ASSESSING SUBSURFACE FILTRATION AND DILUTION PROCESSES IN RIVERBANK FILTRATION TREATMENT

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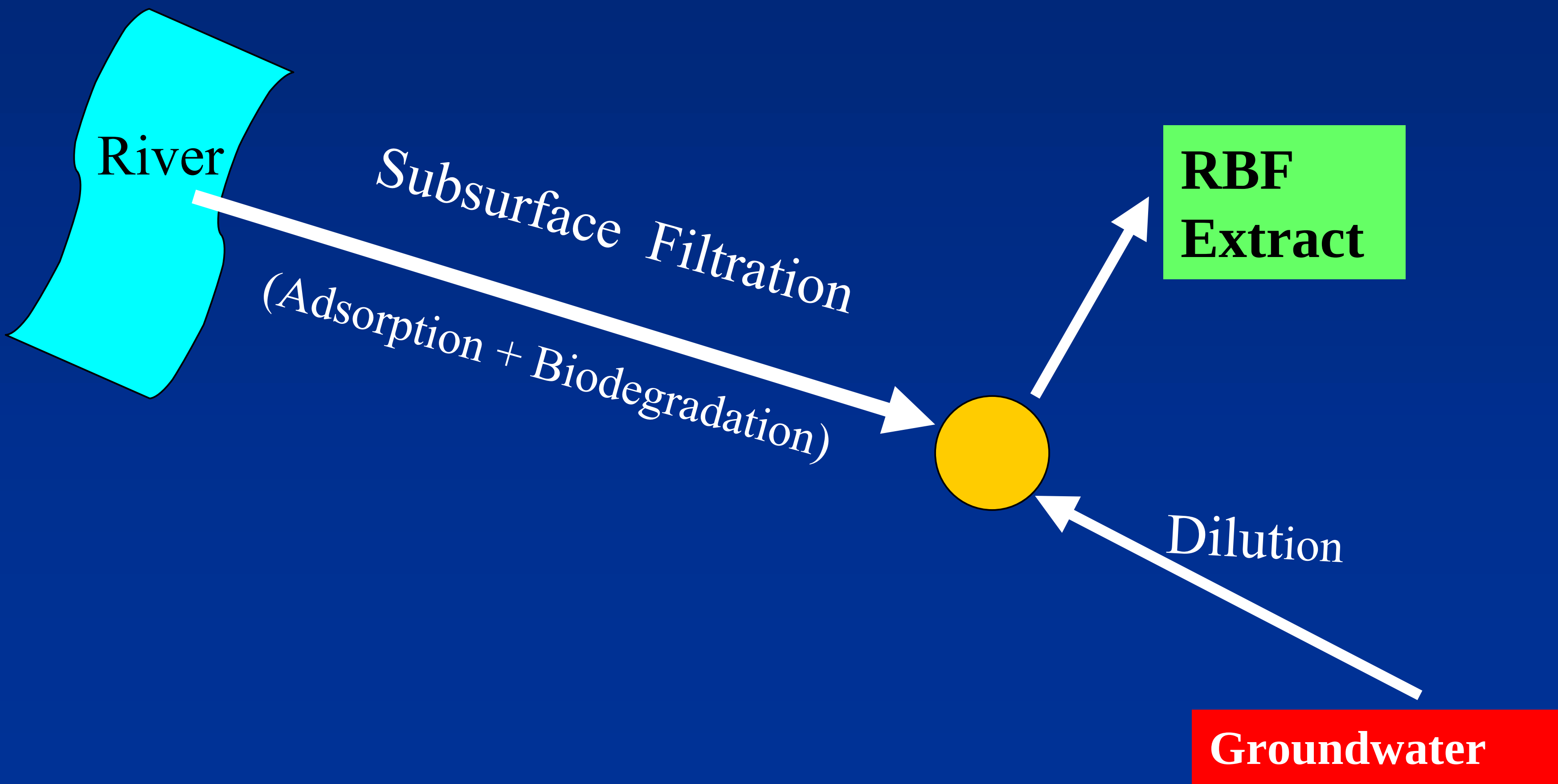
Processes Taking Place at an RBF site



ASSESSING REMOVAL CAPABILITITES OF RBF

- Difficult to assess removal capability:
  – What is the travel time from the river to the well?
  – due to subsurface filtration?
  – due to groundwater dilution?

