Volume: I: Issue-2: Aug-Oct -2010 IJABPT ISSN 0976-4550
Review Article

TOXICITY OF SODIUM DODECYL SULFATE IN FISHES AND ANIMALS. A REVIEW.

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ABSTRACT : Sodium dodecyl sulfate (SDS) is one of the most commonly used detergent in house holds and in Industry. It is a component of a number of industrially useful products. After use, like all other xenobiotics, it is discharged in water bodies in huge amounts. It is now realized that it is toxic to fishes and to animals. In this review, we have made an attempt to compile the data regarding the toxicity of Sodium Dodecyl sulfate in fishes and animals.
Keywords: Sodium Dodecyl sulafate (SDS), Alcohol sulfates (AS), Toxicity, Fishes.

Introduction

Cleanliness has been an important concern for human beings from time immemorial thus initially, soap making and gradually production of synthetic detergents came into being. Subsequently with time and upsurge of industrial revolution, other uses of detergents were realized. The present detergent industry is not solely concerned with household needs but is also catering to the needs of industry and other areas where detergents are now widely used. Among different classes of detergents available, only few types of detergents are currently used in large quantities in the market. Excluding soap, which is definitely the most widely used anionic detergent, the market is dominated by Linear Alkylbenzene Sulfonate (LAS), and alcohol derivatives like Alcohol sulfates (AS), Alcohol Ether Sulfates (AES) and Alcohol Ethoxylates (AE) (Karsa, 1992).

Sodium Dodecyl Sulfate (SDS), a primary alkyl sulfate is a member of Alcohol sulfate family. Synthetic primary alkyl sulfates are based on feedstocks derived from long-chain olefins by the use of the oxo process, which yields a mixture of linear and branched primary alcohols. Sulfonation of the mixed alcohols produces a mixture of linear primary alkyl sulfates (LPAS) and branched primary alkyl sulfates (BPAS), which have excellent detergent properties and are widely used in heavy-duty detergent applications. SDS denoted by molecular formula $NaC_{12}H_{25}SO_4$, has a molecular weight of 288.38 g mol^{-1}. SDS synthesis is a relatively simple process involving the sulfation of 1-dodecanol followed by neutralization with a cation source. Purification is accomplished through repeated extraction. It is available commercially in both broad-cut and purified forms (Dolkemeyer, 2000).

SDS is widely used in household products such as, toothpaste's, shampoos, shaving foams, bubble baths, and cosmetics. In industry it is used as leather softening agent, wool cleaning agent, in paper industry as penetrant, flocculating agent, de-inking agent, in building construction as additive of concrete, oil well fire fighting, fire fighting devices, engine degreasers, floor cleaners, and car wash soaps etc. SDS can enhance absorption of chemicals through skin, gastrointestinal mucosa, and other mucous membranes. Importantly it is also used in trans- epidermal, nasal and ocular drug delivery systems, to enhance the intestinal absorption of poorly absorbed drugs and it is also now widely used in biochemical research involving electrophoresis (Hauthal, 1992).

Occurrence of SDS in environment arises mainly from its presence in complex domestic and industrial effluents as well as its release directly from some applications (e.g., oil dispersants and pesticides). It has been reported that SDS is toxic and affects survival of aquatic animals such as fishes, microbes like yeasts and bacteria. It is also toxic to mammals like mice and humans but to a lesser extent (Fendinger et. al., 1994).

Toxicity of SDS in Various organisms

Fishes:

SDS has been shown to be toxic to fishes. Morphological changes occur in the kidney and spleen of gilthead (*Sparus aurata*, L) if they are exposed to SDS concentrations of 5, 8.5, 10 and 15 mg/l. Intensity of morphological changes depend on detergent concentrations and length of exposure. Kidney showed loss of normal structure with tubular and renal corpuscle retraction; spleen showed tendency to damage the reticulae structure and a progressive increase of leucocytes and red cells infiltration (Ribelles et. al., 1995). Similar result was also reported in trunk kidney of juvenile turbot (*Scophthalmus maximus*, L). When lots of 20 juvenile turbots were exposed to SDS concentrations of 3, 5, 7 and 10 mg/l: the exposure time required for 50% mortality of the specimens was 384, 190, 12 and 4 h. The abnormalities observed in kidney included vacuolation and desquamation of epithelial cells and degeneration of glomeruli and tubules. Some changes in the normal distribution of carbohydrates and proteins were also observed. Altogether the function of kidney was seriously affected indicating that mortality of turbots may be significantly affected if exposed to increased concentrations of SDS (Rosety et. al., 2001).
There are reports, which reveal that SDS affects metabolism and swimming capacity of fish (*Cyprinus carpio*) (Barbieri et. al., 1998). It was found that oxygen consumption increases while swimming capacity decreases with increasing concentrations of SDS in all size classes of fish studied. At the highest concentration (10 ppm), swimming capacity was reduced 5 times and oxygen consumption increased 2.8 times in comparison to the control. In general, the effects on swimming activity were more pronounced in smaller fish whereas the effects on oxygen consumption were more pronounced in larger ones. Sub-lethal chronic effects of SDS on the survival, metabolism, and growth of juveniles of *Centropomus parallelus* at three different salinities have also been reported (Rocha et. al., 2007). For each group of exposure to nominal concentrations of SDS (0.10 and 0.25 mg/L) at the different salinities (5, 20, and 30 %), there were significant differences in the specific growth rate, oxygen consumption, and ammonia excretion rates, O: N atomic ratio at the different exposure periods (15 and 30 days).

