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Correlation Between Some Selected Trace Metal Concentrations in Six Species of Fish from the Arabian Sea

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The role of trace metals in marine ecosystems has been keenly investigated during recent years. The toxicity of the individual metals and their ability to promote various metabolic activities of organisms are well documented (Doudoroff and Katz, 1953). Current investigations are largely based on studies dealing with the influence of trace metals on environmental and physiological processes that govern their distribution in aquatic organisms and the ability of the latter to accumulate both essential and non-essential metals. It is known that abundance of essential trace metals regulates the metal content in the organisms by homeostatic control mechanisms (Bryan and Hummerstone 1973), which when cease to function cause essential trace metals to act in an either acutely or chronically toxic manner. Therefore, a correlation study based on essential and non-essential trace metal concentrations is imperative for extending the existing knowledge of bioaccumulation of trace metals in marine organisms. Earlier studies mainly focussed on the distribution of mercury in some selected fish (Evan et al. 1972; Vinogradov, 1953). The concentration of selected essential trace elements (Cu, Zn, Fe and Pb) in various organs of Tuna fish were estimated by Establier in 1970. Some quantitative correlations between lead, cadmimum, copper, zinc and iron concentrations in frozen tuna fish caught from Canary Islands have also been reported (Galindo et al, 1986). Nonetheless, little is yet known about important essential and non-essential trace metal correlation in fish of commercial importance.

In line with the importance of the distribution of essential and non-essential trace metals cited above, an attempt has been made in the present investigation

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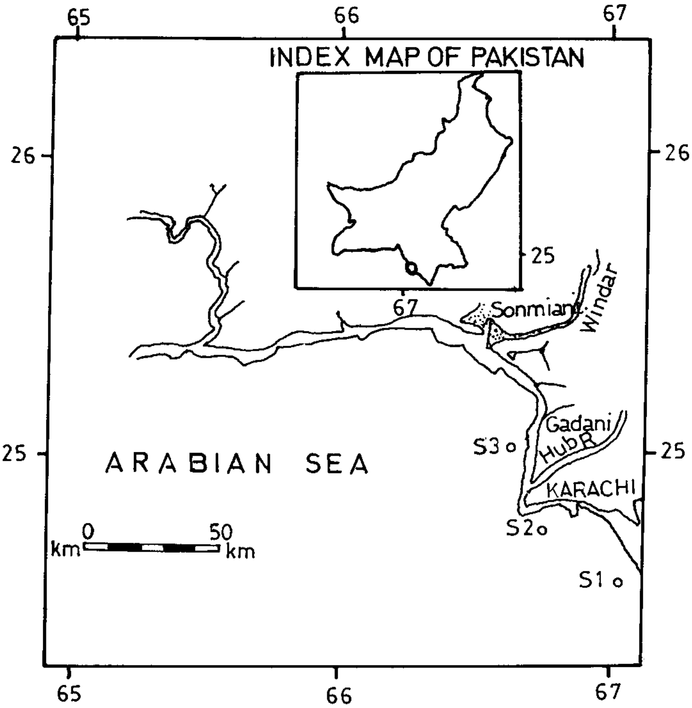

Figure 1. Location of sampling sites along Karachi coast.

to bring out quantitative correlations between the concentrations of iron, copper, lead and zinc in the edible muscle tissue of six species of marine fish: Salmon (salmon sole); tuna (thunnus thynnus); pomfret silver (pampus argenteus); Pomfret black (formioniger); long tail tuna (thynnus tonggel) and Indian oil sardine (sardinella longiceps). These fish are abundantly available in Pakistan along the coastal line of the Arabian Sea and have great commercial value. The computational analysis on the trace metal correlation was conducted using an MSTAT statistical package.

MATERIALS AND METHODS

The eighty-eight samples of fish belonging to six different species (Table 1) were caught from nearshore waters along the Karachi coastal line of the Arabian Sea (Figure 1) and were analyzed for the trace metal content. Atomic absorption method was used to this effect as per analytical procedure given by Teeny et al. The procedure consists of heating a given muscle tissue sample under an infra-red lamp, converting it to a white ash in muffled furnace and digesting in 4% HNO3. A Hitachi flame atomic absorption spectrophotometer, model 170-10, was used throughout the investigation. All reagents used were of GR grade. Calibration of the instrument and analysis of the samples were

Table 1..Trace Metal Concentrations and related statistical parameters for various fish

