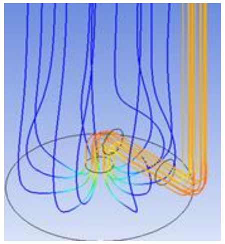
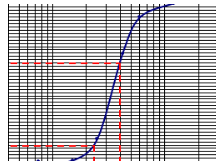
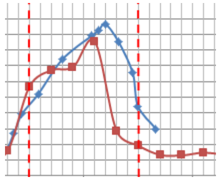
THE USAGE OF COMPUTACIONAL FLUID DYNAMICS AS AUXILIARY IN THE EVALUATION OF OUTLET SETTINGS IN BIOSAND FILTER IN CONTINUOUS OR INTERMMITENT OPERATION

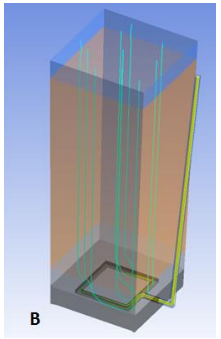
ALLAN CASSIOLATO BERBERT
REGIANE ALMEIDA
RICARDO REZENDE
SANDRO LAUTENCHLAGER

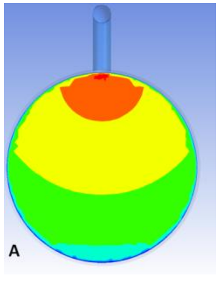
2016











SAFE DRINKING WATER AND ADEQUATE SANITATION ARE CRUCIAL FOR POVERTY REDUCTION, CRUCIAL FOR SUSTAINABLE DEVELOPMENT AND CRUCIAL FOR ACHIEVING ANY AND EVERY ONE OF THE MILLENNIUM DEVELOPMENT GOALS.

BAN KI-MOON, UN SECRETARY GENERAL

01 OBJECTIVE

TO EVALUATE NEW SOLUTIONS FOR THE BIOSAND FILTER GEOMETRY AND THE OUTLET INSIDE THE FILTERS, USING THE CFD TO SIMULATE THE FLOW IN THE MODELS: HYDRAID, CAWST AND PEU/UEM.

PEU/UEM

CAWST

HYDRAID

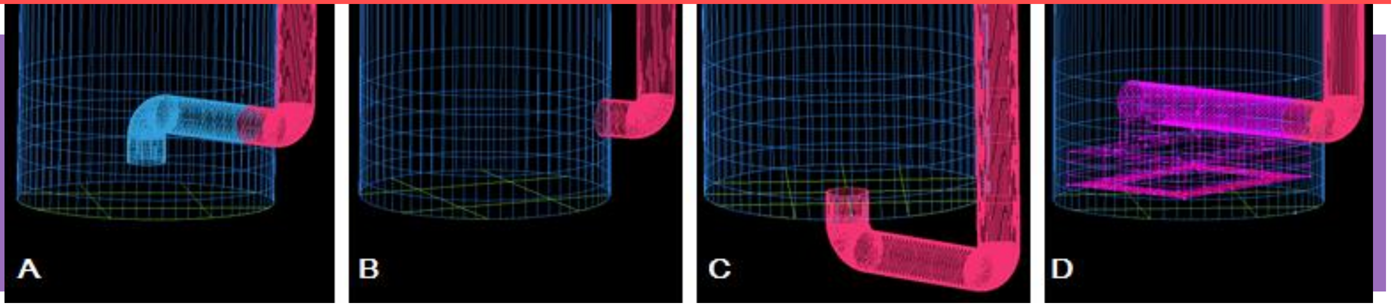
02 METODOLOGY

01

CHOICE OF OUTLET

- 4 DIFFERENT MODELS OF OUTLET FOR PEU/UEM
- MODELS SIMULATION.
- RESULT ANALYSIS

02



03

SIMULATION IN PERM. AND ITERM. REGIME

- COMPARATION BETWEEN USUAL FILTER AND ADOPTED OUTLET.

04

DETERMINATION OF RTD CURVE

- RTD CURVE EXPERIMENTAL FILTER
- RTD CURVE NUMERICAL MODELS

03 CHOICE OF OUTLET

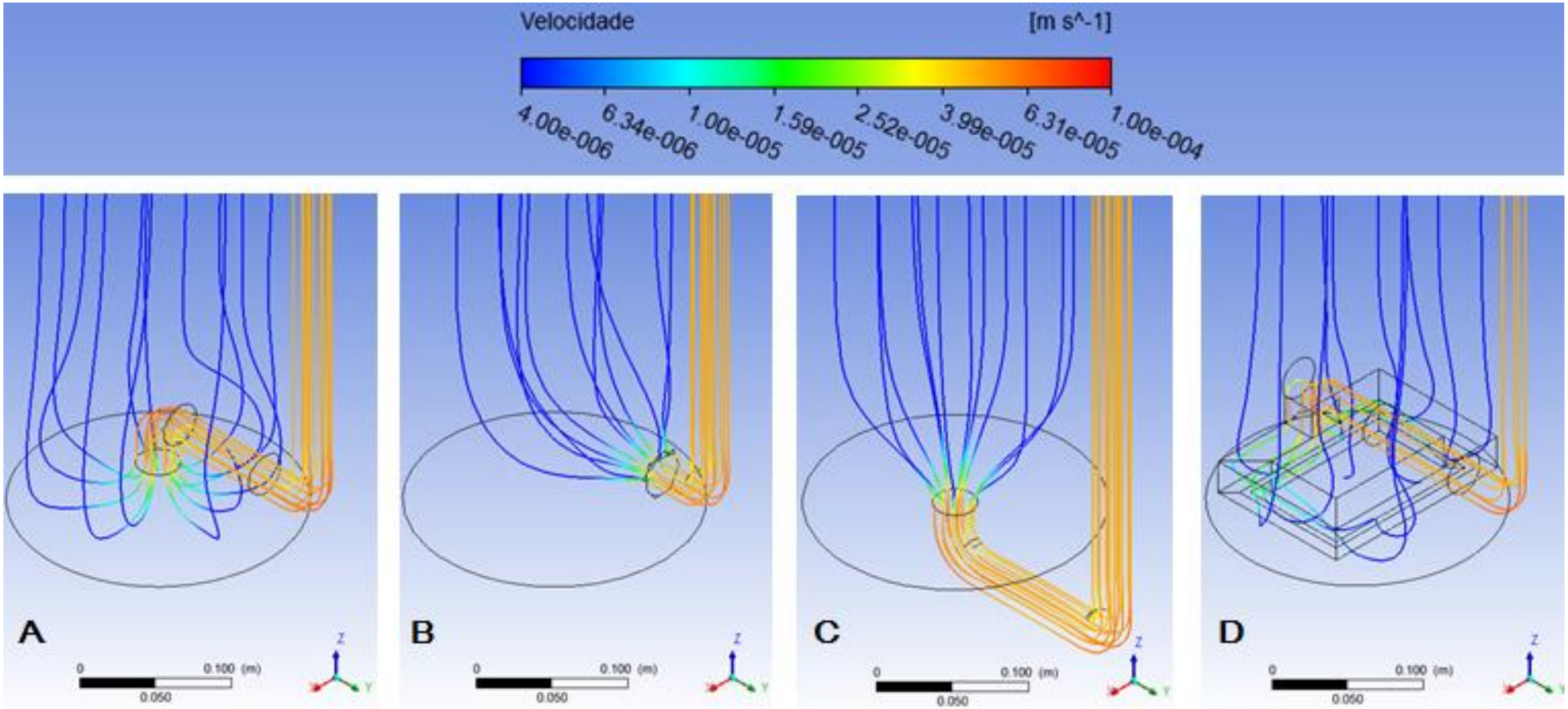
PEU/UEM

FOR THIS STUDY WE USED THE PEU/UEM DESIGN.

SIMULATION OF FILTER CONSIDERING AND NOT CONSIDERING THE POROUS LAYERS FOR THE FOUR OUTLET MODELS

03.1 CHOICE OF OUTLET

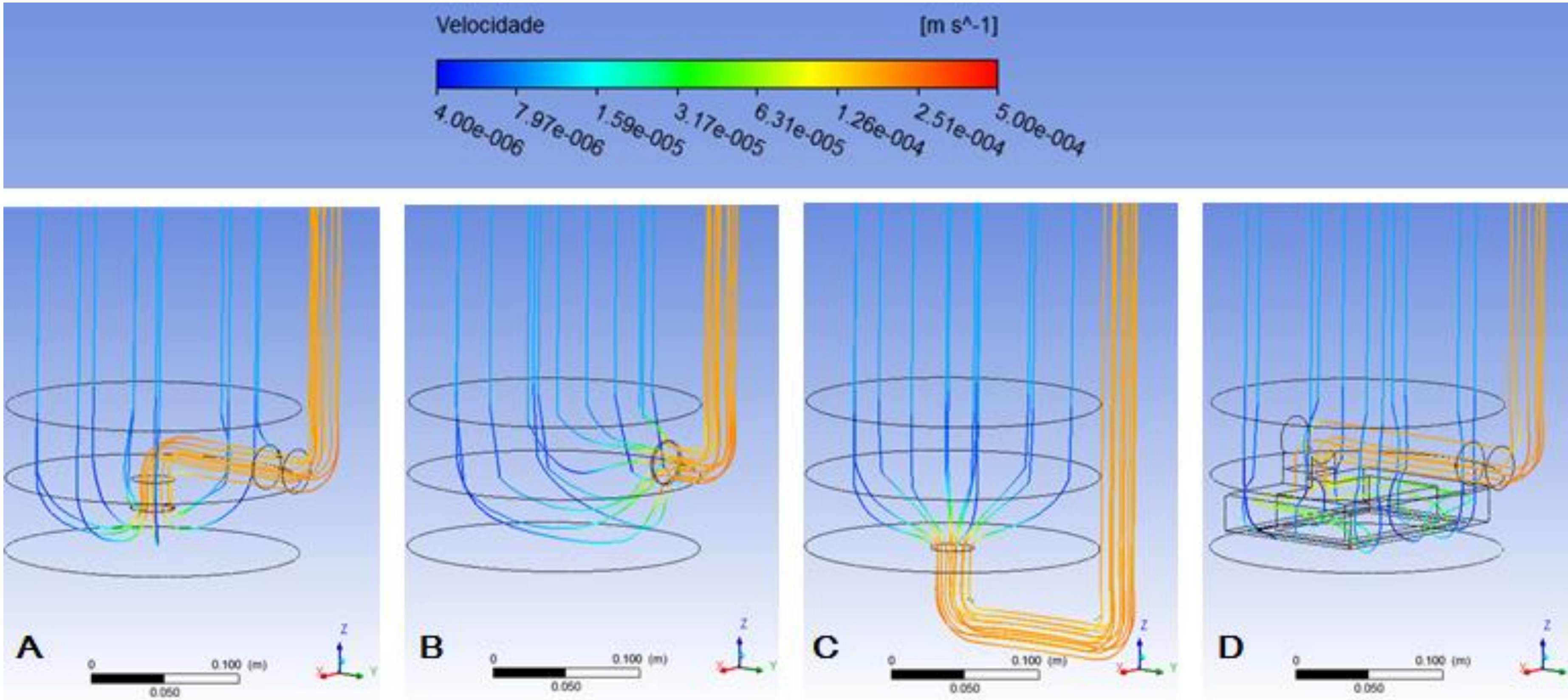
NOT CONSIDERING POROUS LAYERS - FLOWLINE



