Heavy metals removal from dredged sediments using electrokinetics process

M Ammami, A. Benamar, Florence Portet-Koltalo, Huaquing Wang

Heavy metals removal from dredged sediments using electrokinetics process

M.T Ammami[1,2], A. Benamar[1] , F. Portet-Koltalo[2],.H.Q. Wang[1]

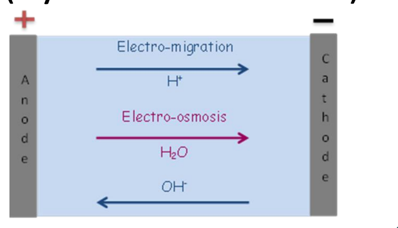
1 Laboratoire ondes et milieux complexes, LOMC UMR 6294 CNRS - Université du Havre, 53 rue de Prony, 76600 Le Havre, France. . Ahmed.benamar@univ-lehavre.fr
2 Laboratoire COBRA, UMR 6014 - CNRS, Université de Rouen, , 55 rue Saint Germain, 27000 Evreux, France. Florence.Koltalo@univ-rouen.fr

Objective: Removal of heavy metals from contaminated dredged sediments

Dredging practices constitute a challenge for developing and maintaining harbor and fluvial activities. They also present a contamination risk of coastal waters which can affect the ecosystems. The unsuitability and restriction to marine disposal of dredged sediments leads ultimately the managers to provide a treatment ashore because of the great volume of material to be treated.
So, Heavy metals fate and transport in contaminated sediments involve difficult risk assessment and remediation challenges.

Electrokinetic (EK) remediation is one of the most suitable technologies for extracting heavy metals from fine grained harbor sediments . Basically, an electric field is applied to the sediment via electrodes, causing movement of charged species in the sediment (by electromigration). This electric field also involves water movement (by electroosmosis).

EK remediation in laboratory scale was used to remove five heavy metals (Cd, Cr, Cu, Zn and Pb) from a model fine soil and a sediment collected from Tancarville (France) canal.



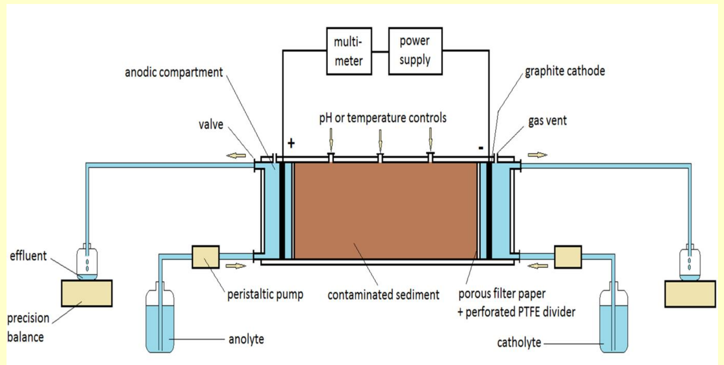
Methodology

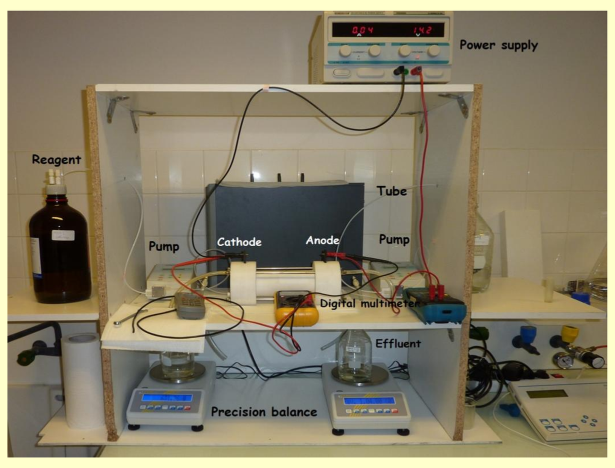
Materials and contamination

	Physical parameters					
	pH	w (%)	Organic matter content (%)	Particle distribution (%)		
				Sand (>63 µm)	Silt	Clay (< 2µm)
Model sediment	6.8	93	2.5	5	75	25
Tancarville sediment	8.4	49	2.5	7.5	86.2	6.3

	Metals/metalloids (mg/Kg)				
	Cd	Cr	Cu	Pb	Zn
Model sediment	24	180	90	552	200
Tancarville sediment	5	85	56	65	406

