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Iron-based water treatment residuals as sorbent of heavy metals and metalloids

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4-8 May 2020
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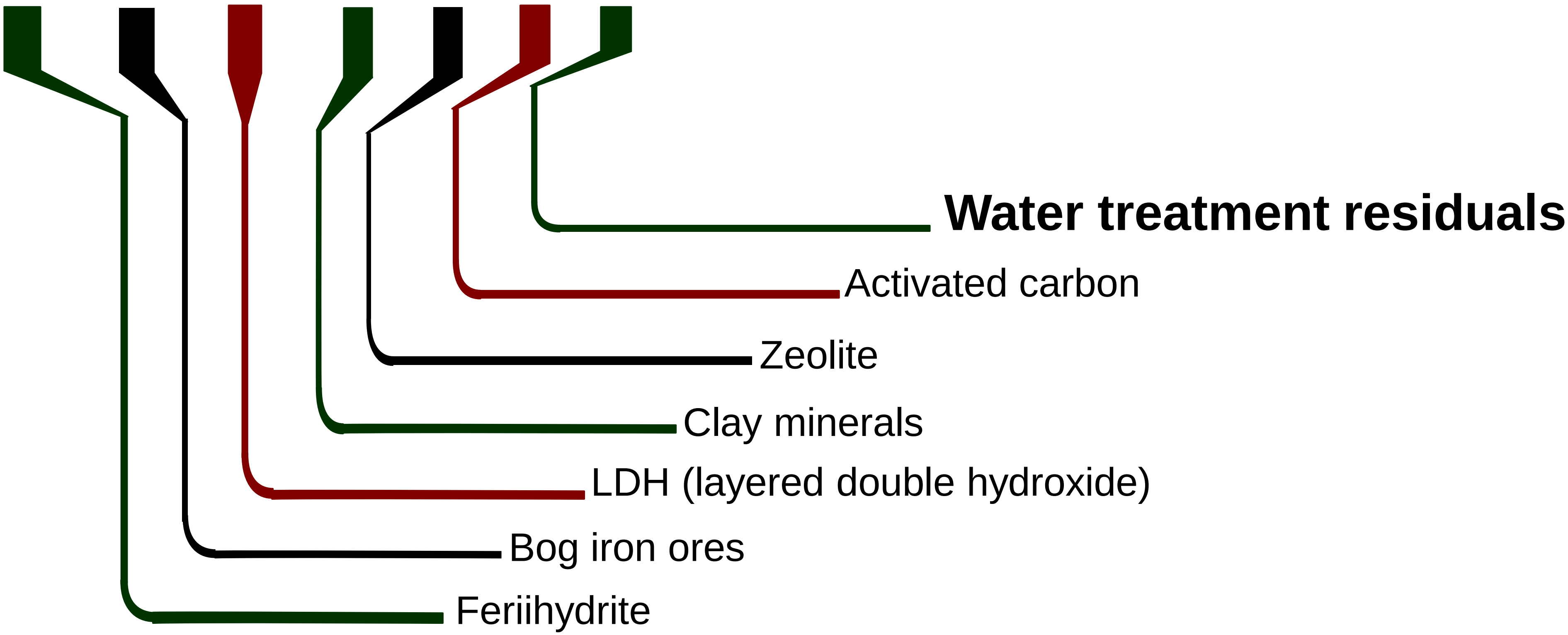
Heavy Metals

Metal having atomic weight greater than sodium (23) and specific gravity (density) > **5 g/cm^3**