PROJECT OBJECTIVES

- To assess riverbank filtration as a viable treatment and pretreatment option;
- To quantify the contribution of river water and groundwater to the *RBF* extraction water;
- To compare riverbank filtration to slow sand filtration in terms of particulate, organic precursors and microbiological removal capabilities expressed in log removal credits.

OPERATIONAL FIELD SITES SELECTED

- Pembroke, NH (8/01-11/02, n=19)
- Milford, NH (11/01-11/02, n=13)
- Jackson, NH (5/02-11/02, n=3)
- Louisville, KY (9/01-5/03, n=11)
- Cedar Rapids, IA (9/02-4/03, n=5)

CHARACTERIZATION OF SAMPLING SITES

Sampling Site	Source river water	Distance between the RBF well and the river
Pembroke (NH)	Soucook River	54.9m
Milford (NH)	Souhegan River	22.9m
Jackson (NH)	Ellis river	5 infiltration galleries each: 6.1m long, 1.2m deep, 1.2m wide
Louisville (KY)	Ohio River	Horizontal well RBF sampling lateral 12.2m below the riverbed
Cedar Rapids (IA).	Cedar River	19.5m

What is the estimated travel time from the river to the well?

Sampling Site	Travel Time	Evaluation of Travel Time
Pembroke, NH	5 days	Darcy's Law in terms of seepage velocity
Milford, NH	1 day	Darcy's Law in terms of seepage velocity
Jackson, NH	<2hrs	Infiltration Gallery
Louisville, KY	1 day	Information provided by the LWC (AWWARF, 2002)
Cedar Rapids, IA	5 days	Information provided by the City of Cedar Rapids Water Department (Schulmayer, 1999)

How much removal is due to filtration and how much due to dilution with groundwater?

	% river water in *RBF* well	% Groundwater in *RBF* well	Parameter upon which ratio is based
Pembroke, NH	40.7±3.7	59.3±3.7	Conductivity
Milford, NH	40.8±6.4	59.2±6.4	Sulfate
Jackson, NH	100	0	Infiltration Gallery
Louisville, KY	78.1±4.4	21.9±4.4	Hardness
Cedar Rapids, IA	70	30	Groundwater Flow Modeling

SELECTED WATER QUALITY PARAMETERS REMOVALS

Parameter	% Total Removal Range	Weighted % average of RBF total removals observed
DOC	18-92	63
UV254 abs.	23-100	73
True Color	50-100	89
Particle Counts	70-99	94
Turbidity	72-99	87

