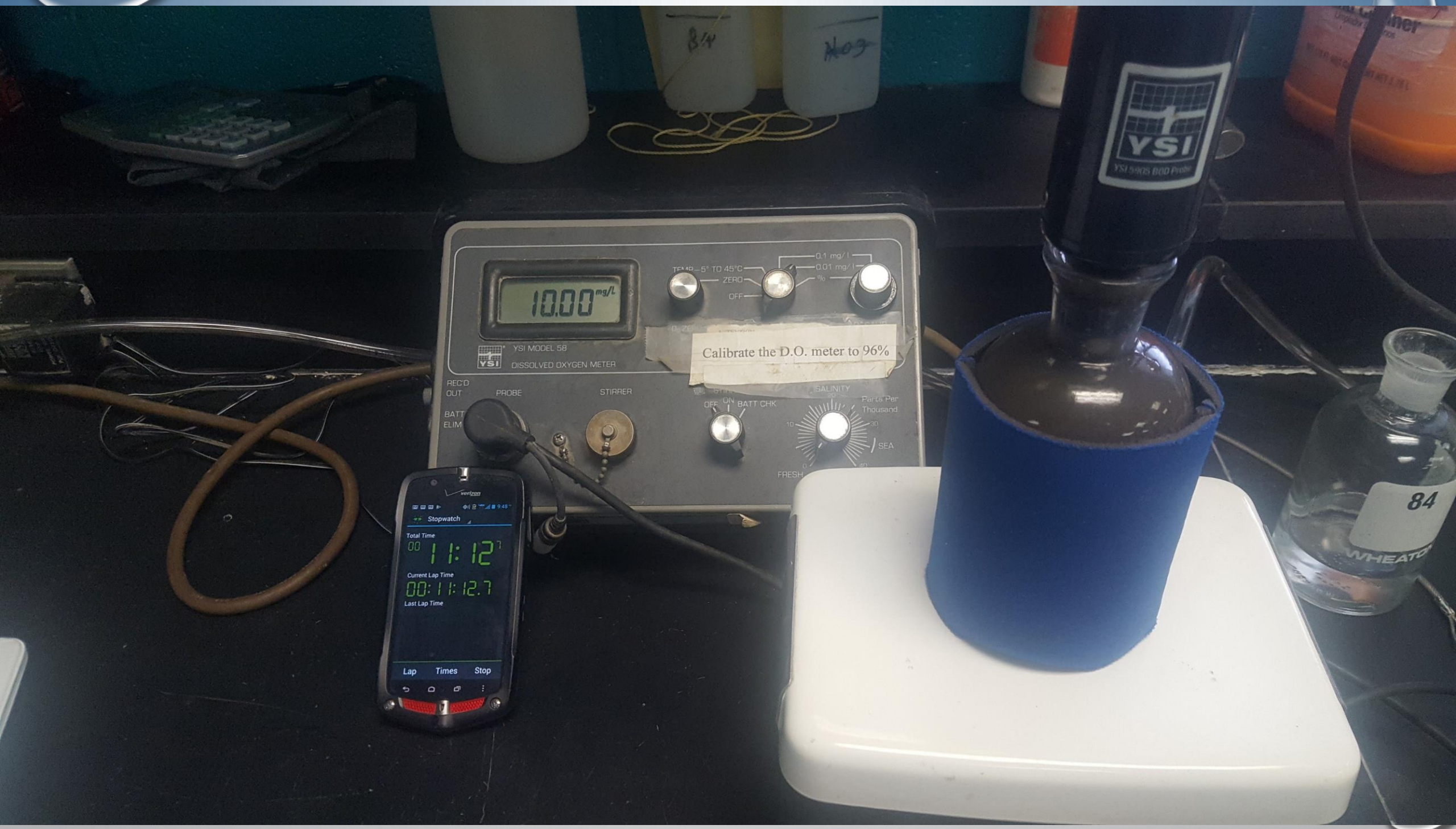
SOUR Test for Biosolids Treatment

Developed by Richard Giani
Edited by Denise Clemens
Pennsylvania Department of
Environmental Protection
www.dep.pa.state.us

EQUIPMENT NEEDED FOR SOUR PROCEDURE

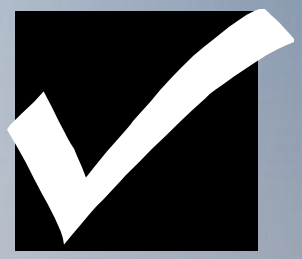
- DISSOLVED OXYGEN METER
- D.O. PROBE
- BOD BOTTLE WITH INSULATOR
- STIR PLATE AND STIR BAR
- STOPWATCH OR TIMER




10.00 mg/L
YSI MODEL 58
DISSOLVED OXYGEN METER
Calibrate the D.O. meter to 96%
PROBE
STIRRER
BATT CHK
SALINITY
Parts Per Thousand
SEA
FRESH
YSI
Stopwatch
Total Time
00 11:12.7
Current Lap Time
00:11:12.7
Last Lap Time
Lap
Times
Stop
84

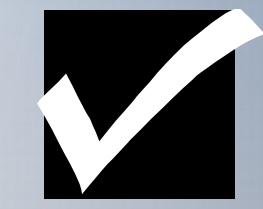
PROCEDURE

- COLLECT ABOUT 500 ML OF BIOSOLIDS IN 1 LITER BOTTLE



SAMPLING

PROCEDURE

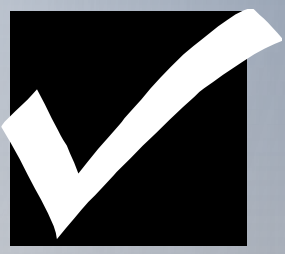


- CAP BOTTLE AND SHAKE WELL FOR 2 MINUTES

PROCEDURE

PROCEDURE

- POUR SAMPLE INTO 300 ML BOD BOTTLE (INSULATED)



PROCEDURE

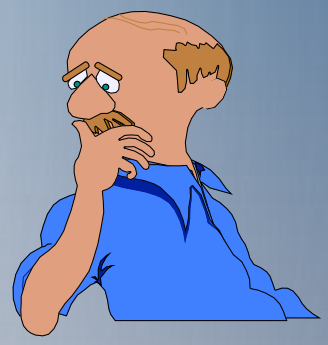
- PLACE ON STIR PLATE AND TURN ON
- IMMEDIATELY PLACE BOD PROBE INTO BOTTLE
- WHEN THE D.O. READINGS STABILIZE, THEN FALL, BEGIN TAKING TEMPERATURE AND DO READINGS ONCE A MINUTE


YSI
10.00 mg/L
YSI MODEL 58
DISSOLVED OXYGEN METER
Calibrate the D.O. meter to 96%
RECD
OUT
PROBE
STIRRER
BATT CHK
SALINITY
Parts Per Thousand
FRESH
SEA
Stopwatch
Total Time
00 11:12.7
Current Lap Time
00:11:12.7
Last Lap Time
Lap
Times
Stop
84

PROCEDURE

- THE TEST IS COMPLETE AFTER 15 MINUTES OR WHEN THE DO DROPS BELOW A PREDETERMINED LOWER LIMIT (USUALLY 1 MG/L)
- DETERMINE THE SLOPE OF D.O. VS TIME
- THE SLOPE IS THE OXYGEN UPTAKE RATE IN (MG/L)/MIN

CALCULATIONS



- SLOPE = $\frac{\text{CHANGE IN D.O. MG/L}}{\text{CHANGE IN TIME, MINUTES}}$

- $\frac{D_1 - D_2}{T_2 - T_1}$ = SLOPE MG/L O_2 / MIN

OUR = SLOPE X 60 = MG/L O_2 / HR.

$$\text{SOUR} = \frac{\text{MG/L } O_2 \text{ / HR. (OUR)}}{\text{MG/L VOLATILE SUSP. SOLIDS}} \times 1000$$

(503 USE GRAM TOTAL SOLIDS G/L)

Sample Source			
Time of Sample			
Date			
Time (minutes)	D.O. mg/L	Change in D.O. mg/L	Temp °C
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
15			
20			
25			
30			

Calculations

Slope = $\frac{\text{Change in D.O. mg/L}}{\text{Change in Time, Minutes}}$ = _____

Oxygen Uptake Rate = Slope x 60 = _____mg/L/hr

Volatile Suspended Solids mg/L= _____

SOUR = $\frac{\text{Uptake rate mg/L/hr}}{\text{mg/L VSS x1000}}$ = _____mg/L/hr/g DW

Ohio Environmental Protection Agency

Division of Surface Water

Specific Oxygen Uptake Rate (SOUR) Worksheet

Date of Data Entry:

Total Solids

Sample volume used for total solids test:	25	mL
Weight of dish:	17.68	g
Weight of dish + dried solids:	17.77	g
Weight of dried solids:	0.09	g
Total Solids:	3.6	g/L

