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Assessment of Cadmium in Raw Milk of Rural and Urban Areas of Kota, Rajasthan

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ABSTRACT

Milk is an essential diet supplement for all age groups. The presence of any toxicant or heavy metals in milk poses a negative influence on human health. The present study was conducted to assess the concentration of cadmium in raw milk samples of urban and rural areas of the Kota region. Around 200 milk samples from both urban and rural areas were taken. These samples were analyzed with the help of Atomic Absorption Spectrophotometer (AAS-6300). From the result, it was found that the cadmium concentration in the milk samples of urban areas exceeded the permissible limit whereas the Cd concentration was found to be within the limits of milk samples from rural areas. Estimated daily intake (EDI) and health risk index (HRI) were calculated for both areas. EDI and HRI for urban areas range from 2.42 E-05 to 10.04 E-05 mg/kg BW/day and 0.0242 to 0.1039 respectively, whereas EDI and HRI for rural areas are up to 1.49E-05 and 0.0149 respectively.

1. INTRODUCTION

Milk is a good source of many micro (Cu, Fe, Zn, and Fe) and macro (Ca, K, and P) elements. Milk also contains a considerable amount of proteins, fats, and vitamins which have a high nutritional value for the growth and development of infants and adolescent age group and also improve calcium deficiency in the elderly person [1-3]. Milk must be produced in its purest form without any contamination due to its significance in the human diet. In India per capita, consumption of milk is 427 gm/day, which is one of the highest data in the world. Along with essential metals, some non-essential metals like Cd, Hg, and Pb due to natural and anthropogenic activities might enter the milk.

Industrial effluent and environmental pollution are the major cause of heavy metal pollution in water and soil. When soils are polluted with heavy metals due to anthropogenic activity; these metals are taken up by plants and subsequently accumulate in their tissues [4]. Animals that graze on such plants and drink polluted water also accumulate such metals in their tissues and milk. Through the consumption of contaminated milk and its products, people are exposed to heavy metals. Milk and its products also become contaminated with heavy metals either through foodstuff and water or through manufacturing and packaging processes [5]. Contaminated milk through different sources poses harmful effects on human health.

Cadmium is commonly used for pigments, coating, and also in battery, PVC stabilizers and alloy industries [6]. Some industrial activities like cement nonferrous metals production, fossil fuel, iron and steel production, waste incineration, fertilizers, etc. are using cadmium significantly [7]. Cadmium is strongly adsorbed to the organic matter in soils. When cadmium is present in soils it can be extremely dangerous, as the uptake through food will increase [8]. Cadmium is considered one of the most hazardous metals for human beings [9]. Normal cell transforms into a malignant cell to its long-term exposure [10]. Higher cadmium levels decrease sperm count and lead to infertility [11]. Exposure to cadmium causes cardiovascular disease [12]. Cadmium affects the vitamin D metabolic pathways [13]. Increased cadmium level in the blood leads to kidney damage [14] urinary cadmium has lots of hazardous effects on other tissues like lungs, periodontal tissues, high blood pressure, and diabetes, they also affect mammary glands [15] when humans are exposed to cadmium present in air water, soil or edibles even in low concentration causes health issues [16].

Kota city has a 1200 MW coal-based power plant KSTPS (Kota Super Thermal Power Station) present in the centre of the city, which produces approximately 3000 metric tons of fly ash per day. Numerous large and small-scale industries, which include Kota stone, DCM Shriram Consolidated Limited (DSCL), Multi-metals Limited, Samtel Glass Limited, Chambal Fertilizers and Chemicals Limited (CFCL), Shriram Fertilizers and Metal India, and Shriram Rayons etc are present in Kota city. Urban Areas have significantly more anthropogenic sources of metal contamination than rural areas. However, no investigations have been reported on the assessment of heavy metals in milk samples of Kota till now. The present study was carried out on milk samples that were collected from rural and urban areas of the Kota region. In this paper, we report the presence of Cadmium in the milk samples of both rural and urban areas of Kota.

