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DETERMINATION OF MERCURY'S BIOACCUMULATION FACTOR IN MILK FISH (*Chanos chanos*) OF SEMARANG MUNICIPALITY FISHPONDS USING NEUTRON ACTIVATION ANALYSIS

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ABSTRACT

Determination of bioaccumulation factor of mercury (^{200}Hg) in Chanos chanos of Semarang municipality fishponds has been carried out by applying the neutron activation analysis (NAA) and gamma spectrometry analysis. The gamma spectrometry technique was employed to analyze the gamma radiation exposure from activated samples. The heavy metal ^{200}Hg can be identified in water and milk fish (Chanos chanos), along with natural radionuclides ^{40}K in water. The concentration of Mercury in the water at the 3 villages was 0.950 10^{-6} ppm, 284 10^{-6}, and 350 10^{-6} ppm respectively. Whilst mercury concentration in the milk fish was 186 10^{-3}, 068 10^{-3}, and 098 10^{-3} ppm for Mangunharjo, Mangkang dan Karanganyar respectively. Bioaccumulation factor can be estimated from the ratio of these heavy metal element in the sample and the water. Result shows that the bioaccumulation factor for mercury at 3 villages (Mangunharjo, Mangkang dan Karanganyar) is 195.942, 238.961, 279.614 respectively.

Keywords: Bioaccumulation factor, Mercury, Semarang municipality fishponds,Neutron Activation Analysis.

I. INTRODUCTION

Semarang municipality brackhis-water fishponds (tambaks) are specific ecosystem of Semarang waters. From the radioecological point of view, Semarang estuary has been contaminated by various waste from releases of bedrock trap, mainland deposition as product of geomorphological process, and atmospheric fall-out (Sasongko, 1997). Indeed, Semarang waters has various functions and allotments: harbour activities, bonded zone area, industries and settlements, reclamation area for industrial estate, urban domestic sewage discharge, and fishing activities.

Contamination of soils and waters with metallic compounds or elements may lead to toxemias in fishes and resulted in direct mortality, biological accumulation, chronic toxicity and subtle changes in physiological functions leading to an inability to survive (Pickering and Henderson, 1966; Post, 1987).

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The presence of mercury in the fish body what ever the level is a potential danger for both fish itself and human beings.

The analysis of mercury as a heavy metal element can represent a useful way to evaluate the quality of waters and safety for aquaculture (Chapman, 1985, Prayitno, 1987), thereby the presence of mercury in Semarang waters could hopefully distinguish whether the sources are local or not in origin. Counting of activated mercury in the milk fish sample could determine the quality of Semarang waters, especially their brackhiswater ponds.

This study is aimed at identifying the nature of mercury in *Chanos chanos* from Semarang fishponds in order to determine the bioaccumulation factor.

II. MATERIAL AND METHODS

Sampling location was purposively determined i.e.; Mangkang, Mangunharjo and Karanganyar villages. In each site, 20 litres of water was taken from 3 depths with ratios of 0.2, 0.6 and 0.8; then 1 ml of HCl or HNO_3, as fixative was added to each litre of water. In each site, samples of minimum wet mass-weight 2 kg milk fish *(Chanos chanos)* was taken from fishponds with an average weight of 200 gr.; then 1 litre of liquid nitrogen was added to each sample as a frozen factor.

Following the routine protocol adopted from Nareh and Shaleh (1993), preparation began by filtering the water sample through 1μm Millipore paper to let approximately 100 ml filtrate, which were then dripped evenly onto the planset. Having been dried under a 1000-watt light bulb for 6 hours in room temperature (31,3°C), dry samples of approximately 1 mm thick were ready to be counted.

Frozen milk fish sample was taken by means of a large pincer and then burnt in a muffle furnace of 1500°C for 3 hours in the laboratory. The remaining ashes were evenly spread onto planset to make approximately 1 mm thickness sample for further analysis.

