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A study of heavy metal presence in cow milk of different dairy farms near Karnafuli paper mills, Chittagong, Bangladesh

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ABSTRACT: *Cow milk is considered as one of the food sources that contaminated with heavy metals, because the cows graze on the grass grown in lands which somehow come in contact with the untreated effluent of industries. The study sheds light in assessing the content of selected metals in milk of cows of different ages collected from dairy farms located at Karnafuli paper mills, Chittagong, Bangladesh. In total 50 cows were taken for study,(10 cows of each age) and Chromium (Cr), Iron (Fe), Cadmium (Cd), Lead (Pb), Zinc (Zn), Manganese (Mn), Nickel (Ni), Copper (Cu), Mercury (Hg) concentrations were measure and the overall mean metal concentrations of total 50 milk sample were found in the following order: Fe>Cr>Mn>Zn>Ni>PB>Hg>Sc>Cd>As. In most cases, it is noticeable that metal concentration increased with the increasing age of cows. Finally, human health risk associated with drinking the milk is identified using Target Health Quotient (THQ) measure and found that Cadmium, Chromium, Arsenic and Mercury are the most dangerous poisonous element present in the cow milk.*

Keywords- *Cow milk, Estimated Daily Intake, Heavy metal, Recommended Dietary Allowances, Target Health Quotient*

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I. INTRODUCTION

Milk is bio active substance which is an essential source of nutrition for new born child and other mammals. Cow's milk is widely devoured by human children and adults after the age of weaning. Milk is considered as excellent source of Calcium (Ca) which largely helps in the growth and development of children and also helps to reduce osteoporosis in old people. Other macro elements such Potassium (K), Phosphorus (P) can be found. Some microelements and heavy metals are also found in milk. Micro elements such as copper (Cu), iron, selenium (Se), and Zinc (Zn) are known to be essential for human growth. However, heavy metals such as Arsenic (As), Cadmium (Cd), Mercury (Hg), Lead (Pb) have no helpful impacts on human wellbeing. Milk is considered as an important foodstuff in our daily life but in recent few years contamination of milk has become one of the most threatening aspects .The existence of trace element and heavy metal in dairy products and milk has been recorded in various countries and regions. Milk is addressed as an ideal food. It is also considered as an excellent source of Calcium (Ca), fewer amount of Zinc (Zn), and a very small content of Copper (Cu) and Iron (Fe) [1]. It is highly consumed food and the average annual milk production rate in Bangladesh 22, 64,000 tonnes and the available rate per person is 13 kg annually (According to FAO).In recent years food contamination, specially contamination of milk by heavy metals is considered as one of the most dangerous aspect [2].Most attention has been paid in metal residues in milk due to milk is highly consumed by infants and children [3]. The excess amount of heavy metal and trace element is the only reason behind it. The element containing atomic density greater than 6g/cm is known as trace element which is a general collective terminology. This term is widely applicable to a group of elements i.e. Cadmium, Copper, Iron Lead and Zinc which are most susceptible to pollution and toxicity problems [4]. Other elements such as Chromium and Mercury are also well known as induced an excessive level of toxicity [5]. The existence of trace element and heavy metal is dairy products and milk has been recorded in various countries and regions [3, 5-16]. The adverse effect of these trace elements on living and environmental objects is beyond imagination. Children are the most likely to be affected due to the incipient development in the digestive track produces high absorption [11]. Among them Lead and Cadmium are considered influential carcinogens and are associated with etiology

of a number of diseases in the cardiovascular system, kidneys, nervous system, blood and skeletal system. [12]. Wilson's disease (excessive accumulation of Copper in brain, liver, Kidney and Cornea) and Menken's disease (peculiar hair, severe mental retardation, neurological impairment and death before 3 years of age) are the result of toxic level of Copper and Lead [13]. The toxic con tent of metals in milk and dairy products depend on several factors. In particular, environmental conditions, possible contamination during the manufacturing processes, the processing equipment, reagents, accidental contamination during storage and marketing processes and leaching from containers [5]. Land application of sewage sludge, sewage water and industrial wastes gradually increasing the toxic metals in the soil environment, thus are increasingly taken up by plants and therefore, transferred into the food chain sourcing severe damage to both animal and human health [14].
A noticeable amount of Cd and Pb can easily be moved from contaminated soil to plant and grass resulting accumulation of this highly influential toxic metals in grazing ruminants, significantly, in cattle [15, 16]. The poisoning of Pb is considered the most susceptible toxic effects in case of farm ruminants [17]. Moreover the presence of Cd and Pb in a very less concentration can cause various metabolic disorders resulting extremely serious consequence [18] and both are very well known air pollutant thus directly emitted into air due to industrial activities [19]. Heavy metals come in contact of animal through air water and feed where as the ingestion of unwholesome feeding stuffs has been considered the primary source of metal residues in the secreted milk [20].The recent studies sheds light on the topic of food contamination, particularly heavy metal residues in raw milk and its adverse effect on human health. Thus it is parallel important to find out the concentration of heavy metal residues for taking further steps to control its level of concentration.

