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An insight of environmental contamination of arsenic on animal health

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ABSTRACT

The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. Exposure to arsenic is mainly via intake of food and drinking water, food being the most important source in most populations. Although adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas. Long-term exposure to arsenic in drinking-water is mainly related to increased risks of skin cancer, but also some other cancers, as well as other skin lesions such as hyperkeratosis and pigmentation changes. Therefore, measures should be taken to reduce arsenic exposure in the general population in order to minimize the risk of adverse health effects. Animal are being exposed to arsenic through contaminated drinking water, feedstuff, grasses, vegetables and different leaves. Arsenic has been the most common causes of inorganic chemical poisoning in farm animals. Although, sub-chronic and chronic exposure of arsenic do not generally reveal external signs or symptoms in farm animals but arsenic (or metabolites) concentrations in blood, hair, hoofs and urine are remained high in animals of arsenic contaminated zones. So it is assumed that concentration of arsenic in blood, urine, hair or milk have been used as biomarkers of arsenic exposure in field animals.

Contents

1. Introduction

Arsenic (As) is an environmental chemical element of high concern for human health [18,20]. Environmental exposure to arsenic imposes a big health issue worldwide. Since the middle of the 19th century, production of heavy metals increased steeply for

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more than 100 years, with concomitant emissions to the environment [11,47]. Chronic arsenic poisoning, or arsenicosis, is typically defined by the classical dermal stigmata, together with internal disorders in the presence of known arsenic exposure. Groundwater contaminated with arsenic is the major source of both human and animal exposure to arsenic. Chronic exposure to arsenic can cause skin, lung and bladder cancers [22]. A small but measurable increase in the incidence of bladder cancer was associated with exposure to concentration as low as 10 ppm of inorganic arsenic [7]. Epidemiological studies suggested a strong correlation between chronic arsenic exposure and various noncancer human diseases, such as hyperkeratosis, atherosclerosis, diabetes, and chronic obstructive pulmonary diseases [32]. In arsenic affected areas, livestock are also exposed to toxic levels of arsenic very similar to human beings. Other than drinking water, feed materials are also considered as a source of arsenic for animal in arsenic contaminated areas. A large number of animals maintained by arsenic affected peoples are provided with arsenic contaminated drinking water, grasses, feedstuffs, vegetables and rice plants. The ingested high amount of arsenic may be retained in the blood, urine, faeces, hair and tissues of animal that is consumed by human beings directly or indirectly. Once cattle are affected, environmental contamination of arsenic occurs through domestic and agricultural use of cow dung [35]. Animals are exposed to arsenic in arsenic contaminated zone. In my review I emphasize the deleterious effect of arsenic on animal health.

2. Occurrence, exposure, effects and significance

Arsenic is an environmental toxicant with wide distribution in rock, soil, water and air. Arsenic compound is classified into two viz. inorganic arsenic and organic arsenic. Inorganic arsenic is generally abundant in groundwater used for drinking in several countries all over the world (e.g. Bangladesh, Chile and China), whereas organic arsenic compounds (such as arsenobetaine) are primarily found in fish, which thus may give rise to human exposure [47]. It is a great environmental contaminant in the Bengal delta basin and is responsible for causing carcinogenicity to millions of people and animals [18,22]. Emissions of heavy metals to the environment occur through wide range of processes and pathways, including to the air to surface waters and to the soil [18]. Atmospheric emissions tend to be of greatest concern in terms of human health, both because of the quantities involved and the widespread dispersion and potential for exposure that often ensues [41]. People may be exposed to potentially harmful chemical, physical and biological agents in air, food, water or soil. However, exposure of arsenic does not result only from the presence of a harmful agent in the environment but the key word in the definition of exposure is contact [3,38]. Soil is being contaminated with arsenic though irrigated water and rice, vegetables, plants are thereby contaminated with arsenic through its uptake to the toxic level [9,10]. 25(twenty) million people of 50 (Fifty) districts involving nearly 85% of the total area of Bangladesh have arsenic in ground water [6]. Arsenic contamination in drinking water has been documented in Nepal, Myanmar, China, Inner Mongolia, Thailand, Vietnam and Japan, South America, Chile, Bolivia, Central northern Mexico, Peru and Argentina, Democratic Republic, and Cambodia [20]. Both human and animal beings are expelled to drink arsenic contaminated water in that particular zone of West Bengal, India. The concentration of arsenic in drinking water exceeds the permissible limit i.e. 0.05 mg/L [35,47].

