Journal of Agricultural Technology 2015 Vol. 11(8): 2369-2375
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Assessment of Heavy Metals in Fish and Water in Cage Fish Culture at Loei River, Loei Province

Netnapa Pongpetch[1], NitiAmchuen[2]**

[1]Environmetal Science Program, Faculty of Science and Technology, LoeiRajabhat University 42000, Thailand
[2]Geographic Information Science Program, School of Information and Communication Technology, University of Phayao 56000, Thailand

NetnapaPongpetchand NitiAmchuen (2015) Assessment of Heavy Metals in Fish and Water in Cage Fish Culture at Loei River, Loei Province. Journal of Agricultural Technology. 11(8): 2369-2375.

The concentrations of heavy metals including Arsenic, Zinc, Lead, Cadmium, Iron, Cromium and Copper (As, Zn, Pb, Cd, Fe, Cr and Cu) in fish andwater in cage fish culture atLoei River (Ban Kam Nerd Pet, Ban ThaManao and Ban That) were investigated. Fish and water samples were collected twenty-four sites and three stations (upper and lower of cage fish culture), respectively. Heavy metal concentrations were analyzed by using ICP-OES. The results showed that mean concentrations of heavy metal in fish were higher than water. Theaverage concentrations in fish were seen as Zn > Fe > As > Cu > Cr >Pb> Cd at Ban Kam Nerd Pet. Meanwhile the mean concentrations of Ban ThaManao and Ban That were found to be Fe > Zn > Cu > As > Cr >Pb> Cd whichAs and Cr at Ban That were exceeded the standard of FDA and IAEA-407, respectively. Furthermore, As and Pb of all sites were exceeded National Standard in China and IAEA-407, respectively. On the other hand, average concentrations in water were recorded to be Fe > Zn > Cu >Pb> Cr > Cd = As which were lower than the National surface Water Quality Standard and WHO.However, the heavy metal load is the need for regular monitoring in aquatic organisms, sediment and water because of the long term effects.

Keywords: aquaculture, aquatic organism, cage fish, contamination, heavy metals

Introduction

Cage fish aquaculture is a crucial factor for food supply because of the increasing human population. However, water contamination is affected by this activity such as nutrients and heavy metals. Heavy metals occur in aquatic systems from natural sources and anthropogenic activities. Heavy metals, unlike organic pollutants, cannot be chemically degraded or biodegraded by microorganisms. Thus, their content has steadily increased in water and subsequently accumulated in sediments, plants, fishes, and even in humans (Che *et al*., 2006). Heavy metals affects aquatic organisms and poses

* **Corresponding Author:** Netnapa Pongpetch, **E-mail:** Netnapa_sut@hotmail.co.th

considerable environmental risks and concerns (Amisah *et al*., 2009). Water pollution by heavy metals, such as copper (Cu) and lead(Pb), increases the health risk of humans who consume the fish (Salami *et al*., 2008). Humans are intensive and very extensive due to their toxicity and their ability to accumulate in the aquatic organisms (Edem *et al*., 2008).

Loei River is a one of branch of Mekong River. The river is 231 km long and originated from PhuLuang Wildlife Sanctuarycovering about four districts including PhuLuang, Wangsaphung. MuangLoei and Chiang Khandistricts, Loei Province. The dominant land use is agriculture land (1,060,017 rai) (Regional Environmental Office 9, 2007). Although, Regional Environmental Office 9 (2014) has studied water quality of Loei River for a long time.Water quality degradation has been observed in 2010-2013. The sensitive parameters were biochemical oxygen demand (BOD) and ammonia (NH_3). In addition, they are focus on biological and chemical investigations but heavy metal was ignored, especially around cage fish culture.

In this paper, Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) was used to analyze heavy metal contamination in fish and water in cage fish aquaculture on Ban Kam Nerd Pet, Ban ThaManao and Ban That. Most of the cage fish aquaculture production comes from these areas. The results of these studies could be a useful tool to identify health hazards for consumer and planning for environment-friendly aquaculture.