II. MATERIALS AND METHOD

2.1 Sample collection

In this study milk samples were collected from some dairy farms located near Karnafuli Paper Mills, Chittagong from September to November 2016. Total 50 cows were chosen to collect milk of age 1 to 5 year of lactating. (10 cows of each age). These cows are fed grass of the forage near which industrial waste are discharged 50 ml of milk from each cow were collected in polyethylene container, that were kept overnight in nitric acid and rinsed well with distilled water to avoid contamination. Fresh milk, after pouring in the bottles, was immediately placed in icebox. The samples were taken to the lab within an hour and frozen at -20°C until analysis.

2.2 Sample preparation and analysis

Wet digestion of the collected milk samples were carried out by the method as described by Richard [21]. One gram of milk sample was taken into 100 ml digestion flask and 10 mil of concentrated nitric acid was added and heated for 20 min. Sample was then cooled to room temperature. The content was then further heated vigorously after adding 5 ml of Perchloric acid till the white fumes appeared and the sample volume reduced to 2-3 ml. The final volume was made to 50 ml by adding die-ionized water. All chemicals were of analytical grade (Merck, Germany). Metals (Cd, Cr Ni and Pb) concentration was determined by AA-700 Atomic Absorption Spectrophotometer (SHIMADZU-Japan)

2.3 Calculation

2.3.1 Estimated daily intake (EDI) of metals

EDI value depends on metal concentration in food, amount of daily food consumption and the body weight of the consumer.
The EDI of metals was determined by the following equation,

$$EDI = \frac{C_{metal} \times W_{food}}{BW} \ (m/kgbw/day)$$

Where C_{metal} (mg/kg) is the concentration of heavy metals in milk, W_{food} denotes the daily average consumtion of food and BW denotes the body weight. The average daily milk consumption per adult person (60 kg BW) was considered to be 200 ml [22, 23]. The daily intake of metal (mg/day) from milk was calculated and its contribution to the Recommended Dietary Allowances (RDAs), established by the Food and Nutrition Board of the Institute of Medicine was shown in [h: 620] with the assumption that the average adult woman and the average adult man consumed the same diet separately expressed for females and males.

2.3.2: Target hazard quotient (THQ)

The THQ is the ratio of estimated daily intake (EDI) to the reference oral dose (RFD_o) for each metal. The THQ<1 implies that the consumption is assumed to be safe.

$$THQ = \frac{EDI}{RFD_0}$$

III. RESULTS AND DISCUSSION

Metals content in milk are of particular concern as milk as largely consumed by infants and children [3] and it is observed in other studies that metal concentration could vary with season, age and breed, dairy period and many other factors. In this study milk from cows of same area of different age are collected to detect the change of metal concentration in them with increasing the lactating age. In tables 1 to 5 below, different metal concentration (unit-parts per million) in collected samples are shown.

Table 1: Metal concentration in milk of cow (1st year of lactation)

Cr	Cd	Fe	Pb	Zn	Mn	Ni	Cu	As	Hg
2	BDL	5	BDL		0.5				
0.7	BDL	6.1	BDL						
6.4	BDL	6.7	BDL	0.3			0.1		
3.2	BDL	4.1	BDL		0.2	0.1			
4.3	BDL	5.3	BDL	BDL	0.1				0.1
3.1	BDL	3.1		BDL	0.1				
2.1	BDL	8.4	0.1	BDL					
7.4	BDL	5.5		0.1					
1.7	BDL	10.1	0.2	BDL	0.3	0.1	0.1		
4.2	BDL	4.7	BDL	0.1					

Table 2: Metal concentration in milk of cow (2nd year o lactation)

Cr	Cd	Fe	Pb	Zn	Mn	Ni	Cu	As	Hg
1.1	BDL	5.6		0.1			0.1		
3.1	BDL	6.1							
3.7	BDL	3.1					0.1		0.1
9.2	BDL	2.8	0.1		0.5	0.1	0.2		0.1
2.7	BDL	2.9		0.1					
9.9	BDL	11.9			0.2				0.1
5.3	BDL	2.9				0.2			
2.1	BDL	3.4	0.2		0.1	0.1	0.4		
4.2	BDL	7.1			0.3	0.3			
3.7	BDL	3.4							

Table 3: Metal concentration in milk of cow (3rd year of lactation)

Cr	Cd	Fe	Pb	Zn	Mn	Ni	Cu	As	Hg
7.2		8.1		0.1	0.1				0.1
2.9		7.7		0.1	0.2		0.1		
8.1		2.1	0.1	0.2		0.1	0.1		
6.7		5.1	0.1	0.1	0.3				0.2
5.5	0.1	8.9			0.4	0.2	0.1		0.1
3.1		9	0.2	0.1	0.1		0.3		
11		8.2			0.5	0.5	0.1		
9.1		7.7		0.1	0.3				0.1
7.2	0.1	8.3	0.1	0.1	0.4	0.1		0.1	0.2
10.7		5.1	0.1	0.2		0.2			