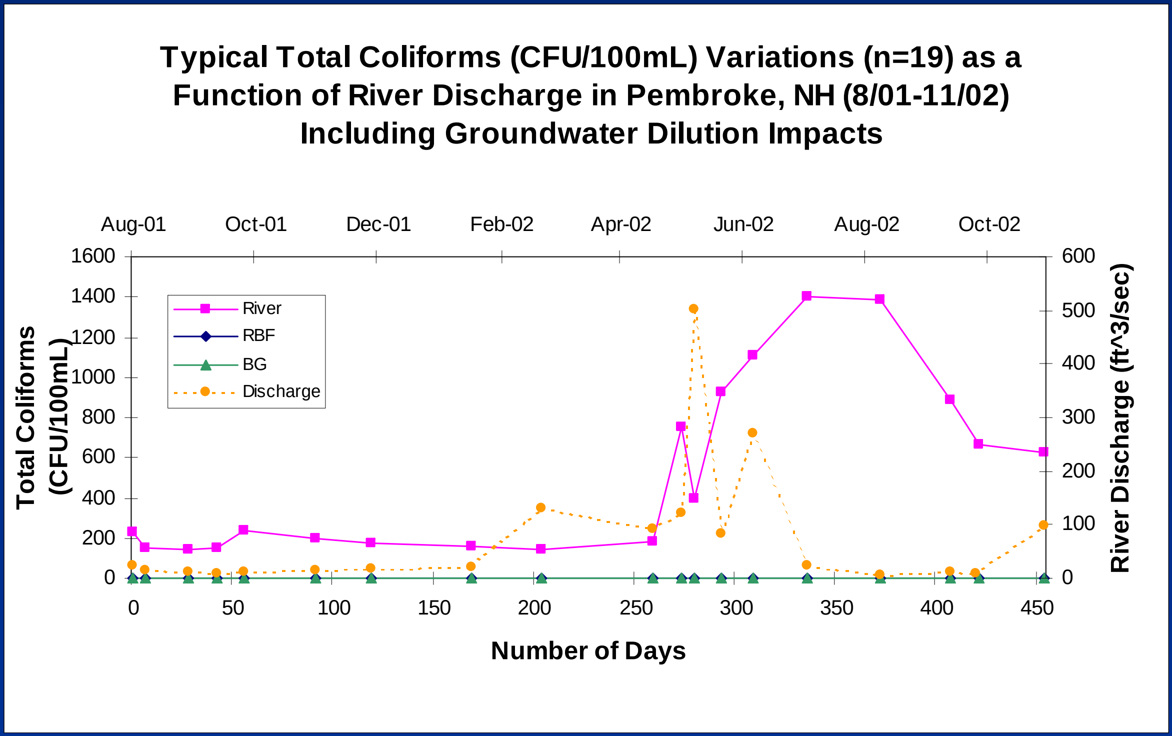
INFLUENCE OF GROUNDWATER DILUTION ON SELECTED PARAMETERS

Parameter	% TOTAL Removal	% Removal due to DILUTION	% Removal due to SUBSURFACE FILTRATION
Turbidity	**87**	10	77
DOC	**63**	29	34

MICROBIAL ANALYSES

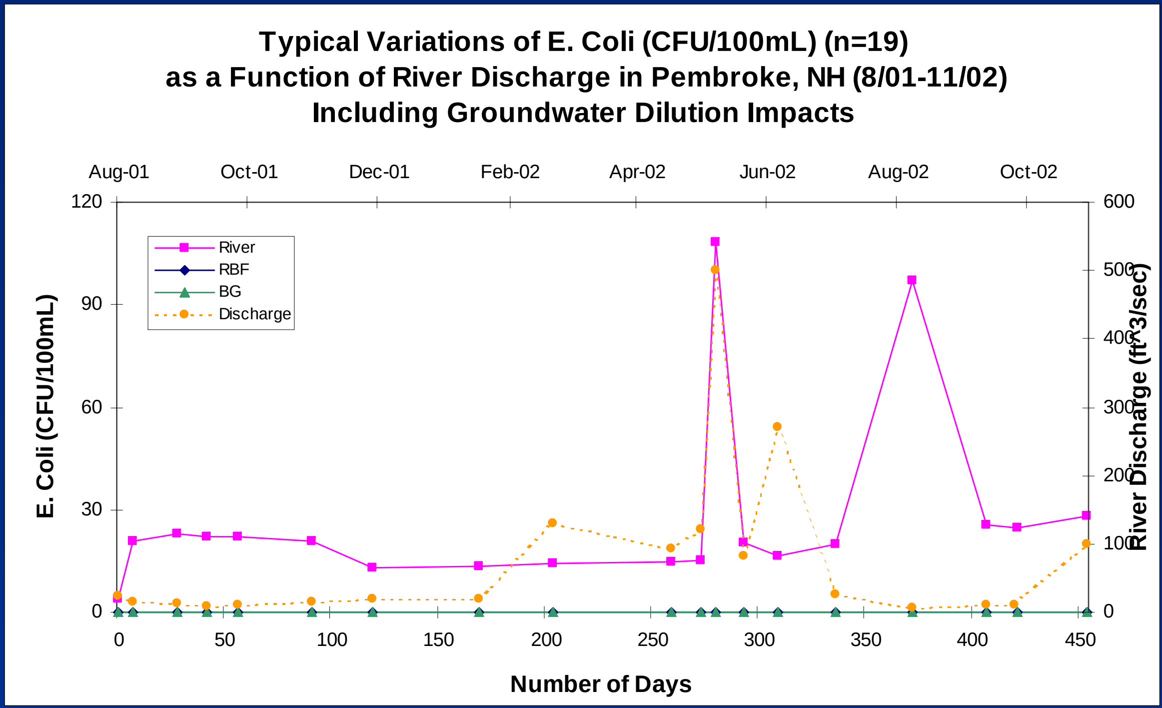
- Total coliforms and *E.coli*
- Aerobic Spore Forming Bacteria
- Virus indicators (male specific &somatic bacteriophage)
- Enteric Viruses
  - Adenovirus Type 40 and 41
  - Astrovirus
  - Enterovirus (poliovirus, coxsackie virus, rotavirus and echovirus)