CENTRAL   LATERAL   BOTTOM   WITH RING

03.2 CHOICE OF OUTLET

CONSIDERING POROUS LAYERS - FLOWLINE



CENTRAL

LATERAL

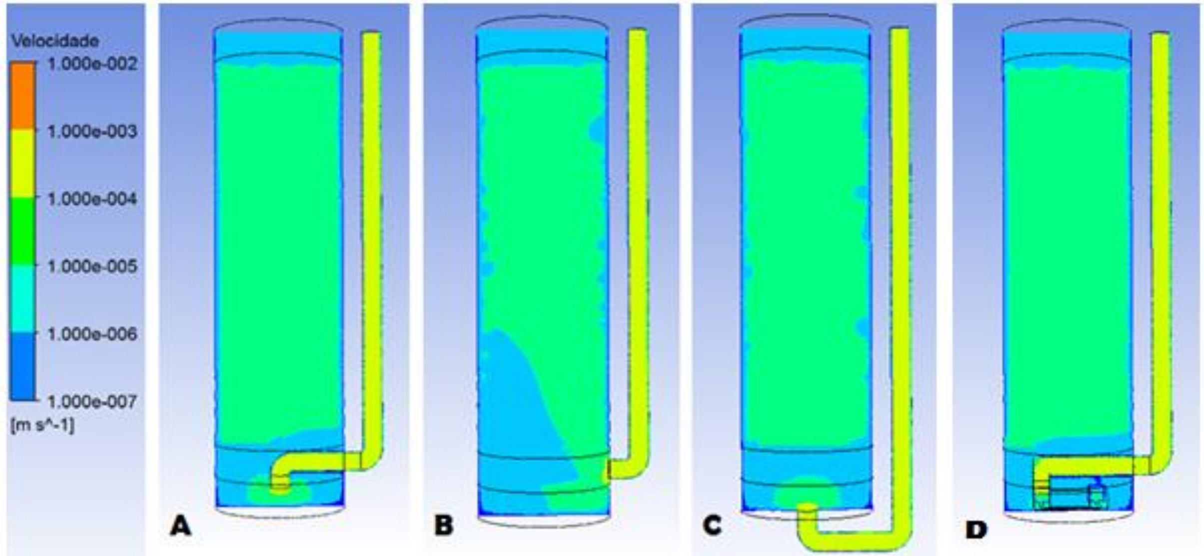
BOTTOM

WITH RING

03.2 CHOICE OF OUTLET

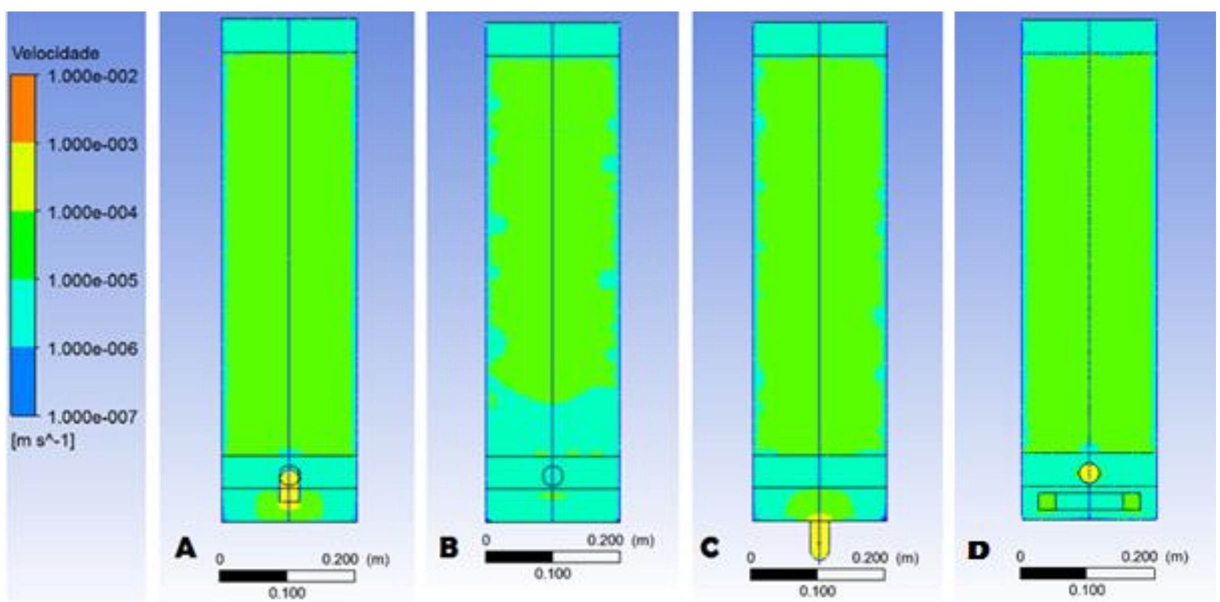
CONSIDERING POROUS LAYERS – VELOCITY PROFILE

AXIS XZ
[Y=0]



CENTRAL | LATERAL | BOTTOM | WITH RING

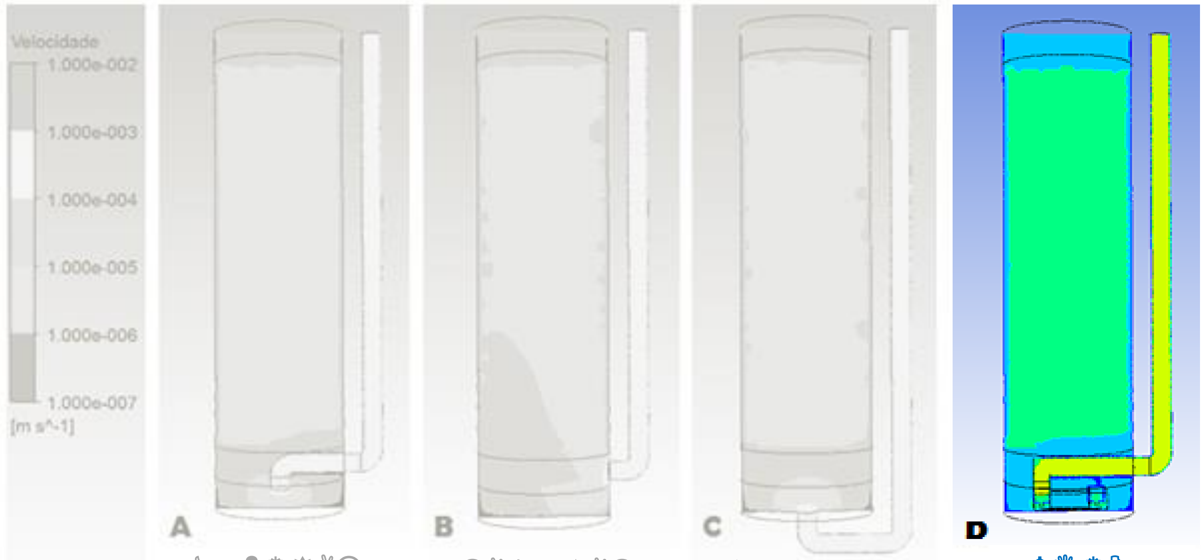
AXIS YZ
[X=0]