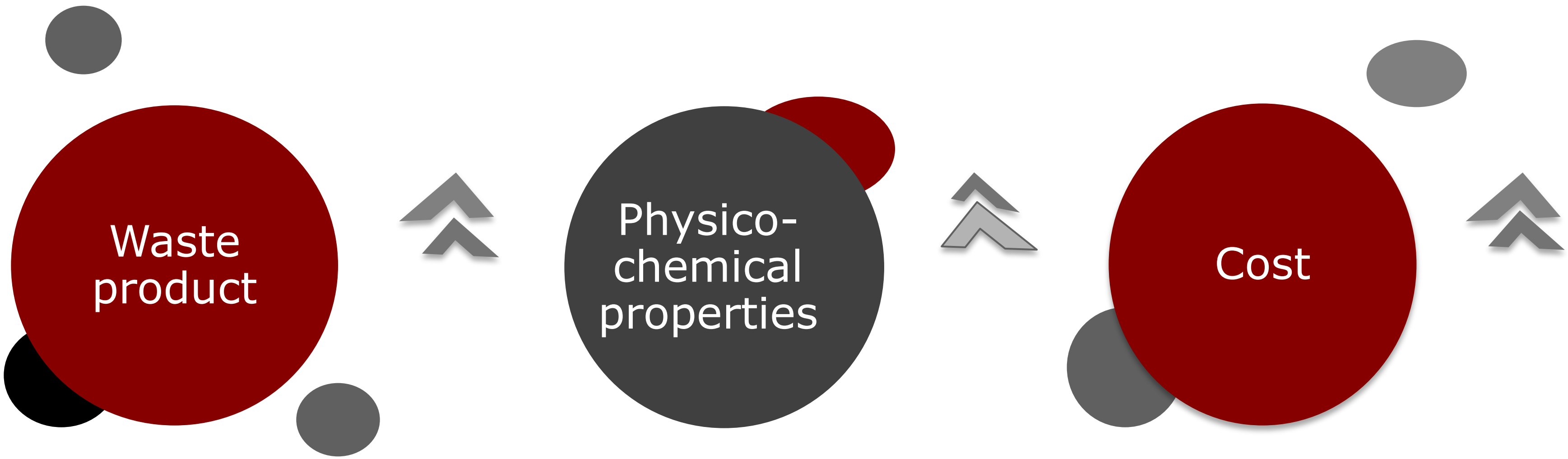
On health effects basis

Essential	Non essential	Less toxic	Highly toxic
Cu, Zn, Co, Cr, Mn, Fe	**Ba, Li, Zr**	**Sn, Al**	**Pb, Hg, Cd**

How to remove heavy metals from water?