Experimental set up



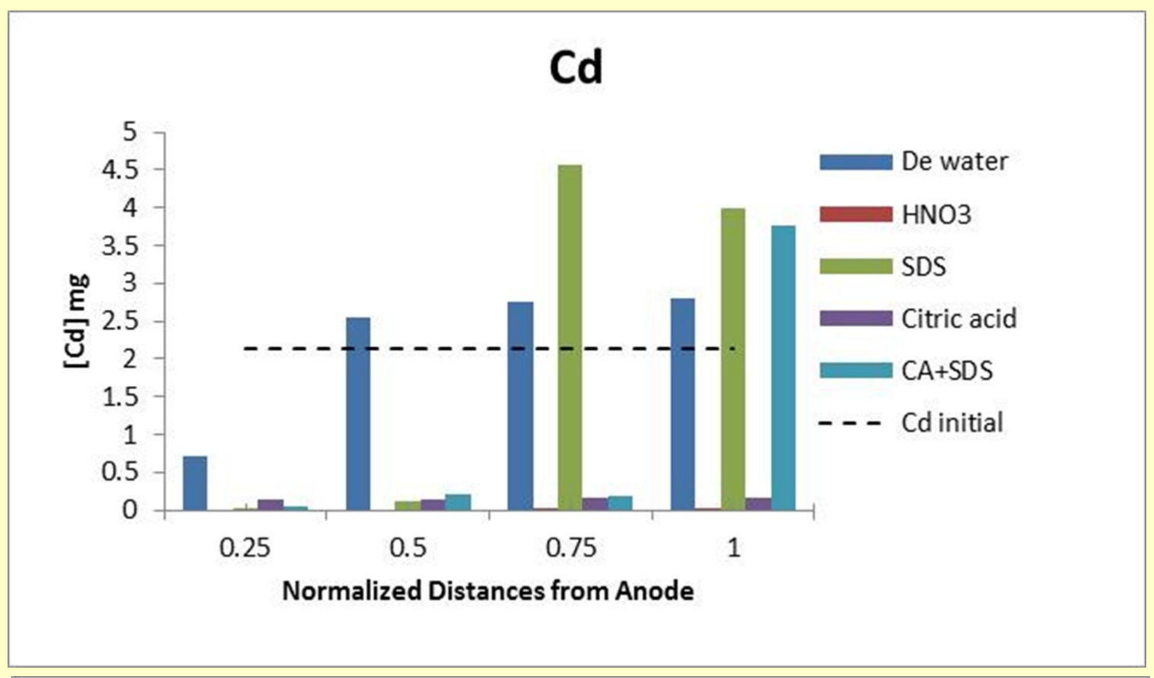


Run tests– Electric field: 1V/cm

Test no.	Electrolyte	Duration (days)	Sediment
EK1	Deionized water	7	model
EK2	Nitric acid (0.1M)	15	model
EK3	SDS (0.04M)	10	model
EK4	Citric acid (0.1M)	10	model
EK5	Citric acid (0.1M) + SDS (0.04M)	10	model
EK6	Citric acid (0.1M)	10	Tanacarville
EK7	Citric acid (0.5M)	10	Tanacarville
EK8	Citric acid (1M)	10	Tanacarville

