Hair mercury levels of male population in Sri Lanka: Implications to fish consumption

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Abstract: Total mercury (T-Hg) concentration was measured in the hair of people who live and work in the Negombo coastal area and Welimada mid country area of Sri Lanka. Hair samples were analysed for T-Hg by CVAAS (cold vapour atomic absorption spectrometry) in males (n= 52, 30 from Negombo and 22 from Welimada). Mean T-Hg level and ranged between 4.38±3.55
(>LOD-13.38) Negombo and 0.39±0.44 (>LOD-1.58) Welimada. The highest value was found in a 25 year businessman in Welimada (1.58 mg/kg), and the 28 years businessman from Negombo (13.38 mg/kg). All individuals from the Negombo area are consuming small fish to large fish ratio 1:1, and the common species are Trenched Sardines (Hurulla) and large fish like skipjack tuna (Balaya) yellowfin tuna (Kelawalla) and Treavallies (Paraw). But in some individuals in Welimada area are consuming small fish and the mean T-Hg was 0.29 mg/kg, while others have 0.67 mg/kg mean value. The 55.8% of the study population (13.6% Welimada& 86.7% Negombo) exceeded the USEPA recommendation 1 mg/kg. These values should be taken into account for future advisories and involvement approaches, which should consider Hg levels from all sources in order to maximize the nutritional input from fish and minimize the toxic risk.
Key words: Hair, Total mercury, CVAAS, Sri Lanka, Fish

1. Introduction

Over the past few years, there has been an increasing evidence of mercury (Hg) pollution over the world and high Hg levels in human hair among coastal communities, for whom fish constitute the dietary mainstay [1]. Metals occur naturally in the environment. Increased by human activities, such as mining, incineration and transport can cause elevated levels of metals in the environment. Natural processes that can release metals into the environment are for example, erosion, forest fires and volcanic activity [2]. Different geographical areas can have different levels of metals. Approximately, 6,000 tons of Hg is released into the environment annually and concentrations continue to rise in many regions of the world. A majority of this Hg is released from coal power plants, and largely from point source in India and China [3].
Hair Hg levels increase with the amount of fish and shellfish in the diet and the amount of Hg in the fish and shell fish species consumed [4, 5]. Instead of dissolving or breaking down, Hg accumulates at ever increasing levels and it has long biological half-life [6]. The concentrations of Hg in tissues of fish consumers may be 10 million times greater than ambient levels in the environment [3]. The highest Hg levels

are found in longest lived marine carnivorous fish such as swordfish, marlin, yellowfin tuna and shark as well as marine mammals such as whales and dolphins [7]. In a survey, the mean Hg concentration in swordfish, yellowfin tuna and black marlin were about 0.90±0.52, 0.30±0.18 and 0.49 ± 0.37 [7]. In authors personal experience, certain populations' especially living in coastal region, are consuming fish than one meal per day. The United States Food and Drug Administrative (USFDA) and Swedish National Food Administration (SNFA) recommends that pregnant women not eat marine fish like shark, swordfish, king mackerel, or tilefish and freshwater fish like northern pike, perch, burbot and halibut [4].

The levels of pollutants in people's bodies can be estimated through biological monitoring, or bio monitoring. Scientists can analyse samples of urine, serum, saliva, blood, breast milk and other tissues (such as hair, body fat and teeth) to measure the levels of various chemicals in the body. The most common way of measuring Hg in hair, blood and urine [8]. Hair analysis is a well-documented and relative inexpensive method that can be used to assess recent exposure to Hg. Mercury is incorporated into hair as it grows and remains in hair for a long time. The level of Hg in human hair can provide valuable information about exposure to Hg in the diet

[9] and measuring hair Hg concentration is a routine analysis at many research laboratories particularly in developed countries. The objective of the present study was to examine variations in hair Hg levels with respect to fish consume practices, in a coastal area and mid country area of Sri Lanka.

2. Materials and Methods

2.1. Sampling

A total of 52 samples was analysed, including 30 male near Negombo harbour area and 22 male representatives of Welimada that is mid country area in Sri Lanka. The survey participants answered questions of potential relevance to the food pattern and behaviour of life. Then the 20 strands of long hair (shorter hair the number of strands was higher than this) were cut from the neck close to the scalp and stored in a sealed polyethylene bag on which the identification (ID) number of the participant is indicated. Then samples were transported to Analytical Chemistry Laboratory, National Aquatic Resources Research and Development Agency (NARA) to the analysis.