Materials and methods

Study area: Loei River is a one of branch of Mekong River. The river has a total area of 3,998 km^2coveringPhuLuang, Wangsaphung. MuangLoei and Chiang Khandistricts, Loei province.There are three seasons including rainy, winter and summer seasons (Regional Environmental Office 9, 2007). The study area of this research was cage fish culture areas in Ban Kam Nerd Pet in MuangLoei district, Ban ThaManaoin MuangLoei district and Ban That in Chiang Khan districts (Figure 1). Land use is dominated by agricultural land(Regional Environmental Office 9, 2007). However, there were an iron factory between Ban ThaManao and Ban That along river.

Samples collection: Fish and water samples were collected from three stations. Fish samples were taken twenty-four samples along cage fish culture. Fish samples were wrapped in aluminium foil and stored on ice until transfer to a laboratory. Meanwhile, water samples were collected upper and lower of cage fish culture areas at 3 m distance. Samples were immediately stored at 4°C and transported to the laboratory for analyses.

Heavy metal analysis: Arsenic (As), Zinc (Zn), Lead (Pb), Cadmiun (Cd), Iron (Fe), Cromium (Cr) and Copper (Cu) in fish and water samples were analyzed by using ICP-OES spectrometer.

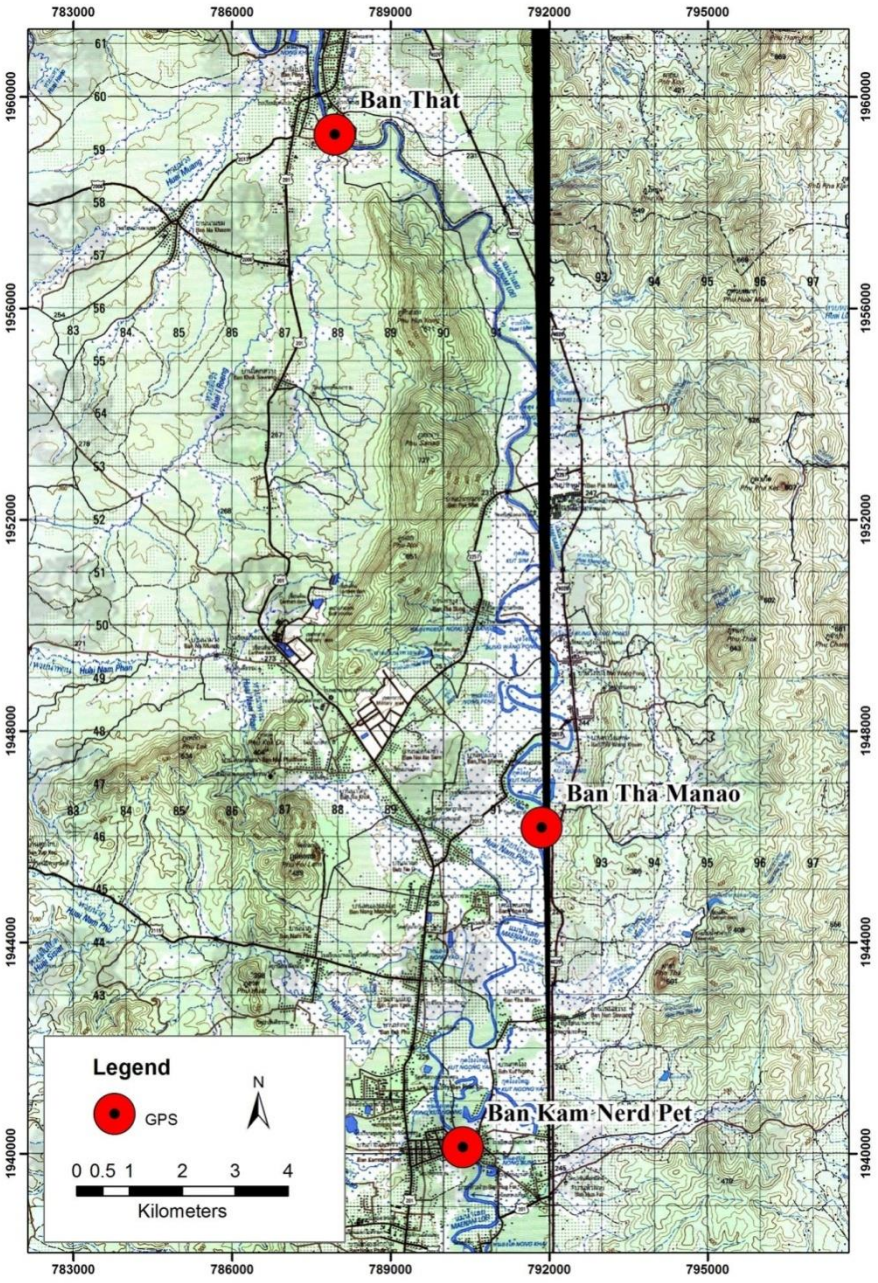

Figure 1. Loei River and Sampling stations

Results and discussion

Heavy metals in fish

The concentrations of heavy metals in fish were shown in Table 1. The highest concentration was found in Ban That where was downstream. The average concentrations were seen as Zn >Fe > As > Cu > Cr > Pb > Cd at Ban Kam Nerd Pet. Meanwhile the mean concentrations of Ban ThaManao and Ban That were found to be Fe > Zn > Cu > As > Cr > Pb > Cd which were similarly by Tokhun and Twai (2012) who studied heavy