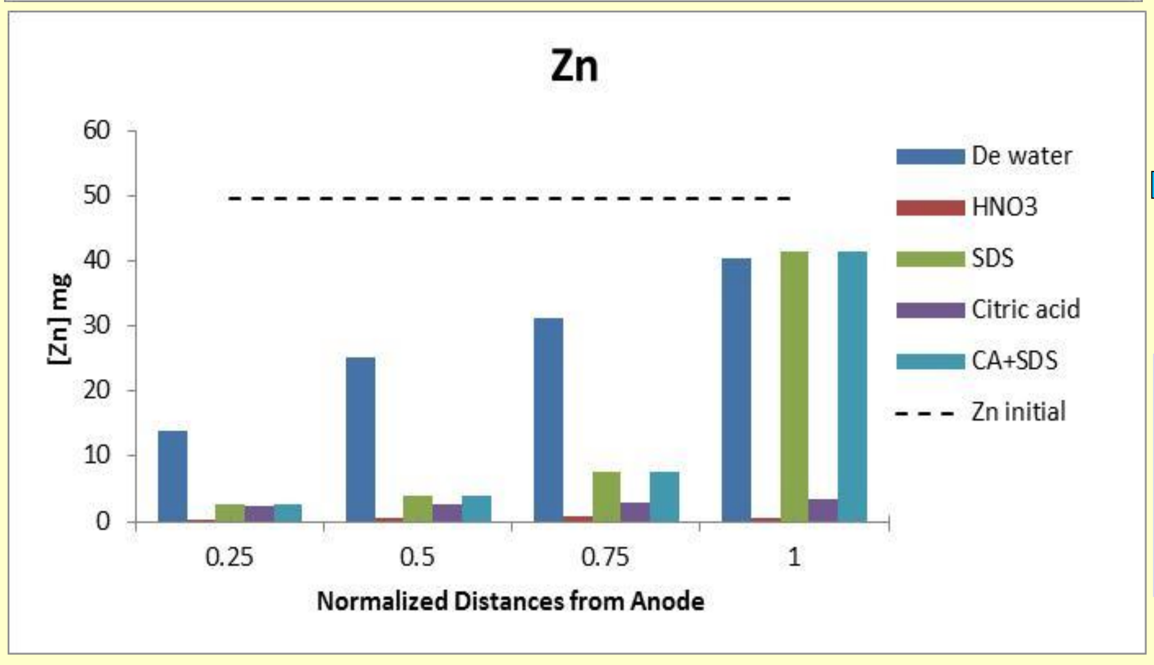
Results of heavy metals removal

Cd and Zn in the model sediment after test



Mobilization of Cd and subsequent migration toward the cathode. Nitric acid provides the better removal, but also Citric acid (0.1 M) presents an efficient additive for the process.

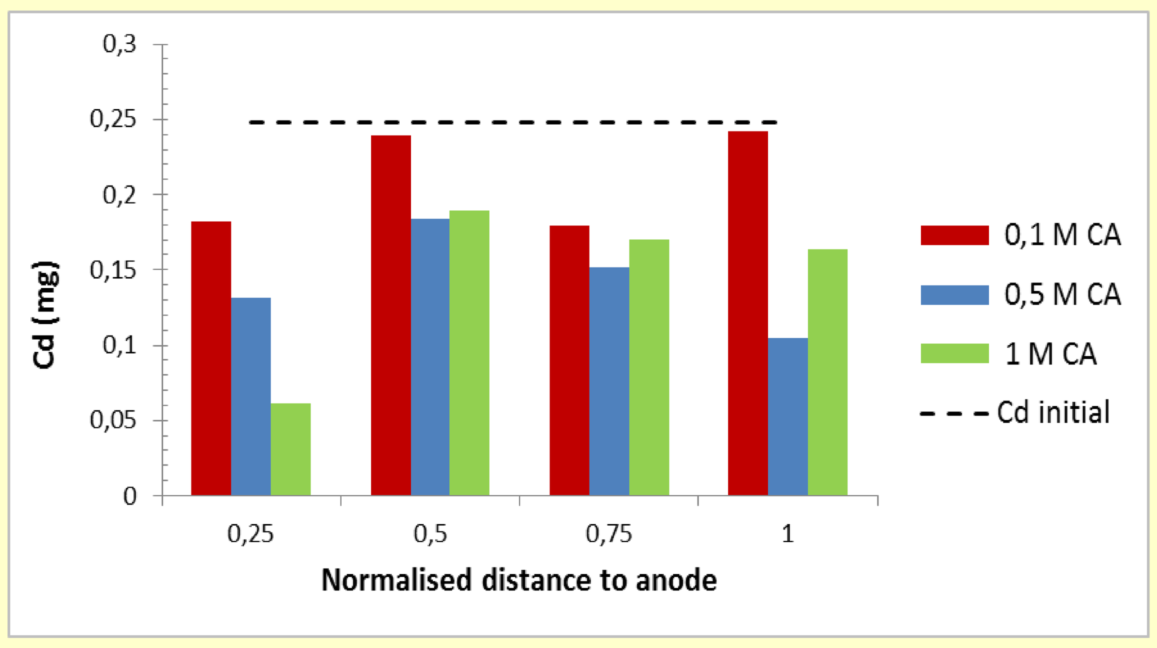
Increasing of fluid processing concentration improve the efficiency of decontamination but optimal concentration value seems to be close to 0.5 M

