A Review On Tributyltin (TBT) Biodegradation By Microbes And Study Of Degradation Pathway.

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Abstract – There are various industrial chemicals which are contaminating the resource of ecosystem. These chemicals are hazardous cannot degradable and recalcitrant in nature. Out of those Tributyltin (TBT) one of the toxic chemicals present in water bodies, due to its usage as a biocide in anti-fouling paint, commonly known as bottom paint, applied to the hulls of ocean going vessels. Bottom paint improves ship performance and durability as it reduces the rate of biofouling (the growth of organisms on the ship's hull). But the problem of TBT arising in the water resources, various reports have been revealed the negative impact on living beings. Thus there is need of biodegradation of Tributyltin , in this direction various microorganisms showed degradation of Tributyltin, in this article reviews on the effect of Tributyltin and its biodegradation process.

Key words- Tributyltin(TBT), biodegradation, recalcitrant , biofouling , hazardous.

Introduction- Tributyltin (TBT) is a effective biocide to facilitate been widely used in numerous industrial processes and it is measured a importunate organic pollutant (Guillette and Iguchi, 2012; Chapman and Guillette, 2013). As recurrently reported, TBT has strong negative effects in both eukaryotic and prokaryotic organisms (Antizar-Ladislao, 2008), being *imposex*—the superimposition of male sexual characteristics on female gastropods effect occurs. Tributyltin composed of tributylstannyl or tributyl stannic hydride compounds which are organotin compounds. A general formula for these compounds is $(n\text{-}C_4H_9)_3Sn\text{-}X$. Also, several studies have verified the potential of TBT to be bioaccumulated, augmenting on the food chain (Murata et al., 2008).

Its properties are-

- These compounds have a low water solubility.
- Suitable as an antifouling agents
- These toxic compounds of TBT prevents the growth of algae, barnacles, molluscs and other organisms on ships hulls and hydrophobic in nature .
- These compounds have a high fat solubility and absorb more easily to organic matter in soils or sediment.
- TBT effects on organisms such as molluscs, oysters and dolphins, have extreme effects on their reproductive systems, central nervous systems and endocrine systems.

- TBT half-life is one or two weeks in marine water system (Davies, Alwyn George., 2004 ; Mora., 1996; *Anti-fouling Systems"*. www.imo.org. *Retrieved 2020-09-16*.)

Uses of Tributyltin-

- TBT compounds are biocides. TBT's antifouling properties was discovered in the 1950s in the Netherlands by van der Kerk and coworkers.
- It prevents microorganisms commencing settling on the hull of a ship and poisons the organisms that do. By the mid 1960s it had become the most popular anti-fouling paint around the globe.
- TBT was mixed into paints to improve the life of antifouling coatings, and ships were able to continue operations for a longer time frame. The paints ensured fuel efficiency and delayed costly ship repairs. It is also comparatively inexpensive (Evans., 1999;Chamo.,1996).

Toxic effect of TBT-

Though it acts as antifouling paint but also effects on the marine organisms. TBT poisones barnacles, algae, and other organisms at the bottom of the food chain, the bioaccumulation of as as sedimentation of TBT increases the invertebrates are highly affected

Present biomagnifications of TBT that has been demonstrated in the lower part of the marine food chain (i.e., planktonic organisms, invertebrates, and fishes).Further the biomagnifications of TBT into larger marine animals such as marine mammals is arguable , that is the Toxic effects in some species occur at 1 nano-gram per liter of water estimated (Walmsley, Simon., 2006; "*Focus on IMO - Anti-fouling systems"*.,2003;Sham et al.,2020)

Remediation for TBT-More recently, microbial usage and bioremediation are fetching the system of selection above old and traditional methods, such as incineration, land filling, and excavation etc (Ayanda et al.,2012). These Organotin compounds (OTs) consist of a group of organometals pollutants characterized by the occurrence of a tin (Sn) atom covalently bound to one or more organic substituent's (e.g., methyl, ethyl, butyl, propyl, phenyl)(Hoch 2001).

