Microorganisms to Test Toxicity of Different Chemicals

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Abstract:

Microorganisms respond to environment depends on the nature of substrates. Bacteria are classified based on phylogenetic profile Archaea, Proteobacteria, Eubacteria and Actinobacteria. All four organisms, during the growth phase develop specificity towards the substrates and human intervention into environment make them resist or eliminated from niche depending on chemical concentrations, exposure time and environmental factors. Bacteria, algae and fungi and protozoa are the group of microorganisms recognized for testing the effects of chemicals. This article summarizes testing different kind of chemicals nitro-aromatic compounds with microorganisms and detoxification mechanism in microorganisms viz. nitro-aromatic compounds, coke plant effluent, alum sludge, turbine fuel with algae, N-substituted aromatics, organic solvents, naphthenic acids, landfill leachate, pesticides, herbicides, explosives and related compound with bacteria and heavy metals and xenobiotics with protozoa. Glutathione (N- (N-L-glutamyl-L-cysteinyl) Glycine) a tripeptide, detoxify through it reaction with electrophilic xenobiotic compounds to form typically less toxic water soluble and excretable products. Microorganisms used for testing toxicity and risk associated with chemicals either organic or inorganic provide toxicity EC, LC and NOE values in effluent treatment.

Keywords:
Microorganisms, Chemicals, Glutathione, Toxicity.

Introduction:

In this review article, role of microorganisms in testing different chemical has briefly described. Microorganisms comprises of, algae, bacteria, fungi and protozoa are known to exhibit response to specific chemical. Although all four organisms, during the growth phase develop specificity towards the substrates. As increasing use of inorganic and organic chemicals causes toxicity to aquatic and terrestrial microorganisms. The phylogenetic profile Archaea, Proteobacteria, Eubacteria and Actinobacteria have been recognized over the decades as compare to 19 groups of bacteria. Bacteria belong to all categories classified as prokaryotes. Human intervention into environment make prokaryotes and eukaryotes become resistant or eliminated from niche depending on chemical concentrations, exposure time and environmental factors. Earlier studies indicated Comparative toxicities of selected industrial chemicals (Vaishnav and Korthals,1990); Microorganisms resistant to heavy metals and toxic chemicals and indicators, and their use in bioremediation (Riaz–ul-Haq and Shakoori, 2000). Multiple glutathione disulfide removal pathways mediate GSSG that is immediately reduced in the cystosol is rapidly

transported the vacuole by the ABC-C transporter Yef. 1. And Trx z and Grx z as efficient backup systems to glutathione reductase or cytosolic GSSG reduction, (Morgan, *et al.*, 2013).

Toxicity Measurement Methods-

Bacteria, algae and fungi and protozoa are the group of microorganisms recognized for testing the effects of chemicals provide toxicity EC, LC and NOE values of the chemicals either inorganic or organic in the effluent. Testing different kind of chemicals with microorganisms viz. nitro-aromatic compounds, coke plant effluent, alum sludge, turbine fuel with algae, N-substituted aromatics, organic solvents, naphthenic acids, landfill leachate, pesticides, herbicides, explosives and related compound with bacteria and heavy metals and xenobiotics with protozoa has summarized in Table-1. Microorganisms detoxify through it reaction with electrophilic xenobiotic compounds to form typically less toxic water soluble and excretable products is a tripeptide, Glutathione [N- (N-L-glutamyl-L-cysteinyl) Glycine] Figure-1 & 2.

Microorganisms used for testing toxicity and risk associated with The mechanism for detoxification of chemicals exist on evolution and function of glutathione and enzyme glutathione S-transferase. In this reaction enzyme is maintaining the redox status in cells and glutathione acts an antioxidant to prevent cellular damage by maintaining essential thiol-(RSSR) cysteine and coenzyme A in their reduced state (RSH) (eq.-1) scavenging hydrogen peroxide (eq.- 2) and hydroxyl redicals. (eq.-3) (Field and Thurman,1996).

$$RGSH+RSSR \quad GSSG +2RSH\text{--------}(1)$$

$$2GSH + H_2O_2 \quad GSSG + 2H_2O\text{------}(2)$$

$$GSH +HO \quad GS +H_2O\text{--------}(3)$$

In algae photosynthetic efficiency, growth and physiological function such as ammonium uptake is enhibited. Similarly bacterial growth, fungi mitochondrial function and protozoa chemosensory response are more sensitive than growth inhibition.

