Modified Date Palm Leaflets for the Treatment of Brackish Water

El-Said El-Shafey, Amal S. J. Al-Hadi
Chemistry Department, College of Science, SQU, Oman

Oman belongs to the arid to semi-arid regions

Average Precipitation

~ 50-100 mm per year[1]

- Seawater TDS >15,000 mg/L
- Brackish water TDS 1000-15,000
- Fresh water TDS <500 mg/L

1. Siebert, S., Nagieb, M., Buerkert, A., AGR WATER MANAGE 89 (2007) 1–14.

- Oman East cost is affected by the salinity since 1990s as a result of seawater intrusion.

Effects of Salinity on crops production

Deficit in water resources gives warning

أرقام عجز موارد المياه في السلطنة تقرع ناقوس الخطر

Al-Shabiba Newspaper, Wed 13 April 2011

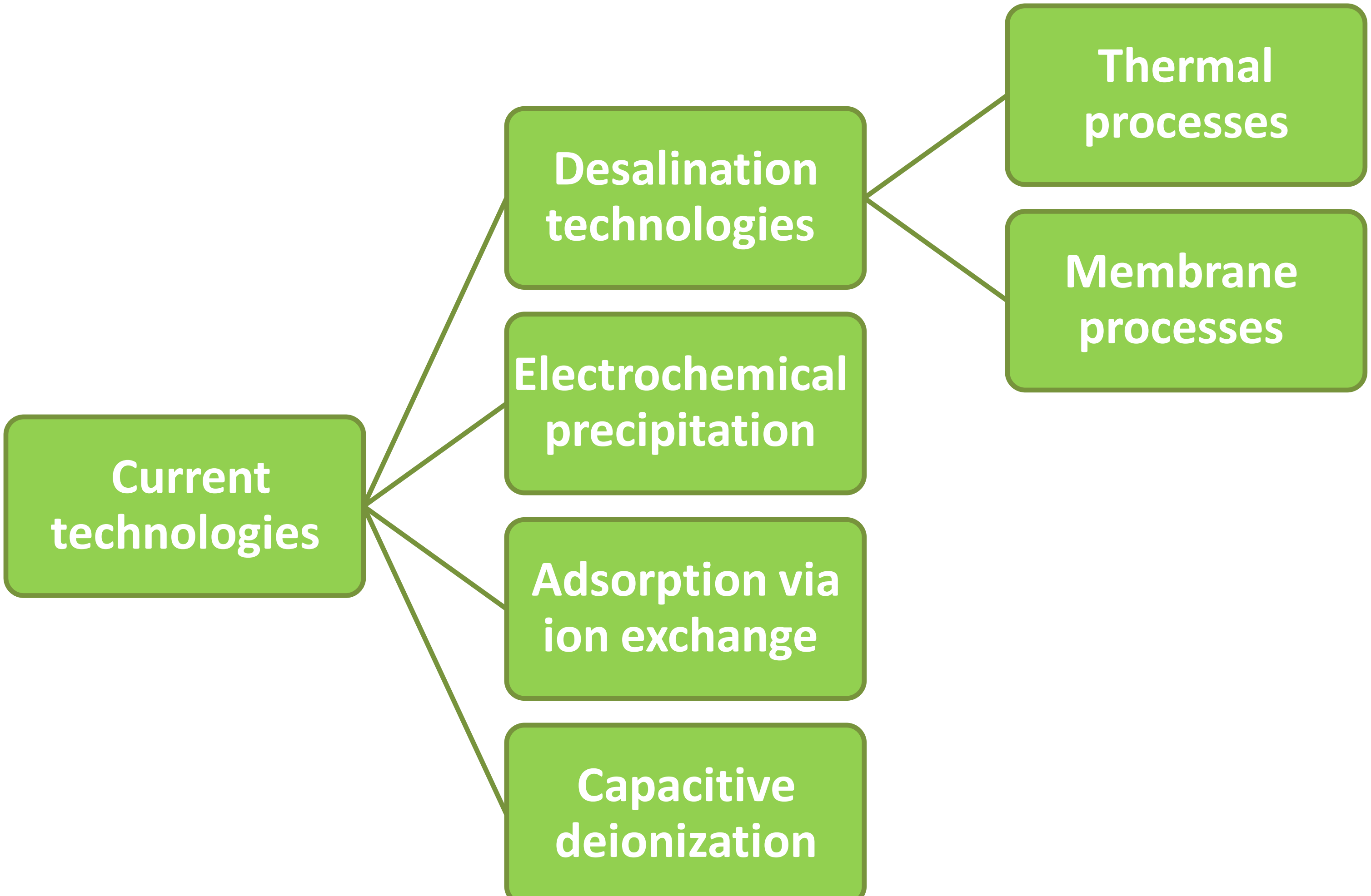
Water Resources and Scarcity

Water balance in million cubic meters per year

Year	Water demand			The available water resources			Deficit
	Agriculture	Drinking	Total	Underground water	Desalination	Total	
1990	1152	73	1225	899	41	940	285
1995	1152	156	1308	949	50	999	309
2000	1250	185	1435	1004	100	1104	331
2020	1250	460	1710	1004	100	1104	606

Qassim Al Jabry **Water resources evaluation and conservation in Oman**, *proceedings of the first Regional conference on water demand management, conservation and control, WHO/UNEP , Jordan 2001.*

Current Technologies of light metals removal



- **The required characteristics for effective technology:**

✓ Relatively simple
✓ Economic viable
✓ Low energy
✓ Environmentally friendly
✓ Sustainable
✓ Reusable

- However, most current technologies lack some of these features

Date palm *(Phoenix dactylifera L.)* Leaflets in Oman

- It is the most important crop grown in Oman with more than 9 million trees.
- About 180,000 tons of dry palm leaflets are produced annually and it is burnt in the farms leading to air pollution.
- GCC states produce 3 million tons per year