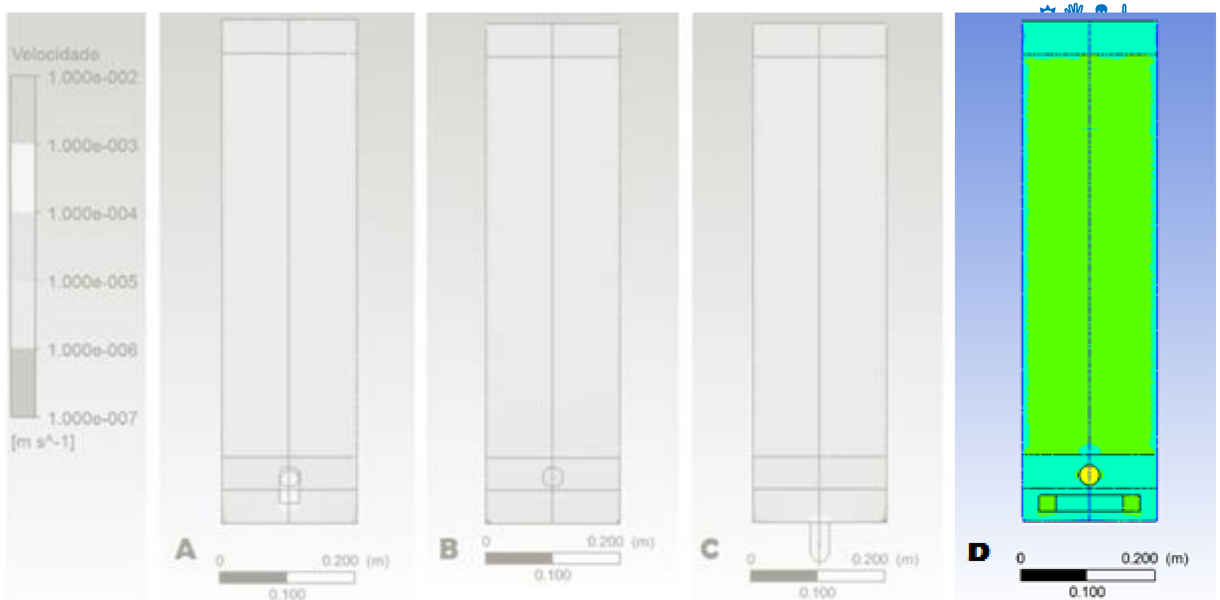


CENTRAL | LATERAL | BOTTOM | WITH RING

CHOICE OF OUTLET

CONSIDERING POROUS LAYERS – VELOCITY PROFILE

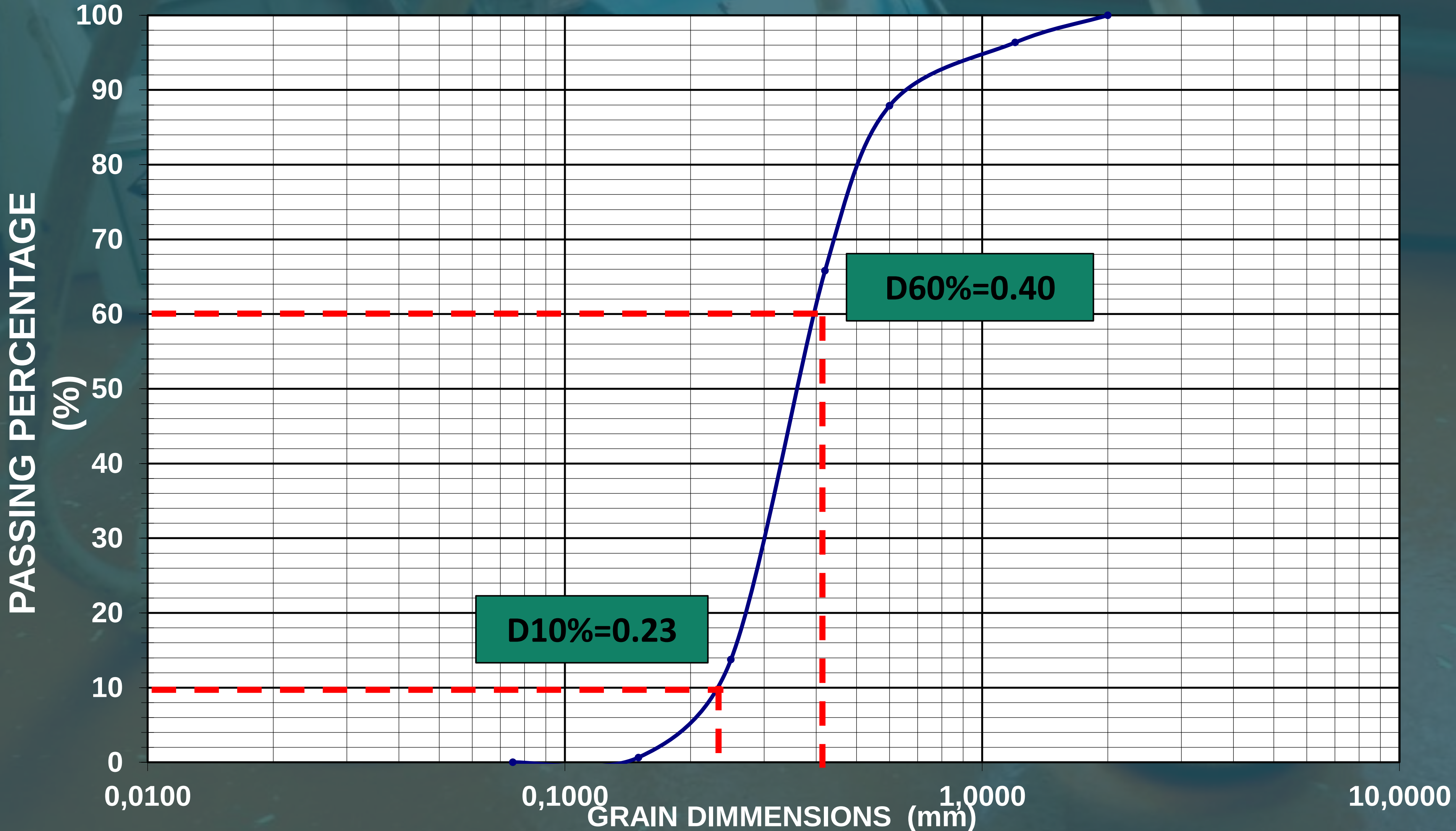




04 BUILDING AND OPERATING THE MODEL

04.1 BUILDING AND OPERATING THE MODEL

GRANULOMETRIC CURVE



04.1

BUILDING AND OPERATING THE MODEL

AGREGATED CHARACTERIZATION

GRAIN SPECIFIC MASS (NBR 6508/84)

ρ=2,75 *(g/cm³)*

MAXIMUM VOID RATIO (NBR 12004/90)

$e_{máx}$=44,22%

$D_{10\%}$

$D_{10\%}$=0,23 *(mm)*

$D_{60\%}$

$D_{60\%}$=0,40 *(mm)*

04.2

BUILDING AND OPERATING THE MODEL

SUPPLY CRITERIA

CONTINOUS OPERATION

SUPPLY 10L/DAY

INTERMITTENT OPERATION

SUPPLY 10L/DAY

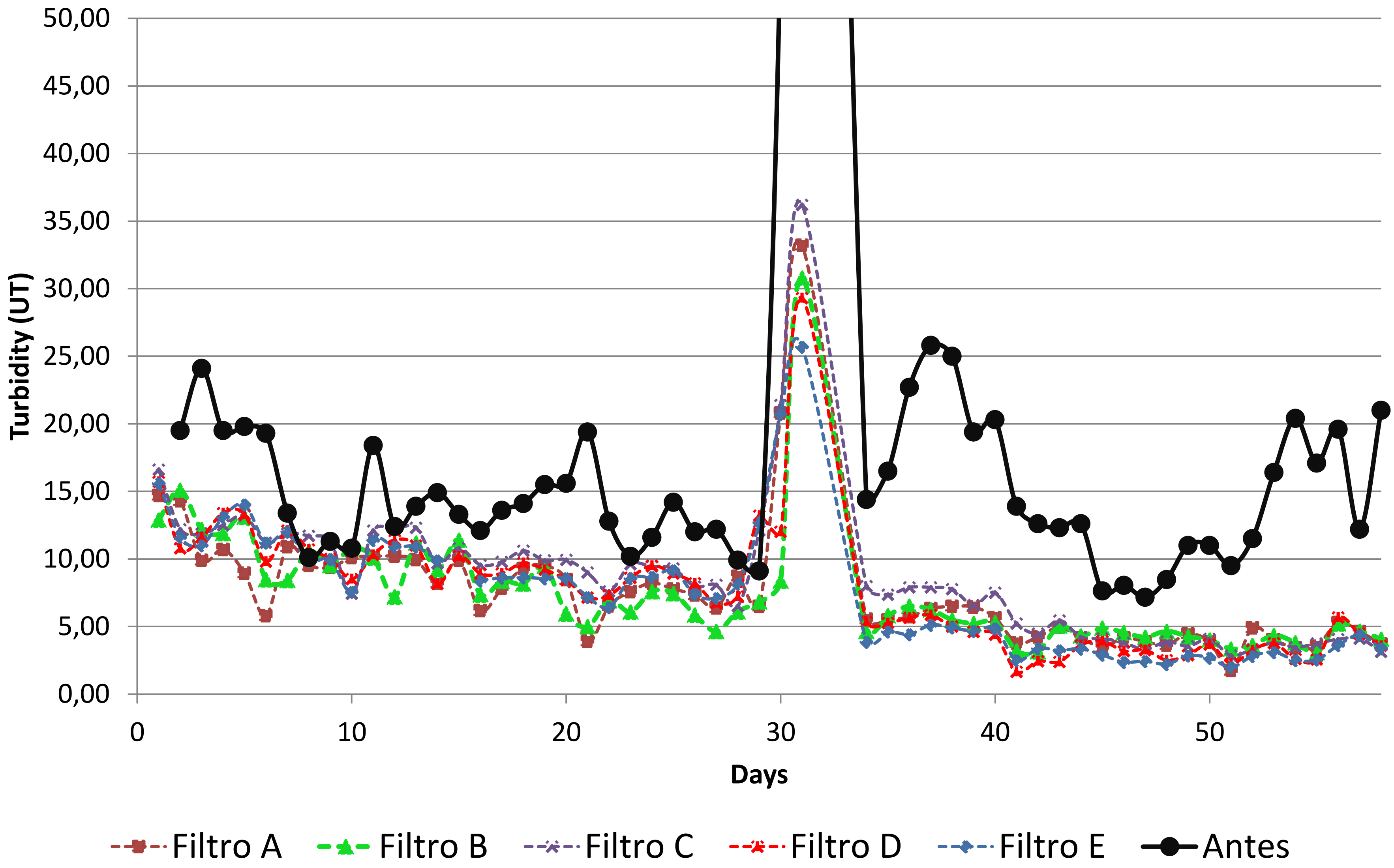
BUILDING AND OPERATING THE MODEL

BACTERIOLOGICAL REMOVAL

INDEX	REMOVAL IN CONTINUOUS OPERATION [$\log_{10}$]				REMOVAL IN INTERMMITENT OPERATION [$\log_{10}$]					
	Filter A		Filter B		Filter C		Filter D		Filter E	
	avg	max	avg	max	avg	max	avg	max	avg	max
Total Coliformes	1,12	2,58	0,88	2,00	0,83	1,67	0,79	1,84	1,01	2,26
E. coli	0,79	1,66	0,83	1,67	0,58	1,14	0,89	1,42	0,77	1,44