2. MATERIALS AND METHODS

2.1. Study Area: - The Kota is located on the banks of the Chambal River in Rajasthan State of northern India. The cartographic coordinates of the Kota district are 25.18°N 75.83°E. The Study area is divided into urban (Fig. 1) and rural (Fig. 2). We collected 80 samples of raw cow milk from four different types of urban areas-industrial, local farm, residential, and riverside. We chose 26 sample collecting locations (shown in fig 2) for rural areas from the five tehsils of Ladpura, Sangod, Digod, Pipalda, and Ramganjmandi in the Kota region. We collected 130 samples, five samples from each sampling location, each from the different villages within a 2-to-8-kilometer radius.

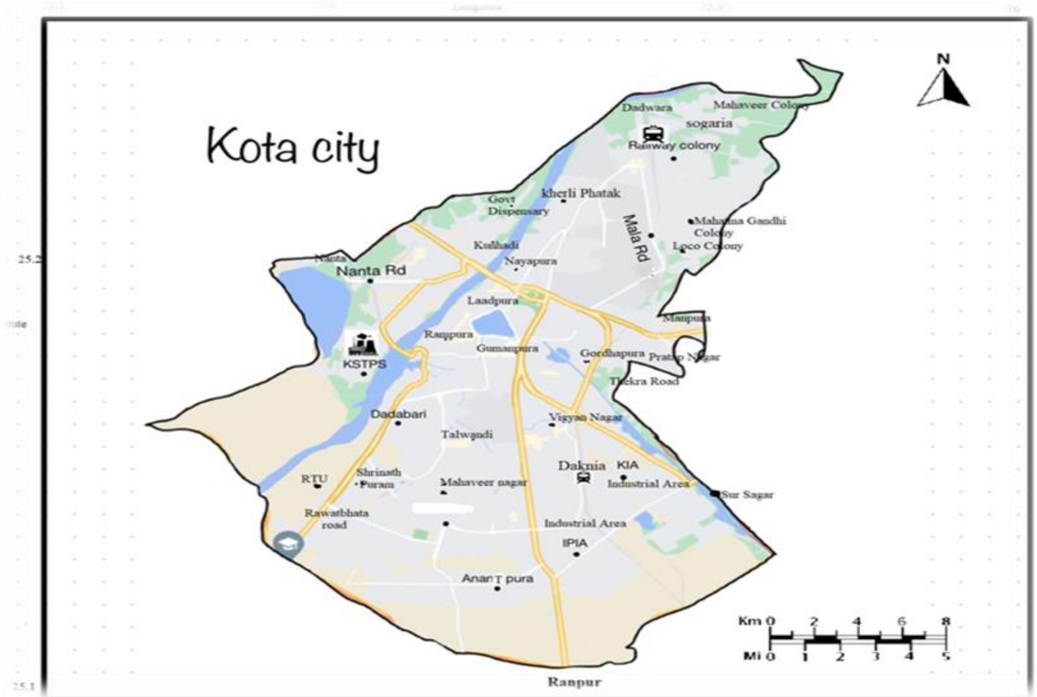

Fig. 1 Study map for urban area of Kota.

