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The effects of arsenic contaminated drinking water of livestock on its total levels in milk samples of different cattle: Risk assessment in children

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HIGHLIGHTS

- The arsenic contaminated drinking water of livestock enhance its levels in cattle's milk.
- Small cattle have significantly higher levels of As in their milk than bigger cattle.
- The high bio-transfer factor of As was occurred in the milk samples of sheep and goat.
- The carcinogenic risk values of As for children drink contaminated milk found >1.
- As in scalp hair of children consumed milk of sheep was higher than those drink cow milk.

GRAPHICAL ABSTRACT

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ABSTRACT

This work was carried out to evaluate the arsenic (As) levels in milk samples of different milch animals, sheep, goats, cows, buffaloes and camels in Tharparkar, Pakistan. The concentration of As in the milk samples of cows, buffalos, sheep, goats and camels were observed in the range of 15.1–18.4, 2.6–7.7, 25.7–33.2, 10.5–37.3 and 6.6–13.7 μg/L, respectively. The levels of As in livestock drinking water of each farms/flocks was found in the range of 238–2000 μg L^{-1}. A positive correlation with Pearson correlation coefficients, ranged as, 0.926–0.974 ($p = 0.001–0.011$) was observed between the As concentration in milk samples of cattle and in corresponding drinking water of farms/flocks. The high bio-transfer factor of As was occurred in the milk samples of sheep. The content of As in scalp hair of children was observed to be elevated, who consumed milk of lower cattle (sheep and goat) than cow and camel. The As content in scalp hair directly proportional to the age of children. The hazardous quotient value of As due to consumption of milk was observed in decreasing order as, sheep > goats > camels > cows. The total hazardous quotient or noncarcinogenic risk values for children consuming the milk of sheep, goat, cow and camels were found >1 of reference dose for As, creates adverse effects on health in childhood stage. The children of all three age group have higher carcinogenic risk factor who are consuming milk of goat and sheep than larger cattle.

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1. Introduction

The water quality have significant effects on human, animal and plants. The widespread water and crop contaminations created by natural release of arsenic (As) from aquifer rocks have been identified in many parts of the world (Smedley and Kinniburgh, 2002). The As is toxic in nature and even at relatively very low concentrations can cause adverse impact on human health (Santhi et al., 2008). The high exposure of As to human created adverse impacts on health such as, keratosis, hypertension, black foot disease, cardiovascular diseases, diabetes, as well as skin, bladder and lung cancers (Abernathy et al., 2003; WHO, 2011).

The As contaminated drinking water is the most important route of its exposure; whereas food become an additional source, because agricultural products can accumulate As from contaminated soil and water (Ohno et al., 2007). Due to nutritional values of milk, obtained from different cattle, is very important diet for human of all age group, especially children. In general milk of animal are consumed by human are commonly depends on regional environments. The As concentration in milk of different animals depends on a large number of factors, such as fodder/silage, environmental contamination and drinking water. The consumption of contaminated milk may also be a contributing factor for arsenical disorders in humans of every age (Sigrist et al., 2010).

The ground and surface water along with soil of Tharparkar, Pakistan are polluted with As (Brahman et al., 2013; Brahman et al., 2014a,b). The As can be transported to plants and grass from water and soil (Mahzuz et al., 2009; Reza and Singh, 2010). The population of every age group of Tharparkar have a high risk to As due to consuming contaminated water and crops/vegetables (Brahman et al., 2014a, 2016). Milch animals, mainly feeding on locally grown silages and preserved foodstuffs. Therefore, they are exposed to high levels of As if the local soil and water is contaminated with its minerals. The consumption of high amount of As by cattle might be excreted through different routes including milk of respective animals. The As contaminated drinking water and milk consume by humans will lead to severe detrimental effects, especially in children (Kennish, 1991; Chitmanat and Traichaiyaporn, 2010; Brahman et al., 2016). A small number of data are presented in the literature concerning As contents in milk obtained from different animals (Coni et al., 1996; Shamsia, 2009; Sigrist et al., 2010).