BUILDING AND OPERATING THE MODEL

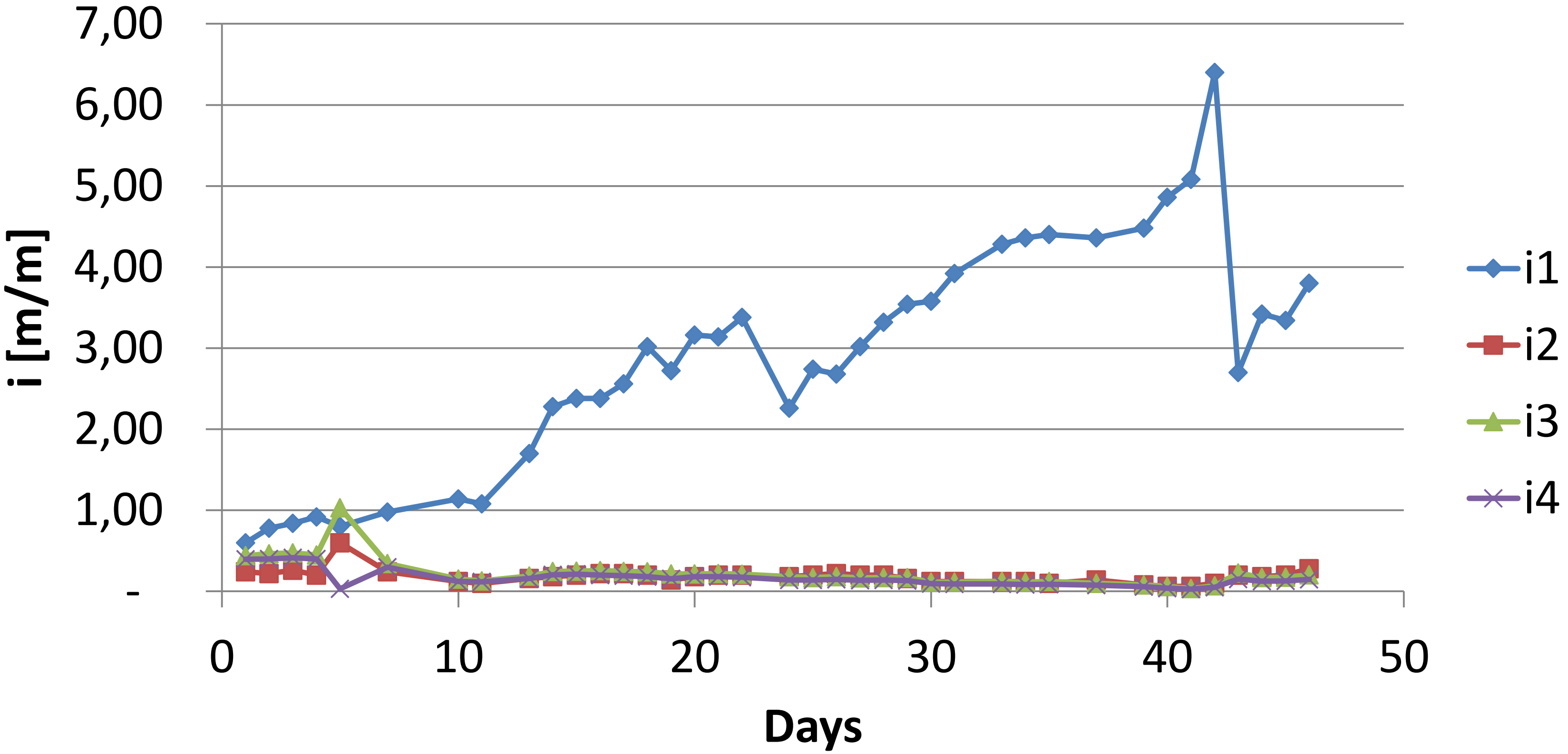
TURBIDITY REMOVAL



04.5

BUILDING AND OPERATING THE MODEL

HEAD LOSS IN THE POROUS LAYERS

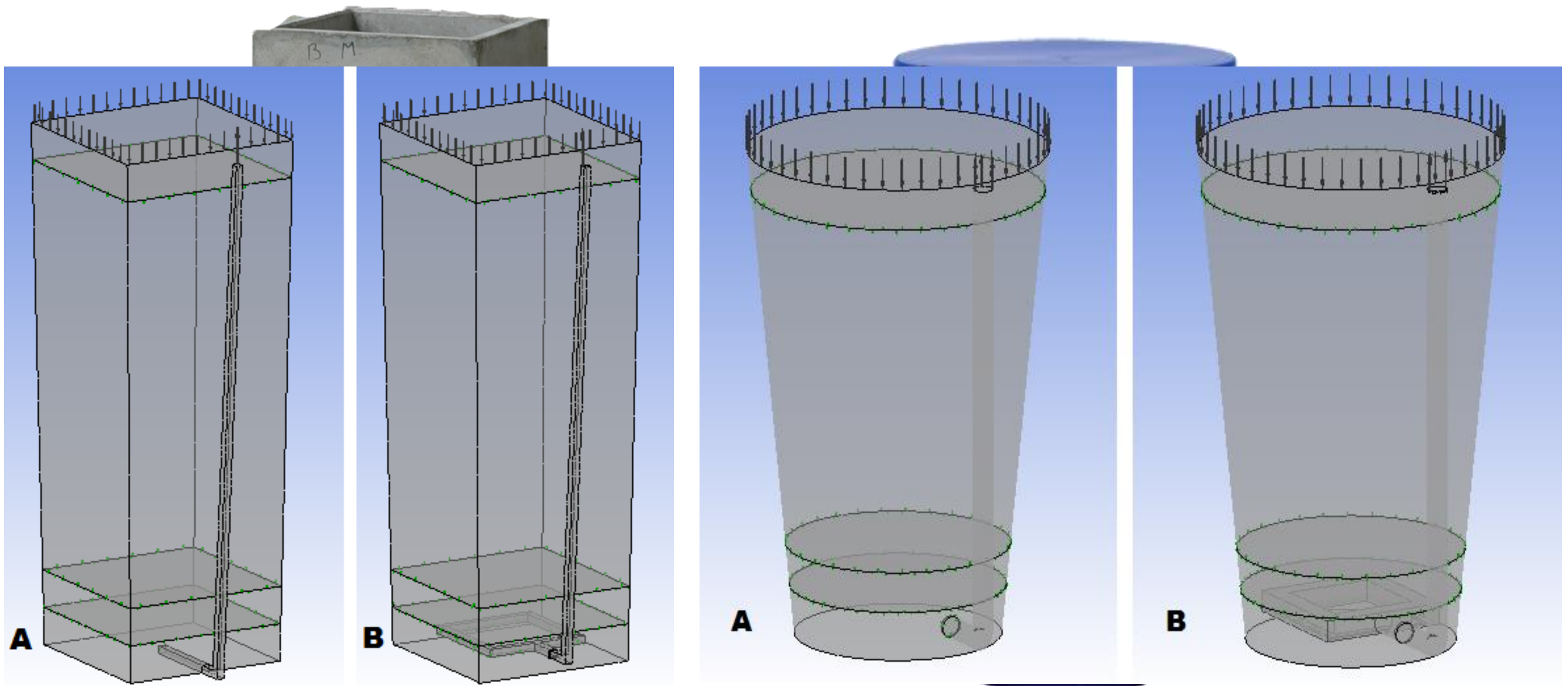


05 SIMULATION IN PERMANENT REGIME

WE SIMULATED THE CAWST AND HYDRAID FILTERS IN PERMANENT REGIME.

FOR EACH ONE WE USED:

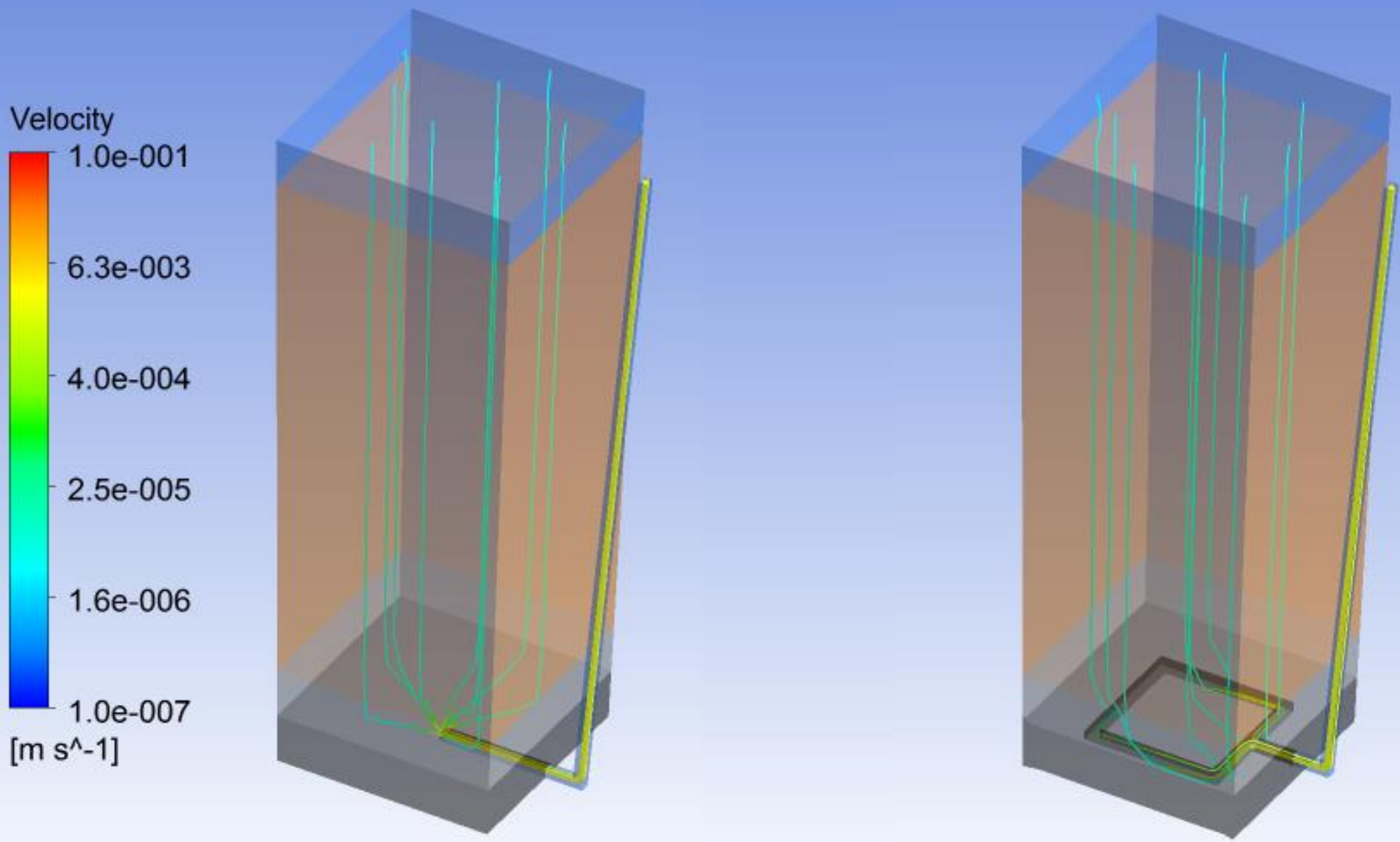
- **CONVENCIONAL MODEL**
- **MODEL WITH RING**