Analysis of brackish water

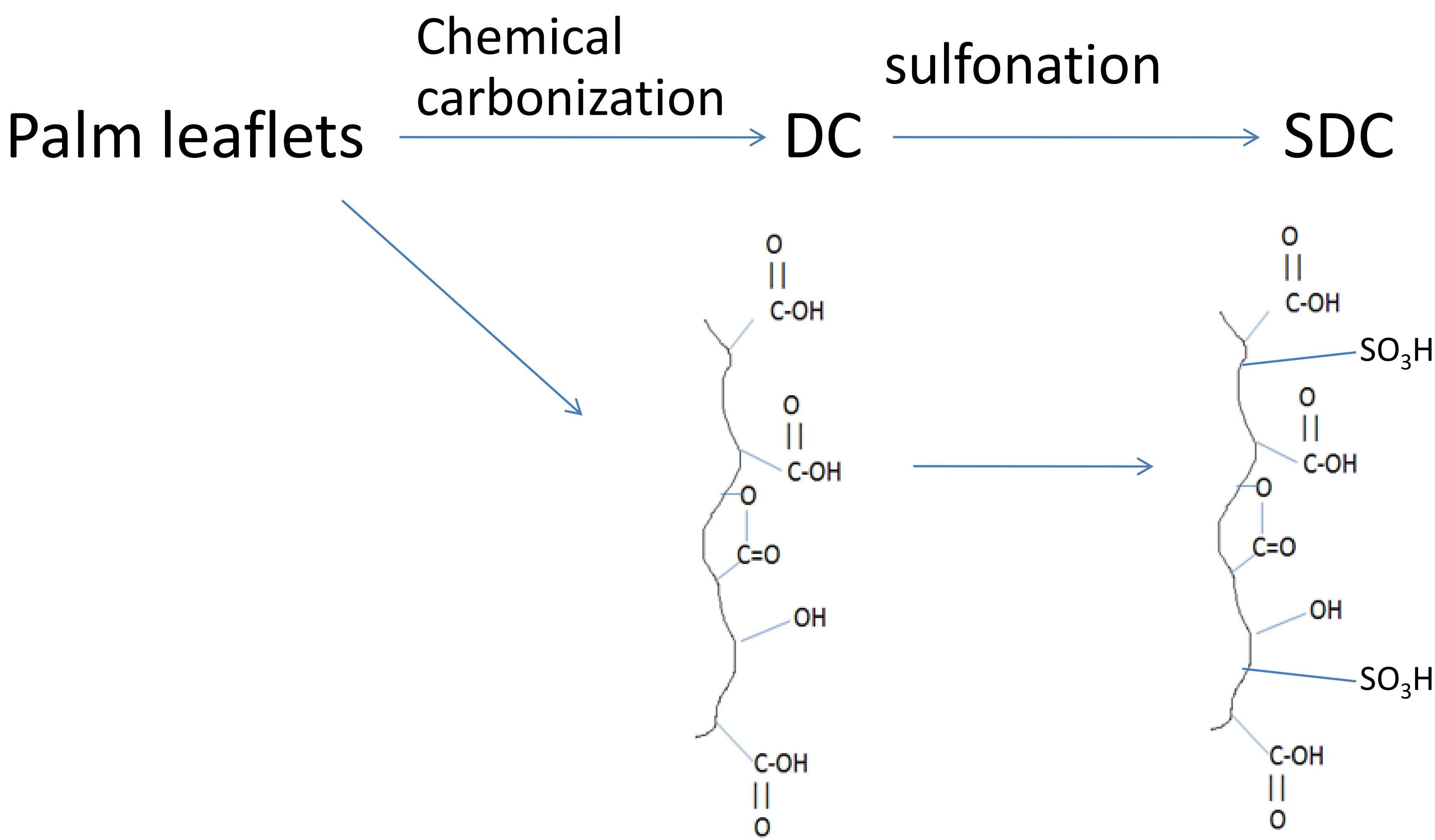
Well Farm	Location
Barka	23.935º N, 58.619º E
Al-Musanaah	23.788º N, 57.515º E
As-Suwaq	23.504º N, 57.250 ºE
AlKhaburah	23.991º N, 57.090ºE
Saham	24.136ºN, 56.884 º E
Sohar	24.278 ºN, 56.7999 ºE
Liwa	24.559º N, 56.565ºE
Shinas	24.806º N, 56.426ºE

Brackish water analysis

Water Source	Conductivity (ms/cm)	TDS (mg L^{-1})	pH	Mg^{2+} (Mg/L)	Ca^{2+} (Mg/L)	Na^{+} (Mg/L)
Barka	11455	7767.5	7.27	1687	966	1302
Al Musanah	1878	1254	7.46	379	88.4	393
Al Suwayq	12007	8183.5	7.78	1626	525	2334
Al Khabura	28739	19506	7.83	1852	1546	7863
Saham	2139	1449.5	7.51	588	27.6	614
Sohar	1195	819	8.29	350	27.6	270
Liwa	22866	15535	7.33	1859	1104	3323
Shinas	1478	1001	8.14	464	27.6	295

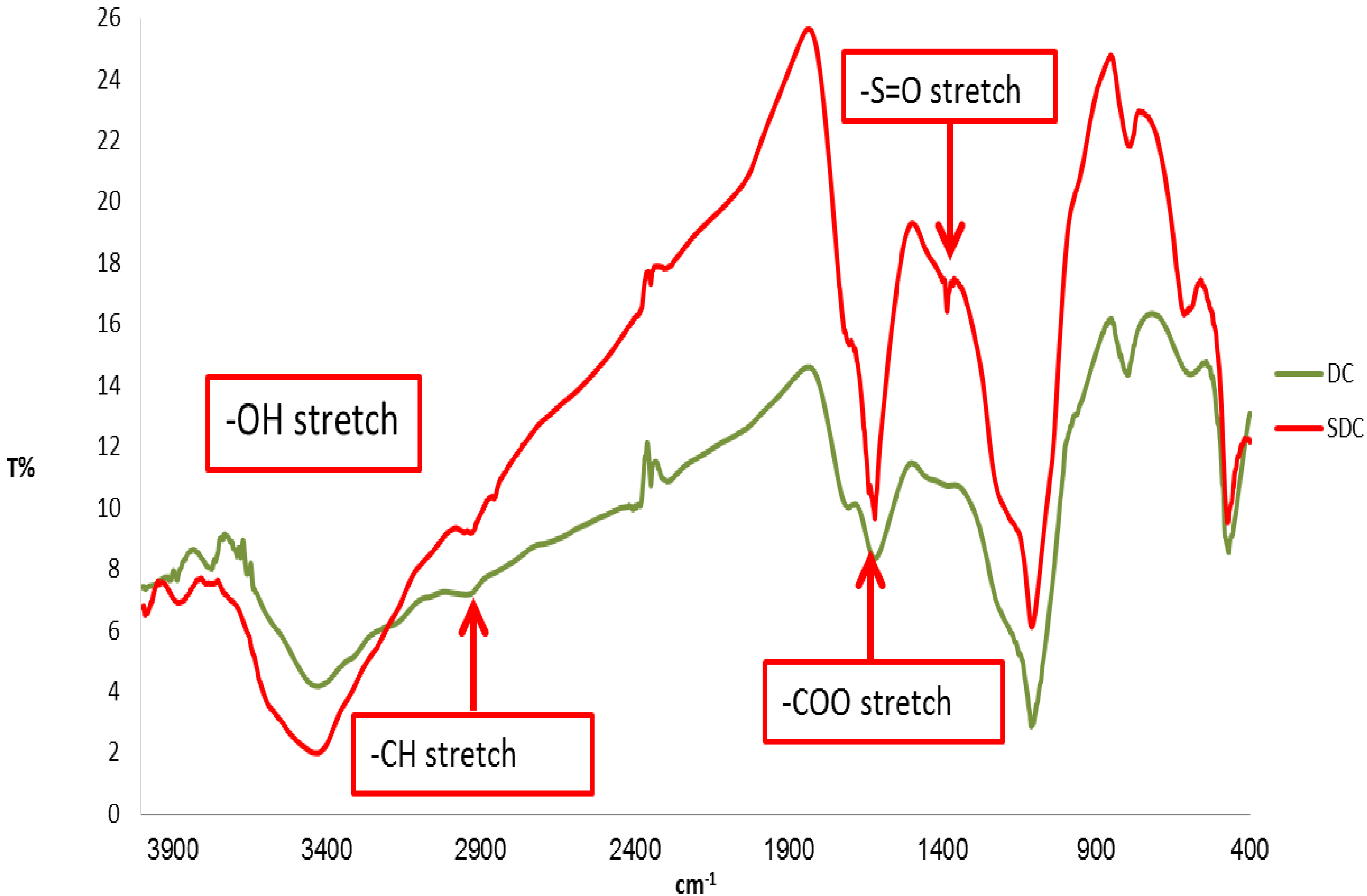
K 0.2 – 27 mg/L, Fe 0-0.47, Zn < 0.35 mg/L, Cr < 0.3 mg/L

