

# Evaluation of NORM residues from the processing of crude oil in a refinery

8<sup>th</sup> International Symposium on  
Naturally Occurring Radioactive Material - NORM VIII  
Rio de Janeiro, Brazil, October 18. – 21., 2016



# Activity of residues

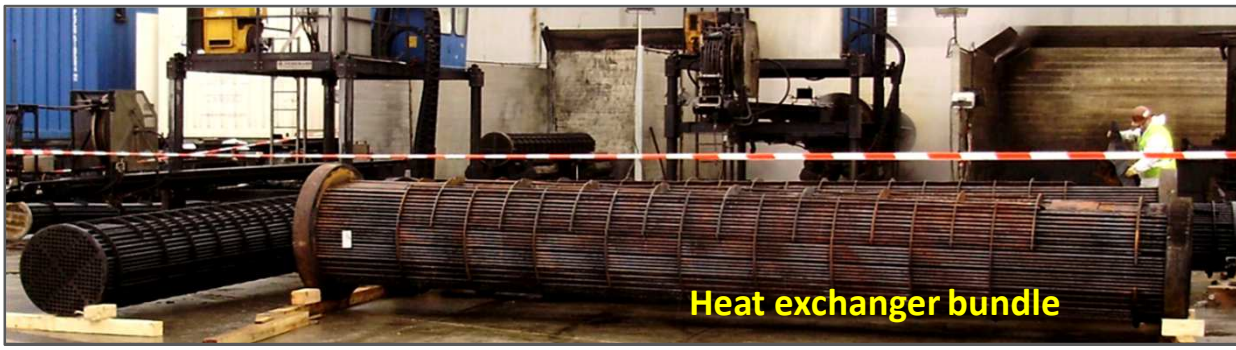
Mass-related activity of different material samples, taken of residues, components and media of the refinery

Radio-nuclide <sup>1</sup>	Activity concentration [Bq/kg] <sup>2</sup>										
	1	2	3	4	5	6	7	8	9	10	11
Th-232	.	.	6	.	.	31	.	.	.	.	.
Ra-228	29	23	164	0,03	109	131	40	275	16	.	.
Th-228	18	25	158	0,02	99	90	38	162	16	5	4
U-238	11	16	7	0,3	52	30	24	83	12	21	.
Th-230	.	17	31	.	.	.	30	103	.	.	.
Ra-226	70	62	455	0,3	170	175	48	391	22	.	14
Pb-210	285	1039	3130	1	444	1961	63	8411	170	259	24567
U-235	0,6	0,9	0,4	0,07	2,2	1,9	1,1	3,7	0,7	.	.
Ac-227	0,3	0,8	0,6	0,04	6,0	3,8	1,0	0,2	2,4	.	.
Pa-231	0,3	.	.	.	6,1	3,5	2,3	.	0,6	.	.
K-40	10	34	37	0,1	48	36	58	39	13	.	.

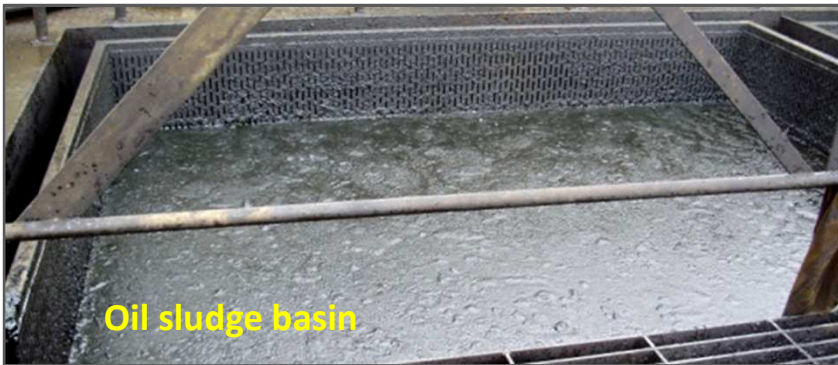
<sup>1</sup> green: Th-232 series; red: U-238 series; blue: U-235 series; brown: K-40

<sup>2</sup> directory of samples:

- |   |                                  |    |                                                       |
|---|----------------------------------|----|-------------------------------------------------------|
| 1 | sewage sludge (conditioned)      | 6  | FCC catalyst (dust out of electrostatic precipitator) |
| 2 | oil sludge                       | 7  | bitumen                                               |
| 3 | desalter sludge                  | 8  | oil sludge deposition on heat exchanger bundle        |
| 4 | sewage water                     | 9  | coke                                                  |
| 5 | FCC catalyst with-drawal (E-cat) | 10 | Distillation column internals (deposit on trays)      |
|   |                                  | 11 | Distillation column internals (deposit on packings)   |



