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# Assessment of some heavy metals in fishes, water and effluent samples From Ayeyawady River Segment near the Fertilizer Industry

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**Abstract:**
This paper presents the research that was conducted to analyze the concentration of some essential metals such as calcium (Ca), iron (Fe) and non-essential metals such as arsenic (As), lead (Pb) and cadmium (Cd) in the Ayeyawady River water, the effluent of fertilizer industry and muscles of three fish species (*Mystus cavasius*, *Mystus leucophasis* and *Wallago attu*). The Salay fertilizer Industry, Chauk Township, Magway Region, Myanmar was chosen as the study site. The study period lasted from July 2013 to February 2014. The concentration of metals in the fish muscles and water samples collected was analyzed by by Flame Atomic absorption spectrophotometry (AAS). With regard to non-essential metal, the metal concentration in the river water and effluent was found in the order As> Ca > Fe > Cd and Pb was not detected. The concentration of Ca and Fe was higher in the river water than that in the effluent. In contrast, the concentration of As and Cd was higher in the effluent than in the river water. Cd and As in both river water and the effluent were higher than the permissible limits set down by FAO/WHO (1983) guidelines. With respect to essential metals, Ca and Fe in the river water was higher than the permissible limit while that in the effluent was lower than the permissible limit of FAO/WHO (1983). In the muscles of the fishes studied, Ca was the highest accumulated metal and Pb was the lowest metal and Cd not detected and the order of metal accumulation was Ca > Fe> Pb. Ca and Fe in muscles of the fishes studied were lower than the permissible limits of FAO/WHO guidelines and Pb was higher than the FAO/WHO guidelines, Cd was not detected except the *Mystus cavasius (drifted* dead fish). The results obtained in the present study revealed that it seems to be toxic to consumers in long-term exposure of lead because of consuming dead fish *drifted down in the study area. Monitoring programme is needed.*

**Key words**: essential metals, non-essential metals, *Mystus cavasius*, *Mystus leucophasis*, *Wallago attu*, fertilizer industry.

## INTRODUCTION

The pollution of aquatic environment by heavy metals has become a worldwide problem during recent years, because they are everlasting and most of them have toxic effects on organisms. Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems (1). Heavy metals are well known environmental pollutants that cause serious health risk to human, their effects are not immediate and show up later many years (2). In recent times, industrial and mechanical activities have outstretched natural concentrations causing serious environmental problems. Aquatic environment is one of the receiving ends for heavy metals which are ploughed back into the food chains through bioaccumulation in plankton and invertebrates to fishes and finally biomagnified in man. Heavy metals are low levels in water and attain considerable concentration in biota (3).

Heavy metals can be categorized as: potentially toxic (aluminum, arsenic, cadmium, antimony, lead and mercury), semi-essential (nickel, vanadium, cobalt) and essential (copper, zinc, selenium, cobalt, manganese, molybdenum, and nickel etc.) (4). For the normal metabolism of the fish, the essential metals are taken up from water, food or sediment and involved in biochemical processes such as enzyme activation. Even

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these essential metals can also cause toxic effect when taken in excessive amounts (5) and (6). Others such as cadmium, lead and mercury have no known biological roles and are detrimental to essential life processes. The World Health Organization as well as the Food and Agriculture Organization of the United Nations state that monitoring eight elements in fish – Hg, Cd, Pb, As, Cu, Zn, Fe, Sn is obligatory and monitoring of others is suggested (7).

According to the Codex Committee for Food Additives and Contaminants, dietary intakes of heavy metals with high public concern need to be monitored on a regular basis and rapidly updated to identify recent dietary intakes of heavy metals in developing countries (6). Fish is a good indicator because they occupy different trophic levels (8), it is easy to be obtained in large quantity, potential to accumulate metals, long lifespan, optimum size for analysis and easy to be sampled (9).

Myanmar, as one of the developing countries, definitely needs a monitoring river system to ensure a safe food supply, especially because the Ayeyawady River is the life artery of Myanmar and the diet of Myanmar people includes an appreciable amount of fish and fish products which may contain some residues of heavy metals. Fertilizer Industry is located at Salay, Chauk Township, Magway Region, Myanmar. The Ayeyawady River Segment near the Salay Fertilizer Industry may be contaminated with heavy metal residues of the effluent from the industry. Most of the pollutants from a fertilizer industry merge as an effluent that has generally high pH, ammonia, nitrogen, potassium, etc. The disposal of an untreated effluent causes a disastrous effect on living organisms (10). It is, therefore, important to monitor the quality of such effluents on a regular basis. Keeping in view these facts, this research work has been conducted.