Table-1: Methods used to test the effects of chemicals on Microorganisms

Microbial Group and Test organism(s)	Test Chemical(s)	Basis of Test	Comments and Reference	Reference
Algae *Scenedesmus obliquus*	Nitroaromatic compounds	Algal growth inhibition	Toxicities varied with type and concentration of compound. Proposed applications of this test include water quality	(Liu *et al.*, 1995).

			monitoring and pollution control	
Scenedesmus subspicatus	Coke plant effluent	Chlorophyll florescence	Decreasing toxicity correlated with decreasing amounts of dissolved organic carbon and ammonia-N in the receiving waters	(Peter *et al.*, 1995)
Selenastrum capricornutm	Alum sludge	*S. capricornutum* growth test, Microtox	Water soluble constituents from slum sludges may affect algal growth	(George *et al.*, 1995)
Selenastrum capricornutm	Ethylene amines	Joint toxicity synergistic effects	Effects of combinations of compounds appeared to be additive at the lethal level	(Van wijk*et al.*, 1994)
Skeletonema sp., *Phaeodactylums* p.,	Biopan p-1487 and vantocil IB (biocides), CarboSea DMA (oil based drilling mud)	Exposure to algae in a marine environment	Chemical used in offshore drilling processed may be toxic in the environment	(Bjoernestad *et al.*, 1993)
Various freshwater species	Turbine fuel Jet-A	Std. Aquatic Microcosm (SAM) Method	The water soluble fraction (WSF) of the jet fuel was correlated to toxicity results	(Landis *et al.*, 1994b)
Various freshwater species	Turbine fuel JP-4	Std. Aquatic Microcosm (SAM) Method	An algal bloom occurred due to the toxicity of JP-4 To dephnids	(Landis *et al.*, 1993a))
Bacteria Acetoclasticmethonogenic cells cultured in an anaerobic sludge blanket	N-substituted aromatics	Methane production in granular sludge	The nature and degree of the aromatic substitution profoundly affected the toxicity of the compound. Nitroaromatic compounds were on average 500-fold more toxic than their corresponding aromatic amines	Donlon*et al.*, 1995
Bacterioplankton	Copper	Acute toxicity test	Moderate copper concentrations alter the metabolic profile of bacterial communities	Tubbing*et al.*, 1995
Photobacterium phosphoreum	Organic solvents	Microtox toxicity in Sediments	Sediment samples were taken from various sources with varying degrees of anthropogenic contamination	Svenson*et al.*, 1994
Photobacteriump hosphoreum	Naphthenic acid	Microtox toxicity of chemicals after biodegradation	Microbial degradation of organic acids reduced toxicity by one half	Herman *et al.*, 1994
Photobacterium phosphoreum	Phenolic compounds	Inhibition of dehydrogenase activity	Biomass growth inhibition was estimated by determining the optical density at 530 nm. This test provides reliable, reproducible results and is more sensitive than the respiration inhibition test	Strotmann*et al.*, 1994

Photobacterium phosphoreum	Landfill leachate	Phytotoxicity assay	The bacterial assay proved to be an effective, inexpensive and consistent method in determining the toxicity of landfill leachates	Devare and Bahadir, 1994
Photobacterium phosphoreum	Phenols	Nitrification inhibition test	This test is useful for estimating toxicity to nitrifying bacteria	Strotmann and Egisaeer, 1995
Photobacterium phosphoreum	80 chlorinated compounds	Theoretical linear salvation energy relationship (TLSER)	Quantum chemical descriptors are used to describe quantitative structure and toxicity relationships of bacteria and the chlorinated compounds	Sixt*et al.*, 1995
Pseudomonas sp.	Agricultural chemicals	Ames test and micronucleus test	Agricultural chemicals were tested for acute toxicity and genetic toxicity before and after biodegradation to describe	Wenyi*et al.*, 1993
Pseudomonas sp.	Chlorpyrifos, organophosphate insecticide	Gene mutation (Ames test)	There was no evidence of genotoxic activity for chlorpyrifos in any of the assays	Gollapudi*et al.*, 1995
S. aureus, E. coli, P. aeruginosa, C. albicans	N-arylazoleacetamide derivatives	Microdilution broth method	Derivatives 8 and 10 of N-arylazoleacetamide showed significant activity (MIC < 32mg/ml) against various fungi Candida species.	Ozkanli*et al.*, 1994
Salmonella typhimurium	Capsaicin thymolbomeol, allulisothiocyanateeugenol, cinnamaldehyde	Ames Salmonella microsomal assay	Three bacterial strains TA97, TA98, and TA100 were each affected differently by the mutagenic test compound	Azizan and Blevins, 1995
Fungi *Aspergilus flavus*	Cymbopogon citratus	Fungal toxicity	The fungicity of the oil of Cymbopogoncitratus is superior to synthetic fungicides. The oil toxicity did not diminish after 7-months of storage. The MIC of the oil was found to be 1000 ppm	Mishra and Dubey, 1994
Candida albicans, *Aspergillus fumagatus*	Antifungal agents (amphotericin B, Fluconazole, itraconazole)	Mitochondrial respiration	Will defined dose-response curves reflecting impairment of mitochondrial function by the antifungal agents were obtained.	Jahn*et al.*, 1995
Tea fungus (symbiosis of osmophilic yeasts and acetic acid bacteria	Sucrose, lactose, glucose, fructose	Enzymatic tests	Max yields of ethanol were recorded with 150 g fructose / L. Lactose and glucose yield only minor amounts of ethanol. The fermentation period was 6-10 days.	Reiss, 1994