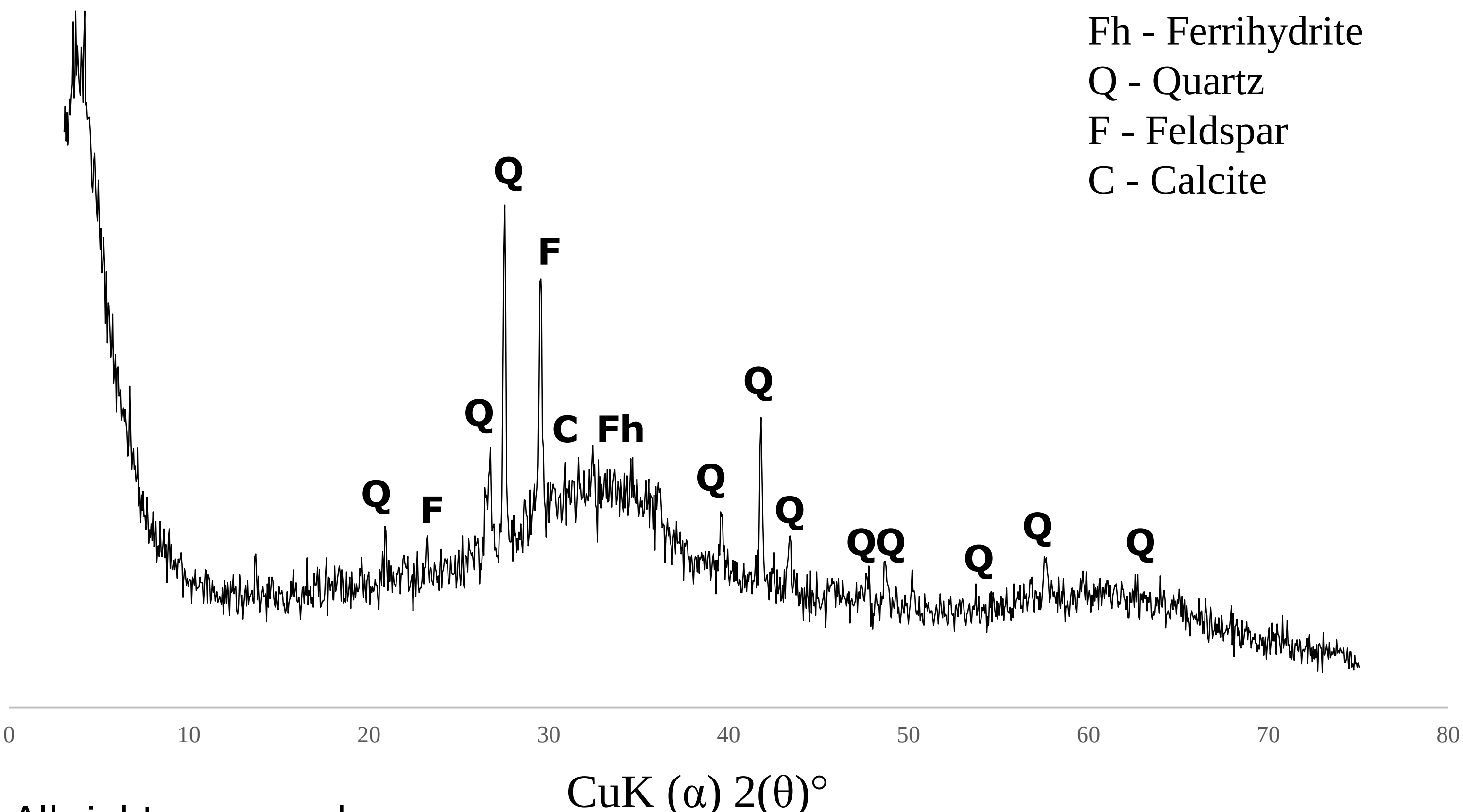


Why water treatment residuals (WTRs)?