TOTAL COLIFORMS (CFU/100mL)



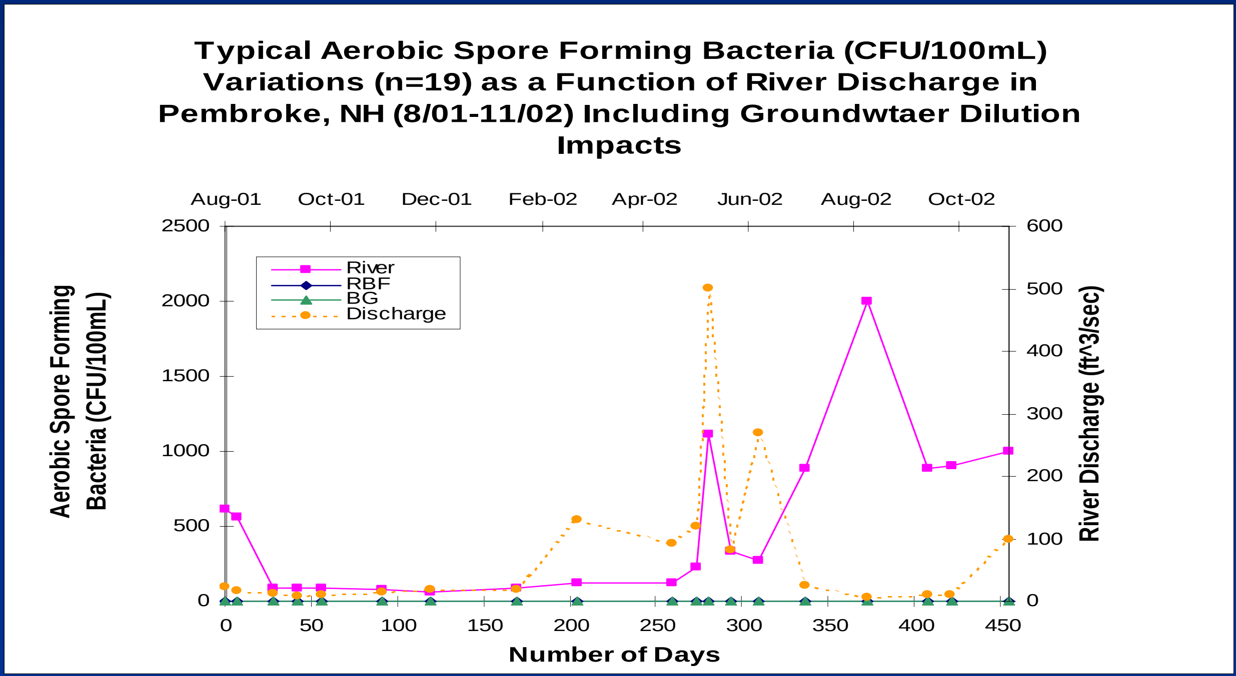
Sampling site	Total removal
Pembroke, NH	>2.1 log
Milford, NH	>2.6 log
Jackson, NH	>0.5 log
Louisville, KY	>1.0 log
Cedar Rapids, IA	>1.4 log

E.coli (CFU/100mL)



Sampling site	Total removal
Pembroke, NH	>0.6 log
Milford, NH	>0.8 log
Jackson, NH	>0.4 log
Louisville, KY	>0.3 log
Cedar Rapids, IA	>0.7 log

AEROBIC SPORE FORMING BACTERIA (CFU/100mL)



Sampling site	Total removal
Pembroke, NH	>1.9 log
Milford, NH	>2.1 log
Louisville, KY	>3.5 log
Cedar Rapids, IA	>2.6 log

VIRUS INDICATORS (PFU/100mL)

- Male Specific Bacteriophage (including MS2)
- Somatic Bacteriophage
- Intensive sampling (Dec 2002): Louisville (n=4)
  Cedar Rapids (n=5)

