CHAPTER 5 CONCLUSIONS

5.1 General approaches

The sewage sludge is introduced as the source of organic sorbent. The sewage sludge is governed from the wastewater treatment plant of Sitthinan Co. Ltd., Pathumthani, Thailand. This wastewater treatment plants are the conventional activated sludge system. The moisture content of sludge sample was high hence it is heated in the oven at temperature around 105 °C until the solids content is ranged 15-60% of total weight. The dried sludge was sieved using a standard sieve with a round opening hole at a diameter of 2.00 mm in order to remove large particles such as rocks, gravels and mung bean peel. The alkaline stabilisation techniques is used to enhance the Cd sorptive capacity of sludge and to stabilise P and Cd.

5.2 Specific approaches

The ratio between biosolids and alkaline materials is 50:50 (by weight), when the ratio of CaO: Fly ash is controlled at 2:5 (by weight), is able to treat the biosolids. Besides, this ratio is suitable to produce the biosolids class A, which can be served the land application. The pH of Cd(II) solution can bring the effect to adsorption of Cd(II) onto treated biosolids. The Cd precipitation is observed wherever the pH of bioslurry becomes alkaline pH. Even though the Cd(II) solution with pH of 3 is employed the final pH of bioslurry supernatant is still at alkaline condition (pH=9.8). The treated sludge has the Cd sorption capacity of 6.127 mgCd/gOM. The primary sorption is predominantly obtained due to chemical reaction between active sites of OM and Cd. The functional groups of O-H (hydroxyl) and NH_2 stretching (proteins), C=O (carbonyl) and C=N stretching (amide I) are discovered after the alkaline stabilisation. The functional groups of hydroxyl and amide II play an extremely important role in binding of Cd(II). This finding can reveal that the alkaline stabilisation can enhance the biopolymer forming, which can increase the numbers of active sites to adsorp Cd(II) ions. The Langmuir isotherm model can fit well with the adsorption of Cd(II) onto stabilised biosolids. It can simply express that the bonds between biopolymer and Cd(II) ions may be the chemical ponds, which is rigid and irreversible. Hence, the sorped Cd(II) may be effectively trapped onto the treated biosolids.

When MKP fertiliser and organic manure solutions were applied, the equilibrium time for soluble P adsorption on biosoil are 60 and 20 minutes, respectively. Adsorption isotherm equations indicated that the adsorptive surface of biosoil could adsorb phosphorus from MKP fertiliser and organic manure as the result agrees with Freundlich isotherm equation. The value of maximum phosphorus adsorption (K_F) on organic matter in biosoil with MKP fertiliser and organic manure are 67.85 mg-P/g-OM and 4.48 mg-P/g-OM, respectively.

When Cd(II) are adsorbed onto the saturated P biosoil with MKP fertiliser and organic manure are also obeyed the Freundlich isotherm model, the value maximum adsorptive capacity are 82.35 mg Cd/g P and 208.3 mg Cd/g P, respectively. This finding confirms that sorped P can be bound to adsorb Cd. The organic matter is the primary adsorptive site, which can strain P, and the sorped P can further retard ionic Cd via secondary adsorption process.

The FT-IR analysis implies that the main mechanism of Cd and P sorption onto organic matter in biosoil is relied on the chemical bonding and complex forming between Cd, P and OM. The functional groups of O-H (hydroxyl) and N-H stretching (proteins), C-H stretching (alkyl) and C=N stretching (amide II), phenolic –OH and C=O carboxylate stretching could play an extremely important role in binding of Cd. Whenever the biosoil was exhaust with MKP fertiliser, the FT-IR spectrum was oscillated owing to the phosphorous adsorption. The reaction may be in regard with O-H (hydroxyl) and N-H stretching (proteins), C=O (carbonyl) and -CN stretching (amide I), C=N stretching (amide II), phenolic –OH and C=O carboxylate stretching groups bound to phosphorous. Whenever the biosoil is exhausted, the FT-IR spectrum is oscillated owing to the phosphorous adsorption with organic manure. The reaction may be in regard with a O-H (hydroxyl) and N-H stretching (proteins), Aliphatic C-H stretching (fatty acids), C=O (carbonyl) and -CN stretching (amide I), C=N stretching (amide II), phenolic –OH and C=O carboxylate stretching groups.

The FT-IR analysis associated with the sequential extraction techniques showed that Cd species onto biosoil and saturated P biosoil with organic manure presented in are mostly fixed on the OM and residual. On the other hand, the Cd species on saturated P biosoil with MKP-fertiliser are in form of bound to OM, Fe and Mn oxides, exchangeable and

residual. The exchangeable Cd can be stimulated by the reduction of mobilised Cd(II) at acidic pH due to the complex formation with biosoil constituents. To be ensured the complexation between Cd and P on biosoil that occur in the result of residual form can be examined by X- ray diffraction (XRD) technique.

The biosoil saturated with P can Cd can generated the products, it is $Cd_2P_2O_7$. The X-ray diffraction (XRD) spectrums can indicate that Cd^{2+} species are deposited onto active surface of treated biosolids. This silicate mineral can be formed at high temperature and this can strengthen the structure of biosolids. Besides, the silicate mineral can resist the acidic pH solution of Cd(II). Therefore, the mass of alkaline treated biosolids is slightly lost even though the Cd(II) influent at pH of 3 is employed. The phosphate can retard the Cd^{2+} species by forming the complex compounds of $Cd_2P_2O_7$ which is stable form. The Cd(II) can also perform the secondary adsorption with these Cd bound phosphate compounds.

5.3 Recommendation for further works

The study could provide the basic data on the mechanism between Cd(II), P and the biosoil. The biosoil can be in highly effective to store Cd(II) in acidic solution (pH=3). The research could be further improved in some issues including of:

1. To define the interactions of biosoil with the multi species of heavy metals,
2. To evaluate the alternative way to recovery metals from biosoils,
3. To setup the procedure to regenerate the exhausted biosoil,
4. To improve the properties of sludge by using physical or chemical pretreatment processes, and
5. To examine the interaction between biosoil and other phosphate compounds such as K_2HPO_4, $Ca(H_2PO_4)_2$ and $(NH_4)_2HPO_4$.