The TBT toxic effects were reported for the first time in France, in the Bay of Arcachon, where failure to reproduce and shell calcification, led to stunted growth and a collapse in oyster reproduction (Alzieu, 2000).

TBT toxicity to organisms belonging to the five taxonomic kingdoms, from bacteria to mammals and from the molecular to the community level, have been reported (Bernat et al., 2009). It has been reported that for many organisms, TBT is a strong cytotoxic compound that is involved in the perturbation of calcium homeostasis. TBT causes cell killing and programmed cell death (apoptosis) by inducing elevated intracellular calcium concentrations and generation of reactive oxygen species in mitochondria (Konstantinou, 2006).

In bacteria, TBT negatively affects cell growth and metabolism, Toxic for bacteria (Gram negative are, in general, more resistant) Inhibit growth and metabolism .Affect respiration , Decrease bacterial productivity Inhibit solute transport Inhibit biosynthesis of macromolecules and transhydrogenase (Cruz et al., 2012). In fungal strains it Induces oxidative stress, Modification of phospholipids profile ,Modification of lipids peroxidation ,Damage of mycelium, Alteration of lipids homeostasis, Apoptosis occurs (Bernat and Długo´nski, 2012).

In Phytoplankton Reduction of marine microalgae growth, Reduction on primary productivity,Alteration of photosynthetic pigment content, Changes in the community structure Induce of programmed cell death or cell stressor. In Plants Delay and diminish in seed germination,Decrease on growth parameters, Impairment of macroalgae spores motility,

Stress induction, by bioaccumulation, in terrestrial plants used for human consumption (Silva, 2011). In Fish the Growth inhibition ,Masculinization in females, Induce abnormalities in sperm ,Reduce fecundity Liver vacuolation, Larvae malformations, Hyperplasia of the hematopoietic tissue ,Cytochrome P450 system inhibition Neurotoxicity through the modulation of glutamate signaling pathway (Zhang et al., 2008).in mammals , Reduce spermatogenesis in mice, Embryos malformations,Inhibitions of mitochondrial oxidative, phosphorylation, Inhibition of ATP synthesis, Induce adipose tissue differentiation and obesity, Human lymphocytes inhibition, Cytoskeletal damage and cell apoptosis Neurotoxicity DNA damage (Chen et al., 2008).Still, the cellular and molecular mechanisms involved in TBT resistance are unclear. In fact, it seems consensual that different resistance mechanisms can be present among bacterial genera, and also in the same species or strain (Cruz et al., 2013).Despite the severe impact of TBT on living organisms, several studies have reported TBT-resistant bacteria from water and sediment (Hernould et al.,2008). For example in *Pseudomonas aeruginosa* 25W Up-regulated genes, as ribosomal protein, ribosome-modulation factor, cold-shock protein and elongation factor Tu genes *ygi*W gene, hydrogen peroxide and cadmium stress protein gene ((Fukushima et al., 2012).

Aeromonas molluscorum Av27, possesses a gene, Av27-*sug*E, which confers resistance to TBT to a sensitive *E. coli* HB101 (Cruz et al., 2013). In fungi *C. elegans* it was observed that changes in fatty acid compositions occurred during TBT degradation, suggesting that the high TBT resistance verified is associated with the modulation of the fatty acids composition and the biocide degradation (Bernat and Dlugonski, 2007). Tam et al. (2001) studied the effect of TBT over six species of two different genera of green microalgae (*Chlorella* sp. and *Scenedesmus* sp.). Among them, *Chlorella vulgaris* showed to be the most TBT-resistant species, and the seven-days IC50 values measured in terms of cell number and chlorophyll content were 220 and 262 μg L–1, respectively.

Apart from resistance , various strains reported , which are able to degrade the TBT, some of the such strains are - *Ankistrodesmus falcatus, Chlorella ulgaris ,Scenedesmus obliquus ,Dunaliella salina ,Dunaliella viridis, Pseudomonas diminuta, Cunninghamella elegans,* (Bernat and Dlugonski, 2006). The biosorption and

biodegradation of TBT by two red tide microalgae, *Leptocylindrus danicus* and *Amphidinium carterae*, was also investigated Xie et al. (2011).