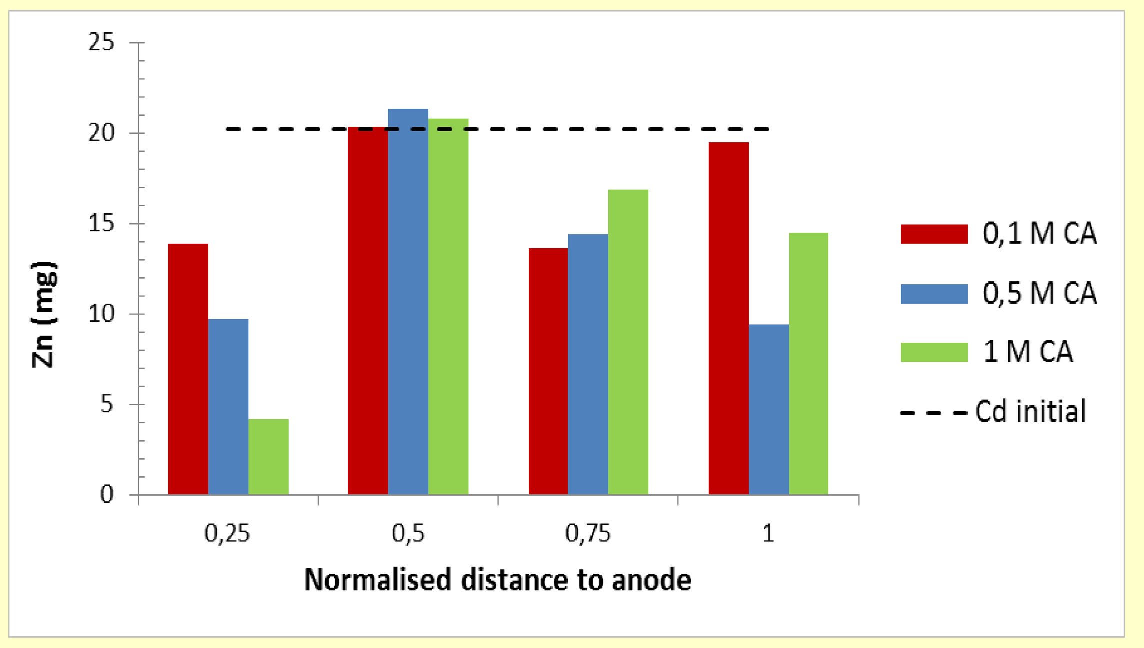


Facilitated mobilization of Zn, providing a better removal compared to other metals, without accumulation inside a part of the sediment

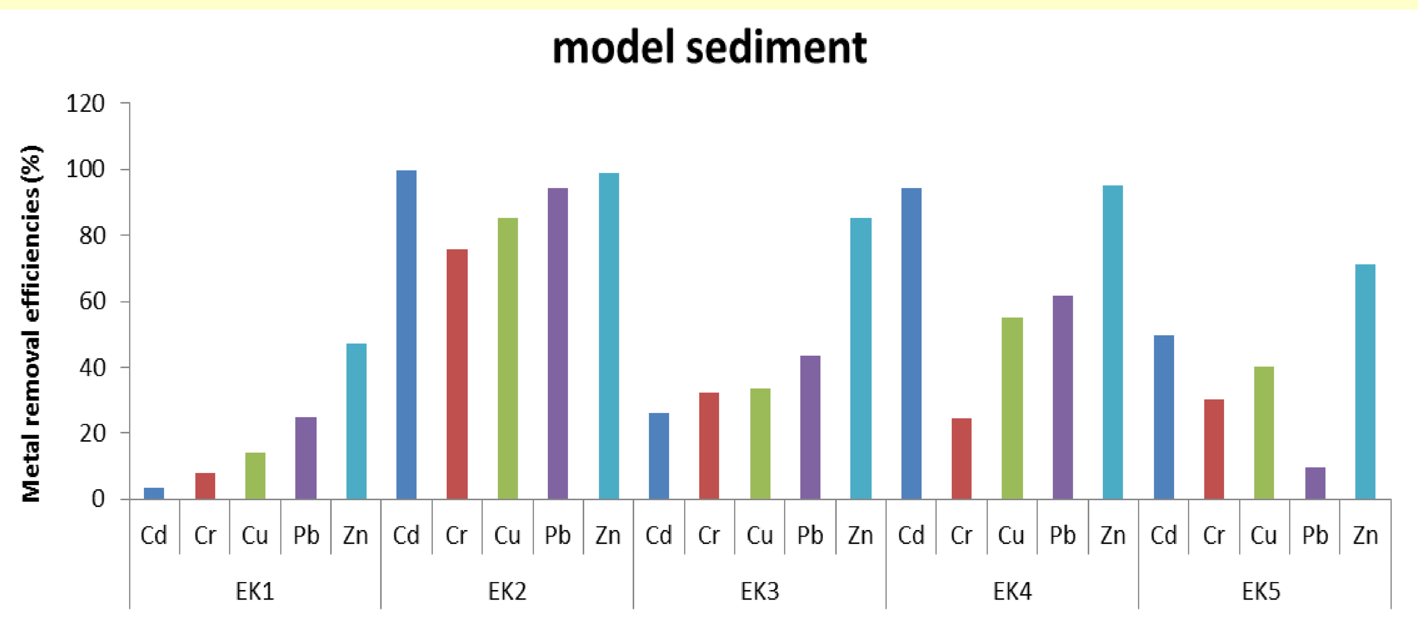
Great removal of Zn and Cd from natural sediment matrix is less obvious, owing to strong adsorption accomplished over a long time.

