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Assessment of heavy metals in water hyacinth (*Eichhornia crassipes*) plants and its toxic effects on cattle

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Abstract
The present study was conducted to quantitatively measure the levels of heavy metals in water hyacinth (*Eichhornia crassipes*) plants and its effects on cattle inhabitating in and around sewage water polluted areas of Tamil Nadu during the year 2015-16. The field investigation was carried out in randomly selected cattle aged three years and above in the study area. Chronic diarrhoea, emaciation, anaemia and allergic dermatitis were some important clinical signs recorded in the cattle of study area. Fresh water hyacinth plant materials spread over sewage water was collected and heavy metals like lead, zinc, cadmium and copper were analysed. Heavy metals like lead (341.0±30.0) and zinc (126.0±12.0) concentrations were recorded higher level compared to permissible levels in plant. Lead concentration was very higher than the other metals. The selected areas were surrounded with many automobiles workshops. As the water hyacinth has the capacity of absorbing the micro and macro minerals, the concentration of heavy metals might be higher in the water hyacinth plants. Toxicity of lead and zinc were confirmed by estimating the level of lead and zinc in the plasma and milk samples collected from the 20 cattle aged three years and above of the study area. The lead and zinc concentrations in plasma were 2.616±0.355mg/L and 0.086 mg/L, respectively which indicated the heavy metal toxicity in cattle. From this study, it can be concluded that the water hyacinth plant grown in sewage water involved in heavy metal toxicity in cattle reared in the study area.

Keywords: Water hyacinth (*Eichhornia crassipes*), heavy metal toxicity, lead, zinc, cattle

Introduction
Plant poisoning has been the subject of practical lore since ancient times, but theirsystematic study is very limited. The world list of toxic plants includes about 1500 species whose identity as toxic plants has not been well established. Plant poisoning in farm animals have particular important in areas where open grazing method is followed. Water hyacinth (*Eichhornia crassipes*) is a free-floating perennial aquatic plant. The leaves are broad, thick, glossy and ovate. The stalks are usually long, spongy and bulbous. The roots are feathery, freely hanging and purple-black in colour. The flowers are attractive consisting of six petals. It grows so fast that it doubles its population in two weeks[1]. Water hyacinth grows abundantly throughout the world and is also widely distributed in the Southern part of Tamil Nadu, India. These plants had received attention because of its potential in removing pollutants when utilized as a biological filtration system[2]. Water hyacinth plant could remove heavy metals like lead, mercury, cadmium, zinc and nickel from heavy metal contaminated effluents [3].
Water hyacinth plant is highly nutritious because of the high protein content and the content of unsaturated fats, carotenes, xanthophylls, starch and minerals such as iron, calcium and phosphorus. This plant is also a good source of amino acids except methionine[4]. In addition, the leaves contained plentiful water soluble vitamins and fat soluble vitamins [5].
Furthermore, it had been reported that there were antioxidants in leaves of water hyacinth plants and it could be used as food ingredients for animals [6]. Even though the water hyacinth plant had rich nutritional value, its dietary toxicity for animal consumption had not yet been evaluated. Most of the farmers in Tamil Nadu state, India are following open grazing method. So, chances of grazing water hyacinth plants are high especially during drought seasons. Therefore, the present study was conducted to quantitatively measure the levels of heavy metals in water hyacinth plants and its effects on cattle inhabitating in and around sewage water polluted areas of southern Tamil Nadu during the year 2015-16.

Materials and Methods
Study area
The study was conducted in and around sewage water polluted areas of southern part of Tamil Nadu, India during the year 2015-16.

The selected areas were surrounded by many automobile workshops.

Clinical examination of cattle

Clinical surveys were conducted in randomly selected 60 cattle aged three years and above to investigate the health status of cattle in the study area. The prevalence and pattern of clinical lesions suggestive of heavy metal toxicity were noted in detail.

Samples collection and analysis

Field samples: The field samples namely, water hyacinth plant and water were collected from the study area. Fresh water leaves were collected randomly from hyacinth plant grown in the stagnant water source which was contaminated with sewage water. The cleaned leaves were dried at 65 ^{0}C for two days and then were ground as per the method described by Pequerul *et al*. [7]. The powdered samples were digested and analysed for heavy metal concentration using atomic absorption spectrometry [8].

Twenty four water samples were collected from stagnant water source which was contaminated with sewage water in the study area as per the method described by Chau *et al.* [9]. The collected water samples were digested using a miture of nitric and perchloric acid according to Chau *et al.* [9]. Concentration of heavy metals in the digested water samples were determined using atomic absorption spectrometry [10].

Biological samples

Blood samples were collected from the randomly selected twenty four cattle aged three years and above in the study area and plasma was separated for heavy metal analysis using by atomic absorption spectrometry as per the method described by Leonidis *et al*. [11].

Data analysis

The data obtained were statistically analysed by the completely randomized design (CRD) using SPSS computer software 17.00 [12].

Results

Toxicity signs

Distribution of major clinical signs observed in the cattle of study area is presented in Table 1. Of the 60 cattle examined, 23 (38.33%) cattle showed toxic signs suggestive of heavy metal toxicity. Chronic watery diarrhoea, emaciation, anaemia and allergic dermatitis were some important clinical signs recorded in the cattle of study area. The hyacinth plant leaves colour diarrhoea was observed in the affected animals.

