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Removal of Dust Suppressor and TRU Elements from Wastewaters of Chernobyl NPP Using Synthetic and Natural Flocculants

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Session #64A

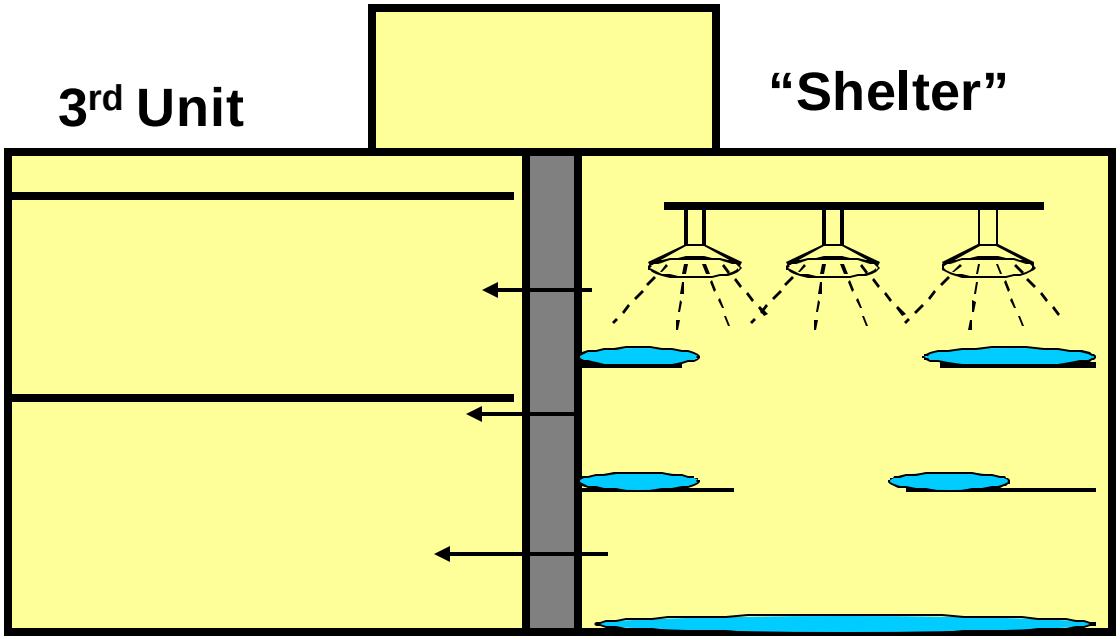
"*Task 13 Conceptual Design of the Pre-Treatment Facility for Shelter Water. Report No. TN/01301. Issued 4th May 2000*"

IAEA expert missions at ChNPP during 2009-2012 to develop principal technology and pilot test unit to remove organic contaminants and TRU from "Shelter" Object wastewaters

