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Review

Arsenic and dichlorvos: Possible interaction between two environmental contaminants

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ABSTRACT

Metals are ubiquitously present in the environment and pesticides are widely used throughout the world. Environmental and occupational exposure to metal along with pesticide is an area of great concern to both the public and regulatory authorities. Our major concern is that combination of these toxicant present in environment may elicit toxicity either due to additive or synergistic interactions or 'joint toxic actions' among these toxicants. It poses a rising threat to human health. Water contamination particularly ground water contamination with arsenic is a serious problem in today's scenario since arsenic is associated with several kinds of health problems, such arsenic associated health anomalies are commonly called as 'Arsenism'. Uncontrolled use and spillage of pesticides into the environment has resulted in alarming situation. Moreover serious concerns are being addressed due to their persistence in the environmental matrices such as air, soil and surface water runoff resulting in continuous exposure of these harmful chemicals to human beings and animals. Bio-availability of these environmental toxicants has been enhanced much due to anthropological activities. Dreadfully very few studies are available on combined exposures to these toxicants on the animal or human system. Studies on the acute and chronic exposure to arsenic and DDVP are well reported and well defined. Arsenic is a common global ground water contaminant while dichlorvos is one of the most commonly and widely employed organophosphate based insecticide used in agriculture, horticulture etc. There is thus a real situation where a human may get exposed to these toxicants while working in a field. This review highlights the individual and combined exposure to arsenic and dichlorvos on health.

Contents

Abbreviations: OP, organophosphorus pesticides; DDVP, dichlorvos; As, arsenic; AChE, acetylcholinesterase; LA, α-alpha-lipoic acid; DMSA, meso 2,3- dimercaptosuccinic acid; MiADMSA, monoisoamyl 2,3- dimercaptosuccinic acid; ROS, reactive oxygen species; GSH, reduced glutathione; GSSG, oxidized glutathione; GST, glutathione *S*-transferase; GPx, glutathione peroxidase; GR, glutathione reductase; SOD, superoxide dismutase; ZPP, zinc protoporphyrin; ppm, parts per million; ppb, parts per billion; OPIDP, organophosphate-induced delayed polyneuropathy; COPIND, organophosphate-induced neuropsychiatric disorder.

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1. Introduction

In today's world, population is continuously being exposed to environmental toxicants including several metals, metalloids, pesticides, chemical warfare agents etc. Of these, metals and pesticides toxicity are more common, causing alarming situation due to their strong persistent nature in the environment and also due to their continual exposure and toxic effects on animal and humans. These chemical mixtures constitutes number of pollutants (in air, water, soil and food) which as a single agent may produce detrimental effects and these effects can either be synergistic, antagonistic or additive in nature. Bio-availability of these environmental toxicants has been enhanced much due to anthropogenic activities. Exposure to metals and pesticides may be occupational, accidental, suicidal or homicidal. Most of the past experimental reports focused on the individual toxic effects of a chemical but there is lack of data for multiple chemical exposures. Much emphasis should be given for better understanding of the joint effects in case of multiple exposures. Various authorities like WHO, USEPA and the European Union have focused towards the need of risk assessment procedures for multiple/joint exposures. Literature supports the abundance of data on single or individual agent in terms of its absorption, metabolism, transformation and excretion in various tissues or cells. Whereas, there is lack of data available on complete mechanism in situation of mixed or multiple exposures and these factors makes the risk assessment of multiple exposure more difficult as compared to the risk assessment of single/individual agent. Studies on the acute and chronic exposure to arsenic or dichlorvos (DDVP) are well reported and well defined. Arsenic is a common global ground water contaminant while dichlorvos is one of the most commonly and widely employed organophosphate based pesticide used in agriculture, horticulture etc. There is thus a real situation where a human may get exposed to these toxicants while working in a field. The present review thus addresses few important issues related to combined exposure to arsenic and dichlorvos particularly when one toxicant might amend the biochemical effects of another toxicant by changing its kinetics resulting in a response which may be antagonistic or synergistic in nature.

2. Arsenic

Arsenic is a metalloid with characteristics of both metals and non-metals and is commonly characterized as a toxic metal. Arsenic is highly toxic and poses severe effects such as genotoxicity, diabetes, cardiovascular and nervous system disorders, and cancer. At molecular level such effects are caused by virtue of increased oxidative stress, DNA damage, and inhibition of various proteins mainly including transcription factors, regulatory proteins, and induction and/or inhibition of apoptosis. The use of arsenic as a deadly poison has been known and reported for many years. Due to its use by the ruling class to murder one another [1] and its potent effects, arsenic has been called the "King of Poisons" [2]. Environmental contamination of arsenic particularly in drinking water sources mainly because of anthropogenic activities is a major cause for concern in many parts of the world. Today arsenic contamination has been reported in many parts of the world and, reports of large scale arsenic contamination in the Gangetic Delta region in Bangladesh and India have generated immense attention. In this part of the world alone, more than 38 million people are at risk of developing arsenic related health hazards. In order to control arsenic contamination in natural water source, World Health Organization has set up guidelines according to which maximum permissible value of arsenic in drinking water is 10 ppb. However, many countries exceed this value and countries like Argentina (200 ppb), Mexico (400 ppb), and the Indo-Bangladesh region (800 ppb) have extremely higher arsenic concentration in drinking water [3].

Arsenic is also used as a bronzing and decolorizing agent in the manufacture of glass, in the production of semiconductors (gallium arsenide, indium arsenide, aluminum gallium arsenide) [4], as a desiccant and defoliant in agriculture, and as a byproduct of the smelting of non-ferrous metals particularly gold and copper (Fig. 1). Pharmacologically, drugs produced from arsenic are called