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Natural Zeolite Mediated Mercury Toxicity in Fish

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Abstract : There is no truly effective treatment of mercuralism, once it gets in to the body. In the present investigation, efforts have been made to study the role of natural zeolite stilbite for remediation of mercury toxicity. Zeolites are naturally and artificially occurring ion exchangers. Heavy metal viz. mercury takes the position of element present in the molecular sieve of zeolite in the exposure water. Thus, heavy metal becomes unavailable to fish. During the study, experimental fish were exposed to mercuric chloride, mercuric chloride + stilbite and stilbite only. Values of protein contents in the liver, kidney and gills of teleost fish *Heteropneustis fossilis* in various experimental groups indicates that the toxicity of mercury is reduced due to addition of zeolite. It is also observed that exposure of fish to stilbite only increase the protein contents in the fish tissue significantly, suggests that natural zeolites can be used not only for the remediation of metal toxicity, rather also for enhancing protein contents in the fish.

Key words : Stilbite, Mercury, Fish, Protein, Liver, Kidney, Gill.

Introduction :

According to both, the World Health Organization (WHO) and the US Environmental Protection Agency (EPA), consumption of fish and marine mammals, is the single most important source of human exposure to methyl mercury. Methyl mercury is a potent neurotoxin that concentrates at increasingly poisonous levels in the body. It can pass through the placental barrier during pregnancy causing severe neurological damage in developing fetuses. Fish dependent populations are not only exposed to mercury but their exposure is the most highly potent organic form of mercury that damages the central nervous system and can decimate fishing communities for generations.

Mercury poisoning, also known as mercuralism, is the phenomenon of toxicities by contact with mercury. Human activities like the application of agricultural fertilizers and industrial waste water disposal are examples of how humans release mercury directly in to the soil and water. Mercury toxicity is a serious problem since it does not degrade in the environment; therefore its removal is difficult. It is highly toxic particularly to children and the developing foetus, where it interferes with development, particularly the maturation process of the brain. Whatever form, mercury is in elemental, inorganic or organic, it is toxic, and there is no truly effective treatment once it gets into the human body. Chelating therapy may help but there are doubts about the effectiveness.

Fish accumulates mercury directly from food and the surrounding water which gets biomagnified in fish and fish products and constitutes an important part of human diet.

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Methyl mercury is a well-known human neurotoxin. The accumulation of heavy metals in different organs of fish as a whole in marine as well as freshwater has been described by several workers (Eaton, 1974; Wright, 1976; Pentreath, 1977; Edgren and Notton, 1980). It has been demonstrated that gills and gut could be important transfer route for mercury in insect nymphs (Saouter *et al*., 1991 and Odin *et al*., 1995 and 1996). Mercury accumulates in fish tissue is usually in the form of methyl mercury, while the source is usually inorganic mercury (Huckabee *et al*., 1979). It is generally agreed that mercury concentrations in carnivorous fish are higher than in non carnivorous species (Watras and Huckabee, 1994). Schweiger (1957) investigated the effect of mercury ions on fish and their food organism and suggested a toxic threshold concentration of 0.03 mg/litre for various species tested.

There is no truly effective treatment of mercuralism, once it gets in to the body. In the present investigation, efforts have been made to study the role of natural zeolite stilbite for remediation of mercury toxicity. Zeolites are naturally and artificially occurring ion exchangers. Heavy metal viz. mercury takes the position of element present in the molecular sieve of zeolite in the exposure water. Thus, heavy metal becomes unavailable to fish.

Zeolites are naturally occurring, fine-grained materials with pronounced ion exchange properties. Small amount of zeolites increase biomass production and improves nitrogenous efficiency. They promote better plant growth by improving the value of fertilizer. They also improve water quality and filtration in aquaculture. Element present within molecular sieve of zeolite is exchanged with heavy metal of water resource. This result into non-availability of heavy metal to fish and thus deleterious effects to fish (Jain *et al*., 1997; Jain, 1999 and Shrivastava *et al*., 2004). Mercury causes depletion in protein, RNA and glycogen contents (Shakoori *et al*., 1994). In the contaminated water the sodium of zeolite is exchanged with heavy metal ions in their molecular sieve; at the same time, natural zeolite helps in protein digestion in cattle, sheep and goats (Petkova *et al*., 1984).

The present study has been planned at assessing the protein contents of liver, kidney and gills of teleost fish *Heteropneustes fossilis* in normal conditions and under the influence of mercuric chloride, mercuric chloride+stilbite and only stilbite. This study explores the possibility of usefulness of natural zeolite stilbite for remediation of mercury toxicity and economic opportunities to fish farmers.

Materials and Methods :

Prior to experimentation, 120 healthy, adult specimens of teleost fish *Heteropneustes fossilis* (Bloch.) have been acclimatized for two weeks to laboratory conditions. By interpolation method, 96h LC_{50} value for $HgCl_2$ determined (2 mgl^{-1} day^{-1}). Fish were divided into four equal groups. Group I served as control while group II, III and IV exposed to sublethal concentration of mercuric chloride, mercuric chloride+stilbite and only stilbite, respectively. During experimental study, sublethal concentration of $HgCl_2$ and equal amount of stilbite powder sprinkled into exposure water. Fishes were sacrificed after 7, 14, 21, 28 and 35 days of exposure, their liver, kidney and gill tissues were removed

Table : Values of protein content (mg/g) in the fish tissue in various treatment groups.