Carbon ion exchanger

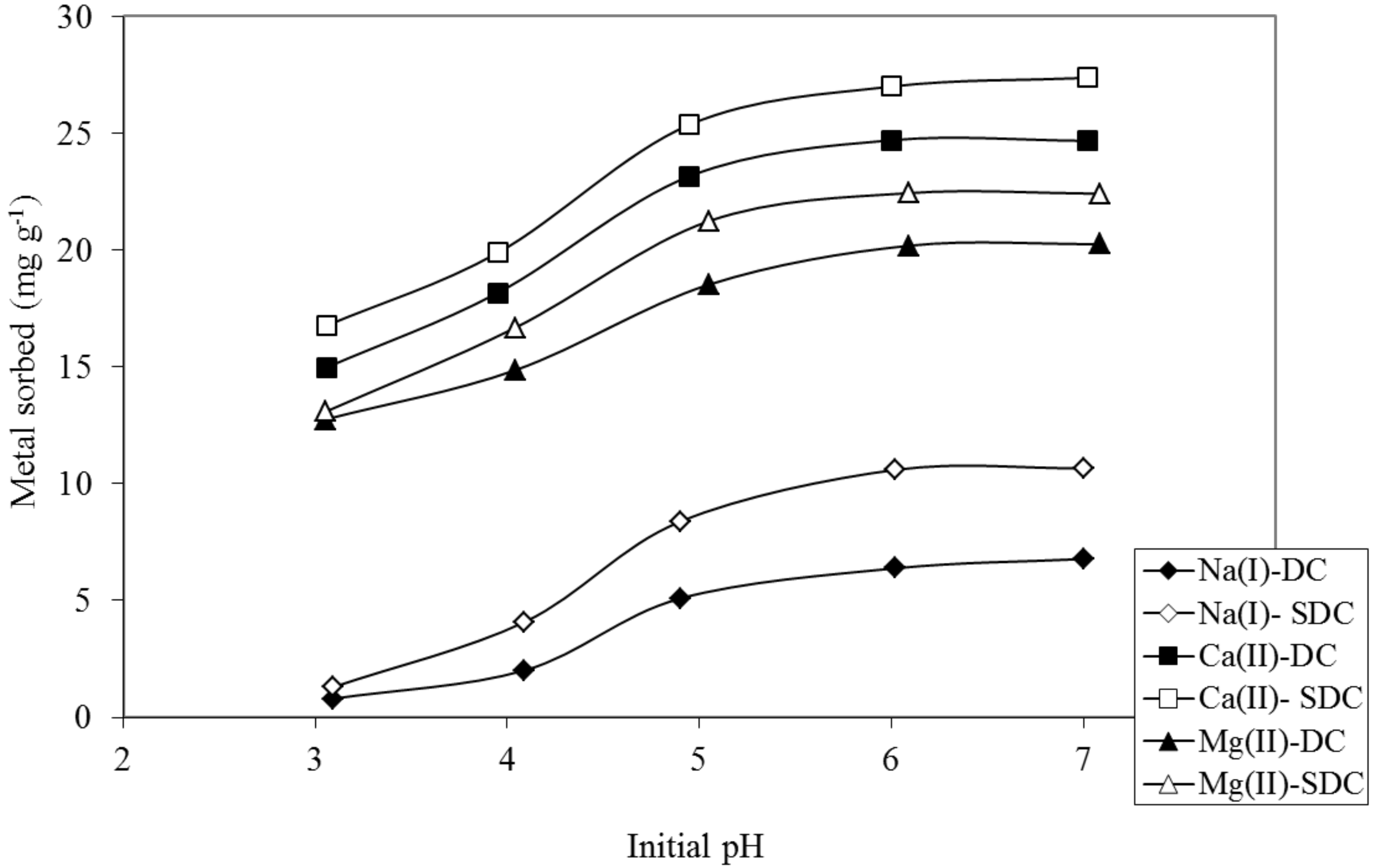


Characterisation of DC and SDC

	Apparent density	Ash content	moisture	EDS Elemental analysis (%)					CEC
				C	O	S	Si	Al	
DC	0.36	17.6%	17%	59.8	34.2	1.32	4.51	0.22	128.6
SDC	0.44	15.1%	18%	**54.7**	**35.9**	**3.91**	**5.16**	**0.3**	**200.2**


26
24
22
20
18
16
14
12
10
8
6
4
2
0
T%
-OH stretch
-CH stretch
-COO stretch
-S=O stretch
DC
SDC
3900
3400
2900
2400
1900
1400
900
400
cm-1

PH effect on metal removal



Ca > Mg >> Na

Sorption favorability

In Charge density:

Mg(II) > Ca(II) > Na(I)