№№ UKR/3/003 12 01, UKR/3/003 12 02, UKR/3/003 12 03,

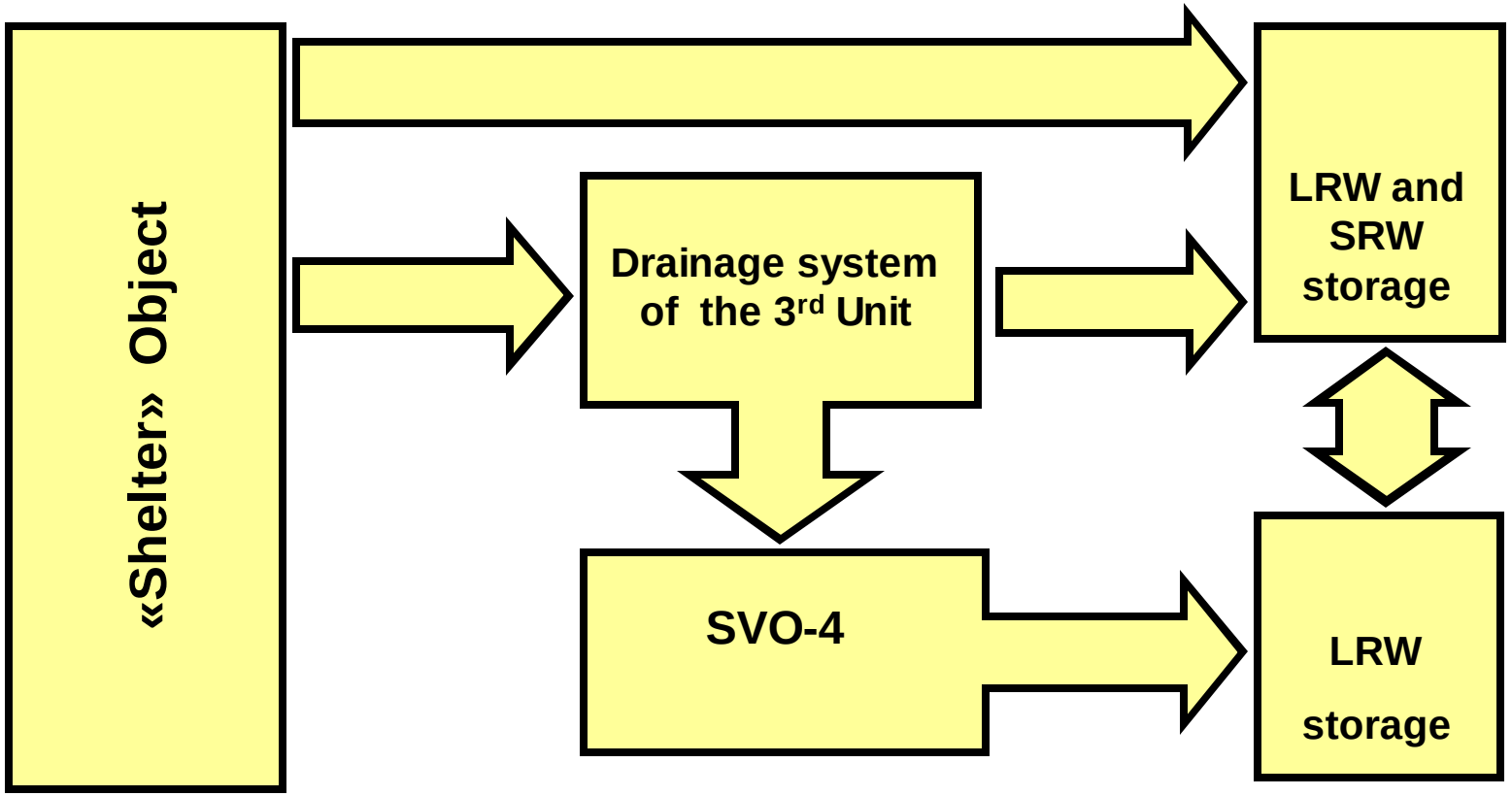
UKR/3/003-19-01, UKR/3/003 24 01

Dust Suppressor Emulsion Application at ChNPP



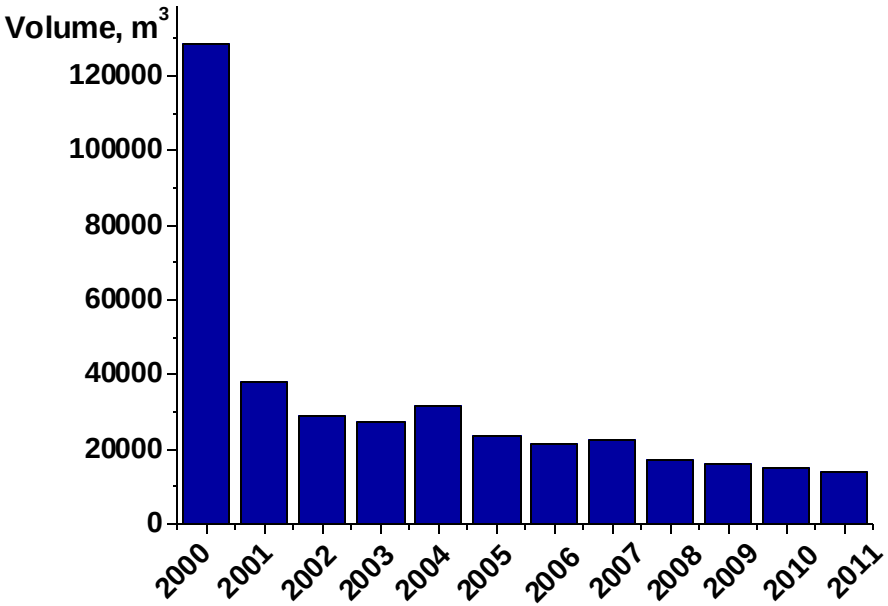
- Sprayed dust suppressor solution and waters after washing spraying system are not separated.
- Non-dried dust suppressor emulsion penetrates down the “Shelter” (Unit 4) rooms to bottom levels and into the adjacent Unit 3 through concrete wall.