The objective of this study was to evaluate the effects of As in livestock drinking water, an important source of exposure on milk producing cattle. In present study, the livestock drinking water and milk samples of sheep (*Ovis aries*), goats (*Capra hircus*), cows (*Bos taurus*), buffaloes (*Bubalus bubalis*), camels (*Camelus*) of different farms/flocks of Tharparkar, Pakistan were analysed for As. The biotransfer factor of As from water to milk samples of different cattle were calculated. Whereas the estimate daily intake, hazardous quotients, target hazardous quotients/noncarcinogenic and cancer risks were calculated due to consumption of milk of different cattle by children of 1–3 year olds. In addition, the scalp hair samples of children were also analysed for As content based on consuming milk of different cattle.

2. Materials and methods

2.1. Sampling

Five dairy farms were selected for collecting the milk samples of cows and buffaloes from Mithi and Nagarparkar districts of Tharparkar. Whereas three to five flocks were selected for sheep, goats and camels. About hundred samples of milk from each type of cattle belongs to different farms and flocks were collected in pre-washed bottles, after milching manually. The drinking water of livestock (stored rain and ground water) was simultaneously collected with milk samples from different farms/flocks during August 2014 to March 2015. The all collected samples were kept in an ice box and transported to the laboratory and frozen at 4 °C in a refrigerator till analysis.

2.2. Socioeconomic and dietary surveys

The socioeconomic status of study population was estimated by determining the family size, education and income. Socioeconomic surveys revealed that most of the people in Tharparkar district, Pakistan, are below the poverty line. The main occupations of peoples of study area are cattle farming and agriculture. Malnutrition and ill-balanced diet was reported in all the endemic villages (Brahman et al., 2014b). Since 2016, hundreds of children <5 years are died, reported in daily news of Pakistan, due to dangerous mix of drought, malnutrition, poverty and poor health infrastructure.

2.3. Study population

The nutritional survey amongst the children of age ranged 1–3 years was conducted. Information on milk sample consumption history was collected by verbal questionnaire, based on the interviews from parents in different villages of Mithi and Nagarparkar. This assumption was made because the consumption of milk would increase the daily intake values of As in addition to drinking water sources, as reported in our previous study (Brahman et al., 2016). The body weight scale was used to obtain the body mass index (BMI) of selected children, which is used to evaluate the health status. The BMI of all selected children were $\leq$13.0.

With the consent of parents, scalp hair samples were collected from children ($n = 285$), age ranged 1–3 years. The parents of children was apprised by scholar themselves, about the working and sampling parameters in the local language (Sindhi). The majority of the children are taken milk of goat (40%), sheep (20%), cow (25%) and 15% miscellaneous sources probably camel, none of the family claim about buffalo milk. Whereas about 45 children's parent inform that their children not drink any type of milk. All selected children are drinking As contaminated ground and stored rain water as reported in our previous studies (Brahman et al., 2013, 2014a, 2016).

2.4. Chemicals and instruments

For the experimental work, ultrapure water was used. All chemicals and reagents were of analytical grades. Nitric acid (HNO_3), hydrogen peroxide (H_2O_2) and sodium hydroxide (NaOH) were obtained from Merck (Darmstadt, Germany). Working standard solutions were made from certified stock standard solution of As 1000 μg/L, (Fluka). 3% (m/v) sodium tetrahydroborate was used as reducing agents. The glasswares were kept for 24 h in 5 M HNO_3 and then cleaned with deionized water. A Perkin Elmer Model 700 (Norwalk, CT, USA) atomic absorption spectrometer, equipped with a deuterium background corrector, MHS-15 hydride generation system was used for the As analysis. The experimental parameters for As analysis were set as recommended by the manufacturer and reported in previous work (Shah et al., 2009).

2.5. Analytical method

Total As in livestock drinking water was measured as reported in our previous work (Brahman et al., 2013, 2014a). Total As concentrations in milk samples were determined, after wet acid digestion in a microwave oven. Triplicate 5.0 ml of composite milk samples of