SOUR

Time (Minutes)	Temperature °C	Dissolved Oxygen (mg/L)
0	25.00	8.42
1		8.12
2		7.72
3		7.28
4		6.89
5	24.00	6.47
6		6.13
7		5.74
8		5.37
9		5.01
10	23.50	4.67
11		4.39
12		4.03
13		3.71
14		3.62
15	22.00	3.36

Oxygen Consumption Rate	0.35	mg/L/minute
SOUR	5.83	(mg/g)/hr

SOUR Temperature Correction

Average Sewage Sludge Temperature During Test °C
23.625

If sewage sludge is > 20°C, SOUR =	4.89	(mg/g)/hr
If sewage sludge is < 20°C, SOUR =	4.56	(mg/g)/hr

SOUR passes if result is ≤ 1.5 (mg/g)hr

Version 11/1/11

https://www.epa.state.oh.us/dsw/sludge/biosolid#137944357-compliance-tools

Time (Minutes)	Dissolved Oxygen mg/L	Change in D.O. mg/L	Temp C	
0	8.71		22.60	
1	8.66	0.05		
2***	8.55	0.11		
3	8.44	0.11		
4	8.34	0.10		
5	8.21	0.13		
6	8.11	0.1		
7	7.99	0.11		
8	7.86	0.13		
9	7.76	0.1		
10	7.67	0.09		
15	7.12		23.20	
20				
25				
30				

$\frac{D_1 - D_2}{T_2 - T_1}$ = SLOPE MG/L O_2 / MIN

$\frac{8.55 - 7.12}{15 - 2} = \frac{1.43}{13} = 0.11$ MG/L/MIN X 60 6.6 **OUR**

6.6 MG/L/ HR. / 14.48 G TS = 0. 46 MG/G/HR.=

SOUR

TEMP CORRECTION = 0.37 MG/G/HR @20 C

Ohio Environmental Protection Agency

Division of Surface Water

Specific Oxygen Uptake Rate (SOUR) Worksheet

Date of Data Entry:

Total Solids

Sample volume used for total solids test:	**10**	mL
Weight of dish:	**17.36**	g
Weight of dish + dried solids:	**17.51**	g
Weight of dried solids:	**0.15**	g
Total Solids:	**15.00**	g/L

SOUR

Time (Minutes)	Temperature °C	Dissolved Oxygen (mg/L)
0	**22.60**	**8.71**
1		**8.66**
2		**8.55**
3		**8.44**
4		**8.34**
5		**8.21**
6		**8.11**
7		**7.99**
8		**7.86**
9		**7.76**
10		**7.67**
11		**7.55**
12		**7.44**
13		**7.33**
14		**7.25**
15	**23.20**	**7.12**

Oxygen Consumption Rate	0.11	mg/L/minute
SOUR	0.44	(mg/g)/hr

SOUR Temperature Correction

Average Sewage Sludge Temperature During Test
°C
22.9

If sewage sludge is > 20°C, SOUR =	**0.38**	(mg/g)/hr
If sewage sludge is < 20°C, SOUR =	**0.36**	(mg/g)/hr

SOUR passes if result is ≤ 1.5 (mg/g)hr

Version 11/1/11

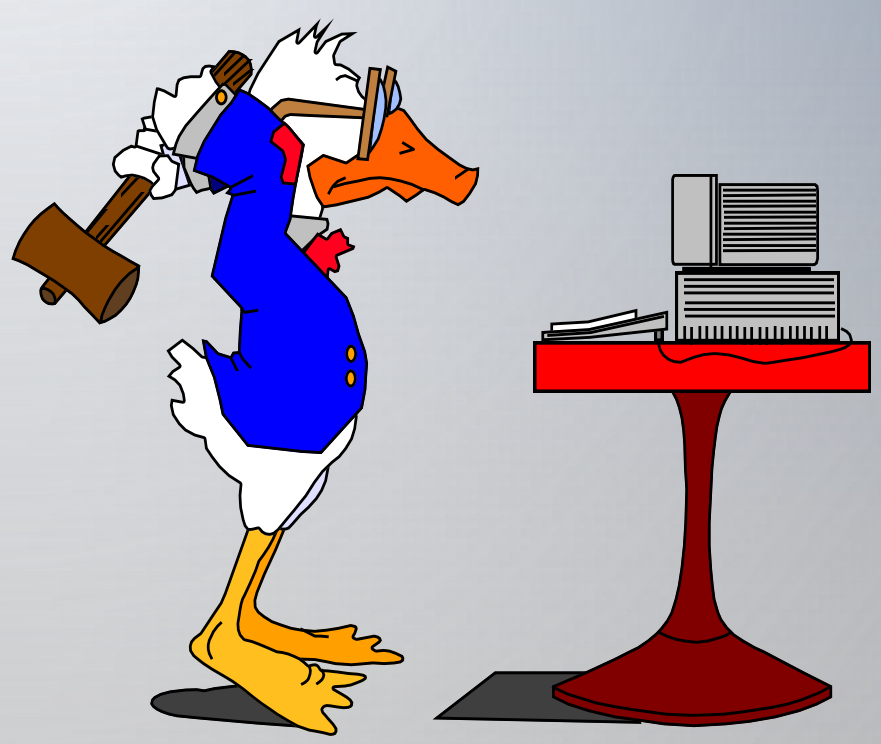

Kimwipes
KIMTECH
YSI
YSI 5010 BOD Probe
DISSOLVED OXYGEN METER
YSI
5100
8.74 *mg /L
Main
20.14°C
9:49 AM
STORE
REVIEW
SEND
CALIBRATE
MODE
ENTER

DID YOU KNOW?