Species/Location*	n**	Level	Trace Metal Concentration µg/g(wet weight)			
			Cu	Zn	Fe	Pb
Salmon/S1,S2,S3	16	Range	0.100-0.215	0.0843-1.357	1.177-1.823	0.022-0.034
		Mean	0.156	1.100	1.500	0.028
		S.D.	±0.059	±0.257	±0.323	±0.006
Tuna/S2,S3	17	Range	0.199-0.219	0.805-1.735	1.769-2.591	0.065-0.089
		Mean	0.209	1.270	2.180	0.078
		S.D.	±0.010	±0.465	±0.411	±0.013
Pomfret silver/ S1,S2,S3	10	Range	0.141-0.281	0.284-0.482	1.378-2.744	0.023-0.039
		Mean	0.211	0.383	2.061	0.031
		S.D.	±0.070	±0.099	±0.683	±0.008
Pomfret black/ S2,S3	16	Range	0.322-0.510	0.386-0.948	0.932-1.852	0.045-0.085
		Mean	0.416	0.667	1.392	0.065
		S.D.	±0.094	±0.281	±0.460	±0.020
Longtail tuna/ S1,S2,S3	18	Range	0.127-0.201	2.630-4.090	0.341-0.509	0.037-0.109
		Mean	0.164	3,490	0.425	0.086
		S.D.	±0.037	±0.600	±0.084	±0.023
Indian Oilsardine/ S1,S2,S3	11	Range	0.129-0.289	1.512-2.714	4.016-5.984	0.049-0.129
		Mean	0.209	2.113	5.000	0.089
		S.D.	±0.080	±0.601	±0.984	±0.040

* with reference to Figure 1. ** number of samples.

Table 2. Corelation equations for intermetal concentrations* in various fish

Species	Equation	Correlation**
Salmon	[Fe] = 0.30 + 1.088[Zn]	0.976
	[Cu] = -0.09 + 0.222[Zn]	0.991
	[Cu] = -0.12 + 9.714[Pb]	0.969
	[Cu] = -0.14 + 0.197[Fe]	0.980
Tuna	[Fe] = 0.86 + 1.042[Zn]	0.979
	[Cu] = 0.19 + 0.016[Zn]	0.917
	[Cu] = 0.18 + 0.355[Pb]	0.685
	[Cu] = 0.18 + 0.041[Fe]	0.853
Pomfret silver	[Fe] = -0.75 + 7.333[Zn]	0.982
	[Cu] = -0.04 + 0.652[Zn]	0.983
	[Cu] = -0.02 + 7.393[Pb]	0.972
	[Cu] = 0.03 + 0.086[Fe]	0.972
Pomfret black	[Fe] = 0.31 + 1.617[Zn]	0.995
	[Cu] = 0.21 + 0.314[Zn]	0.996
	[Cu] = 0.08 + 5.136[Pb]	0.968
	[Cu] = 0.15 + 0.192[Fe]	0.993
Indian Oil sardine	[Fe] = 1.50 + 1.656[Zn]	0.973
	[Cu] = -0.08 + 0.138[Zn]	0.988
	[Cu] = 0.02 + 2.103[Pb]	0.975
	[Cu] = -0.19 + 0.081[Fe]	0.983
Longtail tuna	[Fe] = 0.07 + 0.102[Zn]	0.967
	[Cu] = -0.02 + 0.053[Zn]	0.949
	[Cu] = 0.05 + 1.307[Pb]	0.802
	[Cu] = -0.06 + 0.515[Fe]	0.981

* all concentrations in µg/g. ** at 0.000 significance

Table 3. Multiple-metal correlation equations for various fish

Species	Equation	R^2	Multiple R	St.Error
Salmon	[Zn]= 0.337 + 3.899[Cu] + 0.106[Fe]	0.983	0.991	0.024
Tuna	[Zn]= -3.917 + 17.720[Cu] + 0.679[Fe]	0.984	0.992	0.041
Pomfret silver	[Zn]= 0.874 + 0.752[Cu] + 0.067[Fe]	0.979	0.989	0.012
Pomfret black	[Zn]= -0.451 + 1.800[Cu] + 0.266[Fe]	0.994	0.997	0.016
Longtail tuna	[Zn]= -0.403 - 0.062[Cu] + 9.185[Fe]	0.936	0.967	0.116
Indian oilsardine	[Zn]= 0.551 + 6.664[Cu] + 0.034[Fe]	0.977	0.988	0.068

performed with background corrections. Parallel WHO standars were run for checking our own standards. Control standard samples of fish were periodically analyzed to check the accuracy of the results. Metal correlation equations and multiple regression results were obtained using the MSTAT package on a WANG personal computer.

RESULTS AND DISCUSSION

The extremum concentrations of copper, zinc, iron and lead, together with mean and standard deviation values, for various fish are listed in Table 1. These values indicate that the species under investigation pose no health hazard to the consumer as their trace metal content remains well within the permissible range laid down for their safe consumption (NRC, 1980). The mean values for the concentrations of metals estimated in tuna in the present study are lower than those reported by Vinogradov (1953), and Galindo (1986). The observed concentrations of zinc are far less than the corresponding values quoted by Mershina et al. for various ocean fish. The mean concentration of copper ranges from 0.156-0.416 μg/g (wet weight) for all the fish species, in close agreement to the copper content of 0.15 - 0.75 μg/g by Brooks and Rumsey (1974). The mean zinc values range from 0.383 - 3.490 μg/g, less than the corresponding zinc content found in most marine fish. However, this range is in close agreement with the one given by Van. As et al. (1975). Similarly, the mean iron and lead contents are within the mean ranges quoted by these workers. In general, our results, though for different species of fish, compare well with those by Tenny et al. (1984).