## OBJECTIVE AND RESEARCH QUESTIONS

The objectives of this study are to determine the concentration of some heavy metals in the river water near the outlet of Salay fertilizer Industry and the effluent of industry and to assess the content of these metals in the muscles of three fish species compared with the internationally recommended maximum value FAO/WHO guidelines (11 & 12). The present research is based on random sample collection.

## MATERIALS AND METHODS

Salay is located in the Chauk Township, Magway Region (20° 50′ 5" N Latitude and 94° 45′ 14" E Longitude) (Fig. 1). Fertilizer Industry is located to the Northeast of Salay. The study period lasted from July 2013 to February 2014.

### *1. Sample Collection and Preparation*

Three species of fish (*Mystus cavasius*, *Mystus leucophasis*, *Wallago attu*) were analyzed for metal content. The live captured fish were directly purchased from the local fishermen who were fishing in the Ayeyawady segment of Salay and the dead fish drifting in the Ayeyawady River near the outlet of Fertilizer Industry collected. In this research work, pooled sample of five individual fish for each species was used in order to compensate for limited amount of samples or high biological variation. For each sample, five replicate pieces (5 g each wet weight) of muscle tissue were collected and pooled. Then, samples were sun dried for about five days and then ground by blender into small pieces. After that samples were sun dried again, powdered finely by pestle and sieved. Finally, dried fish powder was stored in airtight container until acid digestion.

Water sample was collected randomly by pre-cleaned bottle from about 100 meters (0.1 Km) away from the outlet of the effluent of the fertilizer Industry after mixing the effluent and

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the river water. The effluent sample was collected from the outlet of the fertilizer Industry before entering the Ayeyawady River.

### 2. *Acid Digestion*

Acid digestion procedure was used following after (13) with slight modifications. About 5 gram of sample (dry weight) was added to polyethylene glass tube. Concentrated nitric acid ($HNO_3$) (65%) 5 ml and then concentrated sulphuric acid ($H_2SO_4$) (80%) 5 ml were added into the sample. The reaction was allowed to proceed and the tubes were placed in room temperature overnight. Next day, the tubes were placed in a water bath and heated up to temperature 80°C for about 2 hours until all the samples were totally dissolved. And then the tubes were removed from the water bath and allowed to cool. After cooling, about 2 ml of hydrogen peroxide ($H_2O_2$) (80%) was added and heated again in the water bath to about 98°C for one and half hours until the sample was clear. Finally, the samples were cooled again to room temperature and the volume was adjusted to 25 ml of deionized water. For water samples, two to three drops of concentrated nitric acid (70%) was added to water samples that was ready to analyze metals.

### 3. *Metal Analysis*

The samples prepared were sent to Universities' Research Centre (URC), Yangon for analysis of metals. The concentration of Calcium (Ca), Iron (Fe), lead (Pb) and cadmium (Cd) for the fish sample and also arsenic (As) for the water sample were determined by Flame Atomic absorption spectrophotometry (AAS) (Perkin Elmer AA analyst 800 and Winlab-32 software). This method is reliable for determination of trace metals in aqueous solution. The value of mean metal concentration was expressed as milligram per litre (mg/l) or part per million (ppm). The samples were analyzed for three times to get more accurate results.


Fig. 1. Location map of Ayeyawady River Segment near the Salay Fertilizer Industry, Chauk Township, Magway Region

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Table 1. Metal concentration compared in river water and effluent of the fertilizer industry

| Sr. No. | Metals | River water (ppm) | Effluent (ppm) | FAO/WHO |
|---|---|---|---|---|
| 1 | As | 5.605 | 8.473 | 0.2 |
| 2 | Ca | 2.387 | 1.579 | 75* |
| 3 | Fe | 0.432 | 0.139 | 0.3 |
| 4 | Pb | ND | ND | 0.05 |
| 5 | Cd | 0.033 | 0.028 | 0.01 |