metal in river cage aquaculture at Namphong River. At Loei River, The metal levels in fish were compared to Food and Drug Administration (FDA) (Ministry of Public Health, 1986), IAEA-407 (Wyse *et al*., 2003) and National Standard in China (National Food Institute, 2003), showed that As and Cr at Ban That were exceeded the standard of FDA and IAEA-407, respectively. Furthermore, As and Pb of all sites were exceeded National Standard in China and IAEA-407, respectively. El-Sayed *et al*. (2011) revealed that heavy metal concentrations associated with drainage sources. The concentrations of heavy metal in industrial drainage and sewage wastewater were higher than agriculture drainage.

Other studies showed that heavy metal concentrations were in the order Pb> Cd > Crat Madivala Lakes of Bangalore, Karnataka (Begum *et al*., 2009). This result was similarly by Jezierska and Witeska (2006). Meanwhile, LoengPuay Marsh at KhonKaen Province, the concentrations of Pb were exceeded the Thai food contaminated standard of Public Health Ministry (Kiatsayomphu and Chaiklieng, 2011).

Heavy metals in water

The concentrations of heavy metals in water were shown in Table 2. The concentrations were found to be Fe > Zn > Cu > Pb > Cr > Cd = As. Comparing the mean concentrations of all heavy metals did not exceed the National surface Water Quality Standard (National Environmental Board, 1994) and World Health Organization (WHO, 1993). This result was similarly by Begum *et al*. (2009). However, Cu concentration were exceeded the National surface Water Quality Standard at Lower Ban That. This is an indication that an urban waste discharged into the Loei River has a significant effect on the ecological balance of the river.

Table1 Heavy metal concentrations in fish (mg/kg) in various sampling station.