- US SPENDS $6 BILLON A YEAR ON TOILET PAPER!
- ON AVERAGE WE USE 57 SQUARES A DAY

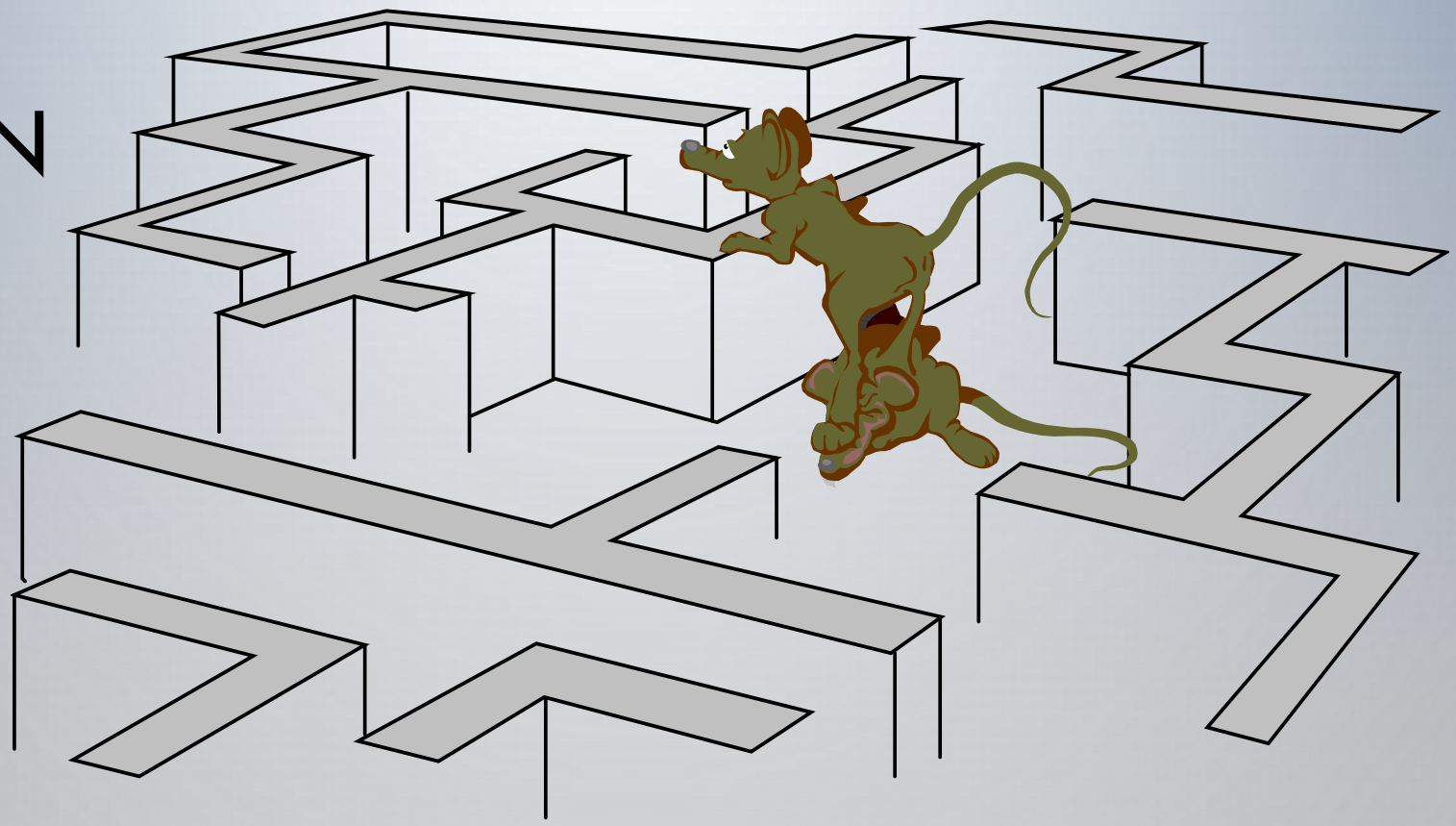
PROBLEMS WITH THE SOUR TEST

- SAMPLE LOCATION
- TIME REQUIREMENT
- TEMPERATURE



SAMPLING PROCEDURE

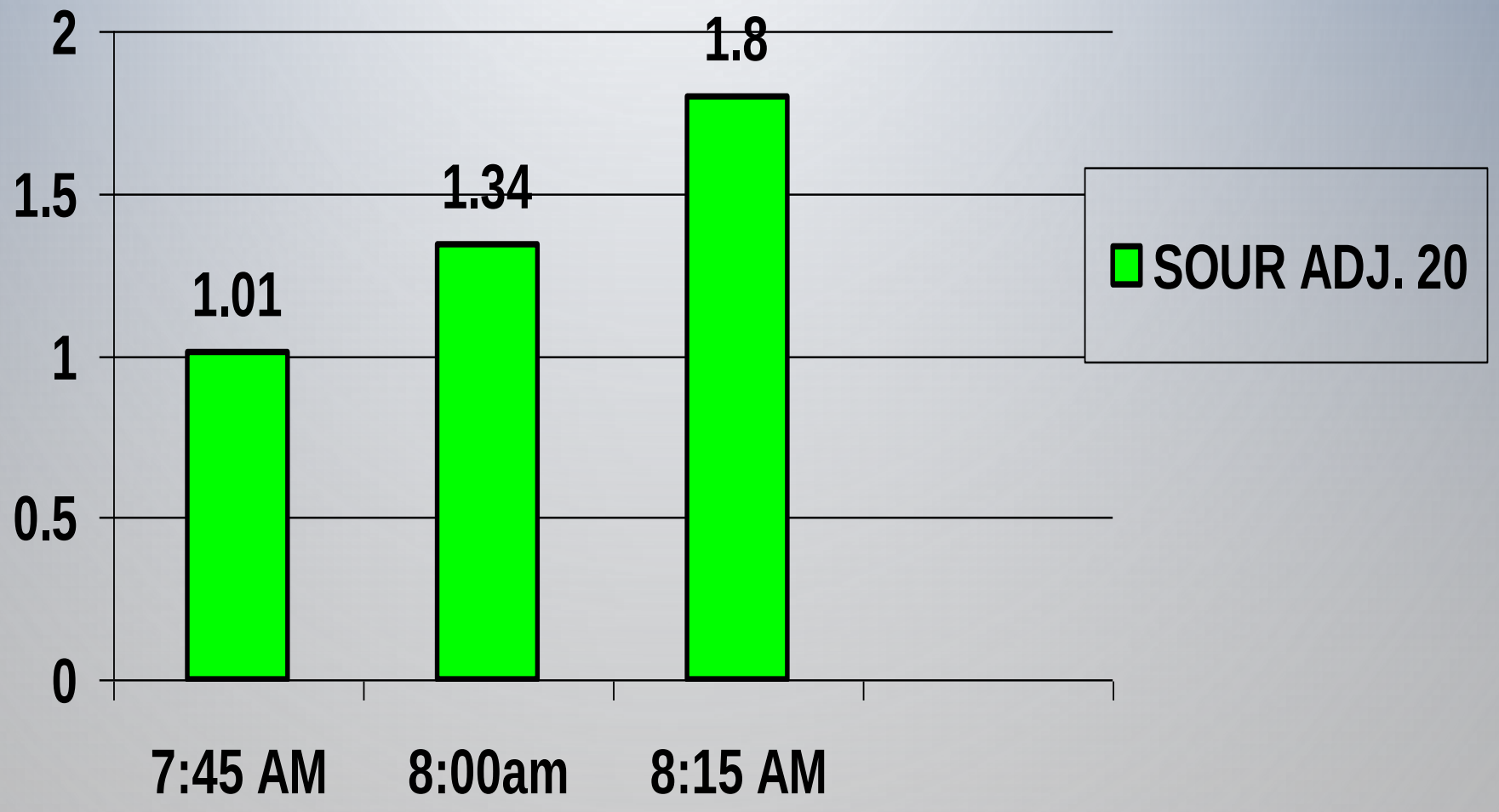
- LOCATION



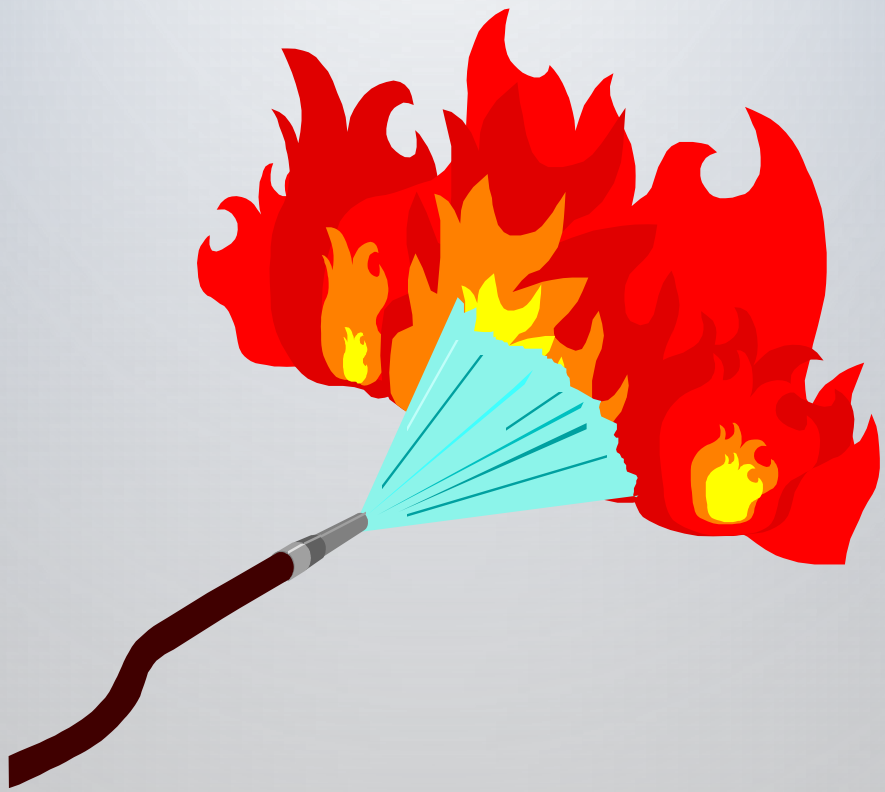
SAMPLING PROCEDURE

- TIMING

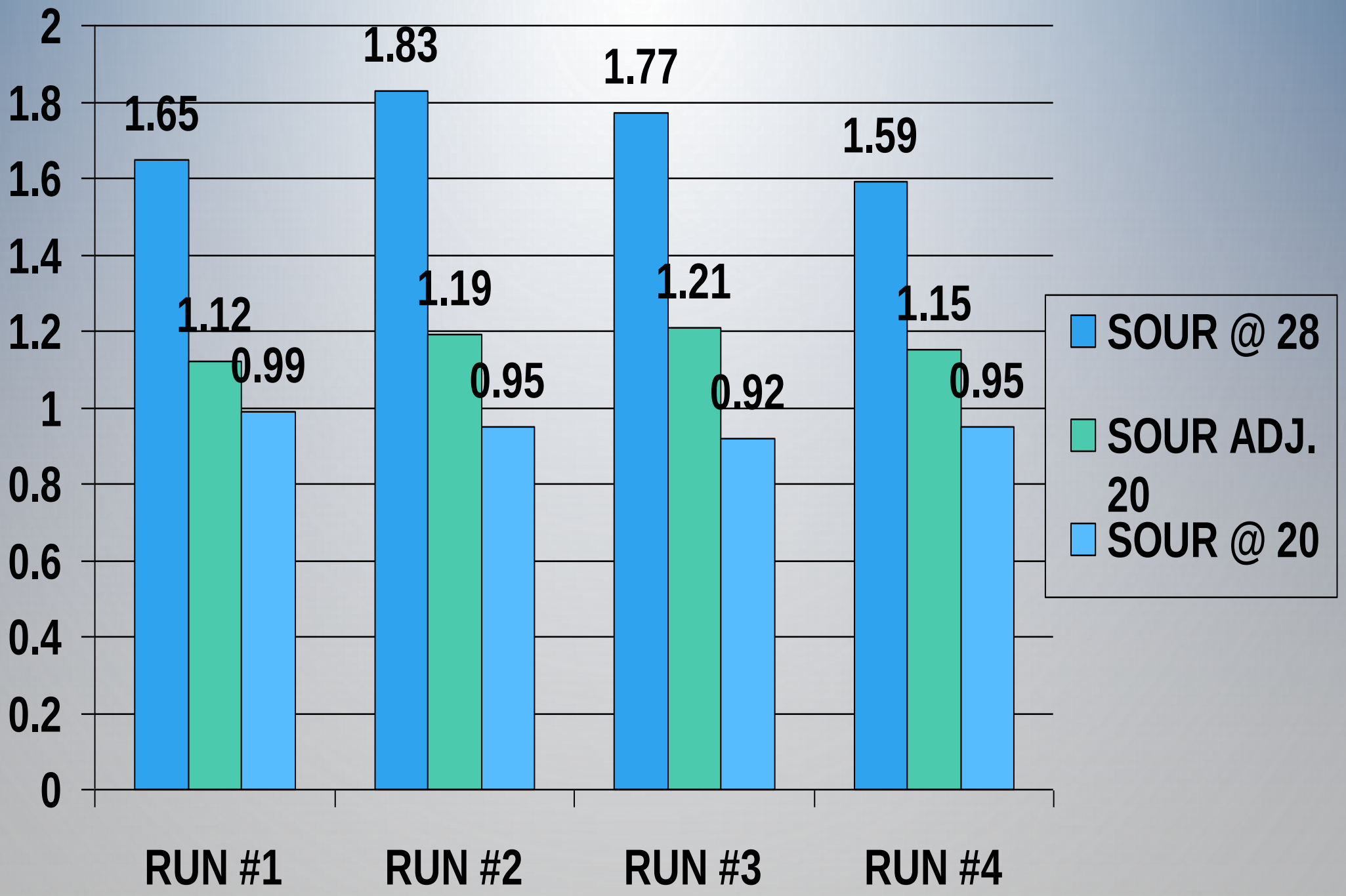
AFFECT OF TIME ON SOUR



TEMPERATURE AFFECT ON SOUR



TEMPERATURE AFFECT ON SOUR

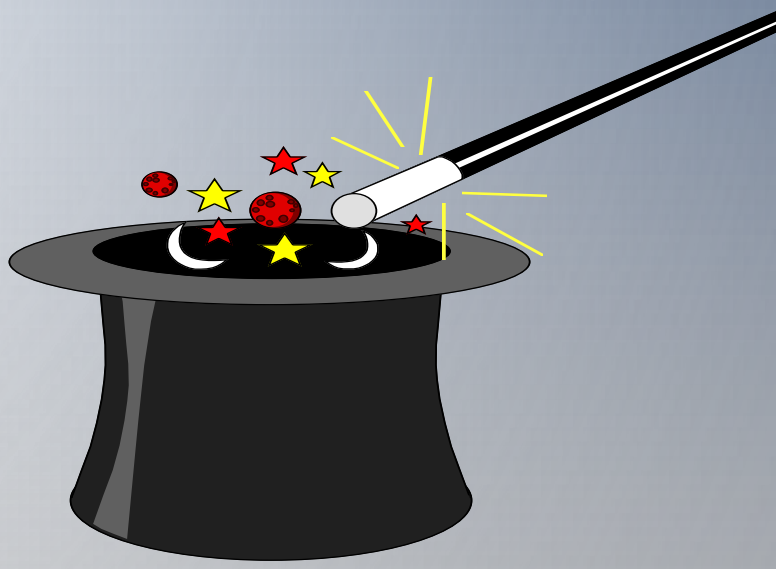


TEMPERATURE AFFECT ON SOUR

- BOD GLASS BOTTLE
- LAB TEMPERATURE?
- INSULATE BOD BOTTLE
- PRE-HEAT OR COOL
- KEEP TEMPERATURE 1 DEG

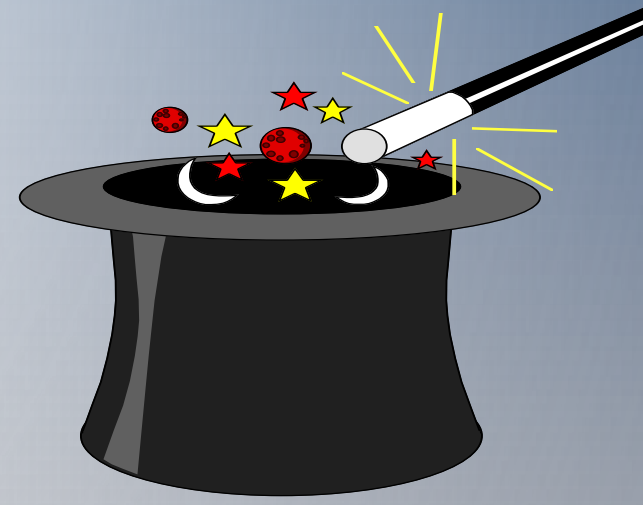