CAWST **HYDRAID**

05.1 SIMULATION IN PERMANENT REGIME

CAWST FILTER– FLOW LINES

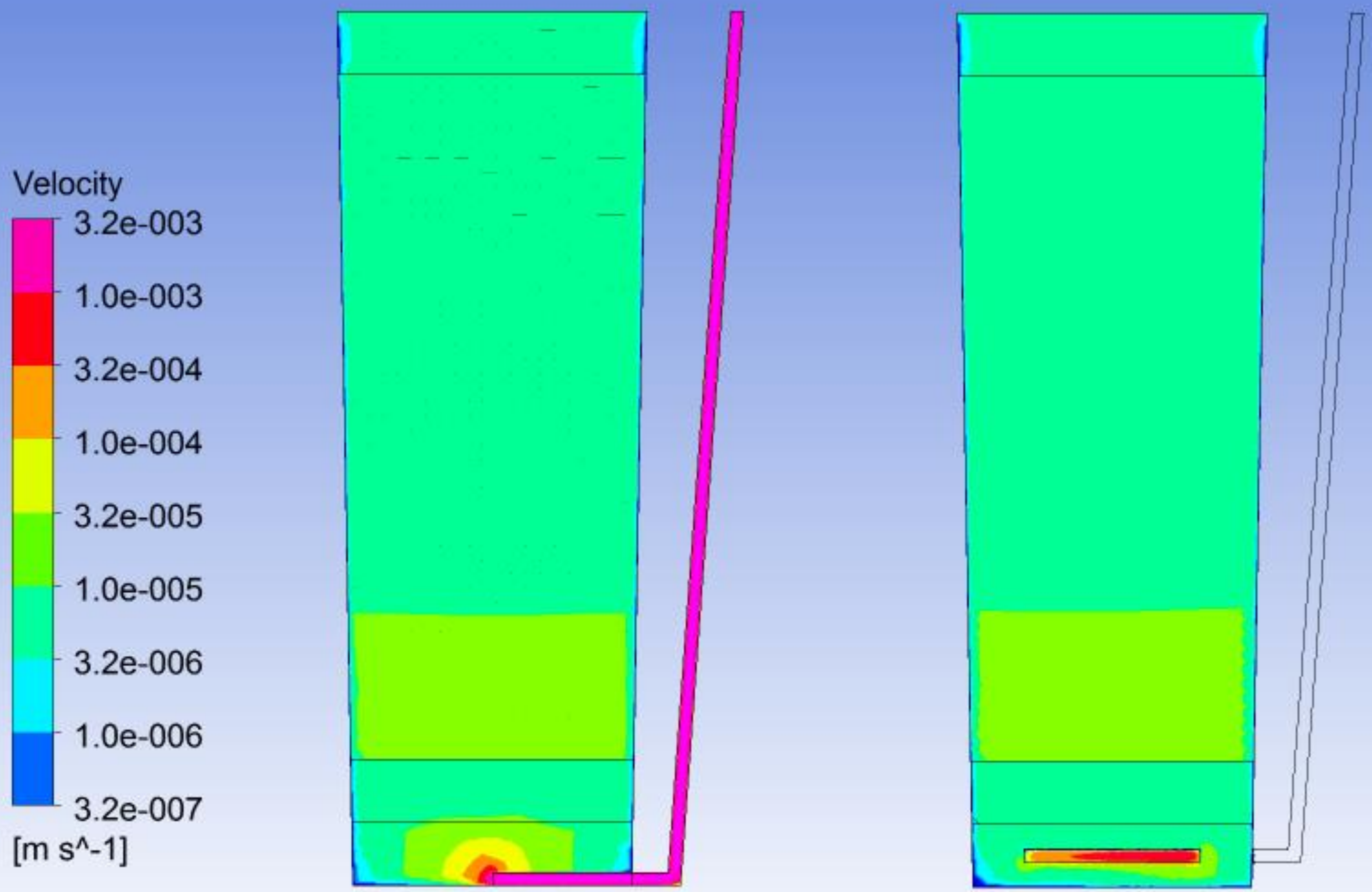


CONVENTIONAL

WITH RING

05.1 SIMULATION IN PERMANENT REGIME

CAWST FILTER – CUT YZ

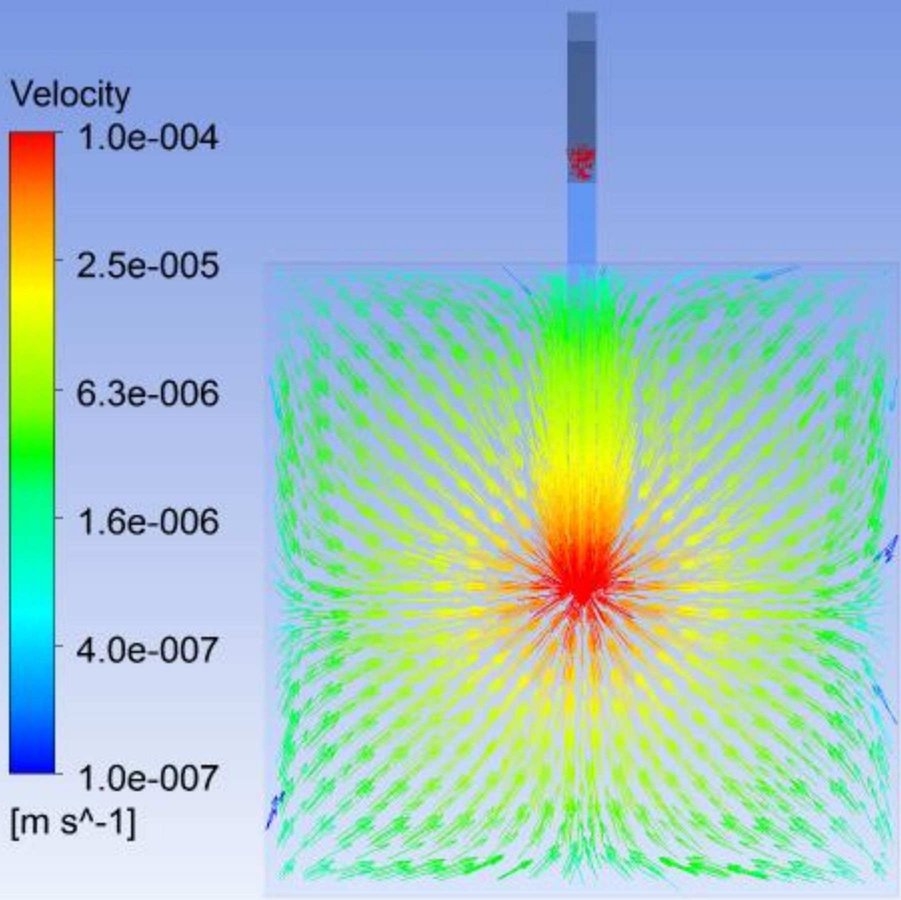


CONVENTIONAL
[Y=0cm]

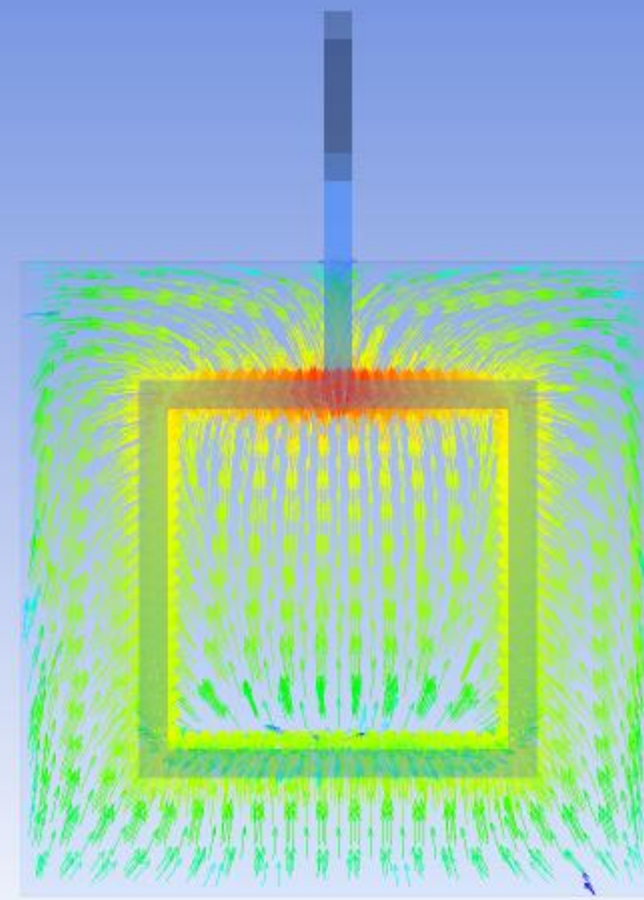
WITH RING
[Y=6cm]

05.1 SIMULATION IN PERMANENT REGIME

CAWST FILTER – CUT XY [Z=1cm]