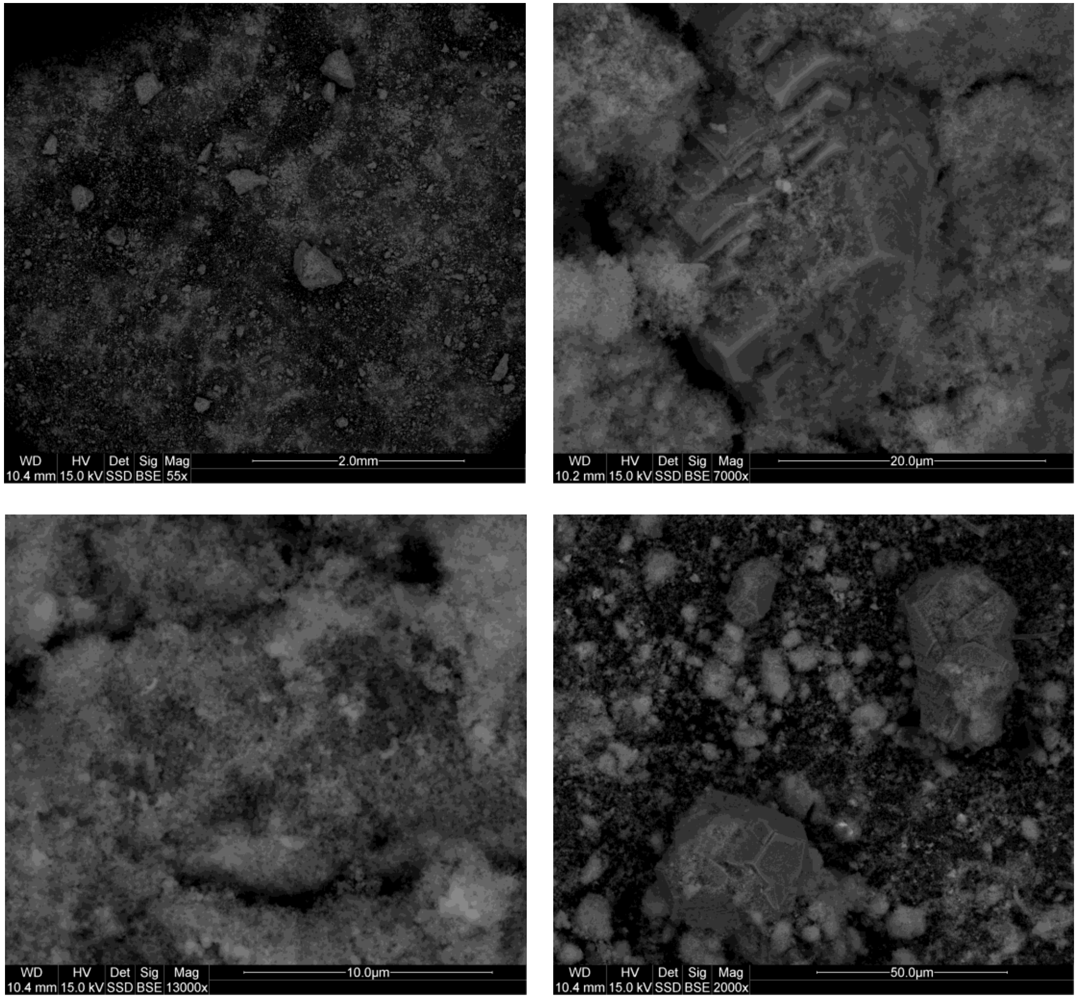


- Environment friendly
- Great sorption properties
- Low cost

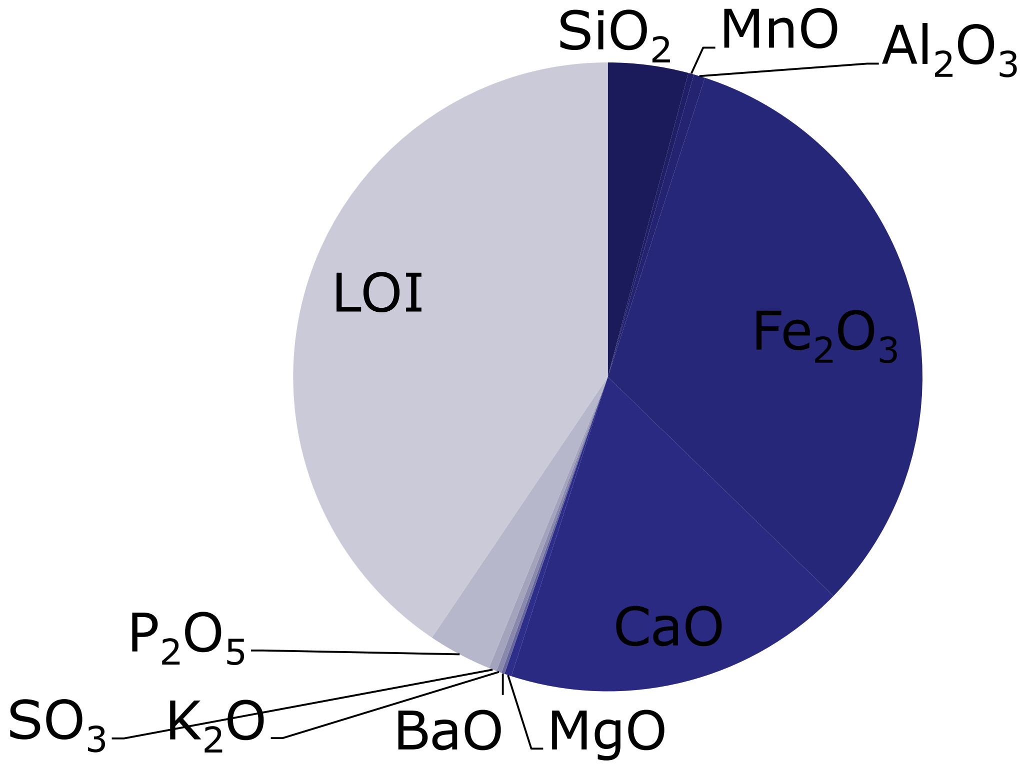
XRD results


Fh - Ferrihydrite
Q - Quartz
F - Feldspar
C - Calcite
Q
F
Q
C
Fh
Q
Q
F
Q
Q
Q
QQ
Q
Q
Q
0
10
20
30
40
50
60
70
80
CuK (α) 2(θ)°

SEM-EDS results



XRF results



XRD results

- The G-WTRs are poorly crystalline material.
- Sample is composed predominately of two-line ferrihydrite with minor quartz and calcite admixture.