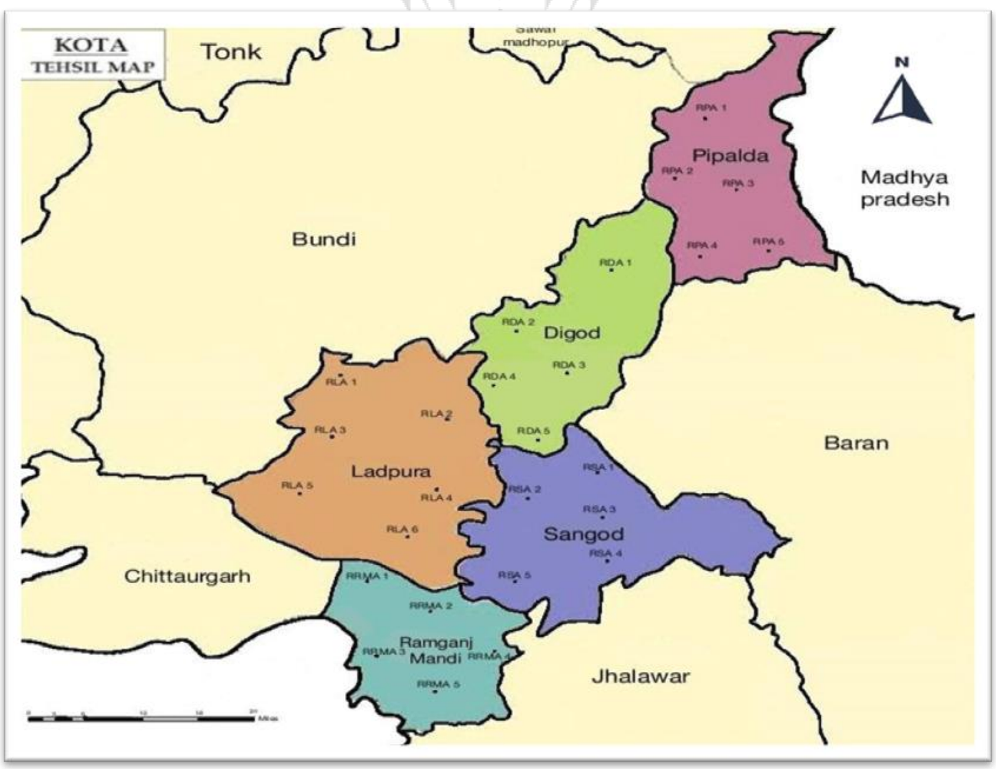

Fig. 2 Study map for rural area of Kota

2.2. Sample Collection

Around 80 samples were collected from the urban area of Kota city which includes the Industrial area, Thermal Area, main Kota city dense residential area, local farms, and nearby areas of Chambal River. Approx. 130 samples were collected from rural areas of Kota tehsil- Ladpura, Digod, Pipalda, Sangod and Ramganjmandi. The milk samples were collected in PTFE bottles and kept at -20°C in a deep freezer.

2.3. Sample Digestion

Among four wet digestion techniques, the most suitable techniques for our work after performing a recovery test was taken. The recovery for the studied metal varied from 96.01 to 96.96. In this method, we had taken 5 ml of milk sample in which 5 ml of 65% HNO_3 and 30% H_2O_2 were added and then digested on a hot plate at 90°C and the temperature was increased gradually up to 120°C and heated until the evolution of brown fumes stopped. After that digested samples were filtered and diluted up to 25 ml in a volumetric flask.

2.4. Sample Analysis

All digested samples were analyzed by using Shimadzu AAS - 6300 for the determination of Cadmium concentration in the sample. Instrumental analysis of Cd was conducted by air acetylene Flame Atomic Absorption Spectrophotometer. Calibration standards were regularly analyzed to ensure the stability of the instrument.

2.5. Data Analysis

a. **Statistical Analysis**: - Statistical analysis was carried out for each sample. Mean, standard deviation, and variance was calculated.

b. **EDI (Estimated Daily intake)**: - Estimated daily intake (EDI) was calculated by using the mean concentration of Cadmium (mg/L), the daily consumption of milk and the average body weight [17].

$$EDI = \frac{Cmetal \times Wmilk}{Bw} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{eq. 1}$$

Where C_{metal} is the mean concentration of metal in milk (mg/L), W_{milk} is the average consumption of milk per day, which is 427 g/day in India [18] and Bw is the average body weight of an Indian adult (in kg) which is 60 kg. [19].

c. **HRI (Health Risk Index):** - The health risk index was calculated as the ratio of estimated daily intake and Oral reference dose $R_f D$. For Cadmium it is 0.001[20,21].

$$HRI = \frac{EDI}{RfD} \quad \text{..........................eq. 2}$$

HRI shows potential health risk when it is ≥ 1 (equal and higher than 1).