Fish tissue	Days of Exposure	Control	Treatment groups					
			$HgCl_2$		$HgCl_2$+Stilbite		Only Stilbite	
Liver	7	82.06±1.65	57.87±1.37	P<0.001	59.97±1.40	P<0.001	86.90±1.70	P<0.001
	14	82.19±1.65	57.08±1.38	P<0.001	60.34±1.41	P<0.001	86.94±1.70	P<0.001
	21	82.29±1.65	58.15±1.39	P<0.001	61.30±1.42	P<0.001	86.12±1.70	P<0.001
	28	82.46±1.65	59.02±1.40	P<0.001	62.43±1.44	P<0.001	88.48±1.71	P<0.001
	35	82.53±1.65	61.02±1.42	P<0.001	63.42±1.45	P<0.001	89.22±1.72	P<0.001
Kidney	7	69.84±1.52	47.08±1.25	P<0.001	50.12±1.29	P<0.001	71.23±1.54	P<0.001
	14	69.88±1.52	48.05±1.26	P<0.001	51.00±1.30	P<0.001	74.51±1.57	P<0.001
	21	69.89±1.52	49.04±1.27	P<0.001	52.20±1.31	P<0.001	75.21±1.58	P<0.001
	28	69.98±1.52	50.15±1.29	P<0.001	53.38±1.33	P<0.001	76.42±1.59	P<0.001
	35	69.98±1.52	51.48±1.31	P<0.001	54.72±1.35	P<0.001	78.06±1.61	P<0.001
Gill	7	63.93±1.46	44.70±1.22	P<0.001	47.67±1.26	P<0.001	64.85±1.47	P<0.001
	14	63.85±1.46	45.68±1.23	P<0.001	48.48±1.27	P<0.001	69.50±1.52	P<0.001
	21	63.98±1.46	46.43±1.24	P<0.001	49.81±1.28	P<0.001	70.02±1.52	P<0.001
	28	64.00±1.46	47.09±1.25	P<0.001	50.73±1.30	P<0.001	71.03±1.53	P<0.001
	35	64.02±1.46	48.81±1.27	P<0.001	51.70±1.31	P<0.001	72.06±1.54	P<0.001

and processed for quantitative estimation of protein by Lowery (Folin-Ciocalteau) method. Student's 't' test was applied for statistical evaluation of data.

Results and Discussion :

According to observation table, values of protein contents in liver, kidney and gills are almost similar to those of the initial control fish. Sublethal concentration of mercuric chloride decreases the protein contents significantly. Addition of stilbite to the exposure water improves the values towards normal. When fishes were exposed to stilbite only, protein contents in the tissue increased in comparison to control.

Ram and Sathyanesan (1984) reported that mercuric chloride reduces the protein, lipid and cholesterol contents in various tissues of C*hanna punctatus*. Sastry and Gupta (1978) emphasized that over all decrease in protein contents is probably due to enzyme inhibition which plays an important role in protein synthesis. Kidney lysosomes tend to accumulate mercury (Suzuki, 1977). Although Backstrom (1969) reported that despite relatively high level of methyl mercury, fishes do not show any over toxicity.

Dhanapakiam *et al*. (1998) studied the gill of mature *Channa punctatus* exposed to effluent of industrial water in the Cauvery river water for 45 days, revealed deformities and also observed that the secondary lamellae of primary filaments showed hyperplasia. Khangarot (1982) reported that gill epithelium-exhibited varying degrees of hypertrophy, the gap between the basement membrane and the epithelial layer increased in size and the lamellar capillary was dilated due to zinc toxicity in *Puntius sophore*. Liver is the most important target organ for heavy metal toxicity (Holocombe *et al*, 1976). Decrease in soluble protein, RNA and glycogen contents and hepatic enzymes due to mercury have been reported by Shakoori *et al*. (1994).

There are a number of metal chelators which are used for the remediation of metal toxicity as reported by Graziano *et al*. (1985); Klavassen (1985); Chislom (1970 & 1971); Friedhein *et al*. (1978) and Hammond (1971). The element in the molecular sieve of zeolites is exchanged with metal ion thus the concentration of metal is decreased in the exposure water; as a result deleterious effects in the tissues are reduced (Jain, 1999, 2001; Jain and Shrivastava, 2000; Jain *et al*., 2003). The removal of ammonia from aqueous solution by natural zeolites has been investigated by Aral *et al.* (1999). Among the various cation exchangers, zeolites are preferred due to its high specificity for heavy metal cations (Sherman, 1978; Semmens and Sayfarth, 1978). In the present study, it can be concluded that natural zeolite stilbite is useful and can be used for attenuation of mercury toxicity and enhancing the protein contents in fish.

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