503 VECTOR ATTRACTION REDUCTION OPTION 4 “SOUR TESTING”

- AEROBIC PROCESS WITH TEMP BETWEEN 10 – 30 DEG C
- 1.5 MG/L O2/HR/ G TS
- GRAM OF TOTAL SOLIDS!
- ADJ SOUR TO 20 C
- 7 TEST OVER TWO-WEEKS PERIOD



503 VECTOR ATTRACTION REDUCTION OPTION 4 "SOUR TESTING"

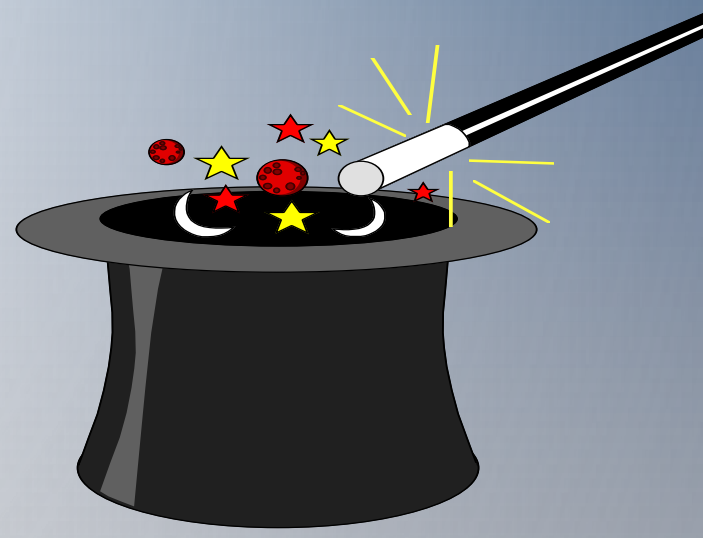
- 2% TS MAX FOR TESTING
- KEEP SAMPLE AT TEMPERATURE OF DIGESTER!
- MAKE SURE DIGESTER AIR HAS NOT BEEN TURN OFF! OR TWO LOW!
- WATCH OUT FOR FORMING
- GOOD MIXING AND GOOD AIR
- GOOD LUCK!



503 VECTOR ATTRACTION REDUCTION OPTION 4 “SOUR TESTING”

- DIGESTER OVER 2% TS
- CUT SAMPLE WITH ?
- DIGESTER SUPERNATANT?
- D.I. WATER?
- EFFLUENT WATER?
- WHAT ABOUT SAMPLE TEMPERATURE?