		Range (PFU/100mL)		
Sampling site	Total removal of MS	river water	RBF extracted water	Groundwater
Louisville, KY	≥0.2 log	4622 ±25	3703±22	3402±18
Cedar Rapids, IA	≥ 0.7 log	3453±20	753±9	BDL

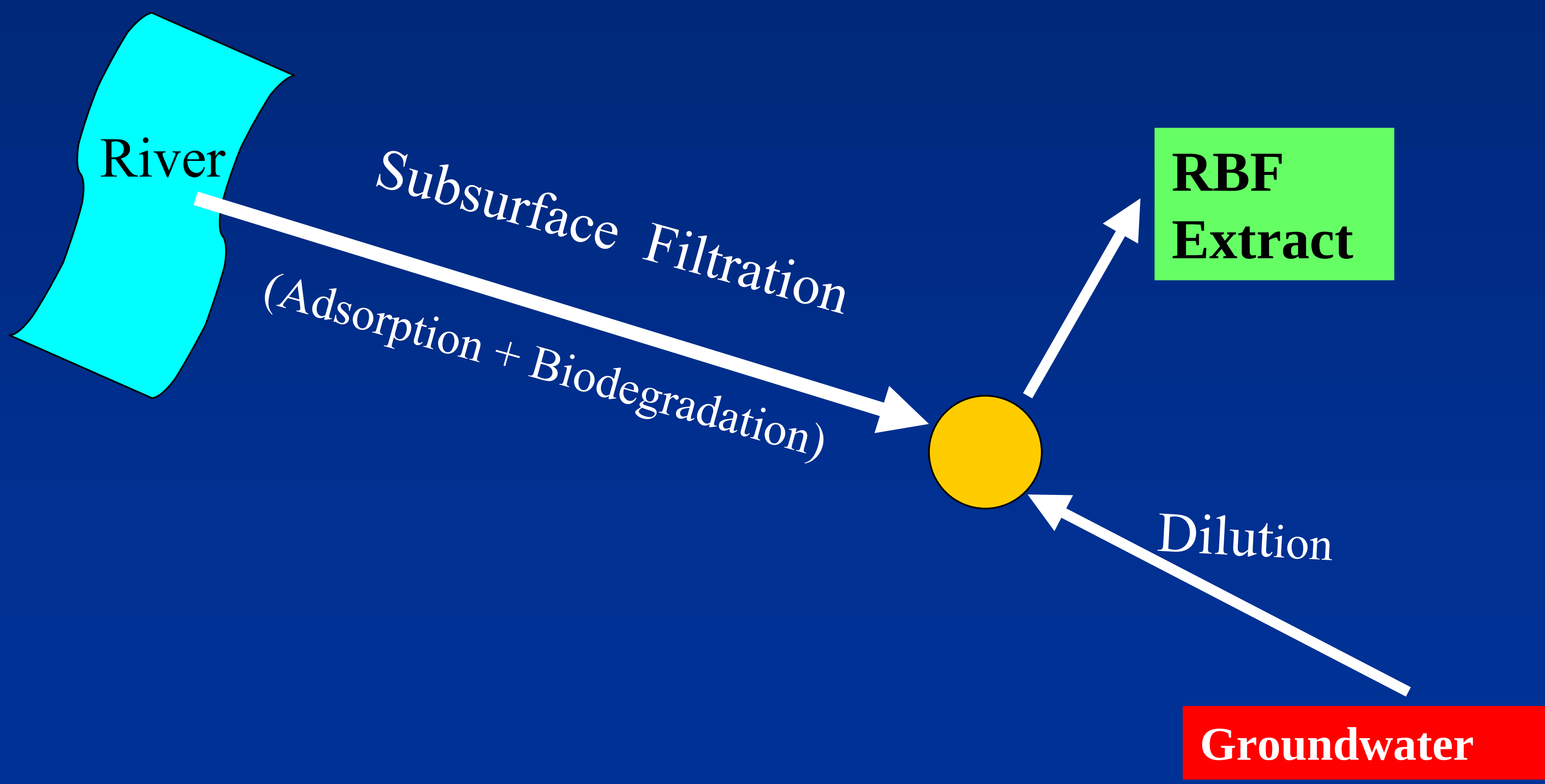
Where Range=average ±analytical error

VIRUSES

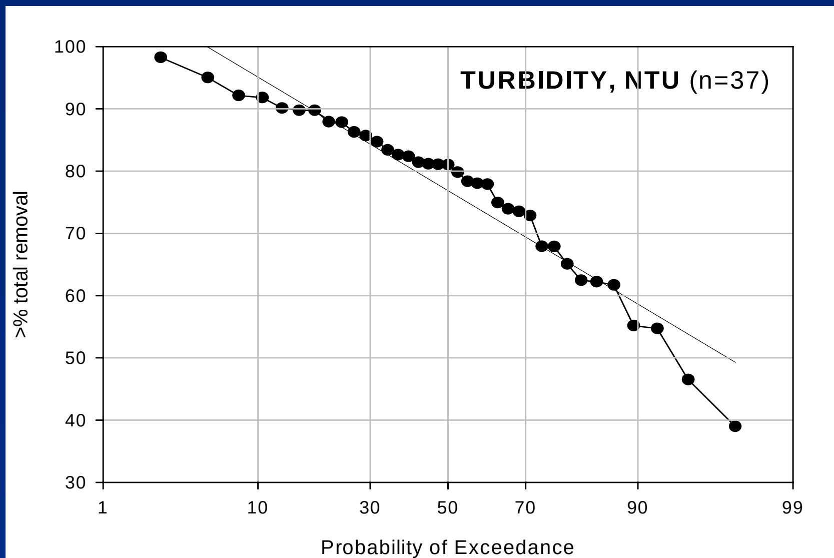