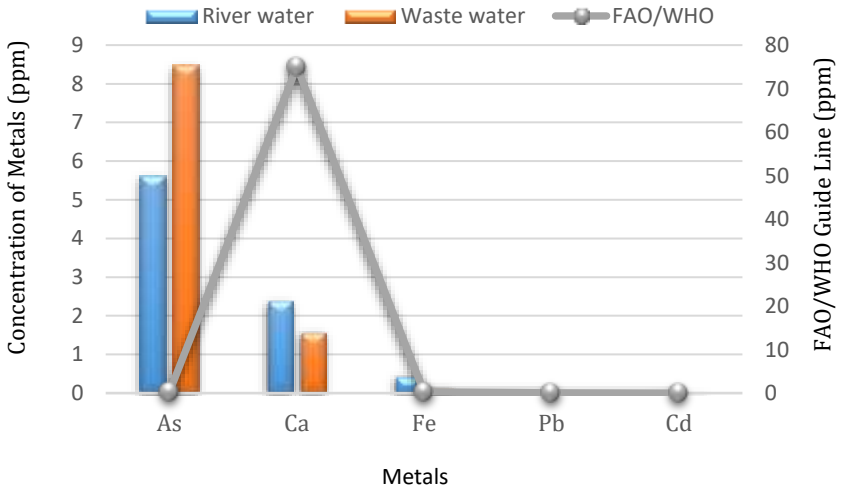


Fig. 2. Assessment of heavy metals in the river water and the effluent with FAO/WHO guidelines

Table 2. Metal concentration of the species studied from Ayeyawady River near the Salay Fertilizer Industry

| Fish species/ Metals | Ca (ppm) | | Fe (ppm) | | Pb (ppm) | | Cd (ppm) | |
|---|---|---|---|---|---|---|---|---|
| | dead fish | live fish | dead fish | live fish | dead fish | live fish | dead fish | live fish |
| *Mystus cavasius* | 12053.41 | 14525.44 | 58.57 | 62.18 | 3.55 | 2.03 | 0.07 | ND |
| *Mystus leucophasis* | 7325.88 | 22771.56 | 61.82 | 69.52 | 3.04 | 1.77 | ND | ND |
| *Wallago attu* | 7623.6 | 2323.17 | 48.09 | 51.59 | 1.65 | 1.39 | ND | ND |
| PL* | | | 100 | | 2.00 | | 1.00 | |

PL*= permissible limit (FAO/WHO)

ND= Not detected

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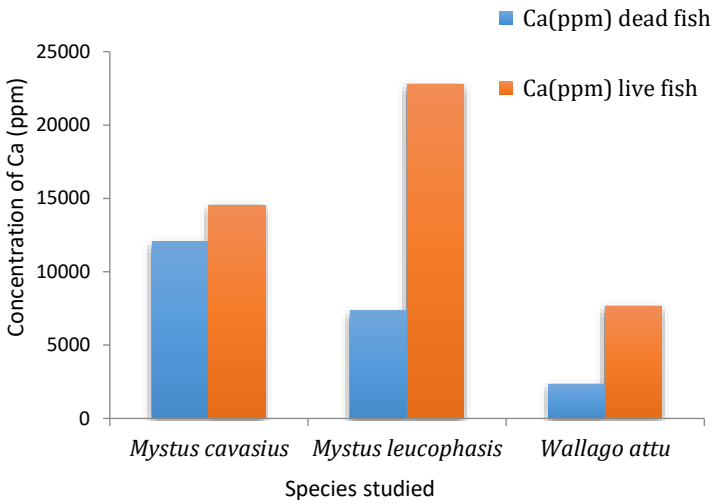