SEM-EDS results

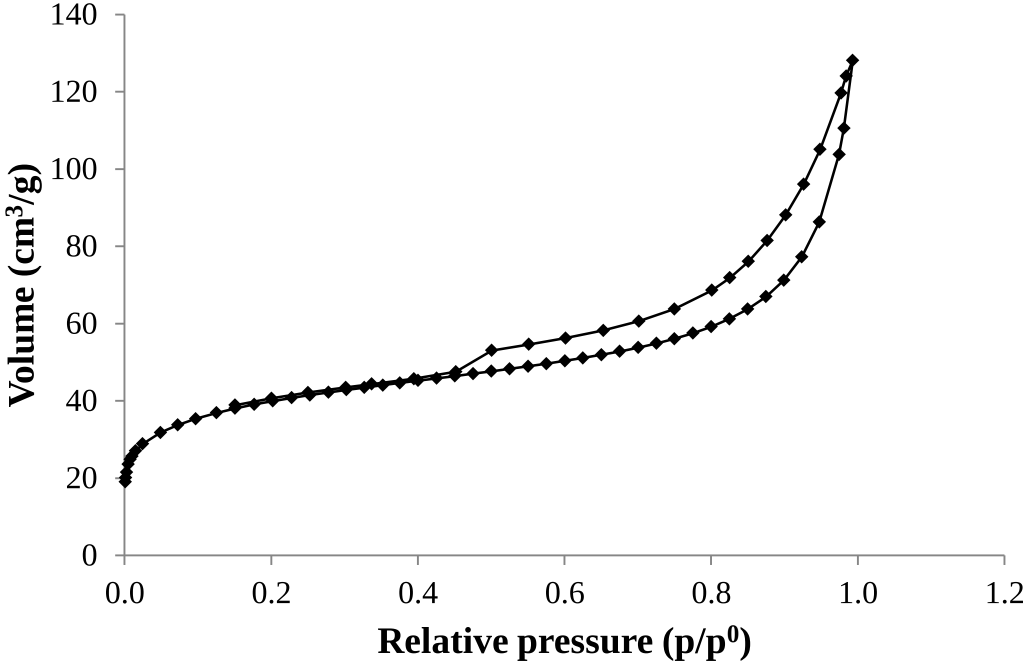
- The samples of G-WTRs reveal a typical microcrystalline-organogenic microstructure, with small carbonate crystals embedded within substantial cryptocrystalline aggregated iron oxyhydroxides.
- The particles have irregular surfaces with edges.

XRF results

- The phase composition of sludge was confirmed by XRF analysis.
- Iron oxides are the predominant chemical components of the G-WTRs – over 32%.
- Silica (4.13%), calcium oxide (17.72%), and phosphorous oxide (3.28%) were also found.

Textural parameters

S_{BET} [m²/g]	203
$V_{tot}^{0.99}$ (cm³/g)	0.202
V_{mic}^{T} (cm³/g)	0.073
V_{mic}^{T}/ $V_{tot}^{0.99}$	0.361
V_{mes} (cm³/g)	0.084
V_{mes}^{BJH}/ $V_{tot}^{0.99}$	0.416
V_{mac} (cm³/g)	0.045
V_{mac}^{BJH}/ $V_{tot}^{0.99}$	0.223



Textural parameters

- The share of each class of pores throughout the whole pore volume was as follows:
  - Share of micropores: 31.1%
  - Share of mesopores: 41.6%
  - Share of macropores: 22.3%