- None detected (ICC-RT-nPCR method) in the samples collected in Louisville, KY nor in Cedar Rapids, IA.

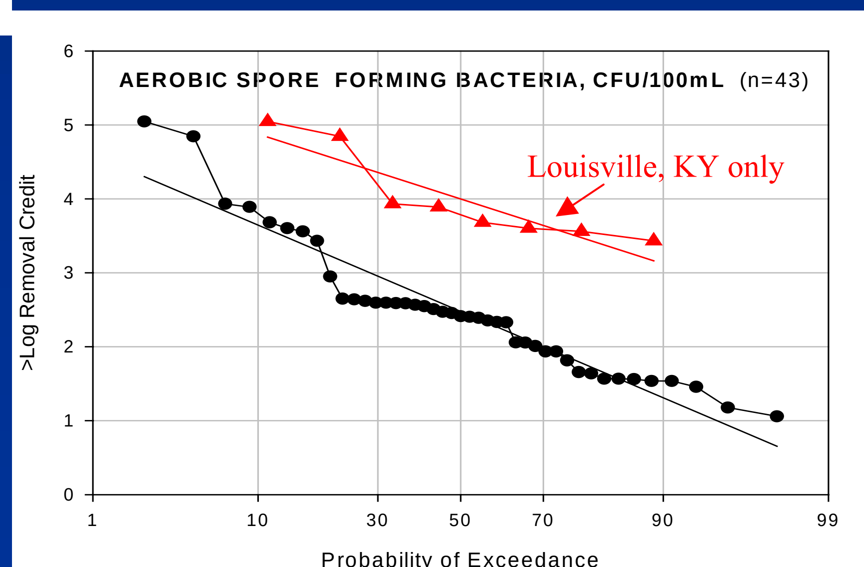
	Liters of water collected	
Sampling site	River	RBF extract
Louisville, KY (3/03)	100L	1000L
Cedar Rapids, IA (1/03)	362L	995L

Processes Taking Place at an RBF site



TREATMENT PROBABILITY DUE TO SUBSURFACE FILTRATION (most conservative estimation for RBF)