Vibrio fisheri	Explosives and related compounds	Bacterial luminescence	The EC 50 values were calculated for 24 test compounds incubated for 30 minutes. For many of the compounds tested, minimal toxicity information is known	Drzyzga et al., 1995
Protozoa *Spirostomumam biguum*	Hg^{2+}, Ag^{+},Cu^{2+},Cd^{2+}, sodium dodecyl sulfate (SDS)	Static acute plate assay, tested for cell deformation and lethality	*S.ambiguum* is an excellent bio-indicator of water toxicity contaminated with heavy metals and surfactants. The test procedure is short and simple	Nalecz-jaweckiet *al.*, 1993
Tetrahymena sp.	Various xenobiotics	Chemosensory test	The chemosensory test was more sensitive than the Tetrahymena growth test	Pauli *et al.*, 1994

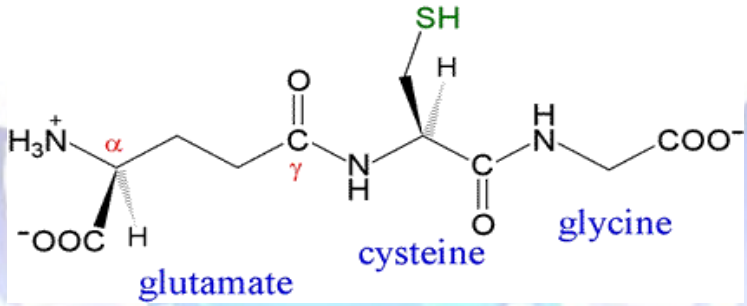
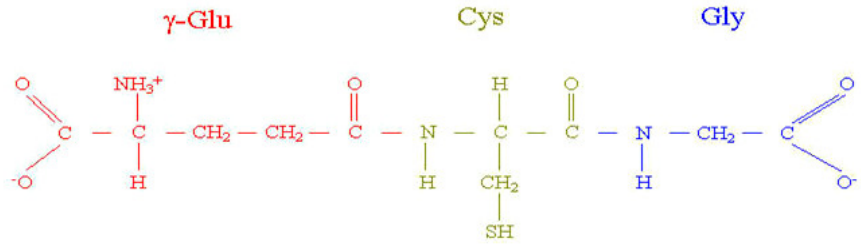


Figure. 1- Glutathione ($C_{10}H_{17}N_3O_6S$) guweb2.gonzaga.edu.425X191



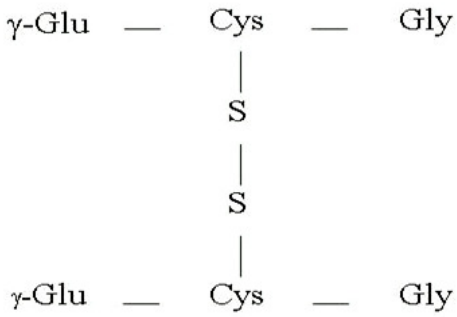


Figure. 2- Glutathione and its oxidized form (www.cryst.bbk.ac.uk. 811X599)

Conclusion:

Researches from weed science, toxicology and biochemistry support the hypothesis of glutathione conjugation and detoxification pathway carried out by aquatic and terrestrial plants and soil microorganisms.

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