Rates of TBT degradation may be influenced by several biotic and abiotic factors, for instance, the nature and density of the microbial population, TBT solubility, dissolved/suspended organic matter, pH, salinity, temperature, and light (Dubey and Roy, 2003).

Moreover, it was found that the debutylation reaction from DBT to MBT is faster than the conversion of TBT to DBT, with little accumulation of DBT in the algal cells (Tsang et al.,1999). In Figure 1 it is presented the degradation of TBT via successive dealkylation on microalgal.

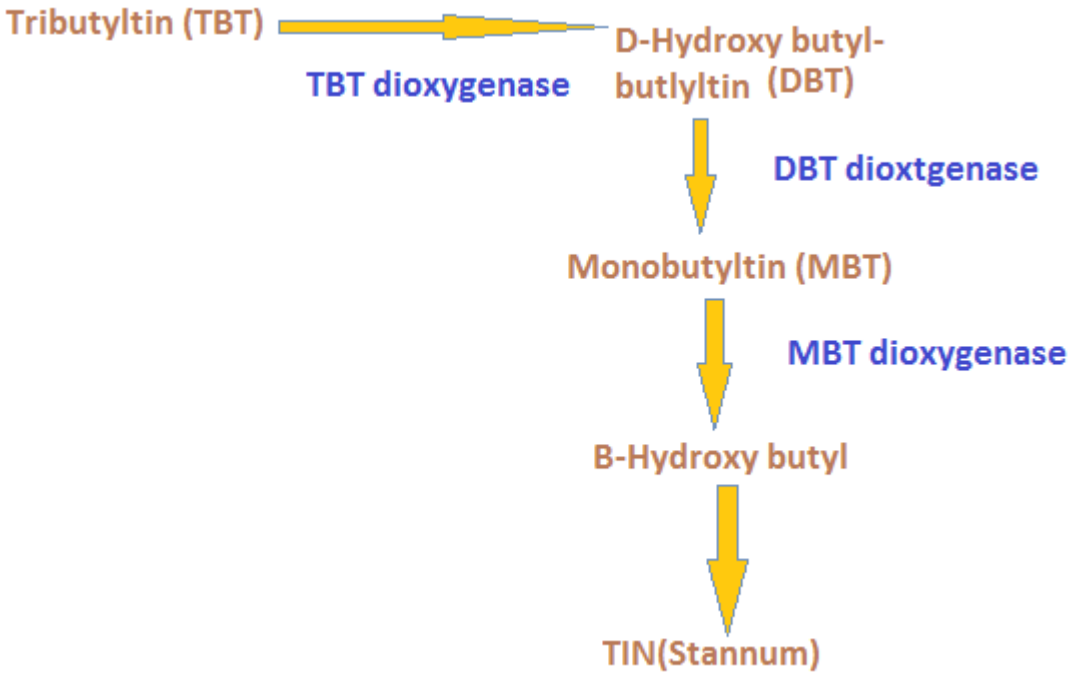

FIGURE 1. metabolic pathway of TBT degradation in microalgal. (from Antizar-Ladislao, 2008) in this DBT converted MBT and inorganic stannum .

Conclusions - TBT is having toxic effect , there is need of biodegradation several points listed here that the implementation of field-scale biodegradation of TBT requires a framework incorporating the following points: (a) the new screening and identification of natural bacterial strains and even other strains ; (b) Determination conditions for growth of microbes and TBT biodegradation; (c) Establishment of new metabolic pathways of TBT degradation; (d) New Identification, localization, and cloning of genes involved in degradation and in TBT resistance; (e) Development of suitable microbial strains using genetic manipulation techniques for practical applications; and (f) Optimization of practical engineering processes for bioremediation of organotin-contaminated.

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