ChNPP 3rd and 4th Unit LRW Accumulation Flow Sheet



Dust suppressor containing LRW

3rd and 4th Unit drainage waters



Salinity: <1 g/L

Total α-activity: 1-2 E+04 Bq/kg

Total β-activity: 0.9-4.0E+06 Bq/kg

Dust suppressor content: 0.1-2 g/L

Evaporator concentrates of 3rd and 4th Units drainage waters

Volume at LRW storage:

13 500 m³

Salinity: 300-500 g/L

Total α-activity: 3-4 E+03 Bq/kg

Total β-activity: 3-4 E+07 Bq/kg

Dust suppressor content: ~0.3-0.5 g/L

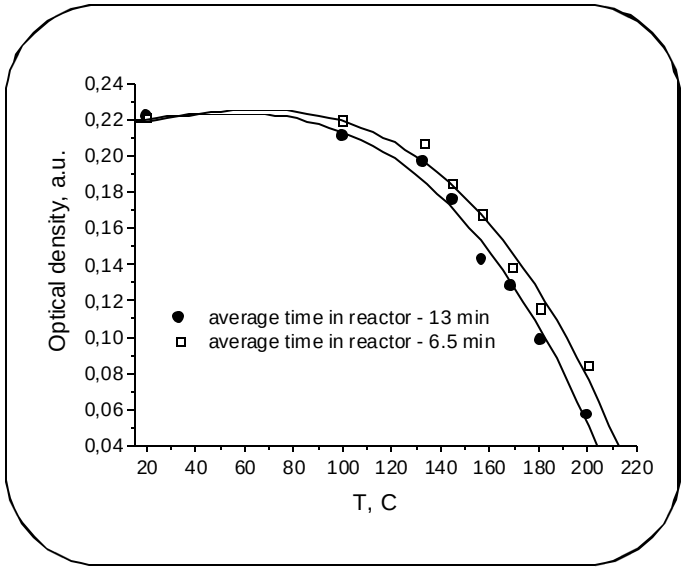
Construction of LRW Treatment Plant is currently suspended

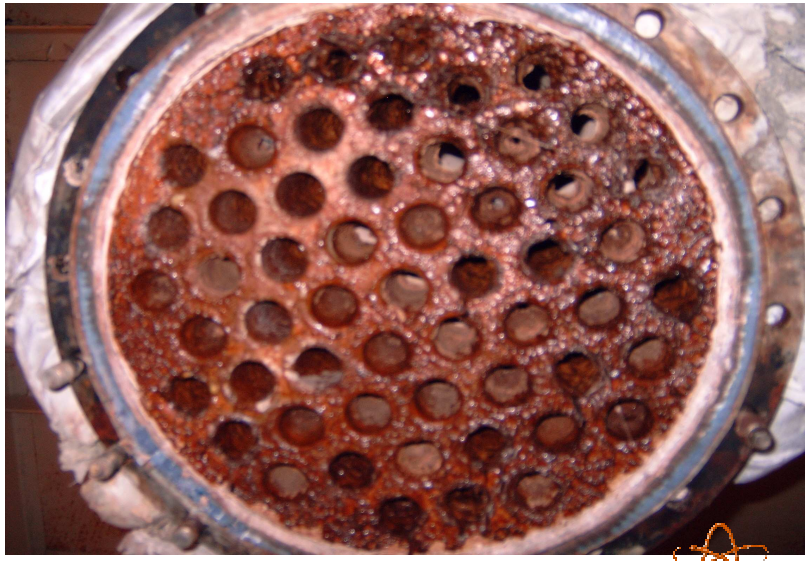
- **Designing is 99% completed**
- **Construction is 98% completed**
- **Mounting is 97% completed**

Problems identified

- Accumulated wastes contain high amounts of dust suppressor and **CANNOT** be treated by evaporation-cementation set up in a new facility.
- TRU content in LRW must be reduced prior to cementation.

Polymerization of dust suppressor under elevated temperature results in formation of virtually insoluble rubber-like deposits on heat-exchangers of the secondary evaporator of SVO-4





Rubber-like precipitates are formed at T >130ºC (salinity > 150 g/L)

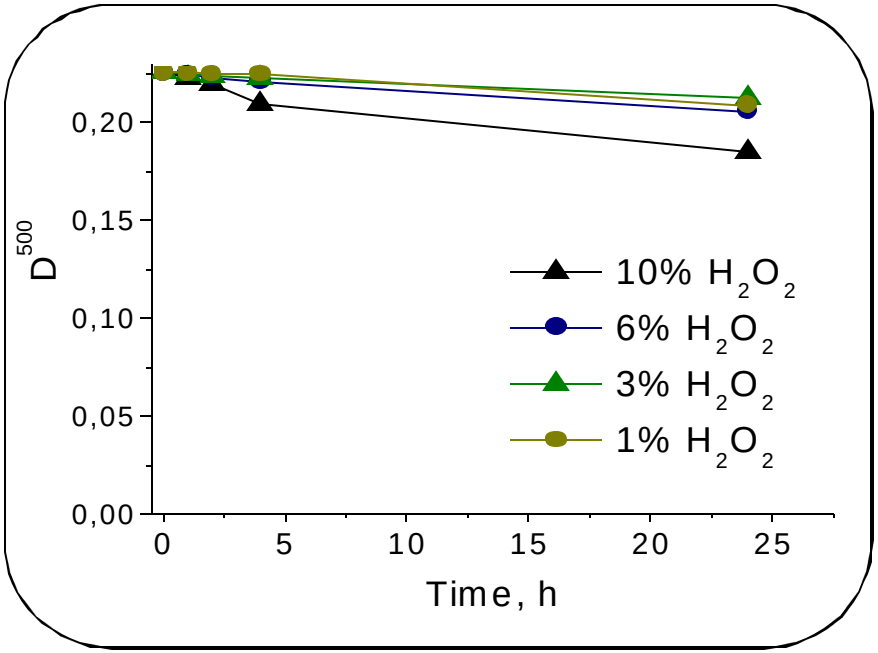
Formation of rubber like precipitates in sealed system of a new LRW Treatment Plant will damage heat exchangers and block facility operation