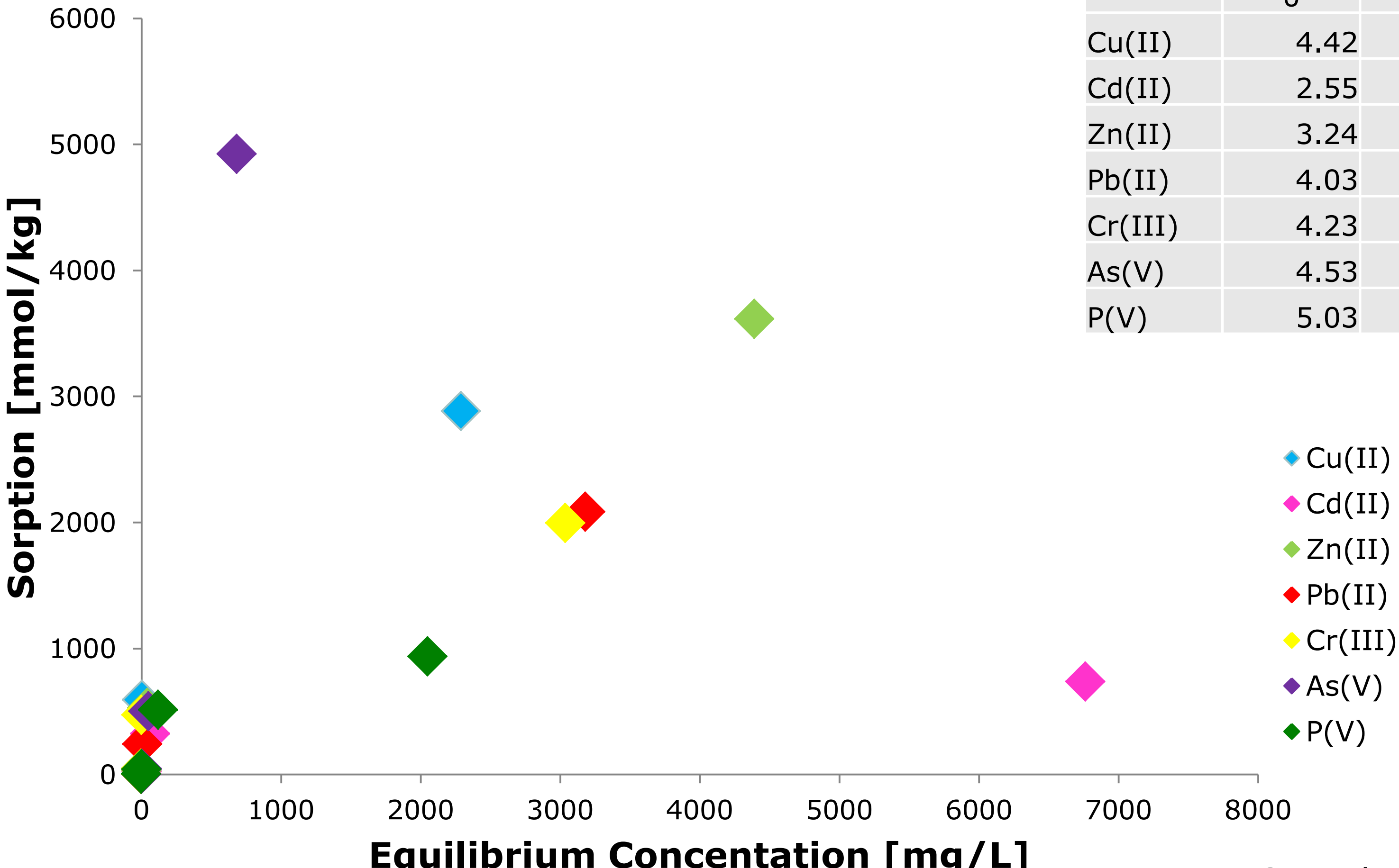
- The predominance of mesopores in the G-WTRs is confirmed by the nitrogen adsorption and desporption isotherm.

- Adsorption isotherm can be classified as type I (the so-called Langmuir isotherm) with H3 or H2/H3 hysteresis. Adsorption increases in the range of medium concentrations which indicated pote distribution.