The acute toxicity of two anionic surfactants namely, alkyl benzene sulfonate (ABS) and SDS was studied on the eggs of gilthead (*Sparus aurata*, L). Clear dose-response relationships for mortality of gilthead eggs was observed for both toxicants; at 30 mg/L 50% mortality took place at 45 minutes for ABS and 8 minutes for SDS. At this concentration, SDS was almost six times more toxic than ABS. It was observed that SDS was more toxic than ABS at high concentrations whereas at low concentrations their toxicity was more or less similar. SDS also affects the fertilizing capability of gilthead (*Sparus aurata L*.) sperm. Exposure to SDS in concentrations of 0.3, 0.6, 1.5, 3 and 6 mg/L for 60 minutes caused a significant inhibitory effect on fertilization success in gilthead *Sparus aurata L.* (Rosety et. al., 2001).

Mammals:

SDS is known to cause harmful effects on humans and animals, which consume water contaminated with it. SDS elicits both, physical and biochemical effects on cells, the membrane being the primary target structure (Singer and Tjeerdema, 1993)). It has been reported that repeated exposures of SDS causes skin irritation and hyperplasia in guinea pigs (Lindberg et. al., 1992). Epidermal cell proliferation and differentiation were investigated *in vitro* after exposure to the SDS (Van de Sandt et. Al., 1995). In a study human skin organ cultures were exposed topically to various concentrations of SDS for 22 h, after which the irritant was removed. Cell proliferation was moderately increased at concentrations of SDS that did not affect the histomorphology (0.1% and 0.2% SDS). A marked increase of cell proliferation was observed at 22 to 44 h after removal of SDS at a concentration (0.4%) that induced slight cellular damage. Exposure of human skin organ cultures to a toxic concentration of SDS led to decreased cell proliferation. Transglutaminase and involucrin were expressed in the more basal layers of the epidermis after exposure to 0.4% or 1.0% SDS. Moreover, intra-epidermal sweat gland ducts were positive for transglutaminase at these irritant concentrations. These *in vitro* data demonstrate that SDS-induced alterations of epidermal cell kinetics, as described *in vivo* are at least partly due to local mechanisms and do not require the influx of infiltrate cells. There was also increase in interleukin-1 alpha or interleukin-6. Rabbit skin cultures appeared more sensitive to SDS than human skin. At nontoxic doses, the irritant induced an increase of epidermal cell proliferation, similar to that observed in human skin discs.

The influence of *in vivo* administration of detergents on serum lipid composition was studied in rats (Miura et. al., 1989). Male Wistar rats received 50 mg SDS/ kg body weight intra peritoneally for 3 consecutive days. SDS administration increased the level of cholesterol esters and phospholipids and reduced the levels of triglycerides and cholesterol esters. In spite of the changes in serum lipid composition, the administration of SDS did not affect the amount of total lipids in rat serum. It was postulated that liver damage due to administration of SDS is responsible for the changes in serum lipid and fatty acid composition in detergent-treated rats.

In another study, cultured bovine lenses were used to study the effects of the surfactant SDS on lens optical properties and mitochondrial integrity (Bantseevet. et. al., 2003). Bovine lenses were exposed to SDS (0.1 to 0.00625%) for 30 min and cultured for 24 h. Compared to controls, loss of sharp focus was evident immediately following exposure to 0.1% SDS. At 24 h loss of sharp focus became evident in all groups. Loss of lens transparency, significant increase in lens wet weight, and axial length was seen at 24 h post exposure in lenses treated with 0.1 to 0.025% SDS. Confocal analysis of 24 h post exposure showed SDS concentration-dependent decrease in number and length of the mitochondria in lens epithelial and superficial cortical fiber cells. The results of this study showed a correlation between lens optical properties and metabolic functions thereby providing a sensitive *in vitro* model of ocular chemical toxicity. Results of confocal analysis suggest that the mitochondrial integrity of the superficial cortical fiber cells is most sensitive to damage caused by SDS.