Possible approaches to remove dust suppressor from LRW

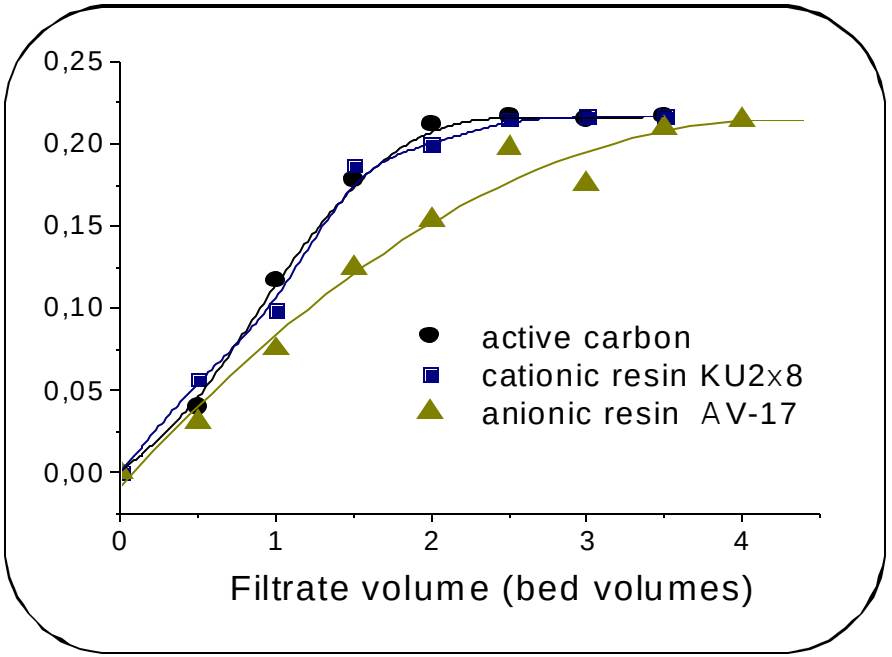
- Oxidation (ozone, peroxides)
- Sorption (active carbon)
- Filtration through ion-exchangers
- Flocculation with cationic polyelectrolytes