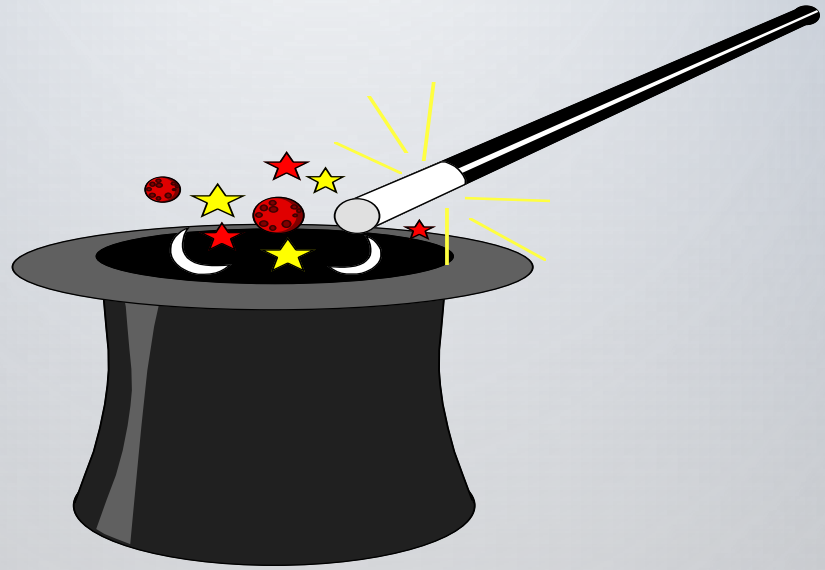
503 VECTOR ATTRACTION REDUCTION OPTION 3 "BENCH SCALE AEROBIC DIGESTION TESTING"



- LAB BENCH SCALE TESTING FOR 30 DAYS @ 20 DEG C
- 2% TS MAX
- IF VSR IS LESS THAN 15 % AFTER 30 DAYS
- MEET THE VECTOR REQUIREMENT

503 VECTOR ATTRACTION REDUCTION OPTION 3 “BENCH SCALE AEROBIC DIGESTION TESTING”

PROCESS CONTROL APPLICATIONS

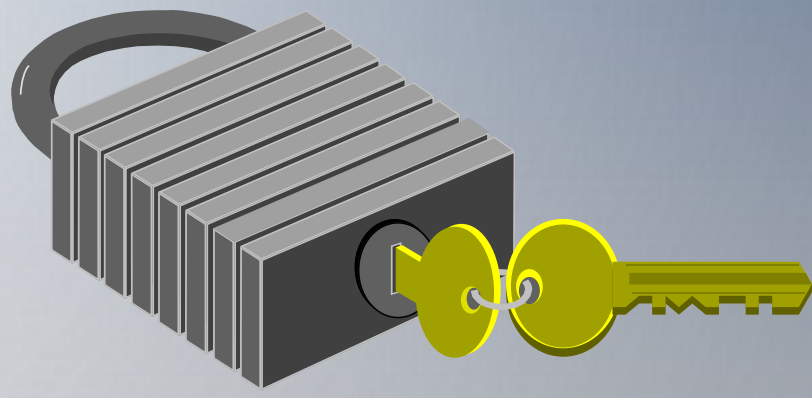


PROCESS CONTROL APPLICATIONS

- USING OUR TO CONTROL TWO-STAGE DIGESTION
- USING OUR TO SET RAS RATES IN CLARIFIER
- USING OUR TO TEST TOXICITY OF SEPTAGE OF HAULED-IN WASTES

PROCESS CONTROL APPLICATIONS

- USING OUR TO CONTROL TWO-STAGE DIGESTION PRIOR TO 503 TESTING

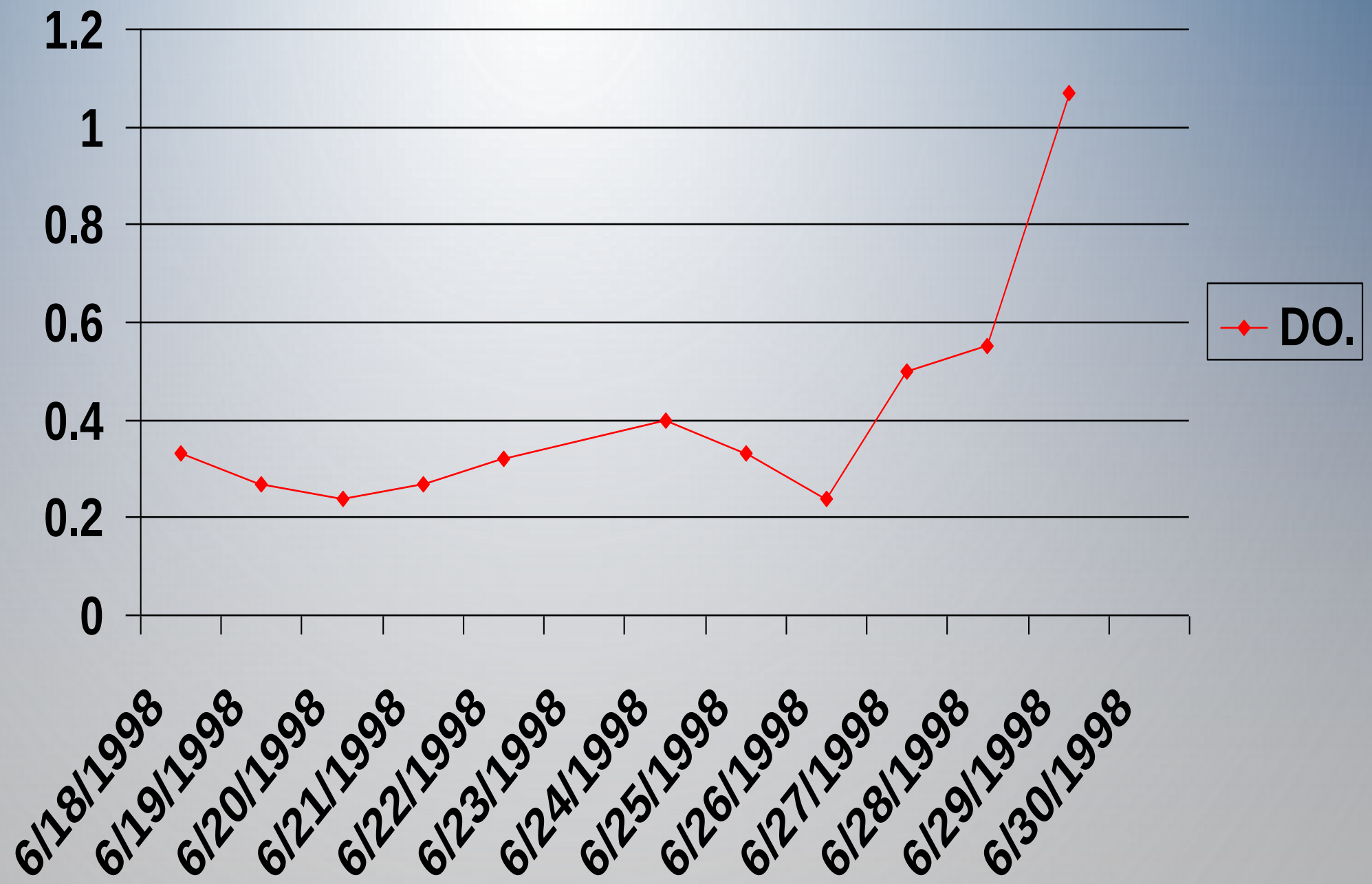


USING OUR TO CONTROL OXYGEN LEVEL

WHAT IS A GOOD D.O. IN A DIGESTER ?