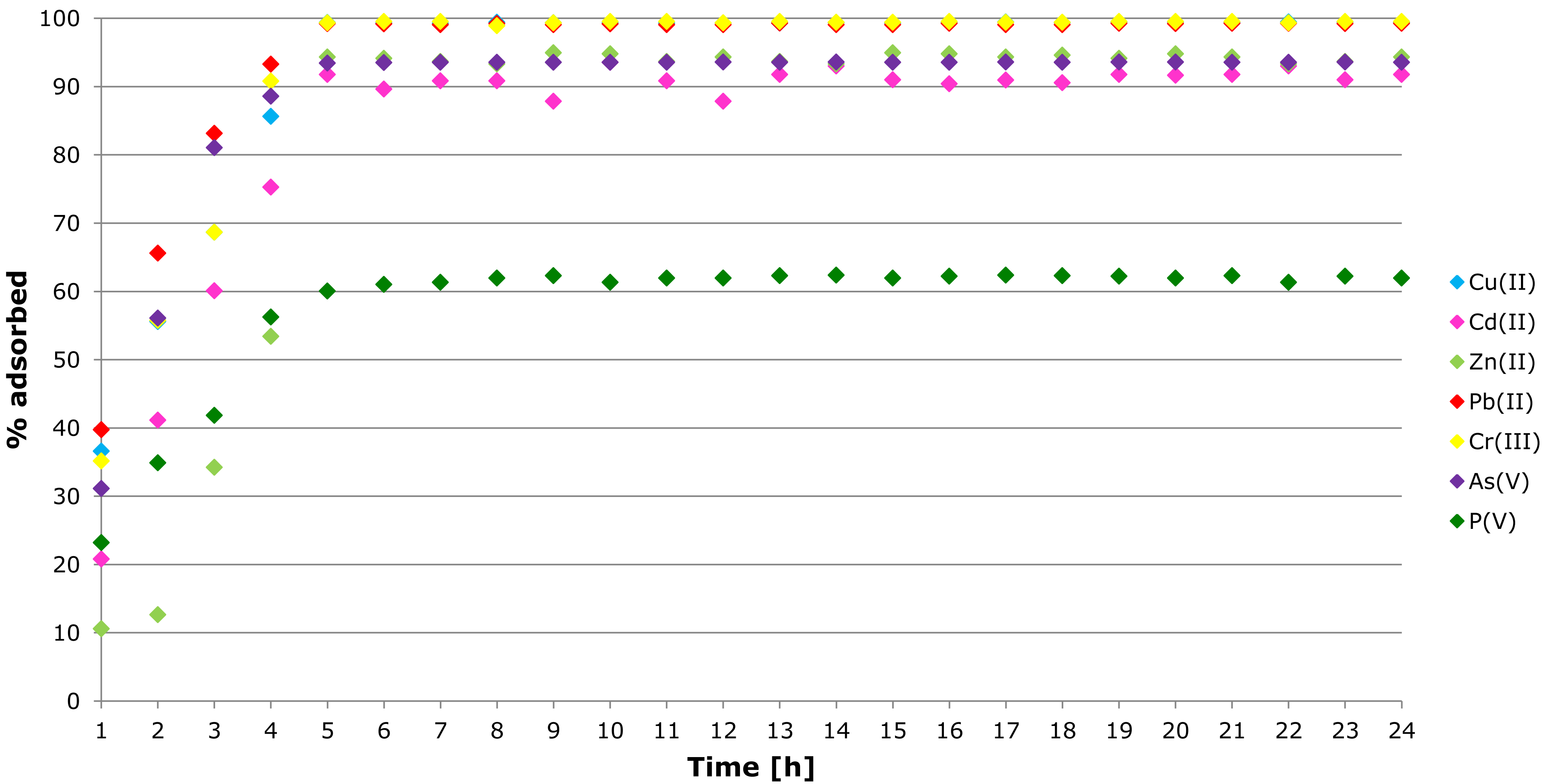
- Specific surface area calculated using BET method is 203 m^2/g.