3. RESULTS AND DISCUSSION

The concentrations of Cd in 80 samples of milk from four different urban areas of Kota are reported in Table No. 1. Data presented in Table 1 shows that the concentration of Cd in the industrial area was the highest which ranges from 0.0015 mg/L to 0.0261 mg/L. The lowest concentration of Cadmium was found in the local farms of Kota where the minimum concentration of Cadmium recorded was below the detection limit and the maximum concentration recorded was 0.0092 mg/L. The average concentration of milk in all four places exceeded the maximum permissible limit of Cadmium i.e. 0.0026 mg/L according to the Codex Alimentarius Commission 2011, IDF 1979 [22,23]. The mean values of Industrial Area > Kota City (Residential Area) > Riverside > Local farm are 0.0146 > 0.0072 > 0.0049 > 0.0034 respectively as shown in Fig. 3.

Table 1: - Cadmium concentration (mg/L) in milk samples of Urban area

Sample site	**Industrial Area N=20**	**Residential Area N=20**	**Riverside Area N=20**	**Local Farm N=20**
MIN	0.0015	BDL	BDL	BDL
MAX	0.0261	0.0132	0.0089	0.0092
AVG	0.0146	0.0072	0.0049	0.0034
SD	0.0040	0.0040	0.0025	0.0026

N= Number of samples

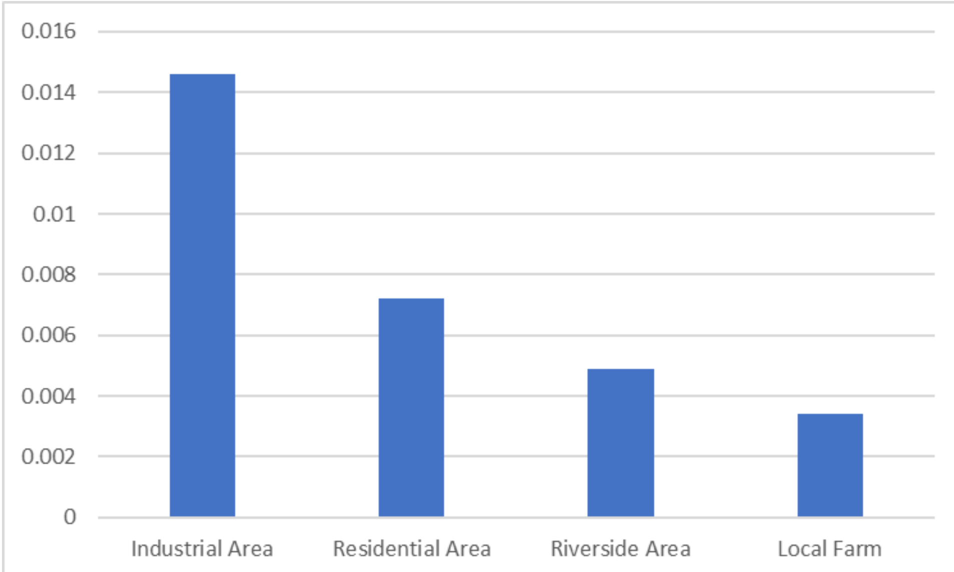

Fig. 3: Average concentration of Cadmium (mg/L) in different urban Areas of Kota

To study the milk samples from the places where the anthropogenic activities are comparatively low, villages of five tehsils of Kota were taken into account for the study of the concentration of Cd. 130 samples of cow's milk from five different tehsils from 26 sampling points (Shown in fig. 2) of Kota were taken and their minimum, maximum and mean values are reported in Table No. 2. Data presented in table 2 shows that the concentration of Cd in rural areas was very low as compared to the urban areas. Cadmium concentrations in milk samples were below detection levels in Sangod, Digod, and Piplda Tehsils. The minimum concentrations of all five places were found to be below the detection limit, and the maximum concentration was 0.0150 at Laadpura tehsil and 0.0.091 at Ramganj Mandi. The mean concentration of Cadmium was found 0.0019 mg/L in the Ramganj Mandi tehsil and 0.0021 mg/L in the Ladpura Tehsil of Kota. The average concentration of Cd in the milk of all five places did not exceed the maximum permissible limit (.0026 mg/L) recommended for Cadmium by different agencies [22,23].