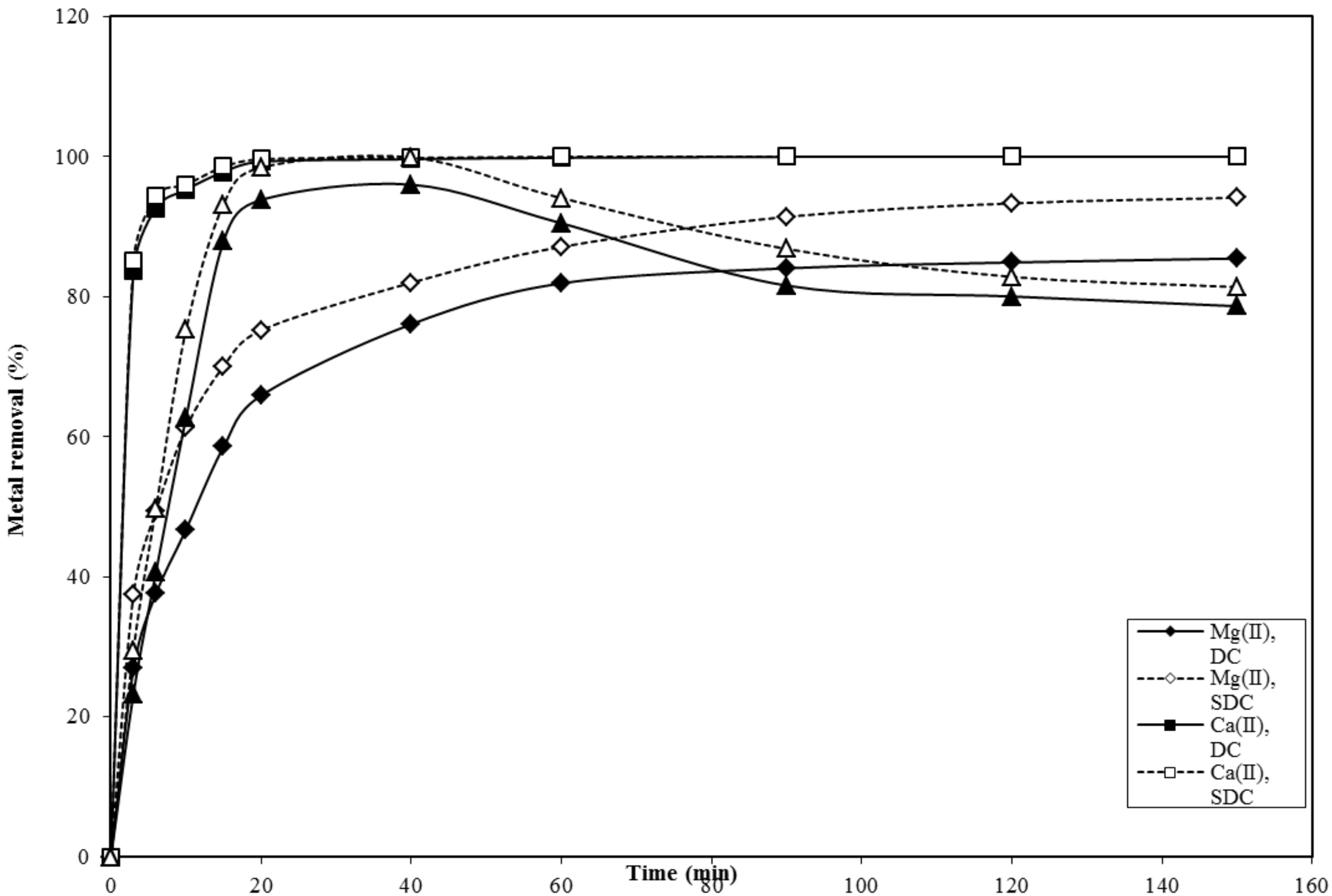
But due to hydration

Mg(II) > Ca(II) > Na(I)

Thus

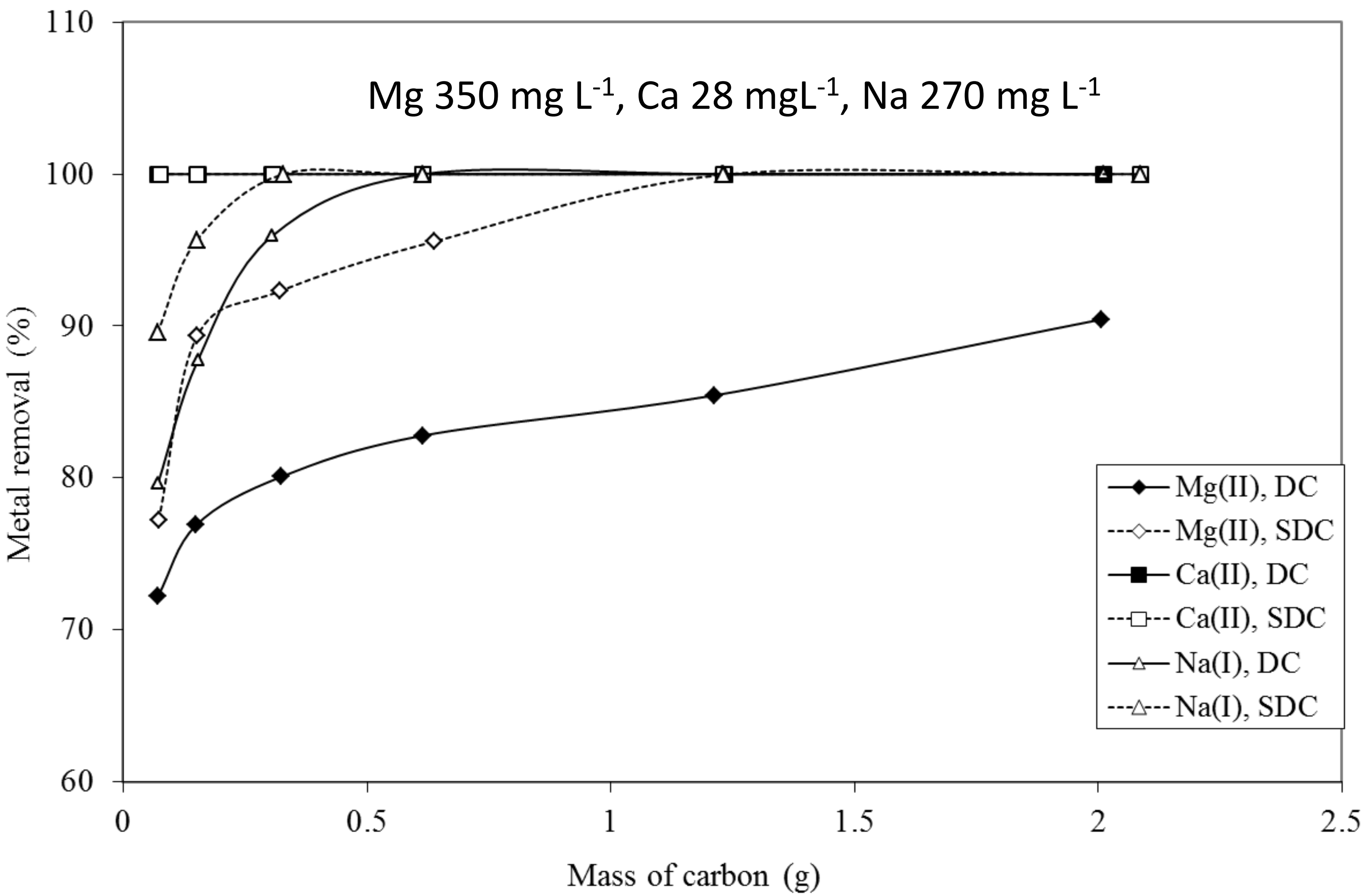
Ca(II) > Mg(II) > Na(I)