Sampling site	Heavy metal						
	As	Zn	Pb	Cd	Fe	Cr	Cu
Ban Kam Nerd Pet I	1.761	11.610	0.319	0.008	10.800	0.335	1.325
Ban Kam Nerd Pet II	2.128	15.040	0.381	0.025	13.030	0.303	1.689
Ban Kam Nerd Pet III	1.764	12.420	0.335	0.012	9.462	0.252	1.478
Ban Kam Nerd Pet IV	1.867	16.180	0.357	0.017	16.500	2.736	1.722
Ban Kam Nerd Pet V	2.103	10.610	0.165	0.022	11.420	0.290	1.637
Ban Kam Nerd Pet VI	1.795	12.480	0.231	0.017	11.220	0.240	1.675
Ban Kam Nerd Pet VII	1.699	12.980	0.255	0.022	9.342	0.230	1.856
Ban Kam Nerd Pet VIII	1.945	12.000	0.252	0.019	14.090	0.549	1.921
Mean	**1.883**	**12.915**	**0.287**	**0.018**	**11.983**	**0.617**	**1.663**
Ban ThaManao I	1.514	10.020	0.176	0.005	13.970	0.196	1.555
Ban ThaManao II	1.173	6.148	0.178	0.004	10.260	0.340	1.490
Ban ThaManao III	1.610	7.035	0.129	0.005	18.99	0.413	1.645
Ban ThaManao IV	1.838	14.140	0.167	0.020	12.460	0.218	1.675
Ban ThaManao V	1.084	8.407	0.090	0.003	29.910	0.219	1.551
Ban ThaManao VI	1.069	8.231	0.157	0.013	6.685	0.158	1.662
Ban ThaManao VII	1.754	9.743	0.211	0.016	9.905	0.240	1.449
Ban ThaManao VIII	2.065	11.370	0.155	0.025	9.006	0.279	1.419
Mean	**1.513**	**9.387**	**0.158**	**0.011**	**13.898**	**0.258**	**1.556**
Ban That I	1.799	13.560	0.328	0.024	25.89	0.298	1.828
Ban That II	2.643	12.900	0.261	0.043	18.950	0.352	1.818
Ban That III	2.056	11.750	0.288	0.043	30.710	1.277	2.436
Ban That IV	2.658	12.650	0.237	0.039	48.190	2.208	2.268
Ban That V	1.819	11.020	0.274	0.024	18.760	0.333	2.331
Ban That VI	2.013	10.820	0.291	0.030	28.010	1.054	2.339
Ban That VII	1.934	12.950	0.207	0.031	18.860	0.622	2.287
Ban That VIII	1.975	12.808	0.216	0.029	17.150	0.273	2.563
Mean	**2.112**	**12.307**	**0.263**	**0.033**	**25.815**	**0.802**	**2.234**
FDA in Thailand	**2.000**	**100.000**	**1.000**	**-**	**-**	**-**	**20.000**
IAEA-407	**12.600**	**67.100**	**0.120**	**0.189**	**146.000**	**0.730**	**3.280**
National standard in China	**0.500**	**50.000**	**0.500**	**0.100**	**-**	**2.000**	**-**

Table2 Heavy metal concentrations in water(mg/L) in various sampling station.

Heavy metal	Ban Kam Nerd Pet			Ban ThaManao			Ban That			Thai Std.*	WHO
	Upper	Lower	Mean	Upper	Lower	Mean	Upper	Lower	Mean		
As	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.01
Zn	0.116	0.083	0.100	0.101	0.104	0.103	0.197	0.080	0.139	1.00	3.00
Pb	0.010	0.006	0.008	0.008	0.009	0.009	0.008	0.009	0.009	0.05	0.05
Cd	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.05	0.01
Fe	1.318	1.145	1.232	1.027	1.003	1.015	1.098	1.231	1.165	-	-
Cr	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.05	0.05
Cu	0.045	0.039	0.042	0.039	0.039	0.039	0.040	0.124	0.082	0.10	2.00

*Thai Standard

Other studies showed that Cd, Cr, Cu, Ni and Pb concentrations of Avsar Dam Lake in Turkey did not exceed WHO, an exception of Fe (Öztürk *et al*., 2009). Nevertheless, Ekpo *et al*. (2013) studied metal concentrations in Akamkpa Local Government Area of Cross River state, Nigeria. The results demonstrated Fe > Zn > Mn > Pb > Cu > Cr > Cd. These values were higher than WHO limits.

Conclusion

The heavy metal concentrations in fish were higher than water. Furthermore, an exception of Ban That, heavy metal concentrations in fish (except As, Crand, Pb) and water (except Cu) did not exceed standard levels. However, the heavy metal concentration is the need for regular monitoring in aquatic organisms, sediment and water because of the long term effects. Therefore, future woke study should follow up by increasing fish organs and sediment's details in future monitoring efforts.

Acknowledgement

The authors gratefully acknowledge funding from Faculty of Scince and Technology under LoeiRajabhat University. We also thank the reviewers who gave comments improving the overall quality of the manuscript.