2.2. Chemical and glassware

All chemicals were of analytical grade and certified for low trace metals content. Deionised water was used throughout. Nitric acid, acetone and Hg standards were obtained from Sigma Aldrich (Dorset, United Kingdom). Precautions were taken to avoid contamination of samples with trace metals. All glassware and plastic used for the study were soaked in 10% HNO_3 and rinsed 3 times with de-ionised water prior to use.

2.3. Equipment

A MARS XP 1500+ microwave accelerated system (CEM, Matthews, USA) was used for sample digestion and Varian 240FS, AAS was used for the trace metal determination (Varian Pvt. Ltd, Mulgrave, Victoria, Australia). The T-Hg was analysed by vapour generation accessory (Varian VGA 77).

2.4. Sample preparation

Transferred of hair sample in a beaker, wash with neutral detergent (diluted 100-fold) and distilled water by decantation, and wash again with a small amount of acetone to remove the water. Dried the hair samples under the ambient temperature. Transferred the hair sample into a new sealed polyethylene bag and cut into a small piece with dissection scissors to make a sample for analysis. Approximately 0.2 g of hair sample was weighed into microwave digestion tube and weigh. Then 10 mL of Conc. HNO_3 acid (65%) was added to sample and samples were digested under pressure in a closed vessel heated by microwaves using a microwave-accelerated system (CEM Mass XP-1500+). The digest was allowed to cool to room temperature and transferred into 50mL volumetric flask and made up to 50 mL with deionized water as a diluent. Freshly prepared Hg standard solution (1 mL/L) was made by appropriate dilution and used for prepared working standard solution. A SnCl2 water used as an acid solution to cold vapour VGA-AAS.

2.5. Quality control

Two replicate determinations were made for each sample. During all analysis, several blank determination was made and a mean blank value was deducted from sample readings before the results was calculated. Limit of detection (LOD) was calculated (LOD= x + 3s), where x is mean of at least 10 measurements of reagent blank solution and s is the standard deviation of those measurements. Accuracy of the method was tested by analysis of certified reference samples (n=10) of human hair; CRM-13 (National Institute for Environmental Studies (NIES), Japan). As well as the analytical chemical laboratory at the NARA has participated proficiency testing program for Hg within the same time in Food Analysis Performance Assessment Scheme (FAPAS), Sand Hutton, York, UK.

2.6. Statistical analysis

The results were statistically analysed by Microsoft Excel 2013 and statistical package for social science (SPSS). A one-way Analysis of Variance (ANOVA) was performed, followed by Tukey's test for comparisons of significant differences.

3. Results and discussion

The suitability of the T-Hg determination method was evaluated in terms of their respective
LOD, recovery value using CRM. NIES-14 was used as the CRM, the recovery of T-Hg was 94.5% and the LOD was 2.5 µg/kg. The results of proficiency testing scheme of analytical chemistry laboratory, NARA with good agreement (report no. 07215/2014, Z value for T-Hg=0).

Trace element concentrations in the human hair samples are well-documented on a global basis, with a focus on the non-essential elements especially on Hg. However, there were unable to find out the studies investigated the trace elements present in the human hair from Sri Lankan as studied here. In this study consists of 52 samples, ranging from 9-48 years in Negombo and 9-48 years in Welimada with a mean value of 28 and 27 years respectively.

In table 1, the consumption of a different fish category is presented; according to the questionnaire given in sampling time. Trenched Sardinesis (Hurulla) most common consumed small fish species while skip jack tuna (Balaya), yellowfin tuna (kelawalla) and treavallies (parava) are the most common large fish species consumed in the studied area. Only 3 individuals from Welimada area did not consume fish frequently and they consume only small species in small quantity (140 g/week). But according to the United State Environmental Protection Agency (USEPA) database, individuals who consumes less than one serving of fish per month are considered as no-fish consumption (100 g/month). In this study, there was no any single individual met with this criteria. With regards dietary habits of fish consumption, the majority of Negombo people were consuming small fish to large fish ratio 1:1 including small fish like sardines and large fish like skip jack tuna, yellowfin tuna and caranx. But the majority of Welimada people was consuming only small fish like sardines (hurulla). However, all participants of this survey consumed fish.