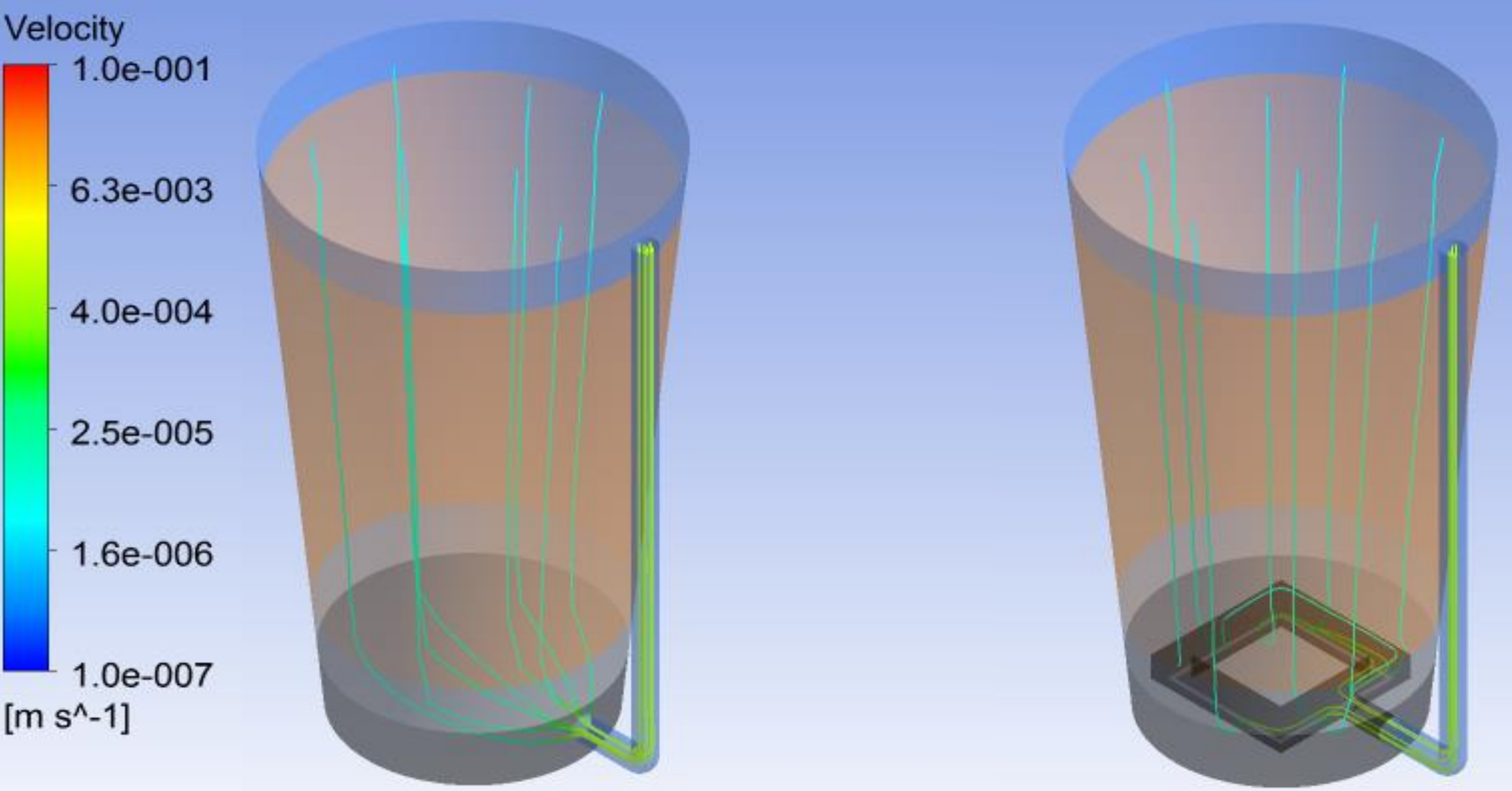
CONVENTIONAL



WITH RING

05.2 SIMULATION IN PERMANENT REGIME

HYDRAID FILTER – FLOW LINES

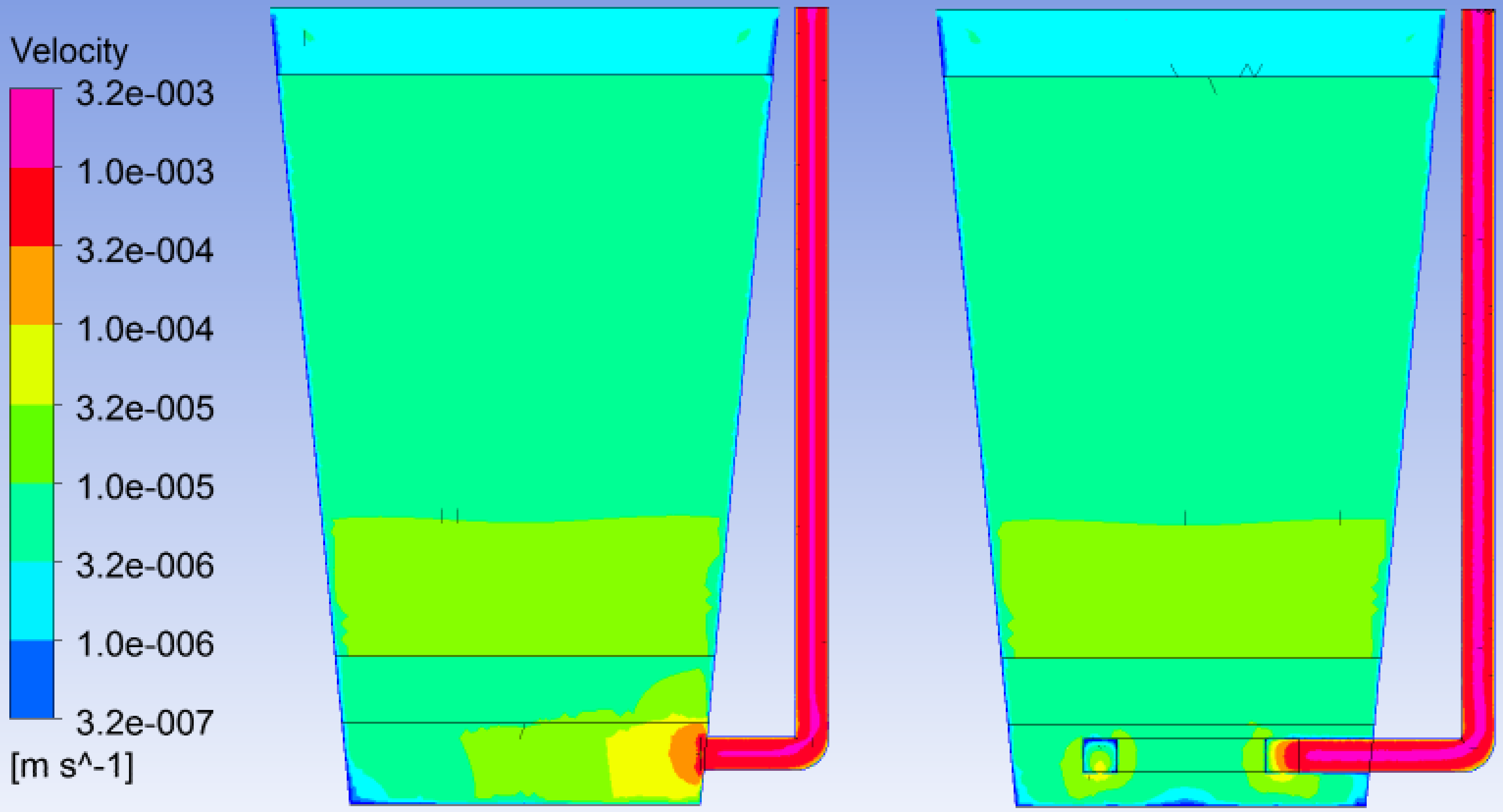


CONVENTIONAL

WITH RING

05.2 SIMULATION IN PERMANENT REGIME

HYDRAID FILTER – CUT YZ

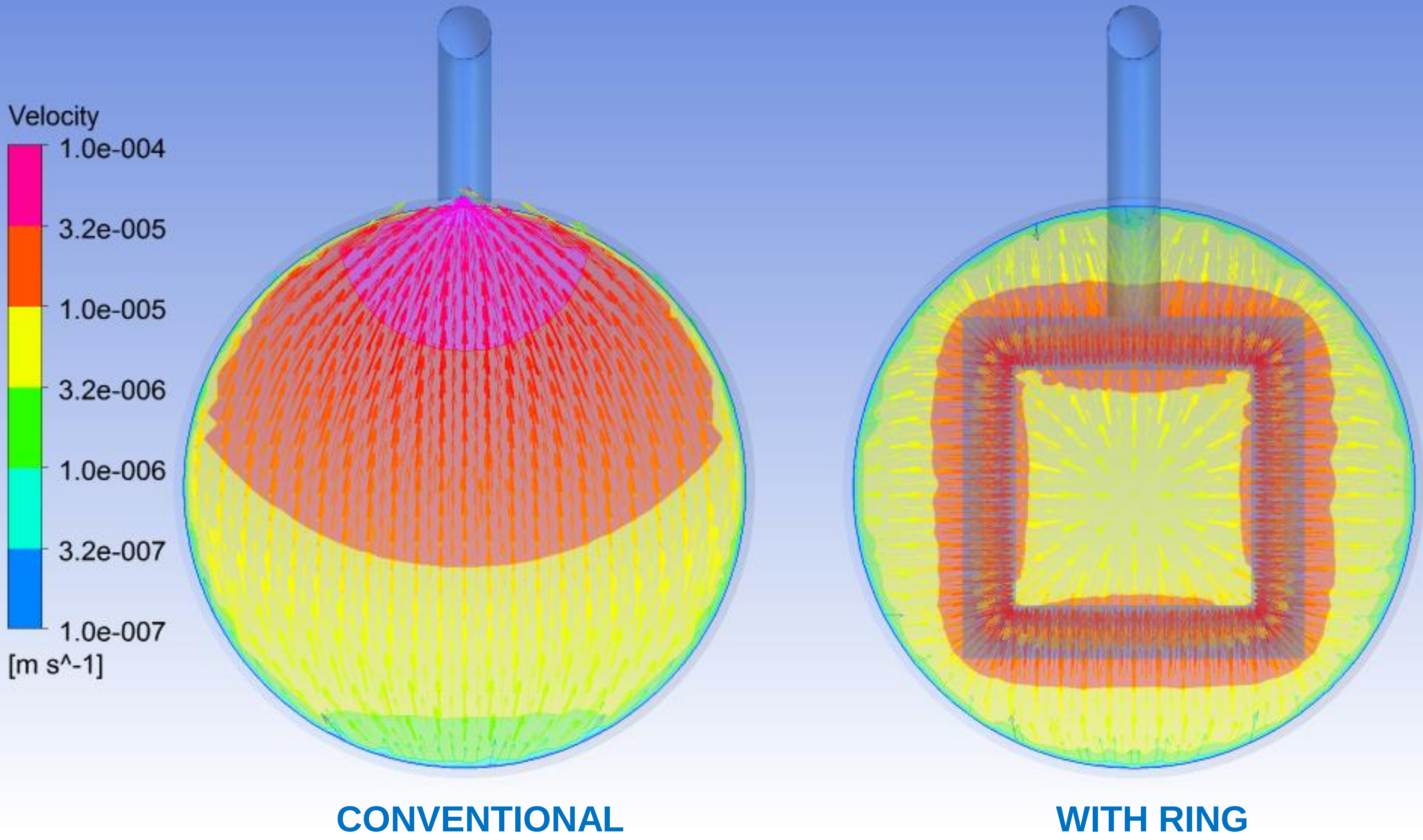


CONVENTIONAL
[Y=0cm]