References

Amisah, S., Adjei-Boateng, D.,Obirikorang, K.A. and Quagrainie (2009). Effects of clam size on heavy metal accumulation in whole soft tissues of Galatea paradoxa (Born, 1778) from the Volta estuary.International Journal of Fisheries and Aquaculture 1(2): 014-021.

Begum, A., HariKrishna, S. and Khan, I. (2009). Analysis of heavy metals in water, sediments and fish samples of Madivala Lakes of Bangalore, Karnataka. International Journal of ChemTech Research 1(2):245-249.

Che, D., Meagher, R.B.,Rugh, C.L., Kim, T., Hearton, A.C. and Merkle, S.A. (2006). Expression of organomercuriallyase in Eastern Cottonwoodenhancesorganomercury resistance. In vitro Cell Dev. Biological Plant 42:228-234.

Edem, C.A., Akpan, B. and Dosunmu, M.I. (2008). A comparative assessment of heavy metals and hydrocarbon accumulation in Sphyrenaafra, Orechromisniloticus and lops lacertafrom Anantigha Beach market in Calabar-Nigeria. African Journal of Environmental Pollution and Health 6:61-64.

Ekpo, F.E., Agu, N.N. and Udoakpan, U.I. (2013). Influence of heavy metals concentration in three common fish, sediment and water collected within quarry environment, Akamkpa L .G. Area, Cross River State, Nigeria. European Journal of Toxicological Sciences 3:1-11.

El-Sayed, E.A., El-Ayyat, M.S., Nasr, E. and Khater, Z.K. (2011). Assessment of heavy metals in water, sediment and fish tissues, from Sharkia province, Egypt. Egyptian Journal of Aquatic Biology and Fisheries 15(2):125-144.

Jezierska, B. and Witeska, M. (2006).The metal uptake and accumulation in fish living in polluted waters. Soil and Water Pollution Minitoring, Protection and Remediation 3-23.107-114.

Kiatsayomphu, S. and Chaiklieng, S. (2011). Assessment on heavy metals contamination and health risk of contaminant exposure from consumptions of fish in LoengPuay Marshat KhonKaen Province. Thai Journal Toxicology 26(2):43-56.

Ministry of Public Health (1986). Standard of food contamination(Food and Drug Administration). The Royal Thai Government Gazette103(23), dated February 16, 1986.

National Environmental Board (1994). Surface water quality standard.The Royal Thai Government Gazette 111(16), dated February 24, 1994.

National Food Institute (2003). National standard in China.National Food Institute of Thailand, Thailand.

Öztürk, M., Özözen, G., Minareci, O. and Minareci, E. (2009). Determination of heavy metals in fish, water and sediments of avsardam lake in turkey. Iranian Journal of Environmental Health Science and Engineering 6(2):73-80.

Regional Environmental Office 9 (2007). Environmental quality assessment report 2007, Loei, UdonThani, NongKhai, SakonNakhon, Nakhon. Phanom. Ministry of Natural Resources and Environment, Thailand.

Regional Environmental Office 9 (2014). Environmental quality assessment report 2014, Loei, UdonThani, NongKhai, SakonNakhon, Nakhon.Phanom. Ministry of Natural Resources and Environment, Thailand.

Salami, I.R., Rahmawati, S., Sutarto, R.I. and Jaya, P.M. (2008). Accumulation of heavy metals in freshwater fish in cage aquaculture at Cirata Reservoir, West Java, Indonesia. Annals of the New York Academy of Sciences 1140:290-6.

Tokhun, N. and Twai, C.B. (2012). Assessment of Water and Sediment in Cage Aquaculture in Namphongriver. Graduated Research Conference 86-91.

World Health Organization (WHO) (1993). Guidelines for drinking water quality. Recommendations, vol. 1, 2nd ed., Geneva.

Wyse, E.J., Azemard, S. and Mora, S.J. (2003). Report on the World-wide Intercomparison Exercise for the Determination of Trace Elements and Methylmercury in Fish Homogenate IAEA-407, IAEA/AL/144 (IAEA/MEL/72), IAEA, Monaco.