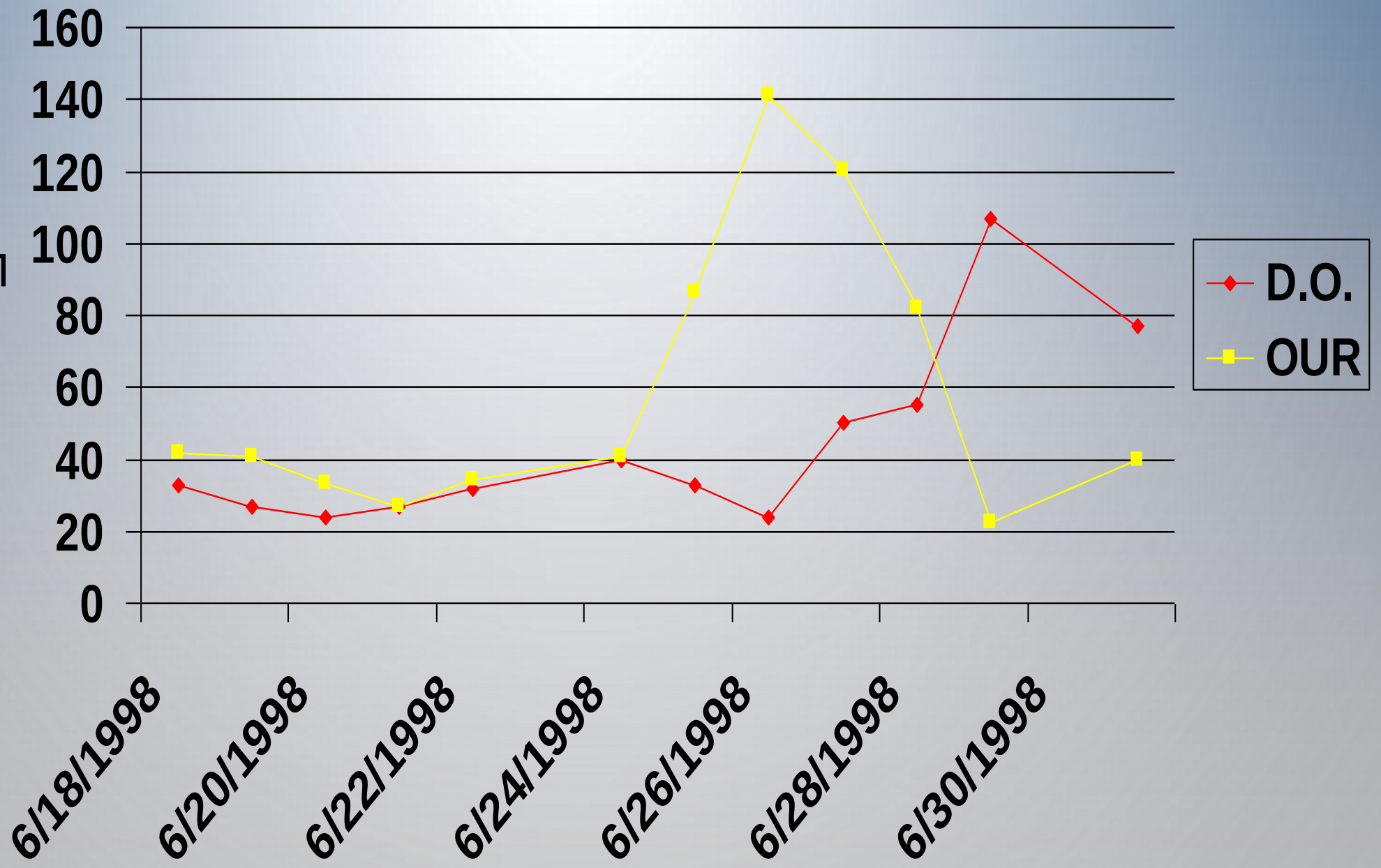
USING OUR TO CONTROL OXYGEN LEVEL

- DIGESTER # 1



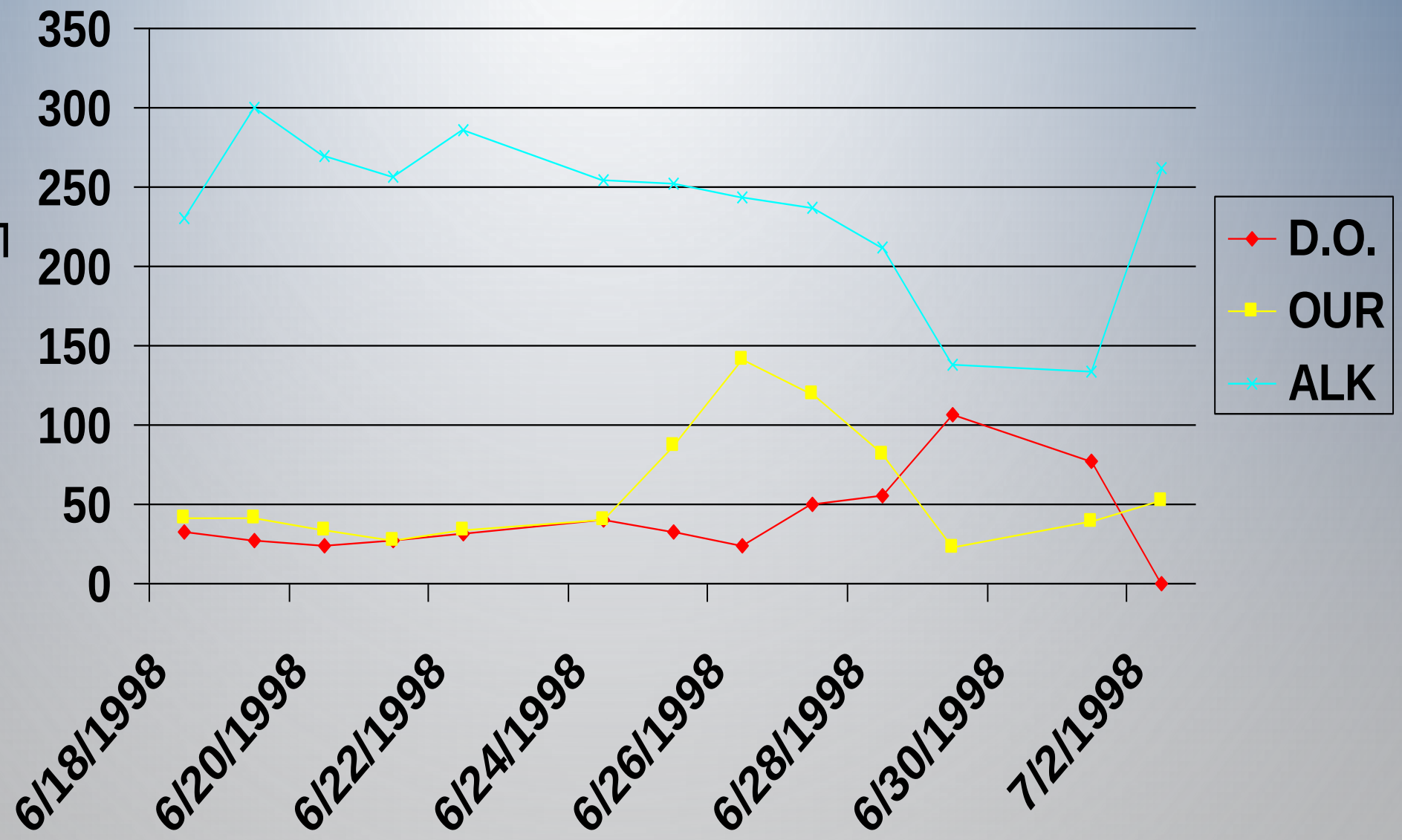
USING OUR TO CONTROL OXYGEN LEVEL

- DIGESTER #1



USING OUR TO CONTROL OXYGEN LEVEL

- DIGESTER # 1

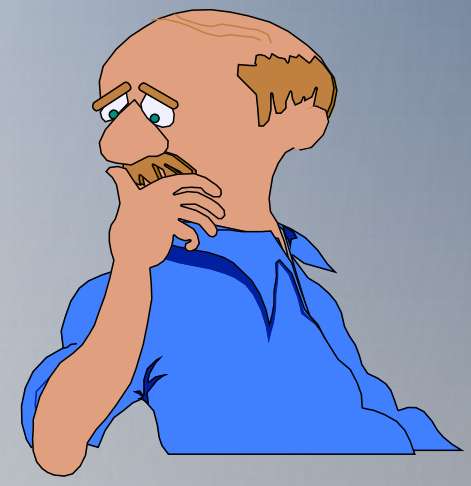


USING OUR TO CONTROL RAS RATE IN CLARIFIER

- WHAT IS THE JOB OF THE CLARIFIER?

USING OUR TO CONTROL RAS RATE IN CLARIFIER

- RAS FLOW 100% OF INFLUENT FLOW?
- 50% OF INFLUENT FLOW?
- 25% OF INFLUENT FLOW?



USING OUR TO CONTROL RAS RATE IN CLARIFIER

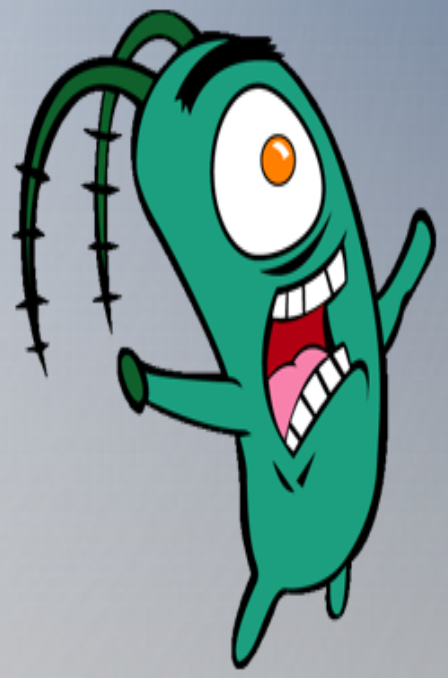
- AS THICK AS POSSIBLE!
- AS SLOW AS POSSIBLE!
- WHAT HAPPEN WHEN YOU SLOW THE RAS TO SLOW?