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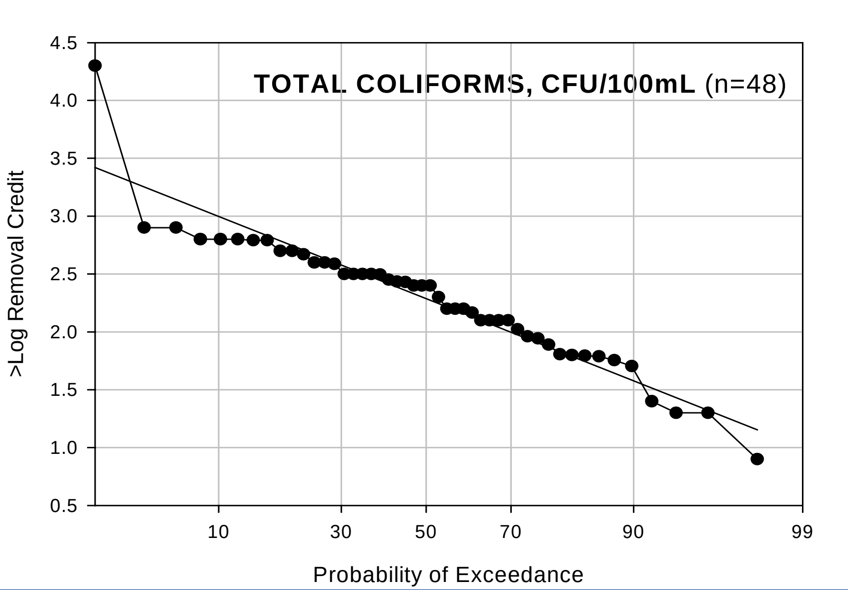

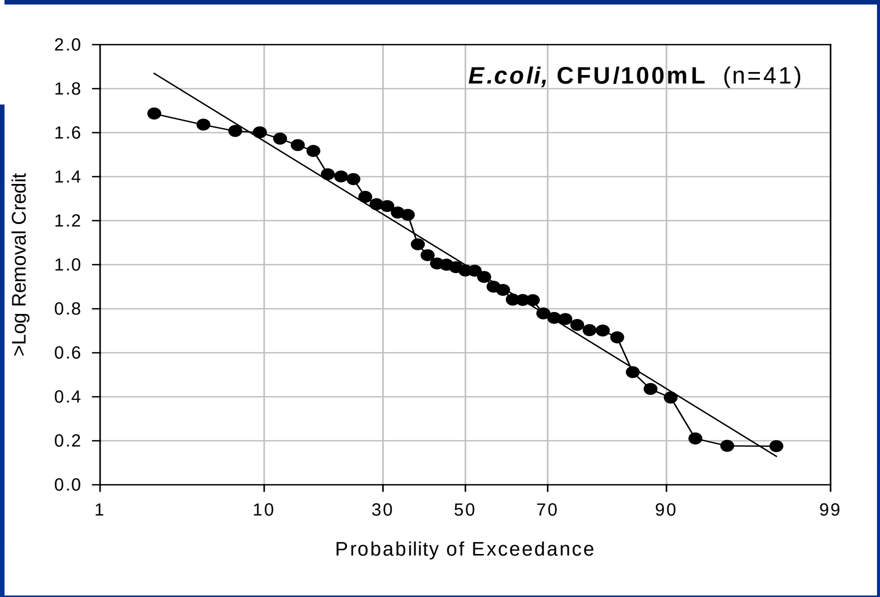

SUBSURFACE FILTRATION MICROBIAL PROBABILITY REMOVALS

Parameter	>70% (probability of exceedance)	>90% (probability of exceedance)
Turbidity	73%	55%
Total coliforms	2.1 log	1.7 log
E.coli	0.8 log	0.4 log
ASFB (spores)	2 log	1.5

SUMMARY OF MOST CONSERVATIVE AVERAGE SITE REMOVALS

Parameter	Minimum removal*
Turbidity	>74%
Total coliforms	>1.0 log
E.coli	>0.3 log
Aerobic Spores	>1.9 log

*based on subsurface filtration only, limited by river water concentrations, and RBF site of lowest average removals.

COMPARING RBF vs. SSF REMOVALS

Parameter	RBF	SSF
DOC	41-85%	8-20%
Total coliforms	>1-1.6 log	1-2 log
E.coli	>0.3-0.8 log	2-3 log
Aerobic spores	>1.9-3.5 log	2.1-2.3 log

CONCLUSIONS

RBF shows potential to be a viable pretreatment and treatment process and warrants log removal credits for microbial pathogen removal

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- The Milford, NH Fish Hatchery personnel
- The Jackson, NH Waterworks personnel
- The Cedar Rapids Water Department, IA
- M. Smith, UNH

QUESTIONS?