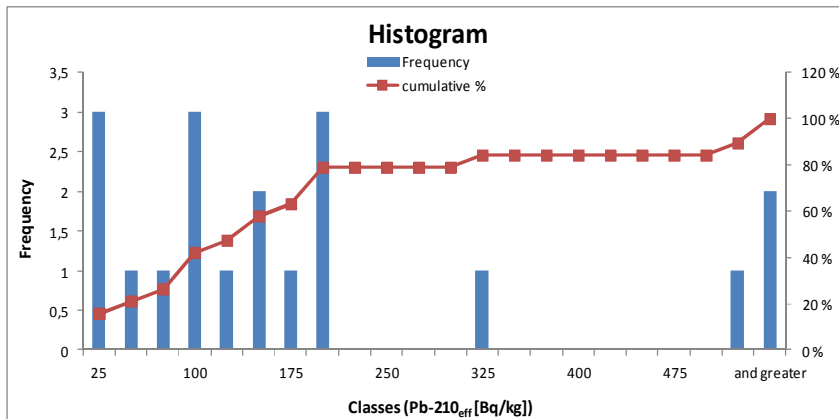
# Evaluation of residues



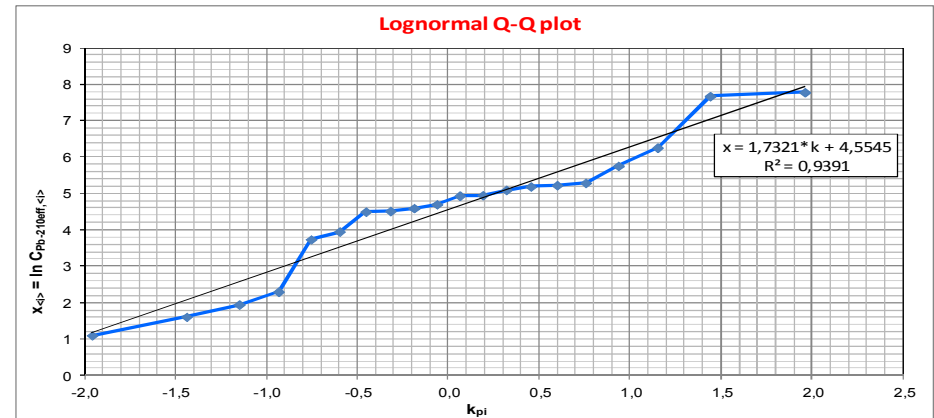
## Mass-related activity of the 20 oil sludge samples

Radio-nuclide <sup>1</sup>	Activity concentration [Bq/kg]									
	1	2	3	4	5	6	7	8	9	10
Pb-210	5	4288	52	10	99	42	4776	3	8	179
Pb-210 <sub>eff</sub>	5	2144	52	10	99	42	2388	3	8	90
	11	12	13	14	15	16	17	18	19	20
Pb-210	396	1039	282	183	163	359	372	278	110	632
Pb-210 <sub>eff</sub>	198	520	141	92	163	180	186	139	110	316

## Frequency distribution of the random sample of n = 20 from the oil sludge basin (Pb-210<sub>eff</sub>)



## Q-Q plot for the logarithm of the measured values (activity of Pb-210<sub>eff</sub> and calculation of the coefficient of determination" R<sup>2</sup>(Ln)



### Control Limit

In Germany the 95 %-upper confidence limit of the mean of a random sample specific activity has to fall below 1 Bq/g concerning dumping or combustion of NORM residues:

$$C_{U-238max} + C_{Th-232max} \leq 1000 \text{ Bq/kg}$$

$$C_{U-238max} \equiv 95\% \text{UCL}_{CU-238max} \quad C_{Th-232max} \equiv 95\% \text{UCL}_{Th-232max}$$

## Results of Data analysis for Pb-210<sub>eff</sub> of a random sample of size n = 10 and n = 20 drawn from a population of oil sludge

	10 samples	20 samples
arithmetic mean	484 Bq/kg	344 Bq/kg
95%UCL (classical)	2	2142 Bq/kg
95%UCL (numerical) <sup>1</sup>	1154 Bq/kg	798 Bq/kg