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## Research Article

### Studies on the impact of sodium fluoride toxicity on crop plant (*Capsicum annum* var. *annuum*) and its bioaccumulation at the different phase

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#### Abstract

In the present investigation to study the effects of different concentration of NaF on different yield and its bioaccumulation in Red chilli (*Capsicum annum*). In a pot experiment and field observation, a Red chilli was irrigated with nil fluoride (0ppm)-(14ppm) NaF (0, 2, 4, 6, 8, 10, 12 and 14ppm). The experiment was carried out for the entire life cycle of 100 days of this red chilli variety. Plants were harvested after 60 days (pre –flowering), 80 days (peak-flowering) and 100 days (post-flowering) of sowing of seeds. Bioaccumulation studies of fluoride in plant parts revealed maximum accumulation in roots parts (9.948mg/kg) and minimum in leaves (6.302mg/kg) in plants treated with 14ppm NaF in pot experiment. But field observation of sodium fluoride in crop plant parts revealed maximum (10.73mg/kg) accumulation in roots and minimum in leaves (7.212mg/kg) in plants treated well, tube well water in field experiment. Result of the study showed that use of groundwater (well and tube well) containing high fluoride content for irrigating red chilli plants may be tolerating high fluoride content and it is biological accumulation in different plant parts.

**Keywords:** Red chilli, High fluoride, Bioaccumulation, Ground water.

## Introduction

Fluoride occurs widely in the earth's crust in a very minute amount but frequently acts as an environmental pollutant (Jacobson *et. al.*, 1966). Fluoride is not only toxic for human but it is also toxic for plant body. In case of plant certain physiological processes are known to be markedly affected by fluoride e.g., decreased plant growth (Elloumi *et. al.*, 2005; Jacobson *et.al.*, 1966), chlorosis (Mc nulty and Newman, 1961), leaf tip burn and necrosis (Hadujue, 1966), decrease in chlorophyll (Mcnulty and Newman, 1961).

Fluoride is absorbed by plant roots (Kamaluddin and Zwiazek, 2003) and is then transported via xylem tic flow to the transpiratory and storage organs. Bioaccumulation of fluoride in different plant parts varies depending on its transfer from soil solution roots and translocation from root to shoot. Sikar district of Rajasthan is some of the fluorosis endemic areas with medium fluoride concentration in the aquifers and soil. As majority of water for drinking and irrigation in this semi- arid region comes from aquifers, such medium leaves of

exposure to fluoride are of great concern. In major regions of Rajasthan lying in semi-arid zones, red chilli is cultivated with fluoride containing groundwater due to erratic rainfall. In the present study, therefore, we have investigated the effects of various increased concentrations of fluoride on morphological, physiological, yield and its bioaccumulation in red chilli plants, after 60, 80 and 100 days of sowing of seeds.

## Materials and Methods

### Plants material, growth conditions and fluoride treatments

The experiments were conducted in the earthen pot in the laboring of Indira Gandhi Centre for HEEPS, University of Rajasthan, Jaipur from July, 2012 to October, 2012 during its growing season by using. The mean ambient temperature during experimental study was 25°C. Certified seeds of red chilli (*Capsicum annum* var. *annuum*) were procured from Agricultural Research Station Durgapura, Jaipur. This variety was proposed for the peninsular zone (PZ) and has higher yield potential, disease resistance, desirable quality parameters and wider adaptability which would be helpful for enhancing the yield levels in peninsular zone of India. Red chilli plants were raised from seeds in the earthen pots filled with sandy-loamy soil and vermiform compost in the 10:1 ratio 10 seeds were sown in each pot and then thinned down to five plants per pot after 20 days of germination and these were sowing seeds in different villages (different fields) and same procedure were followed for field plants. In the experiment, 5 replicates of each pot set viz. control (Nil NaF), 2ppm, 4ppm, 6ppm, 8ppm, 10ppm, 12ppm and 14ppm were taken. Stock solution of 100ppm NaF concentration was prepared by dissolving 0.221 gm of NaF in 1000ml. of distilled water serial dilution of stock solution was done to get the desired concentration.