The data in Table 1 suggest a possible correlation between various trace metals. Statistical analysis was conducted to check if such a correlation existed. The MSTAT package for statistical analysis was used for drawing the regression lines of correlation and it was found that the best correlation existed between iron and zinc, copper and zinc, copper and lead and copper and iron. Typical computer plotted relationships are shown in Figure 2 and Figure 3. The relevant equations obtained through this analysis are given in Table 2 for the six species of fish. Also given in the table are the correlation coefficient values that show a remarkably high positive correlation. Table 3 contains quantitative equations describing the dependence of zinc concentrations in various fish on the corresponding concentrations of copper and iron. The selection of the variables in this case was tentative in that the R-square, multiple and standard error of determination data showed promise for a positive interrelation in

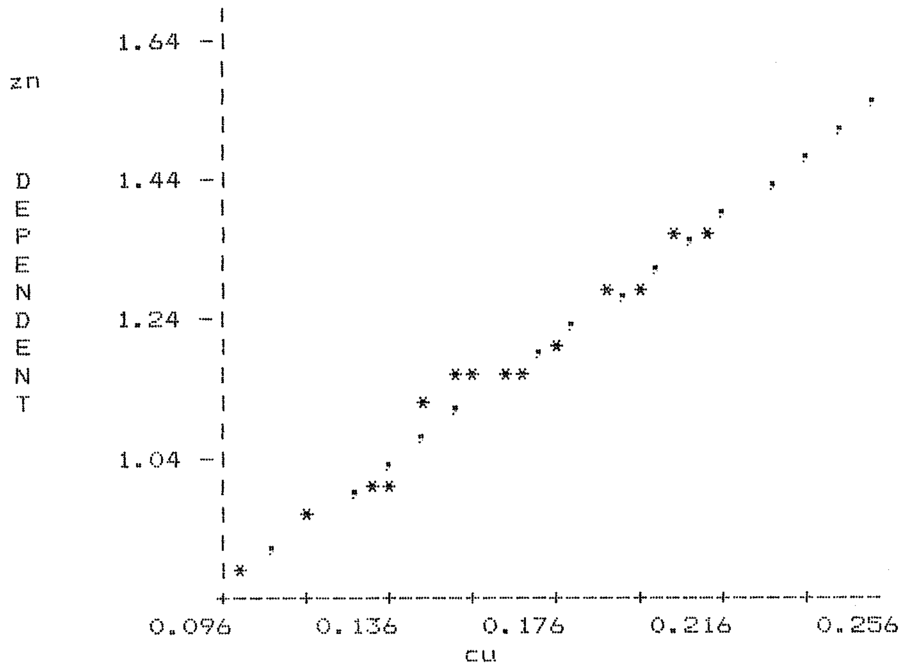

Figure 1.Computer plot of[Zn]versus[Cu]for salmon

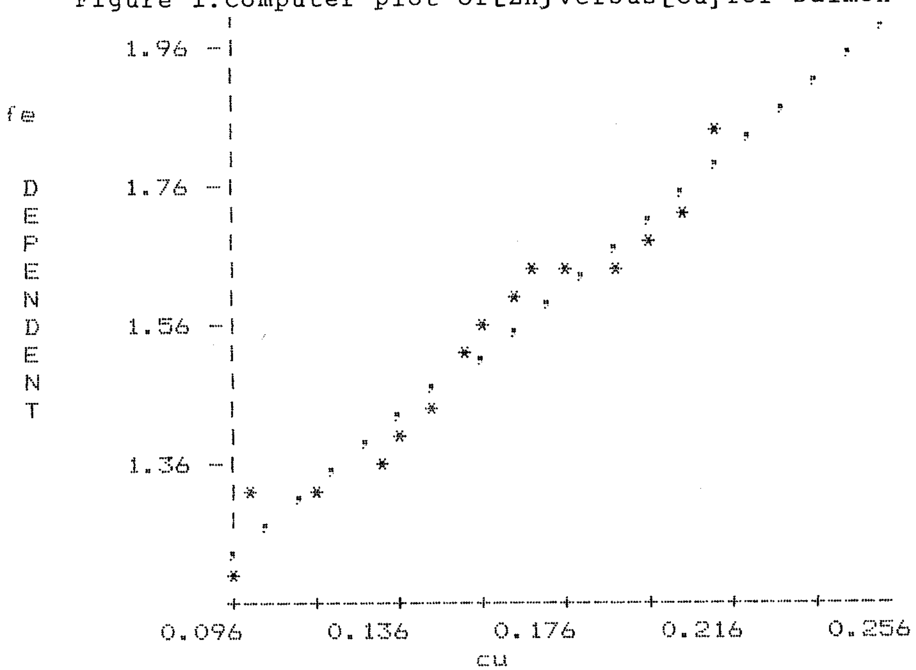

Figure 2.Computer plot of[Fe]versus[Cu]for salmon.

each case. Although the present investigation shows potential of application of trace metal data to the establishment of correlation between six different species of marine fish, yet additional studies are imperative to explain these simple and multiple inter-metallic correlations on metabloic and pollution grounds.

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