Table 4: Metal concentration in mil of cow (4th year of lactation)

Cr	Cd	Fe	Pb	Zn	Mn	Ni	Cu	As	Hg
9.1	0.1	9.1	0.1	0.3	0.1		0.1		0.1
9.4	0.2	8.5	0.1	0.1	0.4				0.2
8.3		7.1	0.1	0.4	0.5	0.1	0.2		0.1
7.2		11.2	0.2	0.3	0.2	0.1	0.1		
6.1		10.2	0.3	0.5	0.9	0.1		0.1	
10.2		11.2	0.1		1.1	0.5	0.1	0.1	0.1
11.1		14.1		0.6	0.3	0.1	0.1		0.1
5.1	0.1	10.3	0.1	0.1	0.1	0.2			
4.2	0.1	7.1	0.1	0.2	0.4	0.1	0.1		0.1

10.7		11.8	0.1	0.3	0.1		0.2		0.2

Table 5: Metal concentration in milk of cow (5th year of lactation)

Cr	Cd	Fe	Pb	Zn	Mn	Ni	Cu	As	Hg
10.4	0.1	11.2	0.1	0.4	0.1	0.1	0.1		0.1
9.7	0.2	13.1	0.2	0.5	0.2	0.2	0.2		0.1
7.4	0.1	10.4	0.1	0.7	0.7	0.1	0.1	0.1	0.1
8.3	0.1	8.1	0.4	0.1	0.4		0.4	0.1	
10.1		8.5	0.2	0.9	0.3	0.7	0.2		0.1
6.7	0.1	11.4		0.5	0.1	0.5	0.7		0.2
5.4	0.3	12.1	0.1	0.1	0.9	0.3	1.1		
7.9	0.1	10.7	0.7	0.3	1.1	0.1	0.5	0.1	0.1
10.3		7.4	0.2	0.2	0.7	0.4	0.2		0.4
9.7		10.2	0.2	0.3	0.5		0.1		

The overall mean metal concentrations of total 50 milk sample were found in the following order: Fe>Cr>Mn>Zn>Ni>PB>Hg>Sc>Cd>As. In most cases, it is noticeable that metal concentration increased with the increasing age of cows. Some metals are very hazardous to human health when they exceed the permissible limit, as every example, chromium could cause renal and hepatic damage, gastric damage, nervous system irritation and even lung cancer.. Cadmium is a dangerous element that can be absorbed via the alimentary tract, permeate through placenta during pregnancy, and damage membranes and DNA. One enters the human body; it may remain in the metabolism from 16 to 33 years and is causing several health problems, such as renal damages and abnormal urinary excretion of proteins. Decrease in bone calcium concentrations by increasing urinary excretion of calcium have also been observer due to exposure to Cd. It also affects reproduction and endocrine systems of women [24].

Ni does not have a specific function in human body. However, it performs as a co-factor for some microbial intestine enzymes. Ni content in the adult human body should remain below 0.1 mg per day as its presence in high amount may cause damage to DNA and cell structures [25]

Hence it's important to point out either consumption of milk is safe or not THQ is calculated and shown in table-6

Table-6: Target Hazard Quotient (THQ)

Metals	Mean Concentration	EDI	RFD	THQ
Cr	6.378	2.13 E-02	1.50 E-02	1.42 E-02
Cd	0.034	1.13 E-04	1.00 E-03	1.13 E-01
Fe	7.642	2.55 E-02	7.00 E-01	3.64 E-02
Pb	0.092	3.07 E-04	4.00 E-03	7.67 E-02
Zn	0.176	5.87 E-04	3.00 E-01	1.96 E-03
Mn	0.274	9.13 E-04	1.40 E-03	6.52 E-02
Ni	0.112	3.73 E-04	2.00 E-02	1.87 E-02
Cu	0.124	4.13 E-04	4.00 E-02	1.03 E-02
As	0.012	4.00 E-05	3.00 E-04	1.33 E-01
Hg	0.062	2.07 E-04	3.00 E-04	6.89 E-01

It's quite amusing that none of the THQ value of metals were higher than 1.Hence it could be inferred that it's safe for human being to drink the milk.

IV. CONCLUSION

This study has authentically shown that metal concentration in cow milk tends to increase with the increase in lactating age which could be because of metals ability to bio-accumulate. Auspiciously the THQ indicated the milk samples to be safe to drink but increase of metal content with age of cow in quite alarming. So, Special surveillance should be kept on metal concentration because, once they are present in concentration greater than the permissible limit, it may be difficult to reduce them to acceptable limit.

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