USING OUR TO CONTROL RAS RATE IN CLARIFIER

- GENERATE NH3 OR RELEASE OF P04
- TOO THICK FOR PUMPS OR FLOW

USING OUR TO CONTROL RAS RATE IN CLARIFIER

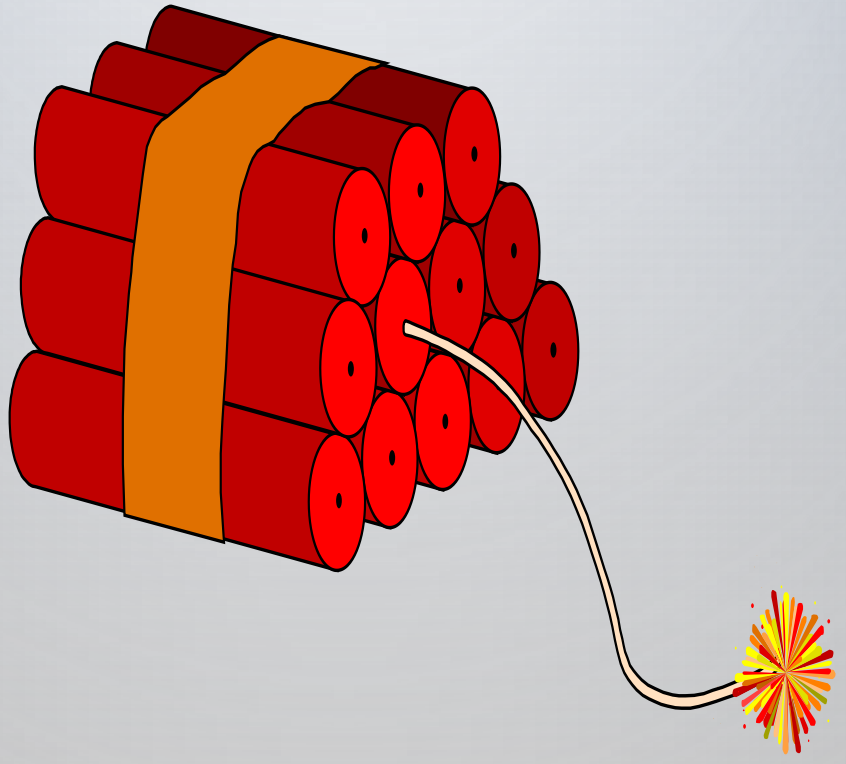
OUR TESTING WILL SHOW WHEN THE RAS BUGS ARE RUNNING OUT OF OXYGEN BEFORE RELEASE OF NH3 OR P04



Sample Source MLSS 4.0 %			
Time of Sample 9:30 AM			
Analyst		Date	
Time (minutes)	D.O. mg/L	Change in D.O. mg/L	Temp °C
0	11.81		
1			
2			
3			
4			
5	11.17		
6			
7			
8			
9			
10	10.23		
15	9.26		
20	8.28		
25	7.21		
30			
Calculations			
Slope =	D1-D2 / T2-T1 = 11.81 - 7.21 / 25 - 1	= 0.191	
Oxygen Uptake Rate	= Slope x 60 = 11.5 mg/L/hr		
Total Solids Gram g/L= _____			

Sample Source RAS #1 12.0%			
Time of Sample 10:45			
Analyst		Date	
Time (minutes)	D.O. mg/L	Change in D.O. mg/L	Temp °C
0	11.2		
1	10.18	1.02	
2	10.15	0.03	
3	9.7	0.45	
4	9.29	0.41	
5			
6	8.47		
7			
8			
9			
10	6.78		
15	4.27		
20	2.41		
25			
30			
Calculations			
Slope =	D1-D2 / T2-T1 = 10.15 - 2.41 / 20 - 2	= 0.43	
Oxygen Uptake Rate	= Slope x 60 =25.8 mg/L/hr		
MLSS 4% RAS 12 = 3X 11.5 X 3 = 34.5 MG/l/hr RAS Rate is GOOD!			

TOXICITY TESTING OF HAULED-IN WASTE



TOXICITY AND TREATABILITY METHOD

- UNFED = MIXTURE OF RAS AND EFFLUENT

  (MLSS BEFORE GOING TO CLARIFIER)

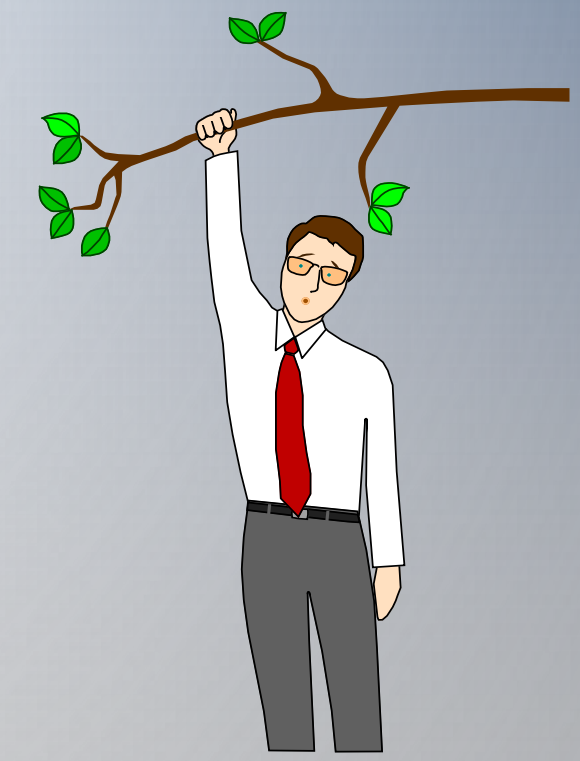
- FED = MIXTURE OF RAS AND PRIMARY EFFLUENT

  USE RAW INFLUENT IF YOU DON'T HAVE PRIMARY

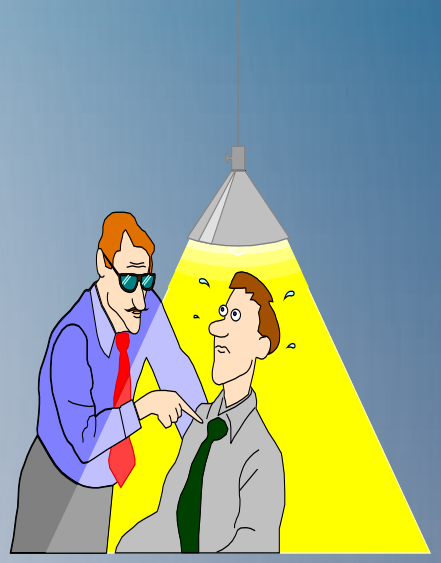
  (MLSS GOING INTO AERATION TANK)

TOXICITY AND TREATABILITY METHOD

- UNKNOW XYZ SAMPLE
- CBOD OF 21,500 MG/L
- CAN YOU TREAT IT?
- HOW LONG TO TREAT IT?
- FLOW RATE OF XYZ INTO PLANT?

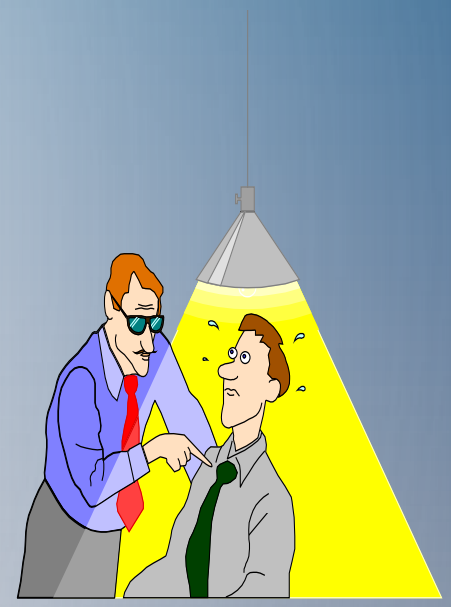


TOXICITY AND TREATABILITY METHOD



- PLANT DESIGN/ LOADING?
- 5.8 MGD @300 MG/L CBOD
- = 14,511 LBS OF CBOD/DAY
- 2.5 MGD @ MAX 252 MG/L CBOD
- = 5,254 LBS OF CBOD/DAY
- 9,257 LBS SF 50 % = 4,628 LBS CBOD

TOXICITY AND TREATABILITY METHOD



- LBS= MGD X BOD X 8.34
- LBS / BOD X 8.34 = MGD
- 4629/(21500 CBOD X 8.34)
- =0.025 MGD OR 17.36 GPM

TOXICITY AND TREATABILITY METHOD

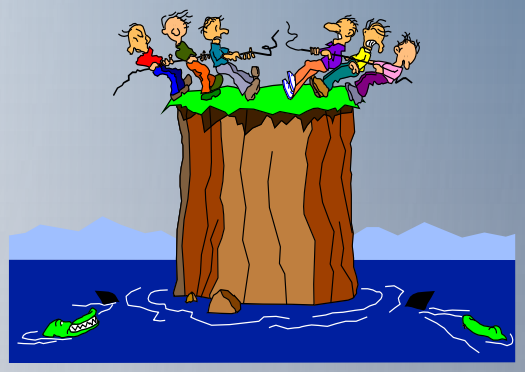
- FED SAMPLE + UNKNOWN WASTE = TREATABILITY TEST