Removal of Dust-Suppressor

by peroxide oxidation



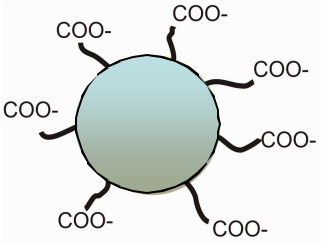
by sorption and ion-exchange filtration



Only up to 10% of dust suppressor can be removed

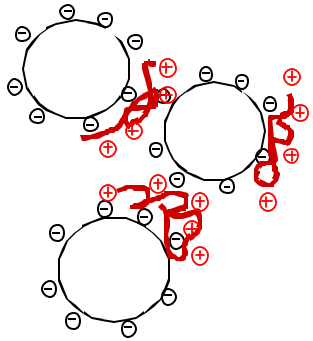
Required DF > 200

Flocculation/sedimentation setup for dust suppressor and TRU removal

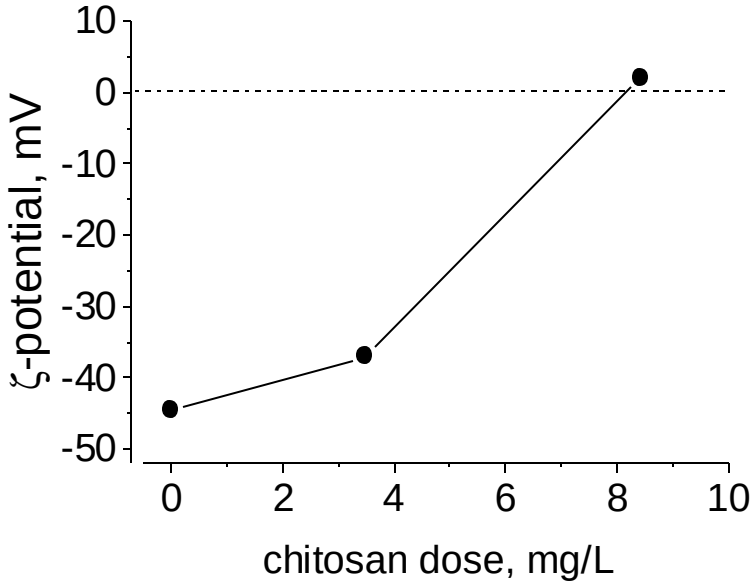


Cationic polymer

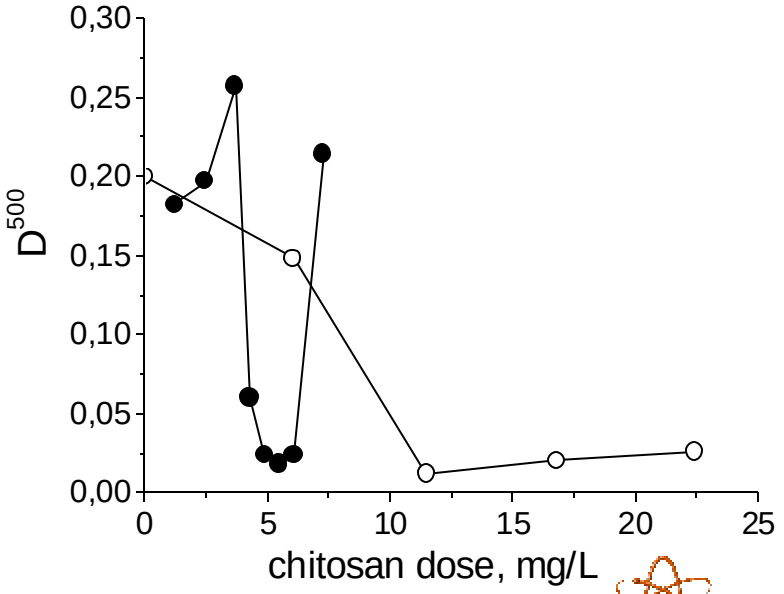
at pH>8 DS coprecipitation with TRU colloids



Charge neutralization of TRU colloids, pH>8



Dust suppressor removal



Composition of LRW used in the Pilot tests

	pH Dry residue, g/L	$[C_2O_4]$ Oxygen consumption, mg/L	Total α-activity β-activity, Bq/kg	Specific activity, Bq/kg	D^{500} DS, mg/L
BTV	9.45 1.10	13.50 220	1.66E+04 9.49E+05	^{60}Co: 3,53E+04 ^{134}Cs: 7,77E+02 ^{137}Cs: 7,54E+05 ^{154}Eu: 2,51E+03 ^{155}Eu: 1,82E+02 ^{241}Am: 1,30E+04	1.825 233
0005	9.71 0.8	22.5 600	1.30E+04 3.62E+06	^{60}Co: 8,92E+02 ^{134}Cs: 6,94E+02 ^{137}Cs: 2,37E+06 ^{154}Eu: 1,80E+03 ^{241}Am: 1,02E+04	2.500 327
201/3 (evaporator concentrate)	11.42 275.4	8730 5000	4.41E+03 3.18E+07	^{60}Co: 8,22E+03 ^{134}Cs: 3,77E+04 ^{137}Cs: 2,63E+07 ^{241}Am: 3,46E+03	0.566 (D^{1000}) 150

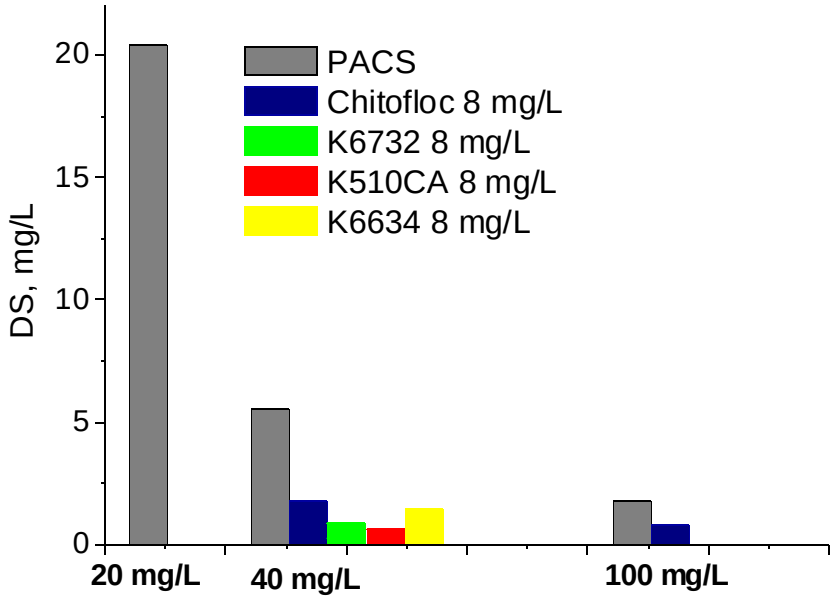
Pilot Unit at Chernobyl NPP

General view of the pilot unit:

service tank (1), precipitation tank (2), accumulation tank (3), membrane pumps for reagents feeding (4), reagent vessels (5), mechanical filters (6), heat-exchanger (7), circulating pumps (8).

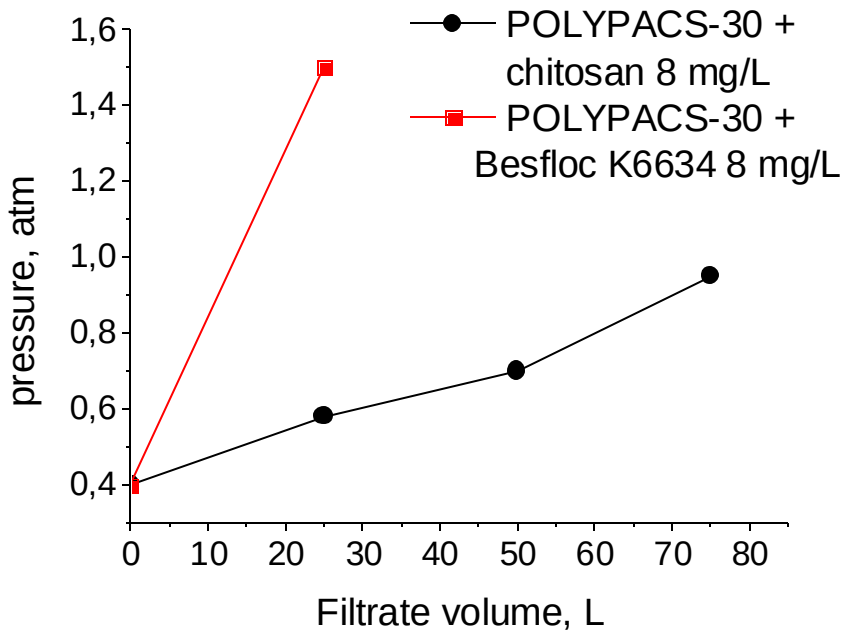
Coagulant/flocculant dose optimization: drainage waters

Residual DS concentration in drainage waters of “Shelter” unit after flocculation



Comparison of chitosan and synthetic flocculants BesFloc (Republic of Korea)

Mechanical filtration of treated LRW



Synthetic flocculants form gel-like precipitates and are not applicable in flocculation-filtration set-up

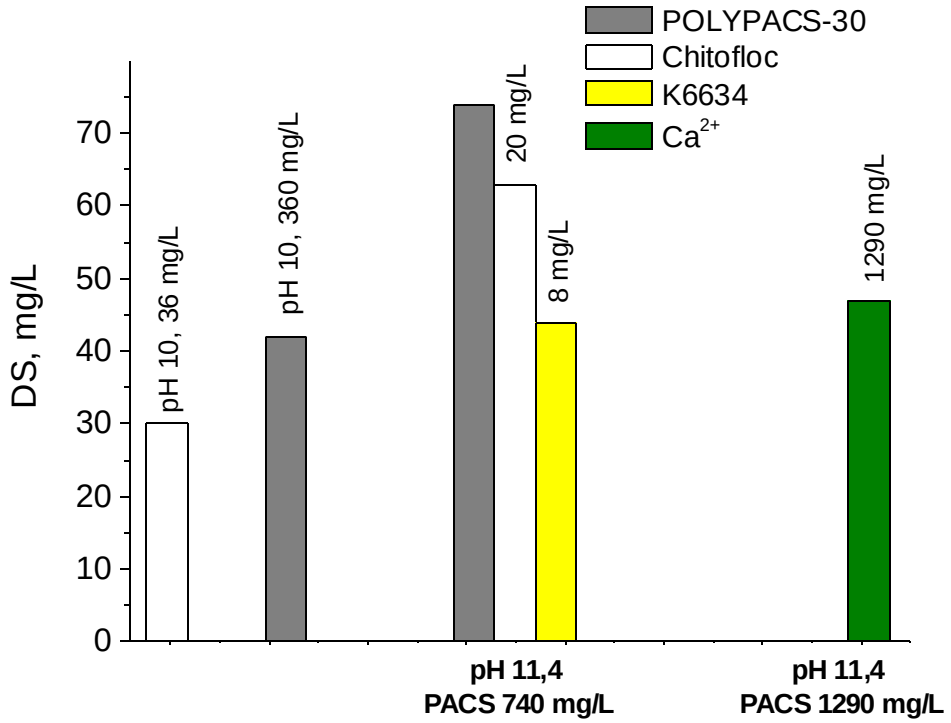
Sedimentation/Filtration Stage

- **Sedimentation time (flocs ripening) – 5-10 min: continuous process is possible**