The Kartini nuclear reactor as an activator consists of neutron sources to activate the sample. The γ-counting consists of coaxial Ge (Li) detector, supported by 400 VA Phillips Stabilizer, 4001Ortec Power Supply, and Canberra 2021 Spectroscopy Amplifier, Canberra High Voltage Power Supply and 7010Ortec Multi Channel Analyzer. This γ-counting was also equipped by Lead House as a shielding (external cover) and an Omnigraphic Houston Instrument 2000 Plotter-Recorder.

According to Susetyo (1988), stability of the gauge-meter was examined statistically by means of *the least square method*, through repeated test result of observations in the same condition. The efficiency of γ-counting was calculated by energy calibration curve constructed from standard source multigamma ^{152}Eu. The relationship of energy and channel-number was sought by calculating the standard source for which the energy was known exactly. Relationship between the energy and the channel-number was linear.

Measurement of gamma energy was carried out by the γ-spectrometer and the efficiency of counting was also determined by *yield* (absolute intensity). The γ-activity of samples was counted by using the efficiency calibration and was measured by comparing the sample activity to the standard source activity.

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According to IAEA (1985), the following equation was applied in calculating "Bioaccumulation Factor" (B_p):

$$B_p = (C_{s,i} / C_{w,i})$$

where:

$C_{s,i}$ = heavy metal concentration-i in sample (kg/l)

$C_{w,i}$ = heavy metal concentration-i in water (kg/l).

III. RESULT

3.1. Preparation of Water and Milk fish Sample

Thickness factor for water in sampling site was range between 0.03453 and 0.04363 gr./l (table-1). Whereas the thickness factor for milk fish sample were ranging from 0.06673 to 0.8245 gr./l (table-1). Those data were becoming very useful when recalculation of the nature and origin of the toxic substances were applied.

3.2. Curve of Calibration

Curve of calibration of γ-energy produces an equation of line-calibration, i.e. **Y = 0.5658 X - 0.3157.** Meanwhile regression line of calibration efficiency was **Y = -0.99 X - 0.95**

Table 1. Thickness of sample at 3 selected sites

Thickness	Sample site		
	Mangkang	Mangunharjo	Karanganyar
Water	0.04363	0.04452	0.03453
Milk fish	0.08245	0.07654	0.06673

3.3. Mercury identification

The isotopes table of Erdtmann (1976) and Erdtmann & Soyka (1979) was used to identify the presence of mercury in both water and milk fish sample. Accordingly, the results are given in Table 2 The results are presented in Table 2.

Table-2 showed that mercury content in the water range from 0.000950 ppm to 0.000350 ppm, whilst in the milk fish was recorded from 0.067865 ppm – 0.186145 ppm. Milk fish from Mangkang village contained the highest count/content of mercury compared to fish samples from other site sites.

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Table 2. The identification of mercury and its concentration in the water and sample

Location	Hg in water *(ppm)*	Hg in sample *(ppm)*
Mangkang	0,000950 ± 0,000135	0,186145 ± 0,012125
Mangunharjo	0,000284 ± 0,000130	0,067865 ± 0,000305
Karanganyar	0,000350 ± 0,000042	0,097865 ± 0,003015

3.4. Bioaccumulation factor of mercury in sample

Table 3. Bioaccumulation factor of mercury in sample

No	Location	$C_{s,i}$ (kg/l)	$C_{w,i}$ (kg/l)	B_p
1	Mangkang	0.186145	0.000950	195.942
2	Mangunharjo	0.067865	0.000284	248.961
3	Karanganyar	0.097865	0.000350	279.614

Table-3 shows that bioaccumulation factor of mercury in the milk fish compared to their environment were 195.942, 248.941, 279.614 for Mangkang, Mangunharjo, and Karanganyar respectively. The highest mercury bioaccumulation was detected in the sample originating from Karanganyar.

IV. DISCUSSION

The existence of mercury in *Chanos chanos* from Semarang fishponds can be identified by using NAA and gamma-spectrometry methods which was identified from γ-peak energy.

The mercury level both in the water and milk fish at 3 sample sites (table-2) were far below maximum allowable concentration found in the water (0.01 ppm) as stated in the Central Java Governor act no. 660.1/26/1990. This was then considered as a safe product. This results demonstrated that this NAA technique is far more accurate than AAS.