- UNKNOWN WASTE GPM X SAMPLE VOL = VOL. UNK WASTE
  INF GPM

- 17.36 GPM XYZ WASTE X6000 MLS = 60 MLS OF XYZ WASTE
  1736 GPM INF

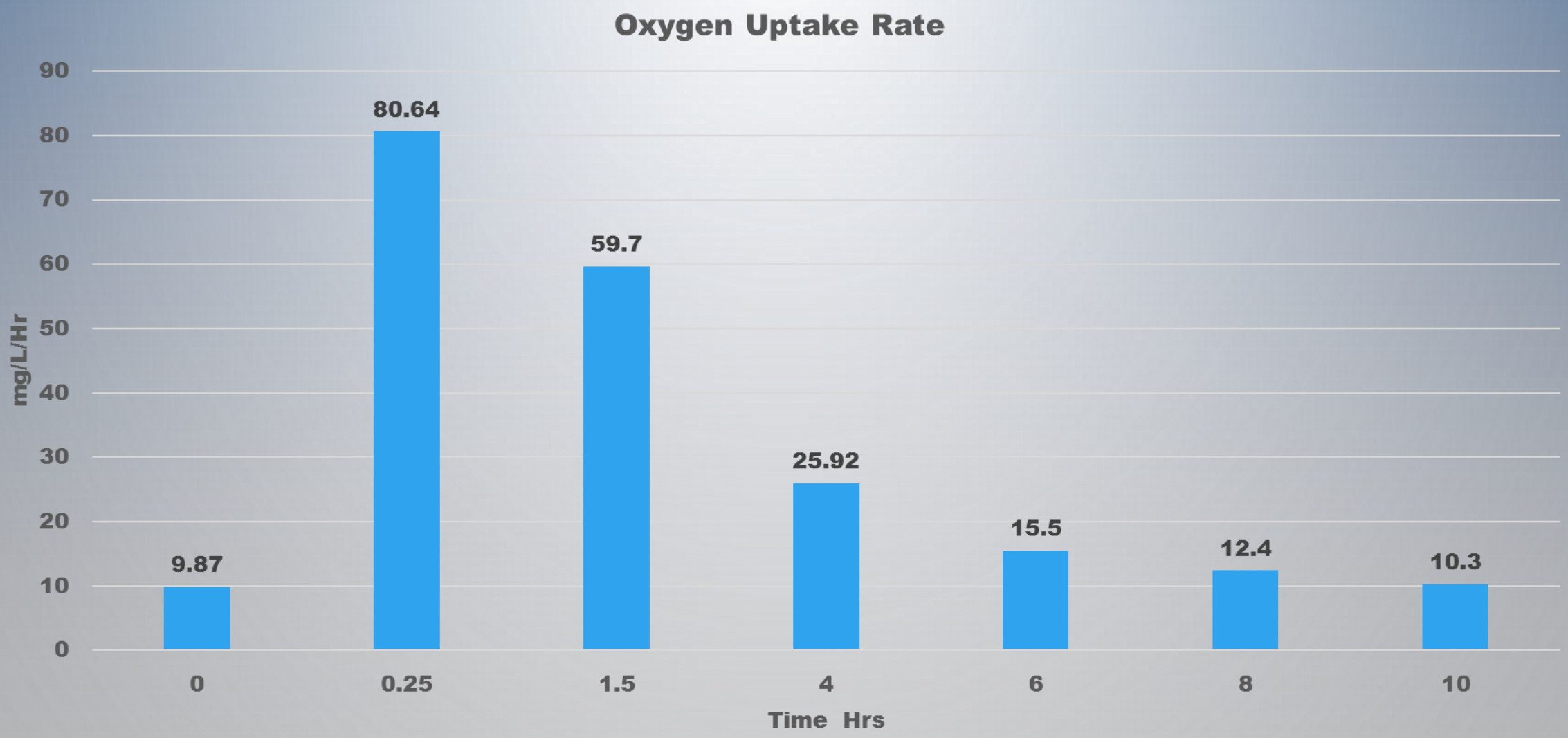
- ADD 60 MLS OF XYZ WASTE TO 6000 MLS OF MLSS SAMPLE.

TOXICITY AND TREATABILITY METHOD



- LET MIX IN BENCH TEST FOR ABOUT 15 MINS
- MAKE SURE D.O. IS ABOVE 2.0 MG/L
- RUN OUR EVERY 30 - 60 MINS UNTIL THE OUR RETURNS TO THE NORMAL RANGE FOR THE UNFED MLSS
- WAS THE WASTE TREATED WITHIN YOUR AERATION TANK DETENTION TIME ?

XYZ OUR TEST

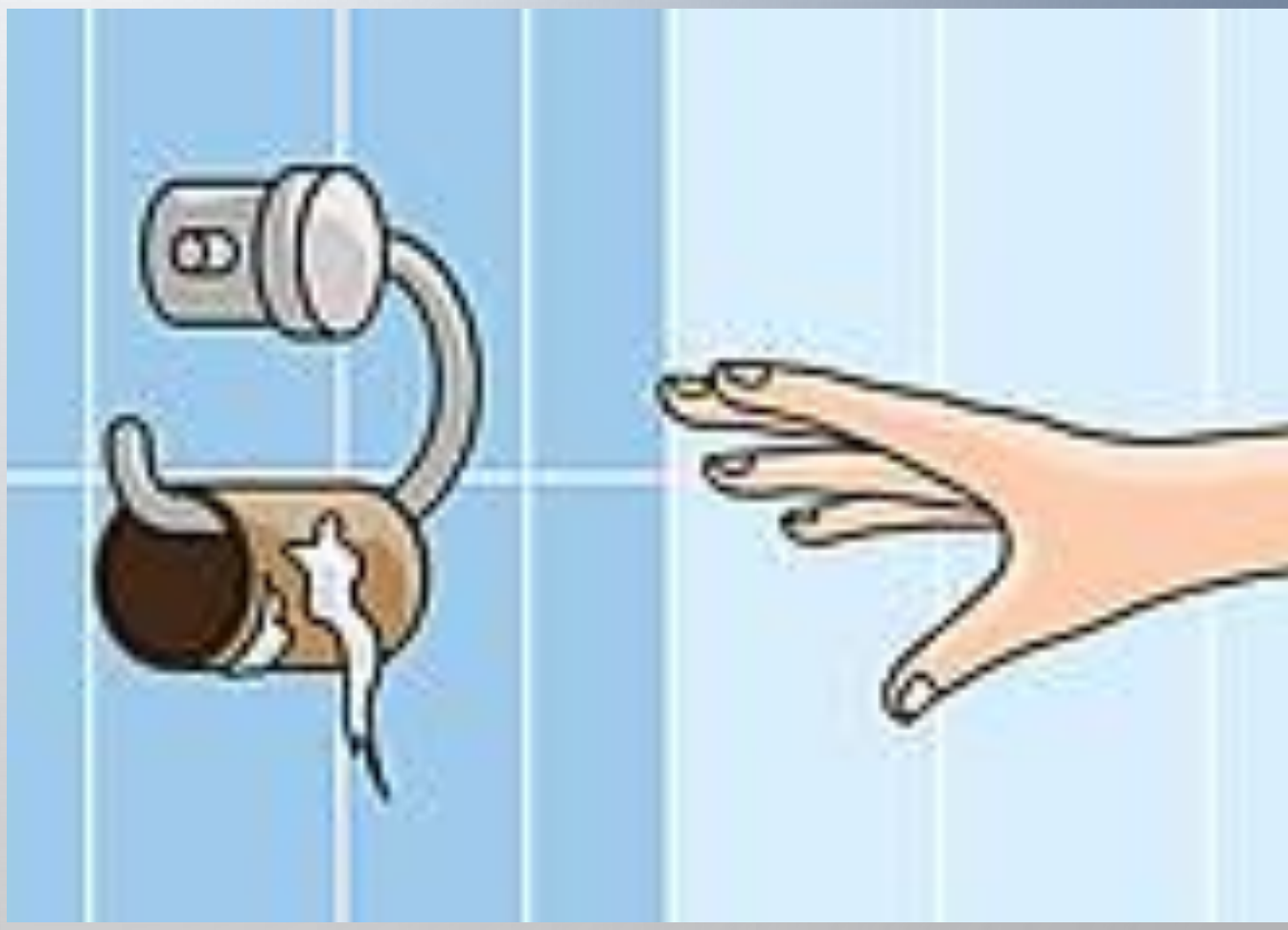

Oxygen Uptake Rate
mg/L/Hr
90
80
70
60
50
40
30
20
10
0
80.64
59.7
25.92
15.5
12.4
10.3
9.87
0
0.25
1.5
4
6
8
10
Time Hrs

QUESTIONS ?

DID YOU KNOW?

- IN DECEMBER 1973 AMERICA EXPERIENCED FIRST TOILET PAPER SHORTAGE

- DUE TO JOHNNY CARSON JOKE ON SHORTAGE OF TOILET PAPER!



DID YOU KNOW?

- OVER OR UNDER THAT THE QUESTION?

- POLL SAYS OVER IS MORE ASSERTIVE
- UNDER ARE MORE PASSIVE
- AVERAGE PERSON WILL USE 100 ROLLS OF TOILET PAPER PER YEAR!

- DAN LEAVITT
- CITY OF LONDON
- DLEAVITT@RROHIO.COM
- 740-852-0279

NEXT OTCO MEETING LOCATION ?