Sorption from Sohar farm well

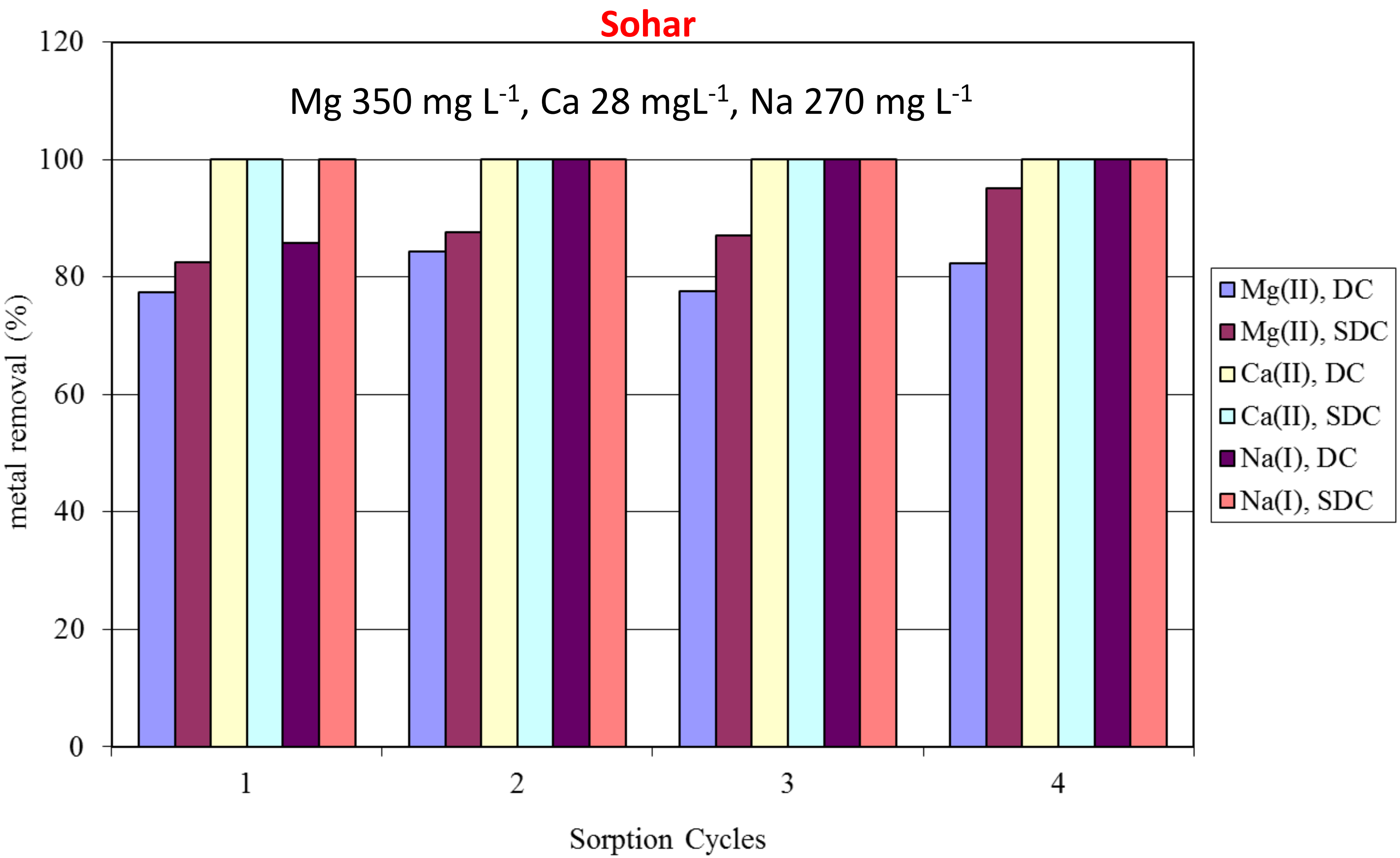


Mg 379 mg L^{-1}, Ca 88.4 mg L^{-1}, Na 393 mg L^{-1})