### Study of physiological characters and yield attributes

For the study of physiological characters plants were harvested for each replicate after pre- stage

(60 days), peak- stage (80 days) and post- stage (100 days) of sowing. The harvested plants were washed gently with water to remove adhering particles. Then plants were studied for various physiological characters and yield attributes. Determination of bioaccumulation of fluoride in various plant parts. For the bioaccumulation study and determination of fluorine contents, all the plant parts were separately packed and oven dried for 24 hours at 80°C. Then, the samples were powdered and digested with nitric acid, followed by neutralization with aqueous KOH and analysis for fluoride was done by potentiometric method with a fluoride ion selective electrode. Same procedure was used field observation plants.

## Results and Discussion

### At pre-flowering stage (pot experiment and field experiment)

Fluoride concentration in plants of red chilli was estimated 0.066mg/kg in root, 0.03mg/kg in shoot and 0.026mg/kg in leaves samples of plants grown under (distilled water) condition and treatment level 14ppm, fluoride concentration was estimated 4.756mg/kg in root, 2.298mg/kg in shoot and 1.932mg/kg in leaves. While in field experiment Site<sub>1</sub> (below in 2ppm) was 1.3mg/kg in root, 0.786mg/kg in shoot and 0.59mg/kg in leaves samples of plants and Site<sub>2</sub> (NaF approximately 14ppm) fluoride concentrations was estimated 6.42mg/kg in root, 5.05mg/kg in shoot and 3.68mg/kg in leaves. Fluoride concentration increased as the concentration of NaF in the treatment increased.

Fluoride concentration in plants of red chilli was found 0.102mg/kg in root, 0.068mg/kg in shoot and 0.04mg/kg in leaves samples of plants grown under (distilled water) condition and treatment level 14ppm, fluoride concentration was estimated 6.126mg/kg in root, 4.972mg/kg in shoot and 3.2mg/kg in leaves. While in field experiment Site<sub>1</sub> (below in 2ppm) was 2.508mg/kg in root, 1.5mg/kg in shoot and 0.294mg/kg in leaves samples of plants and Site<sub>2</sub> (NaF approximately 14ppm) fluoride concentration it was 7.14mg/kg in root, 5.196mg/kg in shoot and 4.356mg/kg in leaves.

**Table 1.** Fluoride analysis in different plant parts of *Capsicum annum var. annum* after harvesting at pre-flowering stage (60 days) in pot experiment.

S. No.	Treatment Levels	Pre stage Fluoride (mg/kg)		
		Root	Shoot	Leaves
1.	Control(nil F <sup>-</sup> )	0.066±0.0005	0.03±0.0003	0.026±0.0001
2.	2ppm	1.058±0.011 (16.03)	0.78±0.148 (26.0)	0.548±0.018 (21.07)
3.	4ppm	2.104±0.026 (31.87)	1.374±0.007 (45.8)	0.838±0.001 (32.23)
4.	6ppm	3.104±0.012 (47.03)	2.006±0.017 (66.86)	1.364±0.003 (52.46)
5.	8ppm	3.382±0.004 (51.24)	2.078±0.009 (69.26)	1.414±0.016 (54.38)
6.	10ppm	3.79±0.007 (57.42)	2.142±0.002 (71.4)	1.78±0.008 (68.46)
7.	12ppm	4.1±0.007 (62.12)	2.19±0.006 (73.0)	1.886±0.008 (72.53)
8.	14ppm	4.756±0.004 (72.06)	2.298±0.003 (76.6)	1.932±0.005 (74.30)