- Mechanical filtration rate is 10 to 120 L/h (filters – 2 dm^3 each)

Filtration media tested:
sand, ion-exchangers «Dowex Monosphere» - cation-exchanger (650NG) and anion-exchanger (550NG) mixed at ratio 1:1.5 to simulate spent ion-exchange resins available at ChNPP

Coagulant/flocculant dose optimization: evaporator concentrates



Reagents tested

-PACS
- chitosan
- BesFloc cationic flocculants
- addition of calcium salts to suppress oxalate effect

Decontamination factor for DS is 5-10

Due to the lack of electrostatic interactions in high salinity media (>200 g/L) flocculation/sedimentation set-up is not efficient for evaporator concentrates

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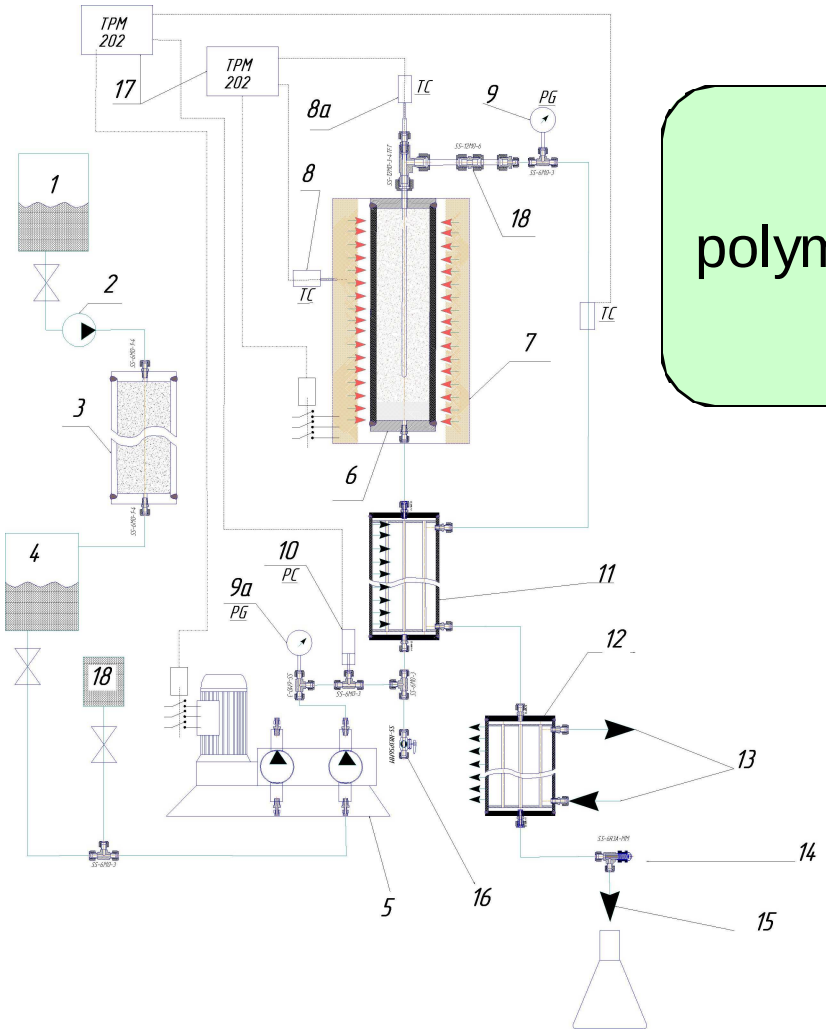
Selected Pilot Test Results

Sample	Reagent dose	D^{500} (filtrate) / DS content, mg/L	Total β-activity, Bq/kg	Total α-activity Bq/kg
Experiment №1 BTV	POLYPACS 200 mg/L Chitofloc 7.8 mg/L	0.053 / 5.51	6.11E+5	n/detected
Experiment №2 BTV	POLYPACS 125 mg/L	0.015 / 0.64	7.05E+5	n/detected
Experiment №3 0005	POLYPACS 260 mg/L Chitofloc 10 mg/L	0.029 / 2.43	1.77 e+6	n/detected

Decontamination factors for drainage waters: DS>500, TUE>1000

How to treat 13 500 m^3 of dust suppressor containing evaporator concentrate?