Sorption from Sohar farm well

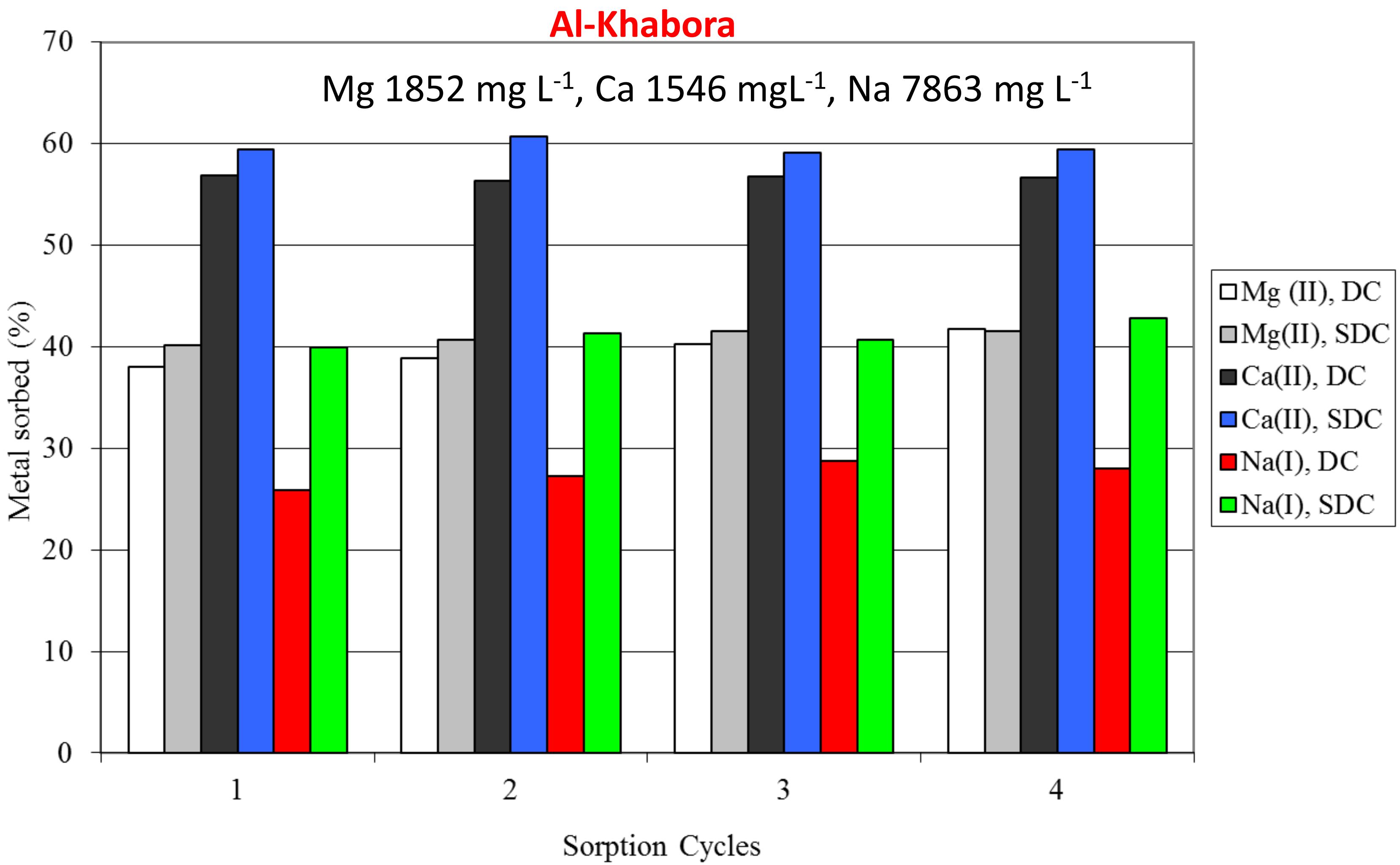


Recycle



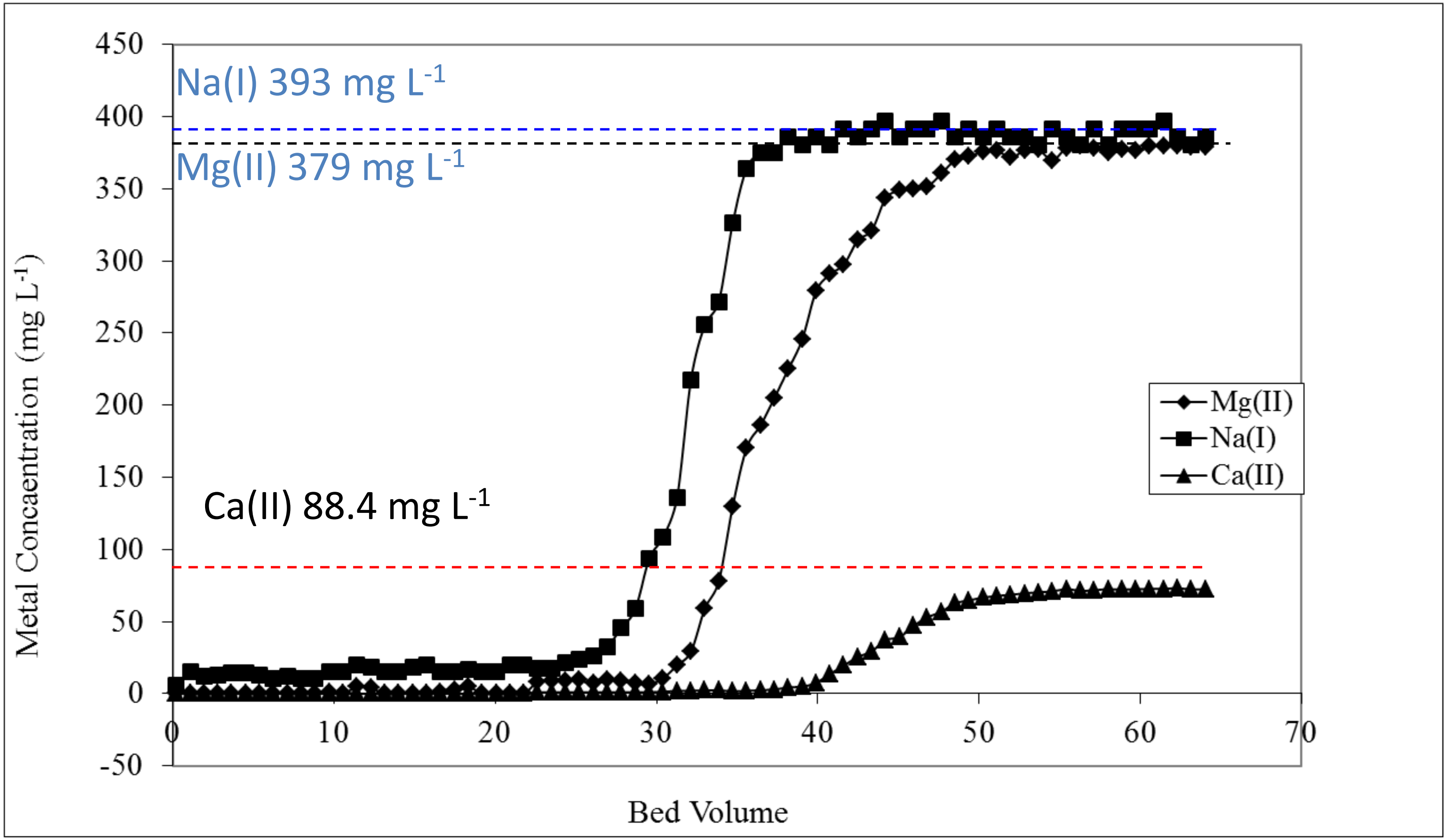
Sohar
Mg 350 mg L-1, Ca 28 mgL-1, Na 270 mg L-1
120
100
80
60
40
20
0
metal removal (%)
1
2
3
4
Sorption Cycles
Mg(II), DC
Mg(II), SDC
Ca(II), DC
Ca(II), SDC
Na(I), DC
Na(I), SDC

