Chapter 6

Conclusions & Scope of future work

The thesis describes the results of the investigation to synthesize novel adsorbents for removal of fluoride and methylene blue.

- Green and efficient adsorbents from water melon rind biochar have been prepared at different temperatures (400 ^{o}C, 600 ^{o}C and 800^{o}C). The 400 ^{o}C pyrolyzed carbon was used for the adsorption of fluoride. The adsorption was effective at acidic pH requiring further water treatment after defluoridation. However, high quantities of sulphate and chloride did not affect the removal. The maximum adsorption capacity of 4PWMR observed to be 20.44 mg/g and follows temkin isotherm model.

- The 800 ^{o}C pyrolyzed carbon 8PWMR was effectively used for the methylene blue adsorption from aqueous solutions. The adsorption capacity for the same was found to be 238.09 mg/g at neutral pH suggesting that the biochar was more effective for adsorption of dyes than fluoride. The adsorption process follows Langmuir isotherm model for methylene blue removal by 8PWMR.

- A novel lanthanum-based hydrogel was prepared using biological molecule sodium cholate for fluoride removal. The adsorption capacity was observed to be 49.26 mg/g at neutral pH indicating its potential as defluoridating agent from ground water sample. The Langmuir model fitted to the adsorption of fluoride by LaC.

- An Al, Zn, Zr based hydrotalcite like compound was synthesized for the removal of fluoride from aqueous solutions. The maximum adsorption capacity was achieved to be 6.96 mg/g following the Langmuir model isotherm model for the adsorption process.

- Zirconium tungstate (ZrW) could be prepared effectively by autoclave technique and solgel method. ZrW was effectively used as adsorbent for methylene blue removal with a maximum adsorption capacity of 239.85 mg/g. The adsorption data was fitted to fruendlich isotherm model suggesting multilayer adsorption onto heterogenous surface.

- The applicability of the adsorbents under study towards real ground water samples collected from Fatehpura, Vadodara (table 6.2) as well as industrial effluents collected from Gujarat fluorochemical industry, Dahej was demonstrated (table 6.3).

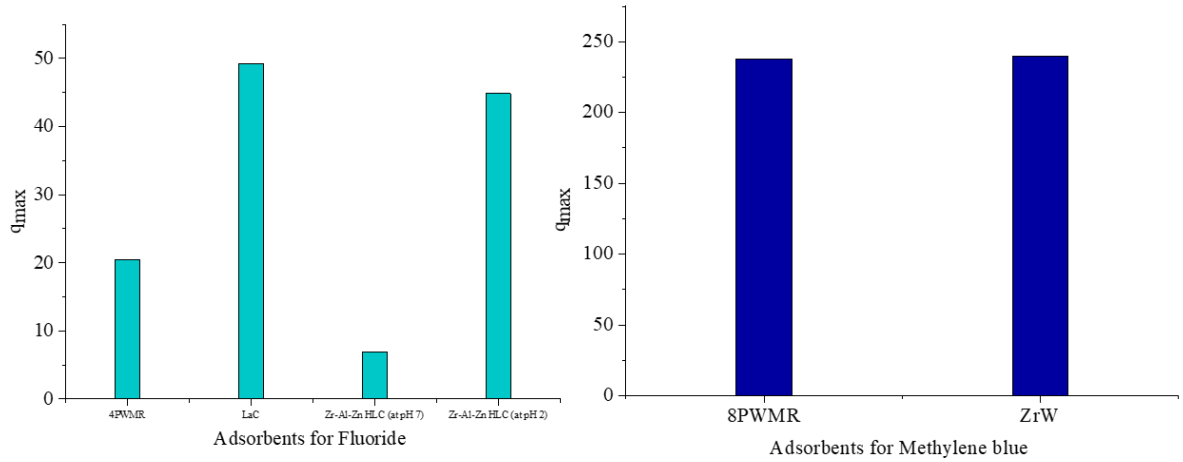
Table 6.1 Characteristics of ground water and Industrial waste water containing fluoride

SI. No.	Parameter	Value	
		Groundwater	Industrial effluent
1	pH	7.9	9.8
2	Conductivity µS/cm	7340	25800
3	TDS mg/L	3670	129000
4	Alkalinity mg/L	60	2600
5	Hardness mg/L	260	-
6	COD mg/L	16	12160
7	Nitrate mg/L	620	-
8	Nitrite mg/L	42.9	-
9	Sulfate mg/L	161	154.0
10	Chloride mg/L	1497	6035
11	Fluoride mg/L	1.49	5570

- Table 6.2 shows that groundwater samples spiked with fluoride at 5, 10 and 15 mg/L could be successfully defluorinated using all 4PWMR, LaC and Zn-Al-Zr HLC.