Cd and Zn in the Tancarville sediment after test

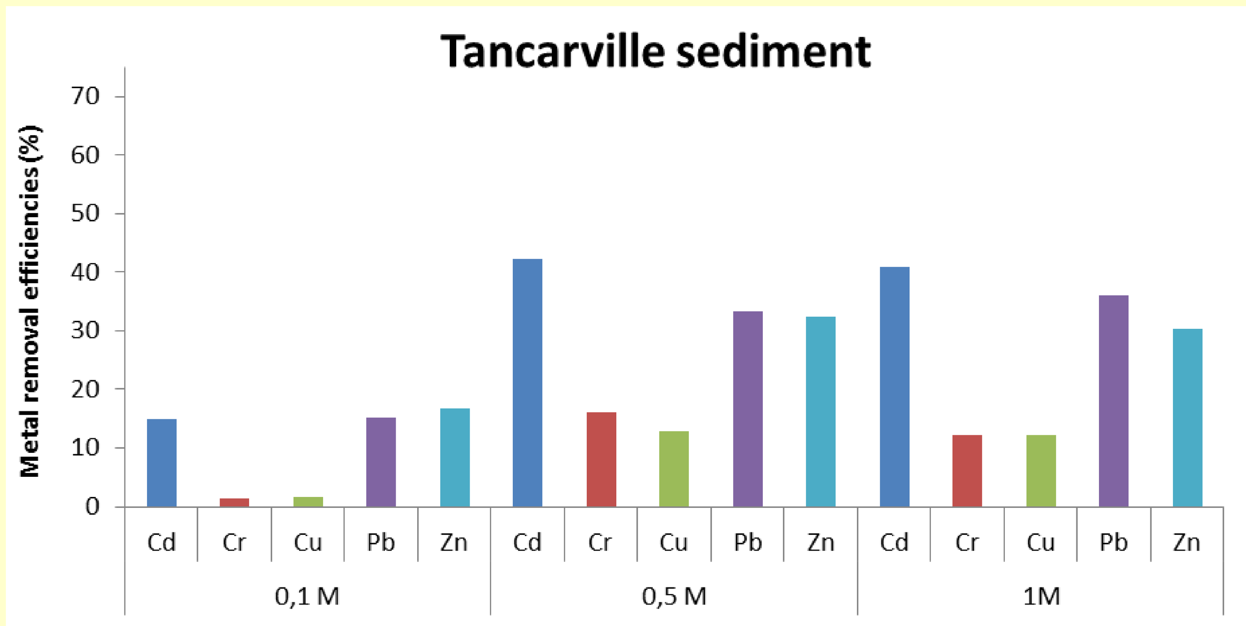




Metal removal efficiencies (%) obtained in various conditions



Test no.	Cd	Cr	Cu	Pb	Zn
EK1	3.4	7.8	14.	24.8	47.3
EK2	99.7	75.6	85.3	94.1	98.9
EK3	25.9	32.2	33.6	43.5	85.0
EK4	94.2	24.5	54.9	61.5	95.1
EK5	49.5	30.2	40.1	9.7	71.2
EK6	14.9	1.3	1.5	19.2	16.9
EK7	42.3	16.1	12.91	33.4	32.3
EK8	41,0	12.2	12.2	36.1	30.4



Tests performed under various processing fluids with different concentrations showed that the best recoveries were obtained in the order Zn>Cd>Pb>Cu>Cr (test EK 4). The results provided in the same conditions (Citric Acid 0.1 M) for Tancarville sediment are less promising. Increasing the processing fluid concentration leads to better removal efficiency.

Summary

Laboratory electromigration experiments show the efficiency of such process on heavy metals removal from fine sediments. Analysis of solid fractions after test allows to highlight the mobility of heavy metals inside the sediment sample. Among all the additives tested for metal removal, nitric acid showed the best removal efficiency, but citric acid, which is environmentally friendly, was also very interesting due to its buffering and chelating capacities. Results revealed that adding a strong inorganic acid (Nitric Acid) into the aqueous fluid was more effective than a weak acid (Citric Acid), but the complexing citric acid was promising for longer treatment. The Citric Acid as enhancing-process fluid provides significant heavy metals removal. Zn and Cd are easy-removed from natural sediment which presents more metals-affinity than model sediment for which removal was more significant. Further results showed that combining an acid and a surfactant allowed simultaneous removal of heavy metals and PAHs.