Recycle

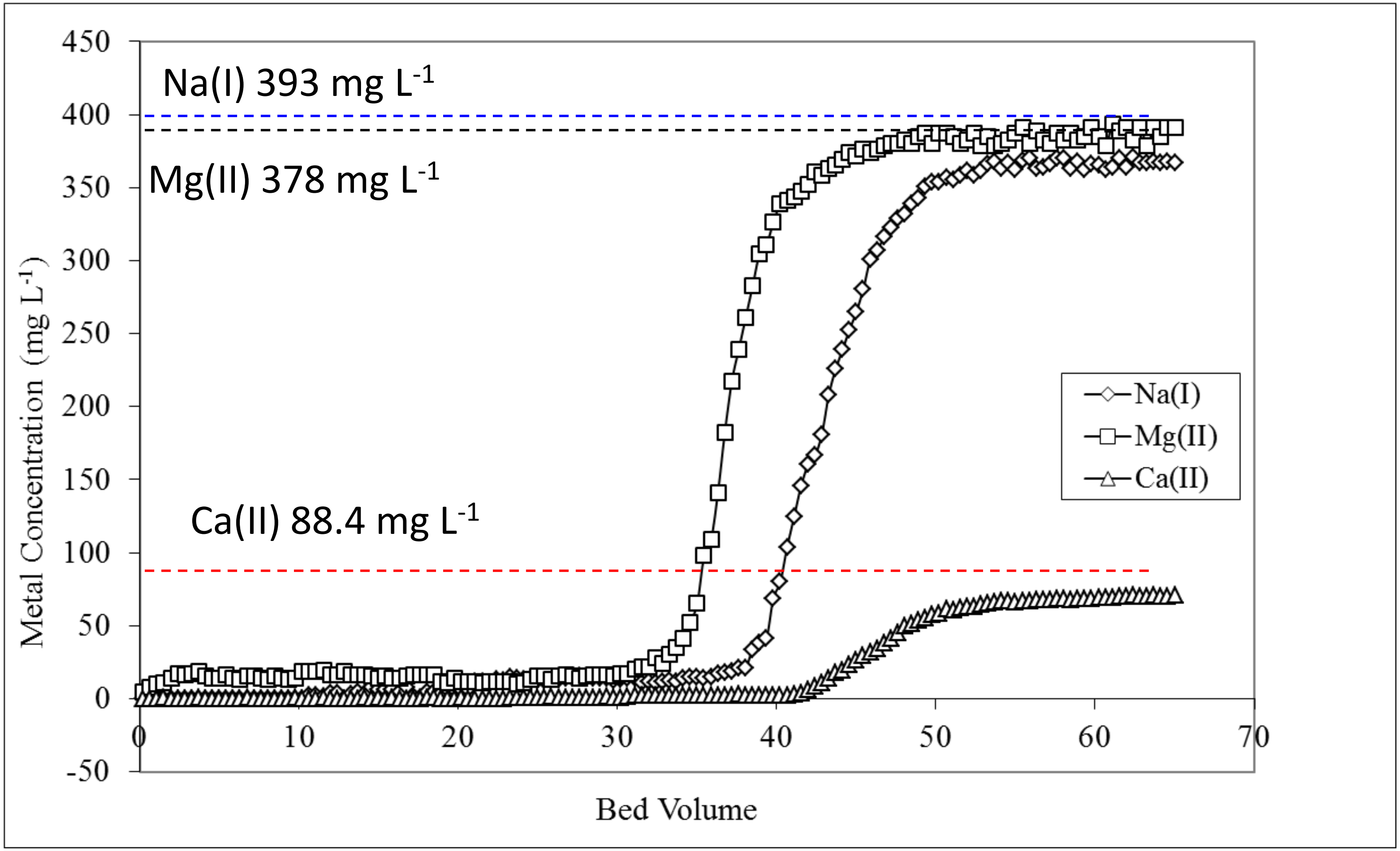


Al-Khabora
Mg 1852 mg L-1, Ca 1546 mgL-1, Na 7863 mg L-1
70
60
50
40
30
20
10
0
Metal sorbed (%)
1
2
3
4
Sorption Cycles
Mg (II), DC
Mg(II), SDC
Ca(II), DC
Ca(II), SDC
Na(I), DC
Na(I), SDC

Cloumn Work: Al Musanah well DC



Cloumn Work: Al Musanah well SDC



Column capacities

- DC: Mg 96 mg/g, Na 69 mg/g, Ca 26 mg/g
- SDC: Mg 100 mg/g, Na 89 mg/g, Ca 35 mg/g