Table 1: Consumption of fish individuals from Negombo and Welimada sampling sites

Consumption type	Welimada	Negombo
Small fish; g/week	294	544
Large fish; g/week	101	823
Total average fish consumption; g/week	395	1367

It is well known that consumption of fish increases Hg concentrations in hair (Table 2). This was also shown in the present study. The average Hg concentration of Negombo samples (4.38 mg/kg) was nearly eleven times higher than the Welimada samples (0.39 mg/kg). As well as when Hg levels compare with fish consumption pattern, the hair Hg level in the Welimada area that consumed generally small fish was lower (0.29 mg/kg) than the person who consumed large fish (0.67 mg/kg) like tuna species and small fish in 1:1 ratio. The reason may be that the Welimada small fish consumed mainly Hurulla and sardine fish with relatively low Hg levels. But in Negombo sample group consumed large fish like tuna and small fish in 1:1 ratio, but not seen the individuals who consumed only small fish. This value is similar to those found in previous studies in Swedish and Canada and India [3, 4]. Jinadasa *et al*, 2014 reported that the Hg level of swordfish, yellowfin tuna and marlin of Sri Lankan waters were 0.90, 0.30 and 0.49 mg/kg respectively [7]. This high Hg value may significantly affect the highest Hg level of hair samples in the Negombo sample site. Finding of earlier studies showed that eating large carnivorous fish were implicated with elevated hair Hg levels [10, 11]. In our study, most of the individuals who are higher hair Hg concentration (>1mg/kg) consumed mainly larger and carnivorous fish. The present work represents a case study with limited sample size from Negombo and Welimada area. In order to evaluate the relationship between fish consumption and hair Hg level, further studies are required. The data may be used for a risk assessment of people in the studied area.

Table 2: Present the results obtained from the analysis of Hg in hair samples of male population living in coastal areas (Negombo) and mid country area (Welimada).

	Avg. Hg concentration ± SD, mg/kg	Range, mg/kg
Negombo	4.38±3.55	>LOD-13.38
Welimada	0.39±0.44	>LOD-1.58

In practical reason all the samples of this study from men. Cecilia, J., *et al*, 2014 and Oskarsson *et al.* (1994) observed that men had significantly higher Hg levels in hair than women [4, 12]. They suggested the reason was for this may be that men consumed larger serving of fish and sex related differences in metabolism. As well as the Hg levels of this study are also lower than values observed among population who depend on fish as a principle component of their diet, such as mothers from the Faroe Island (4.5 mg/kg) and Seychelles Island (5.8 mg/kg) [13].

More than half of the population (55.8%) in this study exceeded the safe limits of 1 mg/kg total hair Hg concentration, as recommended by the USEPA. This is almost similar to the study of Tengku *et al.*, 2010 in Malaysia [14]. They analysed 201 adults (17-72 years) hair samples and 59.3% of the population exceeded the 1 mg/kg level. When examined the hair Hg levels, only 13.6% of Welimada population and 86.7% of Negombo population exceeded the limits of 1 mg/kg. No individuals of Welimada population were not exceeded 5 mg/kg limits, but 10 individuals from Negombo population exceeded the 5 mg/kg limits, a level associated with a 5 % risk of neurological lesion [15]. Seven individuals out of ten that are fishermen.

Tests for Hg exposure in humans have been accomplished using analysis of blood, urine, nail clippings, or hair samples, with blood and hair samples the most commonly cited in the literature. Bio monitoring can show whether and how much an individual or a population has been exposed to a chemical. Although hair Hg concentrations are approximately 250 times greater than blood Hg concentrations. This may be because hair has a greater percentage methyl Hg relative to inorganic Hg than blood [16]. However, because some people are more sensitive than others, it is hard to predict how much someone will be affected by a given concentration of Hg in their bodies. Tengku *et al.* (2010) found that hair Hg level significantly relationship with gender, location of study, the amount of fish, age, body mass index (BMI), number of amalgam filling and use whitening cream [14]. But they conclude that the amount of fish consumed and age showed the greatest relation with Hg in hair.

Since fish is rich in many important nutrients [17, 18]. It is Unsatisfactory that fish consumption must be restricted. As long as the Hg levels in freshwater fish are high, the advice to pregnant women to avoid these species is necessary, but in the long run there is a need to reduce the Hg levels in fish so that they can be consumed without restrictions.

4. Conclusion

The present study provides information into the Hg concentration in hair samples from Negombo and Welimada. In conclusion, we found 55.8% of the study population has hair Hg levels exceeding the USEPA guideline of 1 mg/kg. Data pertaining to the Hg levels in hair samples of the studied area further research are required on the other factors connected such as sex, age and smoking habits. However, not only the risk of Hg contamination, but also food habits and nutritional benefits may have to be considered when determining a regulatory standard of fish. Hair analysis may, at least part, contribute to such decision by providing information on the Hg exposure levels of each individual.

Acknowledgement

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