Fig. 3. Calcium concentration in the muscles of fishes studied

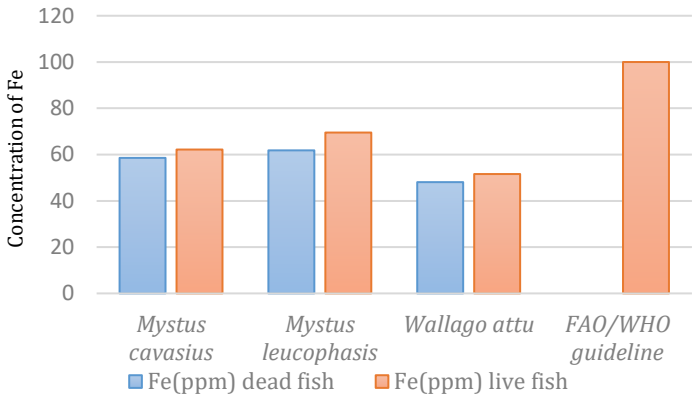


Fig. 4. Iron concentration in the fishes studied compared with FAO/WHO guideline

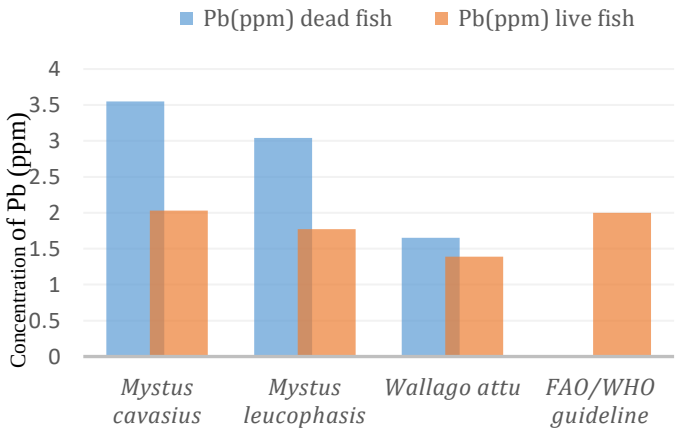


Fig. 5 Lead concentration in the fishes studied compared with FAO/WHO guideline

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## RESULTS

### 1. *Heavy metals in the river water and effluent*

The metal concentration such as calcium (Ca), iron (Fe), arsenic (As), lead (Pb) and cadmium (Cd) in the river water in the Ayeyawady River Segment, Salay and effluent of the outlet of Salay fertilizer Industry, Chauk Township, Magway Region was analyzed (Table 1; Fig. 2). The metal concentration in the river water and effluent were found in the order As> Ca > Fe > Cd. The concentration of essential metals such as Ca and Fe was higher in the river water than that in the effluent. On the other hand, the concentration of non-essential toxic metals, As was higher in the effluent than in the river water and Cd was not different and Pb was not detected in the river water and the effluent. Cd and As in both river water and the effluent were higher than the permissible limits (0.01 ppm for Cd and 0.2 ppm for As) set down by FAO/WHO guidelines (11 & 12) while Ca was far from the permissible limits (75 ppm) and Fe in river water was higher than the permissible limits (0.3 ppm) and that in the effluent lower than the permissible limits set down by FAO/WHO guidelines.

### 2. Concentration of heavy metals in the fish muscles

The accumulation of some essential metals such as calcium (Ca), iron (Fe) and non-essential metals such as lead (Pb) and cadmium (Cd) in the muscles of three fish species (*Mystus cavasius*, *Mystus leucophasis* and *Wallago attu* from the Ayeyawady River of Salay Segment, Chauk Township, Magway Region was analyzed (Table 2). In the muscles of the fishes studied, Ca was the highest accumulated metal and Cd was not detected and the order of metal accumulation was Ca > Fe> Pb. The level of Ca, Fe and Pb in the muscle tissue of fishes studied was lower than compared with FAO/WHO guidelines to assess the metal accumulation.

Among three studied fishes the level of Ca was higher in the live captured fish than the dead fish drifted. According to the species studied, the composition of Ca in the muscle tissue was the highest in *Mystus leucophasis* (22771.56 ppm dry weight or 2.27%) and the lowest in *Wallago attu* (7623.6 ppm d.w or 0.76%) (Fig. 3). Concerned with Fe, the level of Fe was also higher in the live captured fish than the dead fish drifted among three studied fishes. According to the species studied, the composition of Fe in the muscle tissue was the highest in *Mystus leucophasis* (69.5 part per milliom dry weight (ppm d.w)) and the lowest in *Wallago attu* (51.59 ppm d.w). The level of Fe in the muscles of the fishes studied was far from the permissible limit (100 ppm d.w) set down by FAO/WHO guidelines (Fig. 4).

With regard to Pb, the accumulation of Pb in the muscle tissue of fishes studied was higher in the dead fishes drifted fish than that in the live captured fish. According to the species studied, the level of Pb in *Mystus cavasius* (2.03ppm d.w) was the highest and that in *Wallago attu* (1.39 ppm d.w) the lowest. The level of Pb in the muscles of the live fishes studied except *Mystus cavasius* was not exceed the permissible limit (2.00 ppm d.w) set down by FAO/WHO guidelines. In the dead fishes drifted, the level of Pb, except in *Wallago attu* was higher than the permissible limit set down by FAO/WHO guidelines (Fig. 5). The Cd was not detected in all three studied species except the dead fish of *Mystus cavasius* (0.07) that was far from the permissible limit (0.5 ppm d.w) set down by FAO/WHO guidelines.

## DISCUSSION

Fish living in polluted waters tend to accumulate heavy metals in their tissues. Generally, accumulation depends on metal concentration, time of exposure, way of metal uptake, environmental conditions (water temperature, pH, hardness, and salinity) and

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intrinsic factors (fish age, feeding habits). Various metals are accumulated in fish body in different amounts. These differences result from different affinity of metals to fish tissues, different uptake and deposition and excretion rates. Generally, the higher metal concentration in the environment, the more may be taken up and accumulated by fish (14). Multiple factors has been listed that influence metal accumulation in fish such as season, physical and chemical properties of water (15).