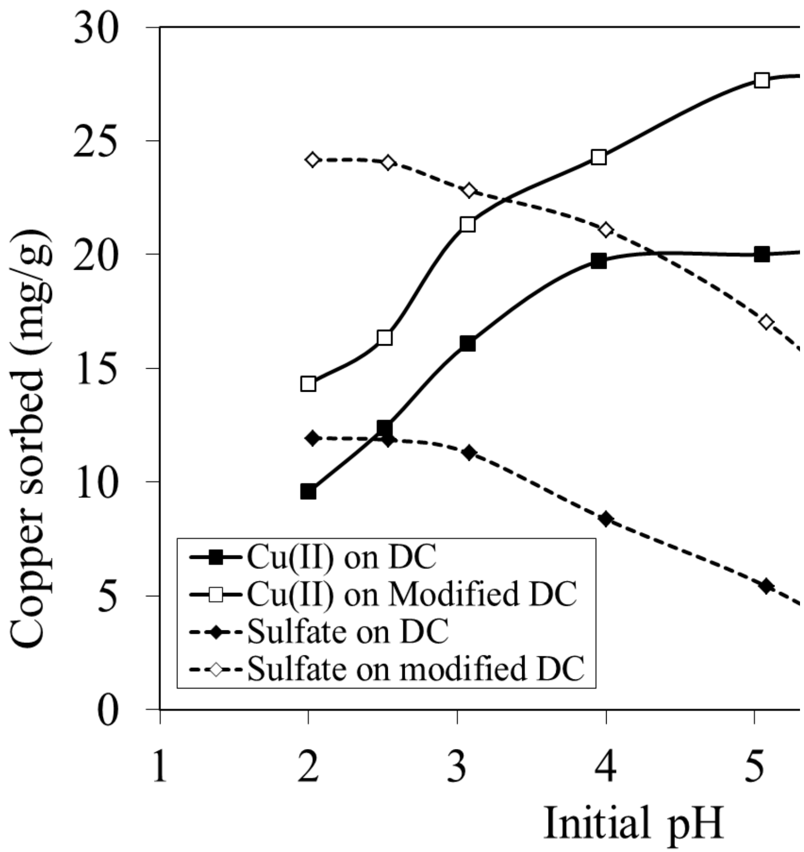
Estimated Cost

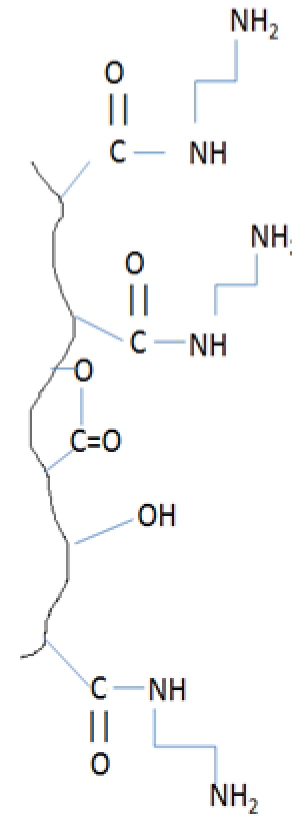
For a reuse of 10 times 0.6 $ / cubic meter

For a reuse of 50 times 0.22 $ /cubic meter

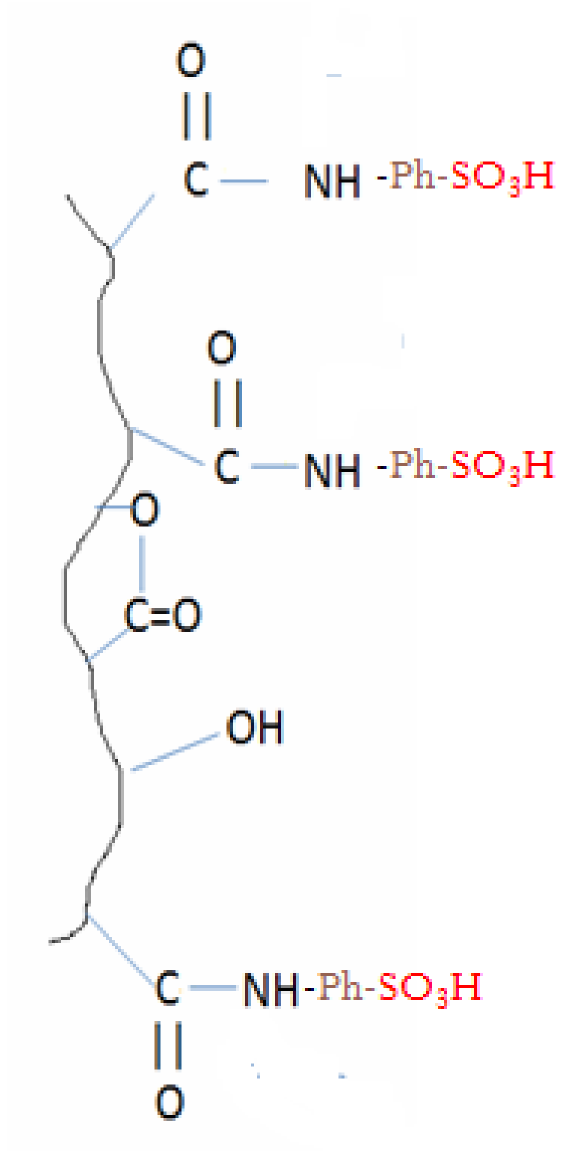
Current & Future work

- Removal of anions

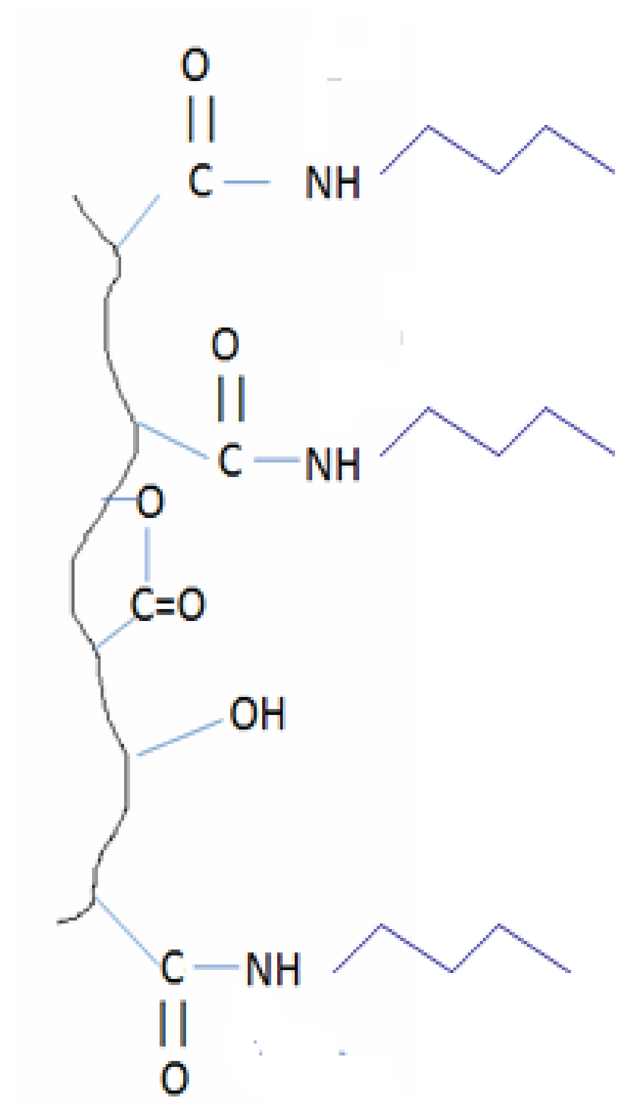




For removal of metals



For removal of organic moieties



Conclusions

1. SDC carbon is more effective than DC in removing Na and other metals.
2. BDC is good for heavy metals and anions
3. Ultimate goal is to prepare a multipurpose filter from cheap sustainable, reusable and effective resource of date palm leaflets

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