Table 1: Distribution of major toxicity signs observed in the cattle of study area (n=60)

Disorders		Number of affected animals	Percentage
Diarrhoea	22		36.67
Emaciation	13		21.67
Anaemia	18		30.00
Allergic dermatitis	6		10.00

Heavy metals in the field samples

The heavy metal levels in plant samples are presented in Table 2. Heavy metals like lead (341.0±9.378) and zinc (126.0±7.063) concentrations were significantly (P <0.01) higher compared to permissible level. The recommended daily intake of lead and zinc is 20 – 280 µg/day and 15 µg/day, respectively. Significantly higher levels of lead and zinc were recorded in this study. Copper and cadmium were below detection limit. Lead concentration was higher than the other metals.

Table 2: Heavy metal levels in the water hyacinth plant (ppm)

Heavy metal	Quantity (ppm)	Maximum Permissible Level (ppm) according to WHO, **2011** [23]
Lead	341.0±9.378	0.01
Zinc	126.0±7.063	5.0
Copper	Below detection limit	1.0
Cadmium	Below detection limit	0.003

Heavy metals in the biological samples

Heavy metal levels (ppm) in plasma and milk are presented in Table 3 which indicated the heavy metal toxicity in cattle.

Table 3: Heavy metal levels in cattle blood collected in the study area (ppm)

Heavy metal	Plasma (ppm)	Milk (ppm)
Lead	2.616 ±0.196	3.012±0.007
Zinc	0.086±0.002	0.102±0.123
Copper	Below detection limit	Below detection limit
Cadmium	Below detection limit	Below detection limit

Discussion

Water hyacinth plants had ability to accumulate heavy metals from the metal containing water. Since scarcity of fodder during summer, animals were forced to graze the available water hyacinth plants grown in the sewage water (Fig.1). Clinical signs observed in the affected animals might be due to ingestion of water hyacinth plants containing lead and zinc above the permissible level.

Fig 1: Cattle grazing water hyacinth plants grown in the sewage water

The affected animal did not show drop in milk yield, instead showed higher milk yield. Water hyacinth plants are capable of accumulating mico and macro minerals from the soil and water. The leaves of water hyacinth plant had 20 to 25% protein on a dry matter basis, and its essential amino acids was quite good [13]. In addition, the leaves contained many water soluble vitamins B1, B2, B3, B5, B6 and B12 and fat soluble vitamins Vitamin E and A [5]. Hence, the nutrient content of the plant might be the reason for enhancement of milk production in the affected animals.

Heavy metals in the field samples

The selected areas were surrounded with many automobiles workshops. Sewage water were polluted with heavy metals

like lead, zinc, etc. which were released from the automobile workshops. Automobile workshops situated in the study area might be responsible for contamination of water with many heavy metals. Lawsal *et al*. [14] recorded 82% and 80% of lead and zinc higher level than normal recommended level in the water bodies nearby automobile workshops. As the water hyacinth has the power of accumulating heavy metals, the concentration of heavy metals i.e. lead and zinc is higher in the water hyacinth plants.

Bansal[15] reported that plants grown on sewer water had higher concentration of zinc and lead in Aligarh district of Uttar Pradesh, India. High levels of melatonin and N1-acetyl-N2-formyl- 5-methoxykynuramine in water hyacinth plant explained why this plant more easily tolerates environmental pollutants, including toxic chemicals and heavy metals and is successfully used in phytoremediation [16]. The findings recorded in this study are in agreement with the findings of Parkpian *et al*. [17]; Rozso *et al*. [18] who reported higher heavy metal contents in water hyacinth plants grown on sewage water.

Heavy metals in the biological samples

Lead is cumulative tissue poison and gets stored in different parts of body especially in bones, kidney, liver and brain. Besides, direct ingestion of lead leading to increased blood lead levels, accumulated lead in the body also acts as a significant source of blood burden[19]. From the skeleton, lead is released gradually back into the blood stream, particularly during physiological or pathological periods of bone demineralization such as pregnancy, lactation and osteoporosis, even if lead exposure has already ceased [20]. The clinical signs observed in the affected cattle of present study are in agreement with reports of Mariam *et al*. [21] in cattle who recorded anaemia and allergies in lead poisoning. Marcal *et al*. [22] observed that the animals reared nearby batteries work were contained higher levels of lead and zinc in the plasma.

Conclusion

From this study, it can be concluded that lead and zinc were more than the maximum permissible limit in plasma and milk of cattle inhabitating in the study area. However cadmium and copper were below the detection limit. The findings of this study confirmed that the automobile workshops functioning in the study area were responsible for heavy metal water contamination and therefore, the water hyacinth plant grown in this area had heavy metals above the permissible levels. As there was scarcity of fodder during the summer months, the cattle reared in this area were forced to consume early sprouted water hyacinth plant leaves and it caused heavy metal toxicity in cattle. The overall data obtained from this study confirmed that the water hyacinth plants are not suitable for consumption by cattle inhabitating in the study area.

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Conflict of interest

The authors declare no conflict of interest

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