- At higher quantities precipitation on minerals may also be occurring, the removal of fluoride by 4PWMR may predominantly involve adsorption and electrostatic interactions. Furthermore, an increase in initial fluoride concentration may have given the necessary driving force to overcome resistance to fluoride mass transfer to PWMR and improved the interaction between fluoride and PWMR.

- The results also indicate that LaC could effectively remove fluoride from ground water samples. The quantitative removal of fluoride in the presence of high concentration of ions suggested the possibility of an inner sphere Lanthanum fluoride complex.
- The outcomes also show that Zr-Al-Zn HLC efficacy was better than biochar but lesser than LaC at pH 7. However, Zr-Al-Zn HLC exhibited maximum adsorption capacity of 44.84 mg/g at pH 2 (figure 6.1) (Wu et al., 2018)



F	4PWMR	LaC	Zr-Al-Zn HLC	Zr-Al-Zn HLC
pH	1	7	7	2
Dose	0.2 g	0.1 g	0.1 g	0.25 g
Contact time	3 h	3 h	3 h	3 h

MB	8PWMR	ZrW
pH	7	7
Dose	0.1 g	0.1 g
Contact time	3 h	2 h

Figure 6. 1 Comparison of adsorption capacity of adsorbents

Table 6.2 Application of adsorbents to groundwater sample for removal of fluoride

	F^- conc. after adsorption (mg/L)		
	4PWMR (pH 1.0, dose 0.2 g, contact time 3 h)	LaC (pH 7.0, dose 0.1 g, contact time 3 h)	Zr-Al-Zn HLC (pH 7.0, dose 0.1 g, contact time 3 h)
25mL groundwater	0.43	0.008	0.011
25mL groundwater+5mg/L F	1.26	0.012	0.018
25mL groundwater+10mg/L F	1.41	0.022	0.031
25mL groundwater+15mg/L F	1.56	0.025	0.040

Table 6.3 Application of adsorbents to industrial effluent sample containing fluoride for removal of fluoride

Adsorbent	F^- conc. after adsorption (mg/L)
4PWMR (pH 1.0, dose 0.2 g, contact time 3 h)	2463
LaC (pH 7.0, dose 0.1 g, contact time 3 h)	1240
Zr-Al-Zn HLC (pH 7.0, dose 0.1 g, contact time 3 h)	2485

- The application of 8PWMR and ZrW was extended to synthetic effluent samples. For this evaluation, three dye effluents were prepared by using cationic dyes, surfactant and salts (composition shown in table 6.4). The 8PWMR and ZrW exhibited 57.18 and

50.46 % removal for synthetic effluent using 0.1 g each respectively. Further detailed investigations are warranted to understand and optimise the efficacy of the biochar for textile effluents.

Table 6.4 Chemical composition of synthetic effluent (Thue et al., 2018)

Dyes	λmax	Concentration (mgL^{-1})
Methylene Blue	663 nm	50
Rhodamine 6G	530 nm	10
Malachite green	425 nm	10
Crystal violet	588 nm	10
Methyl red	410 nm	10
Other Compounds		
NaCl		20
Na_2CO_3		20
CH_3COONa		20
Na_3PO_4		20
$NaNO_3$		20
Sodium dodecyl sulphate		10
Na_2SO_4		10
NH_4Cl		10

- Silver nanoparticles as nanofluids were prepared in water using trimesic acid as capping agent for the reduction of nitroaromatic compounds. Furthermore, the catalyst was supported on iron oxide particles to achieve magnetically separable catalyst. The synthesized catalyst was effective in reduction of nitrophenols, nitroanilines and nitroso derrivatives.

Scope of future work

- The scope of biochar can be expanded by investigation of other dyes and metal ions.
- The hydrotalcite may have the potential for adsorption of dyes which needs to be investigated to expand its applicability.

Reference

Thue, P. S., Sophia, A. C., Lima, E. C., Wamba, A. G. N., de Alencar, W. S., dos Reis, G. S., Rodembusch, F. S., & Dias, S. L. P. (2018). Synthesis and characterization of a novel

organic-inorganic hybrid clay adsorbent for the removal of acid red 1 and acid green 25 from aqueous solutions. *Journal of Cleaner Production*, *171*, 30–44. https://doi.org/10.1016/j.jclepro.2017.09.278

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