WITH RING
[Y=6cm]

05.2 SIMULATION IN PERMANENT REGIME

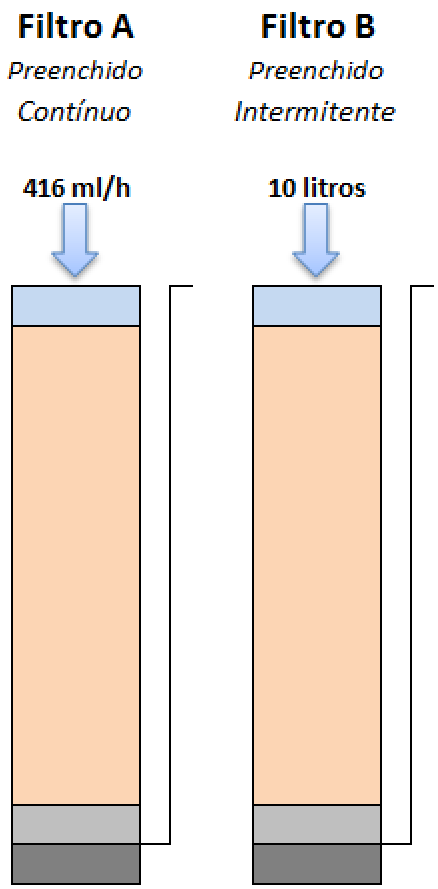
HYDRAID FILTER – CUT XY [Z=1cm]



06 RESIDENCE-TIME DISTRIBUTION

06.1 RESIDENCE-TIME DISTRIBUTION

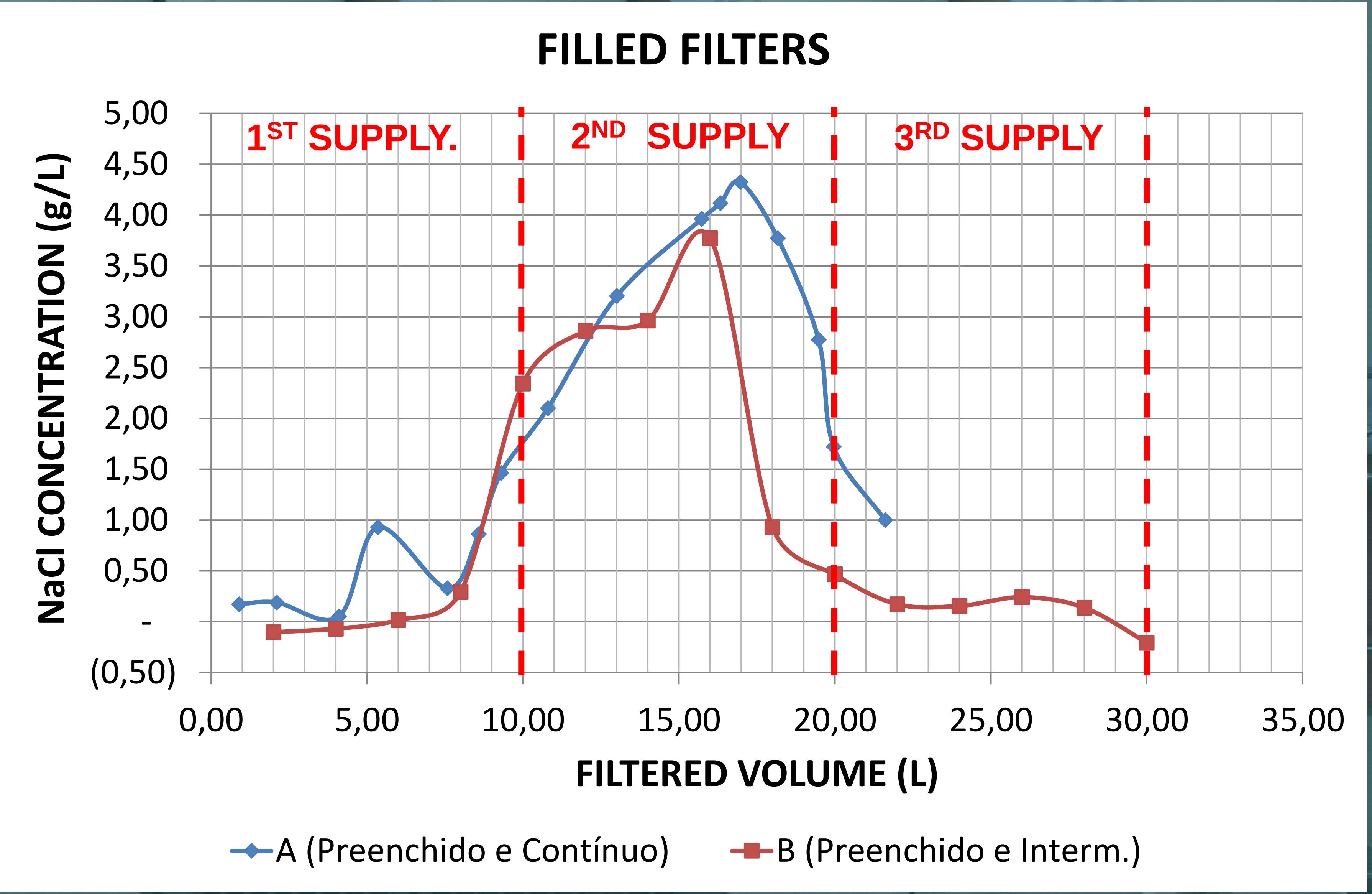
RESIDENCE-TIME



THREE SUPPLIES

IN THE 1st ADDITIONAL CONCENTRATION OF 2g/L OF NaCl.

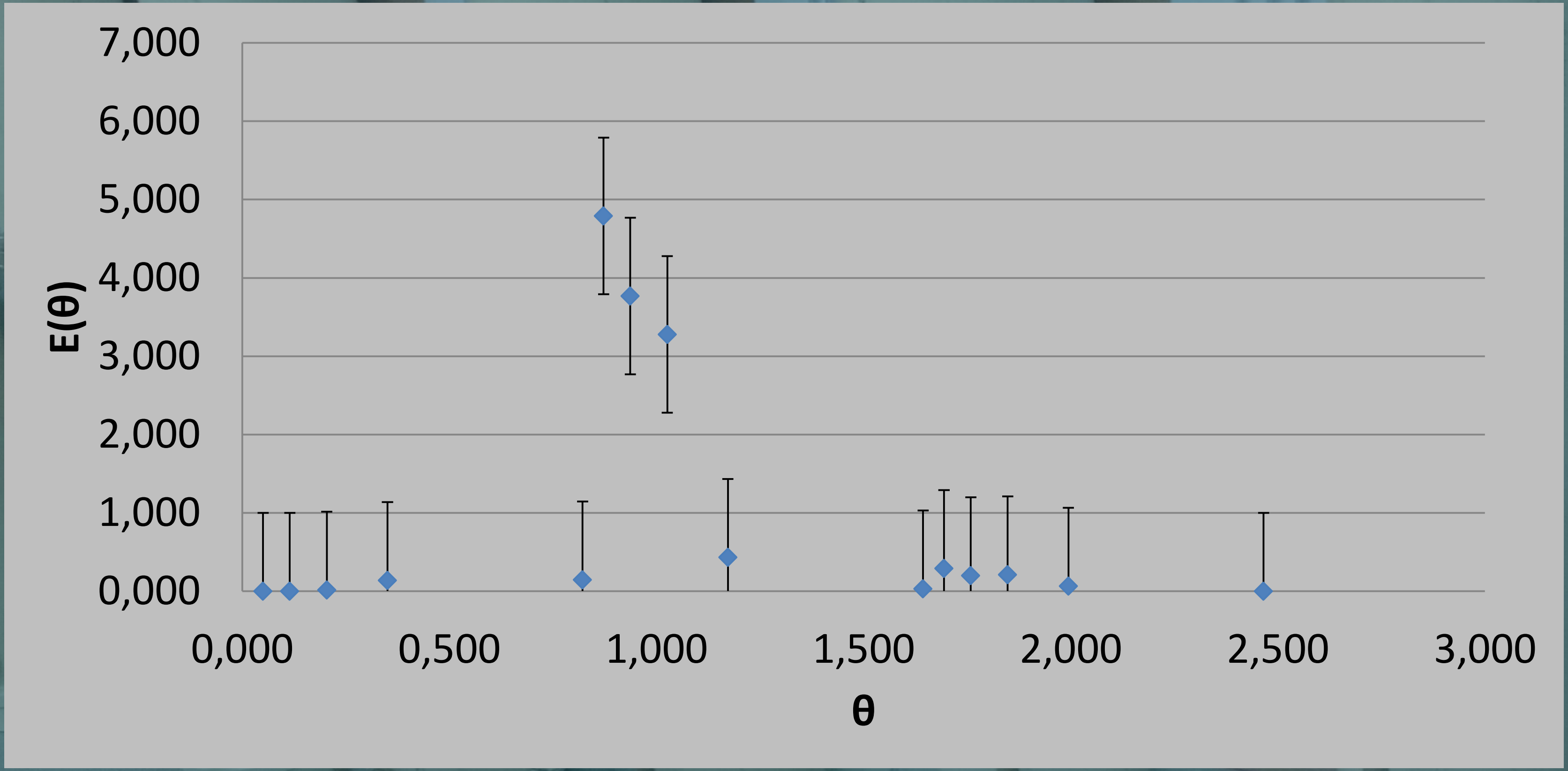
06.1 RESIDENCE-TIME DISTRIBUTION
CONCENTRATION CURVE



