CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of this research was to determine the most effective accumulation and transformation of arsenic in four selected aquatic plants.

Phytoremediation of arsenic contaminated submerged soil by aquatic plants was investigated to select appropriate plants using for removing arsenic contaminated soil, especially submerged soil in wastewater reservoirs. Among investigated plants, *Colocasia esculenta* (L.), *Canna* sp., *Typha angustifolia* (L.), and *Cyperus papyrus* (L.) which was the most effective arsenic remover. The result showed that *T. angustifolia* was the highest arsenic concentration followed by *C. papyrus*, *Canna* sp., and *C. esculenta.* All plants accumulated arsenic content in As(V) incorporated soil more than As(III). Each plant accumulated arsenic in difference organs. The highest accumulation organ of *Canna* sp. and *T. angustifolia* and were rhizome; however *C. esculenta* and *C. papyrus* was accumulated the maximum at root. The accumulation amount of arsenic increased gradually higher by time and mostly absorbed As(V) contaminated soil more than As(III) soil.

Naturally, the oxidization reaction of As(III) to As(V) was always found, but the reduction reaction of As(V) to As(III) was not occurred in the submerged soil. The oxidation reaction increased from 33% to 91% at 15 and 60 days, respectively. However, transformation of both As(III) to As(V) and As(V) to As(III) were found in the tested plants, except the transformation of As(V) to As(III) in *Canna* sp. The percentage of As(V) transformation efficiency of all plants was at the maximum in 15 days, and then decreased to the minimum at 60 days. Among the tested plants, *C. papyrus* was at the highest As(V) transformation efficiency followed by *T. angustifolia*, *Canna* sp., and *C. esculenta*. Leaf of *C. papyrus* was the highest organ of transformation efficiency, followed by corm, rhizome, and root.

5.1.1 To study on the amount and efficiency of total arsenic accumulation in various organs of *Canna* sp., *Colocasia esculenta* (L.) Schott., *Cyperus papyrus* (L.), and *Typha angustifolia* (L.)

As(III) was more toxic than As(V) form. The order of decreasing dry weight was *Canna* sp., *C. esculenta*, *C. papyrus*, and *T. angustifolia*. Total arsenic concentration of *Canna* sp., *C. esculenta*, and *C. papyrus* in As(V) treatment were higher than As(III) treatment, but except only *T. angustifolia*. The order of total arsenic concentration in organs of *Canna* sp was rhizome > root > pseudostem > leaf. In organs of *C. esculenta*, the order of total arsenic concentration was root > corm > leaf > petiole. For *C. papyrus*' organs was root > leaf > rhizome > culm, and the organs of *T. angustifolia*: rhizome > root > leaf. The orders of total arsenic concentration were *T. angustifolia, C. papyrus*, *Canna* sp., and *C. esculenta.*

5.1.2 To compare the total arsenic removal efficiency from soil by the four species viz; *C. esculenta*, *Canna* sp., *C. papyrus*, and *T. angustifolia.*

Arsenic accumulation efficiency could be assessed from bioconcentration factor. A hyper-accumulation plant had a bioconcentration factor more than 1. Plants with the bioconcentration factor more than 1 were *Canna* sp. at 45 and 60 days; *C. esculenta* at 30 days, and *T. angustifolia* at 30 to 60 days. Total arsenic removal efficiency was the greatest at 60 days. The order of total arsenic removal efficiency in plants was *C. papyrus, T. angustifolia*, *Canna* sp., and *C. esculenta.*

5.1.3 To study the possibility of As(III) and As(V) transformation in four aquatic plants.

Total arsenic in control soil stayed nearly at 175 $mg.kg^{-1}$, but total arsenic of treatment soil decreased continuously when harvest times increased.

As(III) concentration in soil didn't analyse in As(V) treatment. There was no reduction reaction in soil. In control soil, As(III) concentration decreased continuously to the lowest at 60 days, and declined lower than treatment soil.

As(V) concentration in soil could be found in As(III) and As(V) treatment. There was oxidation reaction in soil. As(V) concentration in As(V) treatment of control soil stayed nearly at 175 $mg.kg^{-1}$. As (V) concentration in As(III) treatment of control soil increased gradually to the highest at 60 days. As(V) concentration in As(V) treatment of treatment soil decreased continuously from beginning to the end, and declined lower than control soil. As(V) concentration in As(III) treatment of treated soil increased gradually from 15 to 60 days; moreover stayed above control soil.

As(III) transformation efficiency (%) was As(V) transformation to As(III) form. The order of As(III) transformation efficiency (%) was *C. esculenta*, *C. papyrus*, and *T. angustifolia*, but *Canna* sp. didn't transform As(V) to As(III). The order of As(III) transformation efficiency (%) of *C. esculenta* in difference organs was petiole > leaf > corm > root. The order of As(III) transformation efficiency (%) of *C. papyrus* was root > culm > rhizome > leaf. For *T. angustifolia*, the order was rhizome > leaf > root.

As(V) transformation efficiency (%) was As(III) form transformation to As(V) form. The order of As(V) transformation efficiency (%) was *C. papyrus*, *T. angustifolia, Canna* sp., and *C. esculenta*. The order of As(III) transformation efficiency (%) of *C. papyrus* in difference organs was leaf > culm > rhizome > root. The order of As(III) transformation efficiency (%) of *T. angustifolia* was rhizome > leaf > root. For *Canna* sp., the order was root > rhizome > leaf > pseudostem; in addition *C. esculenta*, the order was corm > leaf > root > petiole.

5.1.4 Relationship between total arsenic (in plants and soil and soil factors

Total arsenic in soil of *Canna* sp. showed no significantly different; As(III) and As(V) in soil, and redox potential (Eh); but negative correlation; day, and exchangeable Ca. Accumulation of *Canna* sp. expressed a significantly positive correlation; total arsenic in plant. Total arsenic in soil of *C. esculenta* showed a significantly positive correlation; As(III) and As(V) in soil. Accumulation of *C. esculenta* expressed a significantly positive correlation; total arsenic in plant and day. Total arsenic in soil of *C. papyrus* and *T. angustifolia* displayed a significantly positive correlation; As(III) and As(V) in soil and exchangeable Fe. Accumulation of *C. papyrus* expressed a significantly positive correlation; As(V) in plant; but negative

correlation; As(III) in plant. In addition accumulation of *T. angustifolia* showed a significantly positive correlation; total arsenic in plant and As(V) in soil, but significantly negative correlation; total arsenic in soil.

5.2 Recommendation

From this finding, *C. papyrus* was the most appropriate plant to use for removing arsenic contaminated in submerged soil both in the form of As(III) and As(V). It had grown well in water-logged area and tolerant to this metalloid. Moreover from this research it showed that *C. papyrus*, *T. angustifolia*, and *Canna* sp. were alternative suitable plant for transformation of more toxic form of arsenic (As(V)) to less toxic form (As(III)), so that this two plants should be used for the phytoremediation of arsenic contaminated wastewater mash.

The phytoremediation phenomenon is only removed contaminated heavy metal from the soil to accumulate in plant tissue but it does not absolutely solve the environmental problem. More work waiting for how to destroy or extract arsenic from accumulated plant.