Possible solution:

polymerization of DS under hydrothermal conditions before evaporation

Main subunits of the hydrothermal unit

1 – feeding tank
2, 5 – pumps
3 – sorption filter for cesium removal
4 – tank for treated wastes collection
6 – hydrothermal reactor
7 – oven
8 – thermocouple
12 – cooler

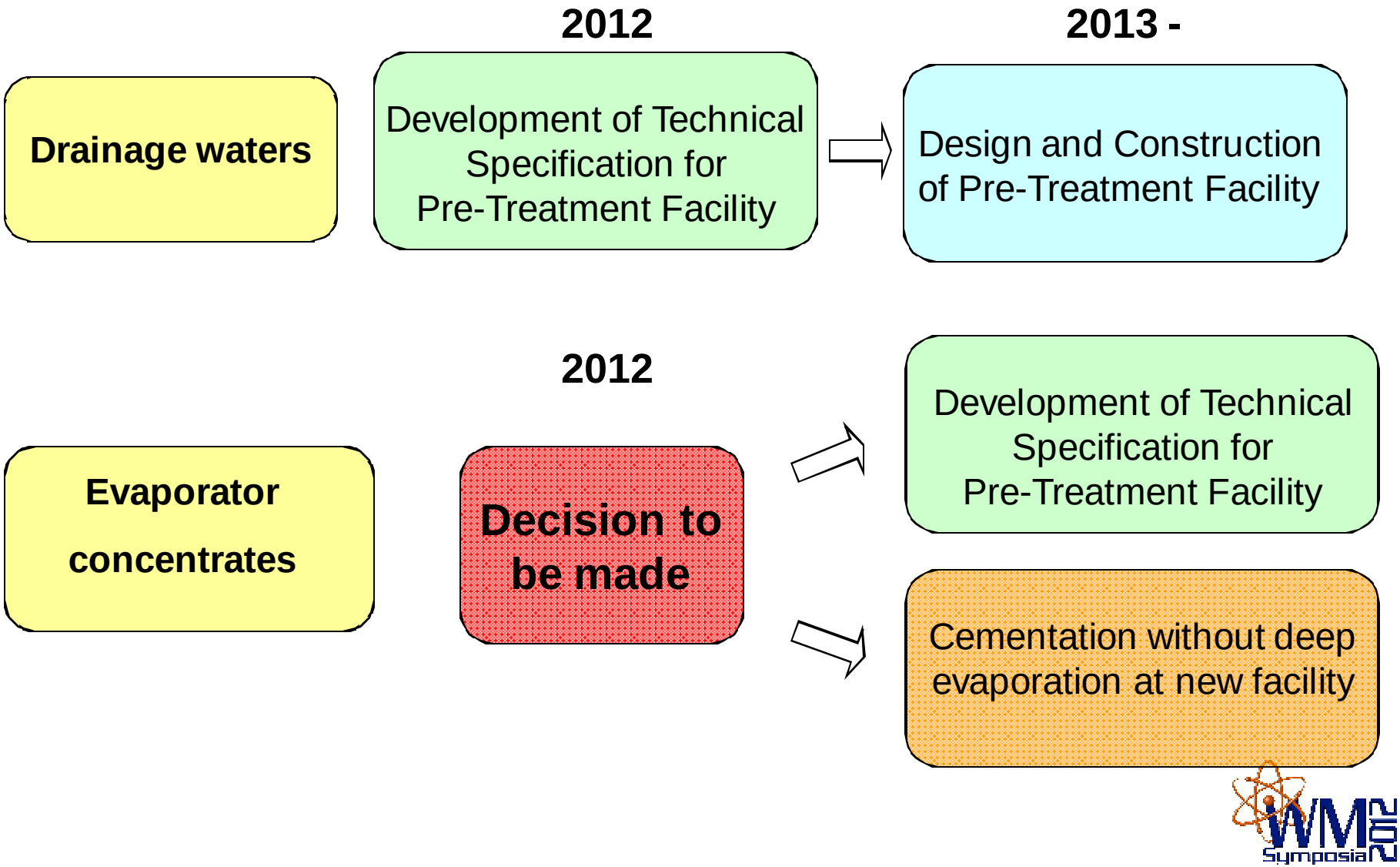
Hydrothermal Unit of the Pilot Unit at ChNPP

Treatment conditions

T = 270-310ºC
P = 80-100 bar

evaporator concentrate before treatment

PROSPECTS


2012
2013 -
Drainage waters
Development of Technical Specification for Pre-Treatment Facility
Design and Construction of Pre-Treatment Facility
2012
Evaporator concentrates
Decision to be made
Development of Technical Specification for Pre-Treatment Facility
Cementation without deep evaporation at new facility