06.2

RESIDENCE-TIME DISTRIBUTION

EMPIRICAL RTD CURVE

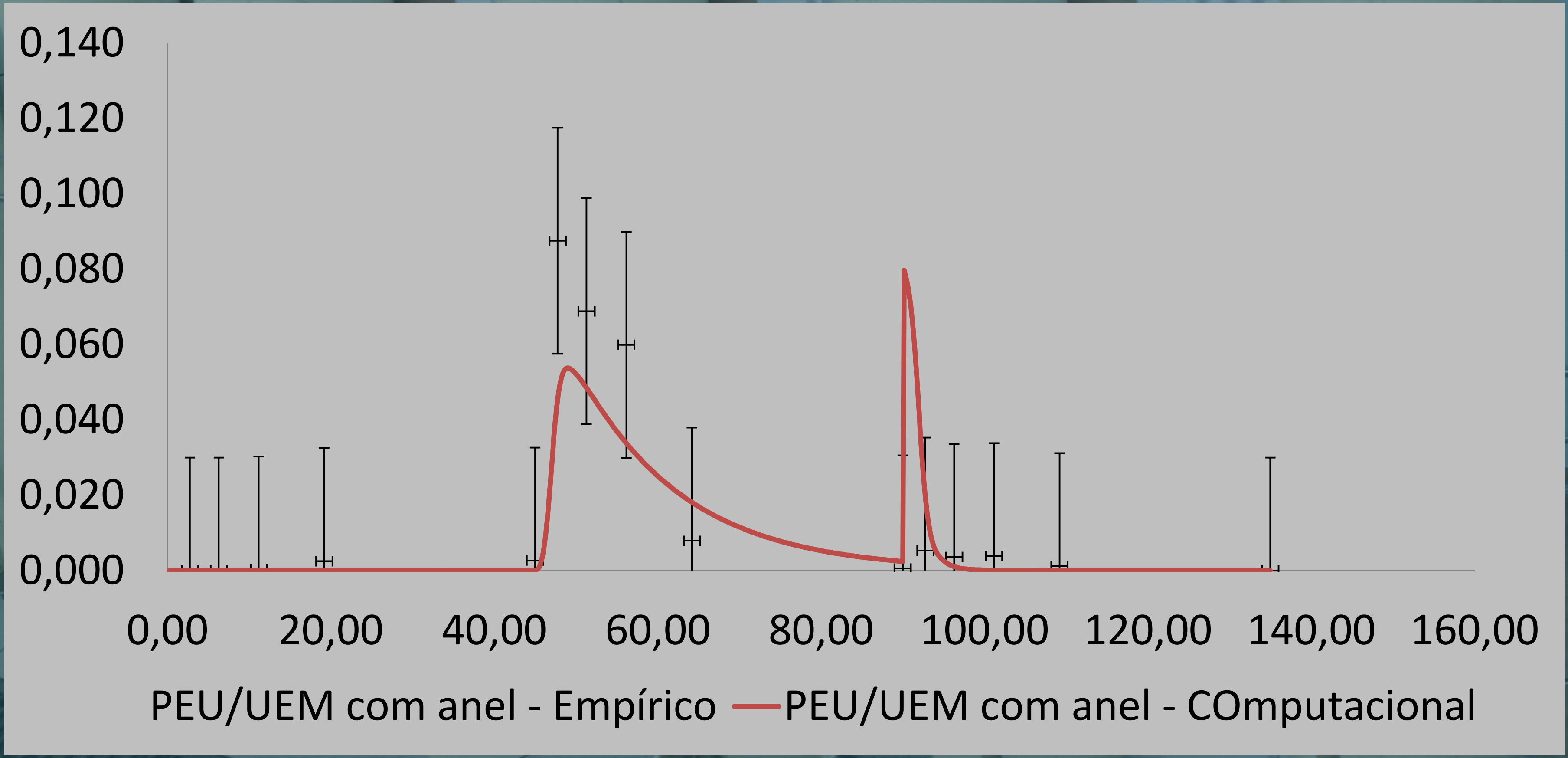


CHARACTERISTIC VOLUME	
Dead Volume	1,52%
Slug Volume	61,53%
Mixture Volume	36,95%

06.3

RESIDENCE-TIME DISTRIBUTION

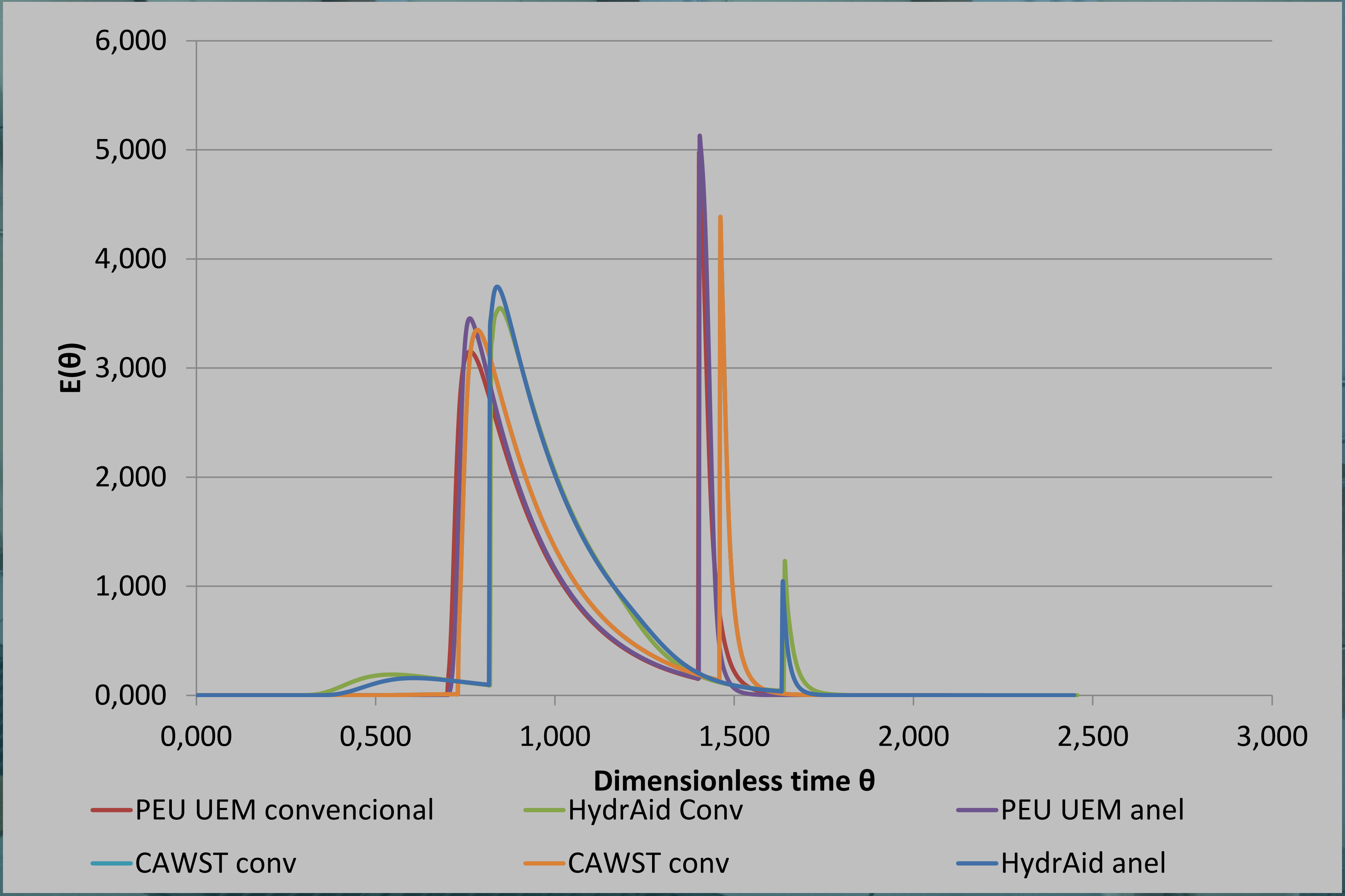
MATHEMATIC AND EXPERIMENTAL RTD COMPARATION



06.4

RESIDENCE-TIME DISTRIBUTION

RTD CURVE OF MATHEMATIC MODELS



06.4 RESIDENCE-TIME DISTRIBUTION

RTD CURVE OF MATHEMATIC MODELS

	PEU/UEM convenc.	PEU/UEM ring	CAWST convenc.	CAWST ring	HydrAid convenc.	HydrAid ring
τ [min]	64,32	64,23	61,7	64,23	54,95	55,14
θmin	0,72	0,73	0,74	0,72	0,52	0,59
θmax	0,84	0,8	0,85	0,82	0,89	0,86
Dead volume	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Slug volume	78,13%	76,42%	79,42%	77,22%	70,37%	72,69%
Mixture volume	21,87%	23,58%	20,58%	22,78%	29,63%	27,31%

07 CONCLUSIONS

- **IN THE EVALUATION OF THE FOUR MODELS OF PEU/UEM FILTER THE CENTRAL AND RING OUTLETS PRESENTED BETTER RESULTS**

- **FOR THE CAWST AND HYDRAID FILTERS THE RING OUTLET PRESENTED BETTER RESULTS REGARDING THE FLOW LINES AND VELOCITY PROFILES.**

- **THE EXPERIMENTAL FILTER ASSISTED IN THE COMPREHENSION AND DETERMINATION OF MATHEMATIC PARAMETERS. THE TURBIDITY AND PH PARAMETERS WERE IN ACCORDANCE WITH THE BRAZILIAN POTABILIZATION NORMS.**

- **IN THIS STUDY ALL THE MATHEMATICAL SOLUTIONS PRESENTED EQUIVALENCE FOR THE RTD CURVES.**

08 FUTURE RECOMMENDATIONS

- EMPIRICALLY EVALUATE THE POTABILIZATION PARAMETERS IN THE VARIATIONS OF BIOSAND FILTERS DESIGNS .

- ADD POTABILIZATION PARAMETERS IN THE VARIATIONS OF MATHEMATIC MODELS.