Appendix A

Sorption concentration Calculations for Pb(II) Sorption

Equation (5.1) is used to determine the sorped concentration at a particular time (q_t) in $mg.g^{-1}$ as follows:

$1mM$ *Initial concentration of* $Pb(II)$
Based on information from table (5.1)
Initial concentration c_0 of $Pb(II)$ in the solution $= 10.77mgL^{-1}$.
$V =$ volume of the sorped liquid phase $= 0.5mL$ diluted with $9.5mL$ distilled water for total of $10mL$ analysed with the ICP-OES.
Initial concentration c_0 of $Pb(II)$ in the solution after dilution $= 215.4mgL^{-1}$.
$m =$dry mass of the biochar sorbent $= 0.8g$

$0.2mM$ *Initial concentration of* $Pb(II)$
Based on information from table (5.1)
Initial concentration c_0 of $Pb(II)$ in the solution $= 5.13mgL^{-1}$.
$V =$ volume of the sorped liquid phase $= 1mL$ diluted with $9mL$ distilled water for total of $10mL$ analysed with the ICP-OES.
Initial concentration c_0 of $Pb(II)$ in the solution after dilution $= 51.3mgL^{-1}$.
$m =$dry mass of the biochar sorbent $= 0.8g$

$0.1mM$ *Initial concentration of* $Pb(II)$

Based on information from table (5.1)

Initial concentration c_0 of $Pb(II)$ in the solution $= 4.97mgL^{-1}$.

c_t = concentration of $Pb(II)$ remaining in solution at any particular time (t)

V = volume of the sorped liquid phase $= 1.5mL$ diluted with $8.5mL$ distilled water for total of $10mL$ analysed with the ICP-OES.

Initial concentration c_0 of $Pb(II)$ in the solution after dilution $= 24.8mgL^{-1}$.

m =dry mass of the biochar sorbent $= 0.8g$

Substituting the values above and values of c_t measured at at every predetermined time step in to equation (5.1), the corresponding sorped concentration (q_t) is obtained.

Appendix B

Determination of Parameters for Pseudo Second Order Kinetic Model

The parameters, K_2 and q_e were obtained using the non-linear pseudo second order equation by optimizing their values with the use of the coefficient of determination procedure outlined in equation (B.1).The values obtained were used to re calculate values to get the predicted values of q_t at different times.

$1mM$ $10.77(mgL^{-1})$	2 (min)	10 (min)	30 (min)	60 (min)	100 (min)	150 (min)	210 (min)	300 (min)	420 (min)	600 (min)	1440 (min)
q_t *model* $(mg.g^{-1})$	0.535	1.966	3.55	4.446	4.94	5.24	5.423	5.57	5.672	5.751	5.863
q_t *measured* $(mg.g^{-1})$	0.1	0.86	3.89	7.74	13.2	14	12.5	15.6	10.3	7.02	5.91
$0.2mM$ $5.13(mgL^{-1})$	2 (min)	10 (min)	30 (min)	60 (min)	100 (min)	150 (min)	210 (min)	300 (min)	420 (min)	600 (min)	1440 (min)
q_t *model* $(mg.g^{-1})$	1.75	5.53	8.63	10.04	10.74	11.13	11.37	11.55	11.67	11.77	11.9
q_t *measured* $(mg.g^{-1})$	7.98	8.89	9.75	11.1	12.1	13.9	14.6	14.3	14.6	13.2	2.99
$0.1mM$ $4.97(mgL^{-1})$	2 (min)	10 (min)	30 (min)	60 (min)	100 (min)	150 (min)	210 (min)	300 (min)	420 (min)	600 (min)	1440 (min)
q_t *model* $(mg.g^{-1})$	0.157	0.74	1.96	3.33	4.61	5.722	6.631	7.53	8.274	8.94	10.03
q_t *measured* $(mg.g^{-1})$	5.49	5.39	5.91	6.66	7.20	7.49	8.52	9.23	9.80	10.4	10.0

TABLE B.1: comparison of measured and second order kinetic model predicted values q_t at different time for different initial $Pb(II)$ concentration

$$
\begin{aligned}
\bar{q}_t measured &= \frac{1}{n}\sum_{i=1}^{n} q_t measured \\
SS_{\text{tot}} &= \sum_i (q_t measured - \bar{q}_t measured)^2, \\
SS_{\text{res}} &= \sum_i (q_t measured - q_t model)^2 \\
& \qquad\qquad r^2 \equiv 1 - \frac{SS_{\text{res}}}{SS_{\text{tot}}}.
\end{aligned}
\tag{B.1}
$$

This procedure was also applied to the Pseudo first order model parameter optimization.

Appendix C

Experiment photographs

In this section, the experimental set-up as well as the equipment used is shown.

FIGURE C.1: $Pb(II)$ and biochar solution agitation – for sorption.

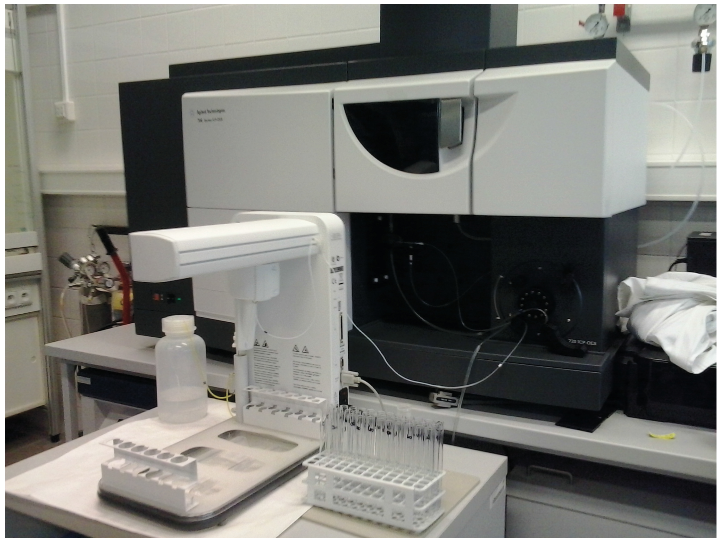

Figure C.2: Loaded standards and samples and ICP-OES instrumentation.