Table 2: - Cadmium concentration (mg/L) in milk samples of Rural area.

	Laadpura N = 30	**Sangod N= 25**	**Digod N = 25**	**Pipalda N = 25**	**Ramganj Mandi N = 25**
Min	BDL	BDL	BDL	BDL	BDL
Max	0.0150	BDL	BDL	BDL	0.0091
Mean	0.0021	BDL	BDL	BDL	0.0019
SD	0.0038	BDL	BDL	BDL	0.0030

N= Number of samples

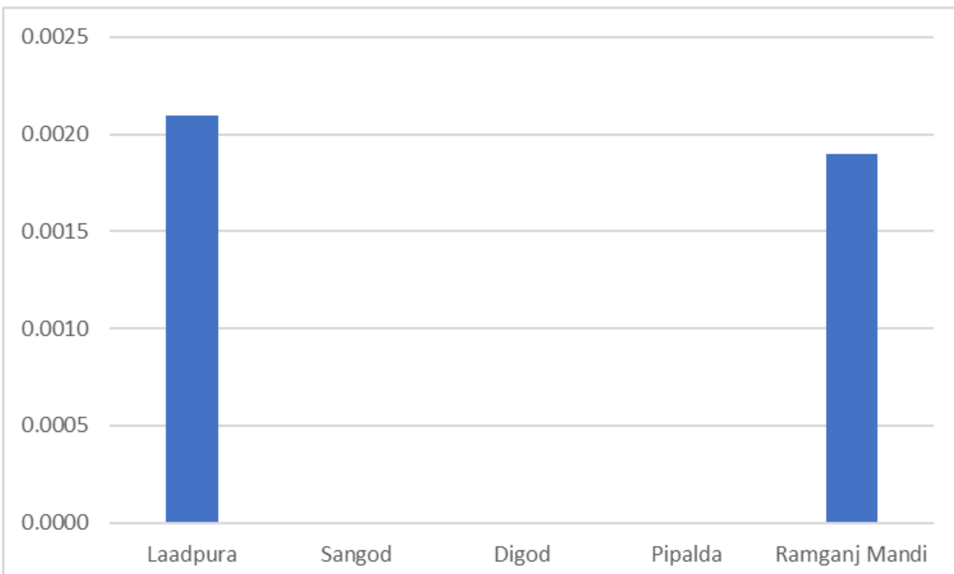

Fig. 4: Average concentration of Cadmium (mg/L) in the different rural areas (Tehsils) of Kota

Table 3 Estimated daily intake of Cadmium through milk and health risk index.

Sample Site		EDI	HRI
Urban Area of Kota City	**Industrial Area**	10.4E-05	0.1039
	Residential Area	5.12E-05	0.0512
	Riverside	3.49E-05	0.0348
	Local Farm	2.42E-05	0.0242
Rural Area of Kota	**Laadpura**	1.49E-05	0.0149
	Sangod	BDL	BDL
	Digod	BDL	BDL
	Piplada	BDL	BDL
	Ramganj Mandi	1.35E-05	0.0135

EDI- Estimated daily Intake in mg/kg bw/day, HRI- Health Risk Index

The result of estimated daily intake and health risk index shown in table 3, clearly indicates that the effect of Cd concentration on human health is very low in rural areas of the Kota region as compared to the urban area. Although both the areas are under the safe limit but long-term exposure especially to children is a matter of concern.

4. CONCLUSION

The study revealed that the major pollution is caused by anthropogenic activities. The elevated levels of Cd were found maximum in the milk of those cattle who grazed and drank water near the industrial areas. It is highly recommended to minimize the contamination by controlling anthropogenic activities and treating industrial effluents. Continuous monitoring is also necessary.

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Conflicts of interest: - The authors declare no conflict of interest.

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