Initial concentration

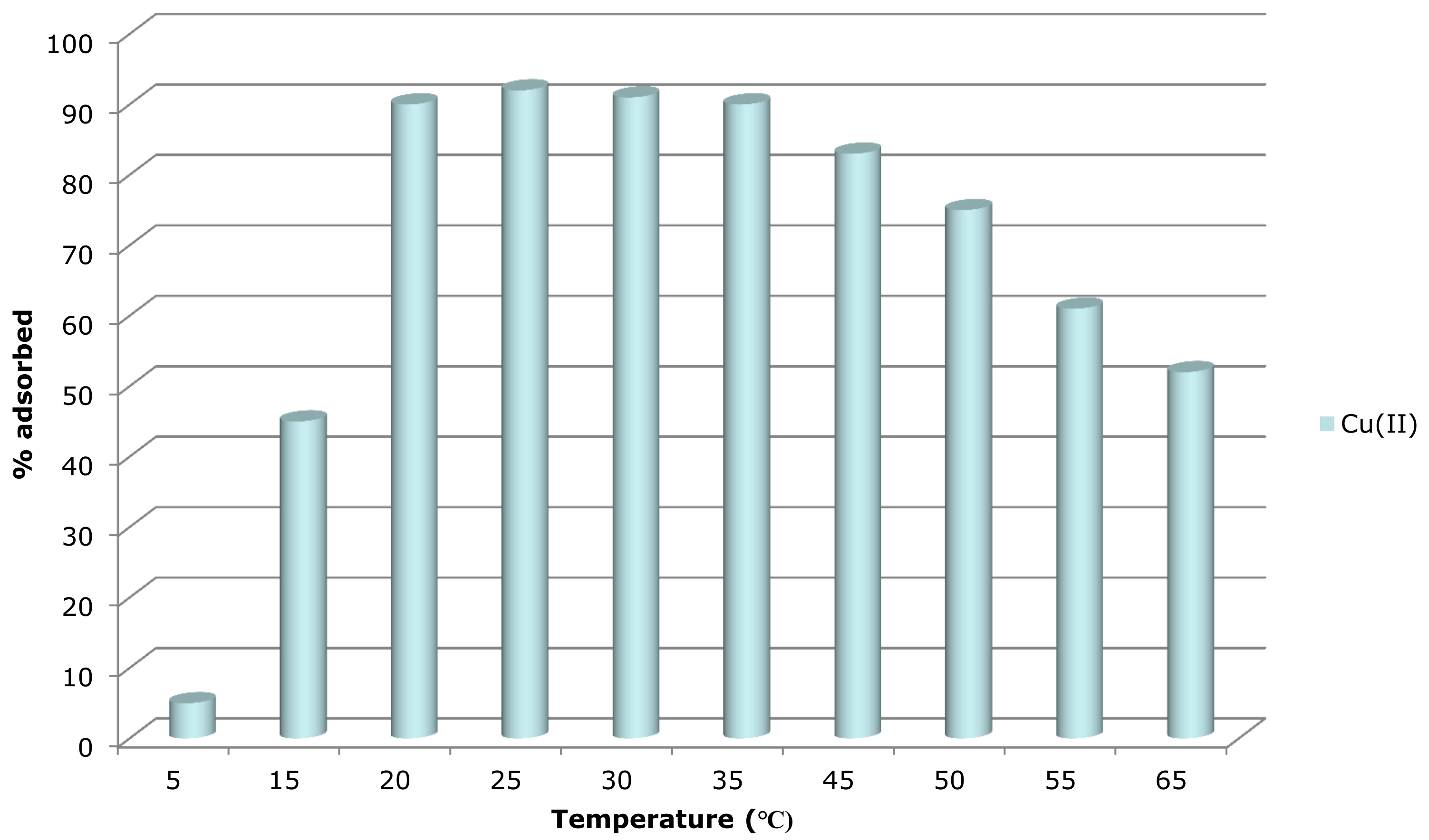
Element	Sorption			
	mmol/kg			
	0	1	10	100
Cu(II)	4.42	49.90	593.99	2883.36
Cd(II)	2.55	25.87	323.07	738.37
Zn(II)	3.24	29.63	529.09	3616.04
Pb(II)	4.03	41.38	243.11	2086.39
Cr(III)	4.23	46.88	472.67	1996.46
As(V)	4.53	45.61	502.26	4923.94
P(V)	5.03	42.04	514.26	937.47



Time



Temperature – Cu(II)



Conclusions

- Cations sorption efficiency was almost 100%, in case of anions – 50-100%.
- Sorption capacity increased with an increase in the initial pollutant concentration.
- Sorption was the most efficient in the temperature range of 20-40 ℃ in all cases.
- The greatest differences in the sorption efficiency were observed within the first 2-4 h.
- The possible mechanism was chemisorption.

Conclusions

- The results showed that G-WTRs can be effective and cheap sorbents of heavy metals and metalloids.

- Furher research including desorption process as well as long-term stability of formed metal-G-WTRs complexes should be provided.

For more detailed information please refer to:

M. Wołowiec, M. Komorowska-Kaufman, A. Pruss, G. Rzepa & T.Bajda (2019) Removal of heavy metals and metalloids using drinking water treatment residuals as adsorbents: A review. Minerals, 9(8): 487.

Wołowiec M., Pruss A. Komorowska-Kaufman M., Lasocka-Gomuła I., Rzepa G. & Bajda T. (2019) The properties of sludge formed as a result of coagulation of backwash water from filters removing iron and manganese from groundwater. SN Applied Sciences, 1:639.

Thank you for your attention!