Arsenic causes hyperpigmentation keratosis, weakness, anaemia, burning sensation of eyes, solid swelling of legs, liver fibrosis, chronic lung disease, gangrene of toes, neuropathy, and skin cancer and other clinical manifestations. Except abdominal pain, the prevalence of all other clinical manifestations tested (e.g., pigmentation, keratosis, hepatomegaly, weakness, nausea, lung disease and neuropathy) were found to be significantly higher in arsenic exposed people (water arsenic>0.05 mg/L) compared to control population (water As level<0.05 mg/L) [17,18]. 6 (Six) million people of seventy-nine blocks of nine district viz. Malda, Murshidabad, Nadia, North and South 24 Parganas, Bardhaman, Hoogly, Howrah and Kolkata in West Bengal, India are affected with the arsenic related health hazards where arsenic concentration exceeds 50μg/lit) [20,35,47]. Bangladesh is one of the worst cases of environmental toxicity. In addition, among 42 heifers 29 died from arsenic poisoning in South America, after an arsenical soil and the grass sample contained 2262 ppm as dry weight [29]. In those areas, over a 44 day period, 4 of 5 affected calves in a 170 herd of beef cattle died after exhibiting clinical signs of lethargy, ataxia, anorexia, and diarrhoea. [14] revealed that histopathological examination of tissues and toxicological analysis of a suspicious powder discovered in the pasture confirmed arsenic trioxide toxicosis.

Arsenic is contaminated in food chain though drinking water, food, meat, milk and egg. The ingestion of bovine milk is one of the most important pathways of exposure to chemicals and the accumulation of persistent organic chemicals in tissues in the agricultural food chain. It was shown that arsenic concentrations in all water samples were over the suggested level for cattle intoxication and ranged from 0.23 to 2.54 mg/L [38]. Besides, the total arsenic concentrations from cow's milk ranged from 0.9 to 27.4 ng/g at Francisco I, Maderond Matamoras countries [41]. In Northen Scotland, the level of arsenic in the blood (19 μg/kg) is at least two orders of magnitude higher than the level of blood in unexposed area [15]. In chronic experimental study, arsenic (ppm) burden in blood, liver, kidney were estimated as 3.49 ± 0.10, 5.45 ± 0.35 and 4.87 ± 0.17 in chronic arsenic (10 ppm) intoxicated rat after 12 weeks [30]. [4] revealed that the concentration of arsenic in blood of acute and subacute arsenic toxicity in goat ranges from 0.13 ± 0.01 to 4.95 ± 0.03 mg% and 0.12 ± 0.02 to 1.32 ± 0.27 mg% respectively in West Bengal, India. Arsenic is deposited in liver, kidney and spleen and most of it is excreted via urine (if salt is not readily absorbed) and much of it is eliminated via faeces [43]. Animals are able to tolerate low levels of arsenic and the normal level in cattle tissues was less than 0.5 ppm. The kidneys are a primary route of excretion whereas liver is the target for arsenic deposition. [42] reported that urine samples contained 0.15–16.4 mg/kg in an outbreak of arsenical poisoning in cattle in Mexico. An estimation of arsenic content in hair samples and the value went as much as 5–10 mg/kg while animals not exposed to arsenic (normal) should contain less than 0.5 mg/kg [40]. The maximum concentration of arsenic in tissue reaches about 8 hrs after ingestion and the animals that survive for 2–3 days may have levels as low as 3 mg/kg [40].

3. Chronic arsenic toxicity and animal health

Arsenic (As) is found in the natural environment, being present in soil, groundwater and plants. Epidemiological evidences indicated that it is also a carcinogen in both human and animal beings [47]. Areas of our planet with a significant presence of inorganic arsenic have been identified, particularly in Asia and other non-European countries. In Europe, the levels of arsenic in the environment are rather low, with the exception of some areas with particular geological formation or industrial process [18,21]. Contamination of arsenic in drinking water is a major health problem throughout the world. Inorganic arsenic has a pronounced acute toxicity in human and experimental animals [33]. Human exposure to arsenic in drinking water has been associated with cancers (lung, bladder and skin), chronic diseases of skin, heart,

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