Most of fish are at the top in aquatic food chain and have potential to accumulate high metal content even in mild polluted conditions and metals accumulated in the muscle tissue of fish are of great importance because of human health concern (16). Therefore, in the present study, metal concentration in fishes studied was used as an index to assess the level of metals in Ayeyawady River Segment of Salay, Chauk Township, Magway Region.

In the present study, As was the highest concentration in both the river water and the effluent from the industry while Cd the lowest concentration and Pb not detected and followed in the order As> Ca > Fe > Cd. The concentration of essential metals such as Ca and Fe was higher in the river water than that in the effluent. On the other hand, the concentration of non-essential and toxic metals; Arsenic was higher in the effluent than in the river water and Cd was not different in both the river water and the effluent. The level of As and Cd in the river water was lower than the report of Odra River in Poland recorded by (17). Arsenic and Cadmium in both river water and the effluent were higher than the permissible limits (0.01 ppm for Cd and 0.2 ppm for As) set down by FAO/WHO (11 & 12) while Ca was far from the permissible limits (75 ppm) and Fe in river water was higher than the permissible limits (0.3 ppm) and that in the effluent lower than the permissible limits set down by FAO/WHO.

The Fe was the second highest metal in the muscle of fish studied. Fish is the major source for iron in adults and children and deficiency of it causes anemia (19). In the present study, the level of Fe in the live captured fishes of all three species was also higher as compared to the dead fishes drifted during the s. According to the species studied, *Mystus leucophasis* had the highest level (69.52 ppm d.w) of Fe while *Wallago attu* the lowest level (48.09 ppm). It was agreed with the findings of Kumar *et al.* (18) who reported that the mean level of Fe was 58.66 ppm (d.w) in freshwater fish muscles from aqualculture ponds, India. According to (20), the level of Fe (15.64 ppm) was found in muscle of *Mystus cavasius* in the Ayeyawady River of Magway Segment. In this study, *Mystus cavasius* had 62.18 ppm of Fe that was higher than (20). The concentration of Fe in the muscles of the species studied was far from the permissible limit (100 ppm d.w) set down by FAO/WHO guidelines. The bioaccumulation pattern of iron in muscle tissue of three fish species from Ayeyawady River of Salay Segment was trend as follows:

*Mystus leucophasis* >*Mystus cavasius* > *Wallago attu*.

With regard to the Pb, the live captured fishes of all three species had lower concentration as compared to the dead fishes drifted in the Ayeyawady River near the outlet of fertilizer industry although Pb was not detected in water and effluent samples. According to species studied, *Mystus cavasius* (2.03 ppm) had the highest level of Pb while *Wallago attu* the lowest level (1.65 ppm). It was agreed with the findings of (18) who reported the mean level of Pb in fish was 1.73 ppm but much higher than the Pb in fresh water fish of Ayeyawady River segment of Mandalay reported by (21). Khin Myint Mar (21) analyzed the level of lead (0.17 ppm) was found in *Mystus cavasius*, (0.14 ppm) in *Mystus leucophasis* and (0.19 ppm) in *Wallago attu*. Among the live captured fishes,

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the concentration of Pb in the muscles of only *Mystus cavasius* was slightly exceed the permissible limit set down by FAO/WHO guidelines (2.0 ppm d.w). Among the dead fishes, the concentration of Pb in the muscles of *M. cavasius* and *M. leucophasis* was exceed the permissible limit set down by FAO/WHO guidelines (2.0 ppm d.w) and in the muscles of *Wallago attu* was lower than FAO/WHO guidelines. The bioaccumulation pattern of Pb in muscle tissue of three fish species from Ayeyawady River Segment of Salay was trend as follows:

*Mystus cavasius* > *Mystus leucophasis* > *Wallago attu*. The level of cadmium (Cd) in the live captured fishes of all three species were not detected and among the dead fishes it was detected only in *Mystus cavasius* (0.07 ppm) that was far from the permissible limit (0.5 ppm d.w) set down by FAO/WHO.

## CONCLUSION

It can be concluded that the level of essential metal such as Fe in the fishes studied from Ayeyawady River of Salay segment, Chauk Township, Magway Region was lower than the permissible limits of FAO/WHO guidelines. As regard with non-essential metals, Pb was higher than the permissible limits of FAO/WHO. The results obtained in the present study revealed that it seems to be toxic to consumers in long term exposure of Pb because of consuming dead fish drifted in the Ayeyawady River Segment of Salay. This research work gives information of heavy metals in some fishes of the study area and seems to be warning to the local residents not to eat the dead fish drifting near the Salay Fertilizer Industry. More intensive study is needed in order to determine the concentration of other metals in fishes from the study area. Monitoring programme is needed.

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