In terms of fish health, Hg concentration of 0.186 ppm did not show any abnormal behaviour or clinical sign. This means that such a concentration does not directly influence fish growth and survival. Although mercury concentration in both water and fish were very low, its potential of accumulating in the fish along with culture period might be significant.

To estimate the bioaccumulation factor of these heavy metal elements in *Chanos chanos* their presence should be identified from both water and samples.

Table-3 shows that bioaccumulation factor of mercury at three sample sites varied from 195.942 to 279.614. This result demonstrates the high association tendency of mercury to the cultured animals in fish ponds. This result might explain the close relation between fish feeding behaviour and

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mercury content in the natural food. Natural milk fish feed (klekap) which consists of phytoplankton and diatom attach to pond bottom. Both plankton and diatom are good media to absorb any inorganic matter present in the water. Sasongko (1998) on his similar research found that $Pb^{212,214}$ content in macrozoo-benthos collected from Semarang waters was 0.87 10^{-16}%. This content is lower compared to mercury content. Our concern now is that the AAS technique was too inexact to be applied to mercury identification.

The detection of mercury in the water and milk fish samples might be in line with what Odum (1993) asserted, ///who stated/// that the identification of mercury and description of its pathways is a part of marine ecology which correlate with the compound, type of waters and the ecology of marine environment. The heavy metal may come from anthropogenic materials. Radionuclide ^{40}K contributed the highest natural radiation compared to decaying materials, ^{232}U, ^{234}U, ^{238}U. Marine environment contributed less than 1% from ^{210}P in fish and shellfish (Sasongko,1998 and UNSCEAR,1988).

Industrial activities in Semarang municipality may produce a significant effect on brackish-water aquaculture activities. This can bee seen from the fact that most of the 'tambaks' had collapsed and inhabitants, people, the population at three sample sites have complained that the water was contaminated and as a result some fish died. Furthermore, well water smelled and some habitants inhabitants experienced skin disease.

Beiser (1987) stated that non-radioactive sample such as milk fish (*Chanos chanos*) can be stimulated by neutron bombardment and may become unstable radioactive elements. As a an unstable element unstable radioactive elements, they always emit radioactive rays to stabilize. In doing so, they create radioactive series that show the change of elements and type of radiation.

Anthropogenic activities such as galvanizing, chemical and other activities have now been widely given been widely considered as sources of hazardous waste or heavy metal.

According to Smith (1984), heavy metal behaviour in aquatic environment might be performed by various complex models within mathematical representation. The model was developed in accordance with the various types of water bodies , e.g.: river, estuary, and sea. Physical conditions affecting the distribution of heavy metal in marine environment are temperature, density and salinity of water, current pattern, wave pattern, as well as the depth of water.

In water, mercury will be diluted and spread, and presumably transferred to biological matter, sediments and suspended particles. Among others, these factors affect the concentration of radionuclides in aquatic environment: mixing process, distribution and interaction with sediments and biological matters (IAEA, 1982). According to Ophel (1977), the concentration of mercury in the water is determined by the distribution, pathways and decay factors.

The most important parameter concerning heavy metal distribution in aquatic environment is the movement of water mass. Whilst in the estuary, it depends on size, foodstuff production and interaction of river to sea waters. Heavy metal elements which were absorbed in small amount by the sediment have the probability of being spread widely (Ophel, 1977).

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Food-web has an important role because each chain absorbs mercury and interchain transfer process of mercury has a constant absorbtion factor. To monitor heavy metal contamination in aquatic environment, one can utilize biological indicator by monitoring of samples as indicator in regular time interval (Dahlgaard, 1991).

V. CONCLUSION

From this research, it can be concluded that:

1. Neutron Activation Analysis (NAA) is more sensitive than AAS, therefore, it is very important to use NAA to analyze the most toxic heavy metal in both water and aquatic organism.
2. Mercury content in the water at 3 sites was two hundreds times lower (0.000284 ppm) than from the milk fish sample (0.067865 ppm) indicated that bioaccumulation factor is very high.
3. The bioaccumulation factor recorded was at least 195.942. This result demonstrates that the potent of mercury accumulated in the fish is significant along with the culture period.

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