In conclusion, available data suggest that the use of SDS in various industry and household products is increasing at an alarming rate. The consequences arising from its overuse and subsequent disposal in waterways are of serious concern especially for health of humans. So, there is a need to figure out methods for degradation of this detergent present in system. Biodegradation of this detergent by bacteria seems to be an efficient and inexpensive method for successful removal of this detergent. There are reports that there are certain group of bacteria belonging to *Pseudomonas sp.*, which are capable of degrading this detergent and utilizing it as a carbon source. However, a detailed study involving the bacteria and there corresponding enzymes are required for developing an appropriate remediation technology for SDS present in any habitat.

Acknowledgements

V.C. is grateful to Council for Scientific and Industrial Research (CSIR), New Delhi, India for the award of Junior Research Fellowship. This study was partly supported by a research grant sanctioned to A.K. by the Department of Biotechnology, Govt. of India, New Delhi (BT/PR1239/AGR./02/065/98).

REFERENCES

A. Ribelles, C. Carrasco, M. Rosety and M. Aldana (1995). A histochemical study of the biological effects of sodium dodecyl sulfate on the intestine of gilthead seabream, *Sparus aurata*. Ecotoxicology and Environmental Safety, 32: 131-138.

A. J. Rocha , V. Gomes, P. V. Ngan , M. J. Passos and R. R. Furia (2007). Effects of anionic surfactant and salinity on the bioenergetics of juveniles of *Centropomus parallelus* (Poey). Ecotoxicology and Environmental Safety, 3: 397-404.

D. R. Karsa (ed.) (1992). The Industrial applications of surfactants. (Special publication 107), Royal Society of Chemistry, Cambridge, UK, vol. III: 286.

H. G. (1992). Hauthal Trends in surfactants. Chimika Oggi, 10: 9-13.

E. Barbieri , P. V. Ngan and V. Gomes (1998). The effect of sodium dodecyl sulfate, on the metabolism and swimming capacity of *Cyprinus carpio.* Revista Brasileira de Biologia. 2: 263-271.

J. J. Van de Sandt , T. A. Bos and A. A. Rutten (1995). Epidermal cell proliferation and terminal differentiation in skin organ culture after topical exposure to sodium dodecyl sulfate. In Vitro Cellular & Developmental Biology – Animal. 10: 761-766

M. Rosety , F. J. Ordonez , R. M. Rosety, J. M. Rosety, I. Rosety , C. Carrasco and A. Ribelles (2001). Comparative study of the acute toxicity of anionic surfactants alkyl benzene sulfonate (ABS) and sodium dodecyl sulfate (SDS) on gilthead, *Sparus aurata* L., eggs. Histology and Histopathology, 4: 1091-1095.

M. M. Singer and R. S. Tjeerdema (1993). Fate and effects of the surfactant sodium dodecyl sulfate. Reviews of Environmental Contamination & Toxicology, 133: 95-149.

M. Lindberg , B. Forslind, Sagstrom and G. M. Roomans (1992) Elemental changes in guinea pig epidermis at repeated exposure to sodium lauryl sulfate. Acta Dermato-Venereologica, 6: 428-431.

N. J. Fendinger, D. J. Versteg, E. Weeg , S. Dyer and R. A. Rapaport (1994). Environmental behavior and fate of anionic surfactants. *In*: Environmental Chemistry of Lakes and Reservoirs, (ed. L. A baker). American Chemical Society, Washington DC, USA: 527-557.

R. M. Rosety, F. J. Ordonez, M. Rosety , J. M. Rosety, I. Rosety , A. Ribelles and C. Carrasco (2001). Morpho-histochemical changes in the gills of turbot, *Scophthalmus maximus L.*, induced by sodium dodecyl sulfate. Ecotoxicology and Environmental Safety, 3: 223-228.

V.Bantseev, D.McCanna, A.Banh, W. W.Wong, K. L.Moran, D. G.Dixon, J. R. Trevithick and J. G. Sivak (2003). Mechanisms of ocular toxicity using the *in vitro* bovine lens and sodium dodecyl sulfate as a chemical model. Toxicological Science, 1: 98-107.

W. Dolkemeyer (2000). Surfactants on the eve of the third millennium, challenges and opportunities. *In*: Proceedings of 5th World Surfactant congress (Cesio), May-June 2000,., Florence, Italy, vol. I: 39-55.

Y.Miura, H. Hisaki, B. Fukushima, T.Nagai and T. Ikeda (1989). Detergent induced changes in serum lipid composition in rats. Lipids, 11: 915-918.