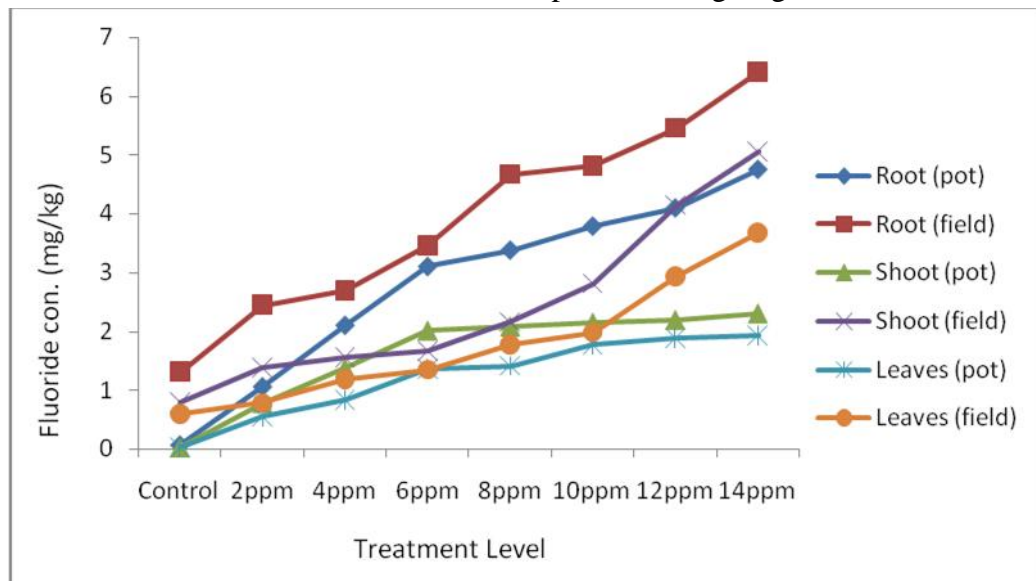
All values of mean ± S.D. and (%)

**Table 2.** Fluoride analysis in different plant parts of *Capsicum annum var. annum* after harvesting at pre-flowering stage (60 days) of the field observation.

S. No.	Site No.	Fluoride (mg/kg)		
		Root	Shoot	Leaves
1.	S <sub>1</sub> (jhilo)	1.3±0.096	0.786±0.037	0.59±0.038
2.	S <sub>2</sub> (Raipur)	2.446±0.071 (1.88)	1.386±0.056 (1.76)	0.778±0.046 (1.31)
3.	S <sub>3</sub> (Puranabas)	2.692±0.097 (2.07)	1.556±0.112 (1.97)	1.184±0.012 (2.00)
4.	S <sub>4</sub> (DhaniAhiran)	3.46±0.083 (2.66)	1.664±0.091 (2.11)	1.344±0.054 (2.27)
5.	S <sub>5</sub> (Naikothi)	4.676±0.313 (3.59)	2.158±0.143 (2.74)	1.774±0.013 (3.00)
6.	S <sub>6</sub> (Dhani Neem kali)	4.814±0.276 (3.70)	2.806±0.049 (3.56)	1.978±0.020 (3.35)
7.	S <sub>7</sub> (Bharala)	5.462±0.144 (4.20)	4.136±0.135 (5.26)	2.932±0.065 (4.96)
8.	S <sub>8</sub> (Thikaria)	6.42±0.106 (4.93)	5.05±0.117 (6.42)	3.68±0.601 (6.23)

All values of mean ± S.D. and (%)

**Figure1.** Effect of different sodium fluoride concentration comparative study of pot experiment and field observation at the pre-flowering stage



Fluoride concentration increased as the concentration of NaF in the treatment increased.

#### At peak-flowering stage (pot experiment and field experiment)

Fluoride concentration in plants of red chilli was estimated 0.102mg/kg in root, 0.068mg/kg in shoot and 0.02mg/kg in leaves samples of plants grown under (distilled water) condition and treatment level 14ppm, fluoride concentration was estimated 6.126mg/kg in root, 4.972mg/kg in shoot and 3.2mg/kg in leaves. While in field experiment Site<sub>1</sub> (below in 2ppm) was 2.502mg/kg in root, 1.5mg/kg in shoot and 1.294mg/kg in leaves samples of plants grown condition and Site<sub>2</sub> (NaF approximately 14ppm) fluoride concentrations was observed 7.14mg/kg in root, 5.196mg/kg in shoot and 4.356mg/kg in leaves. Fluoride concentration increased as the concentration of NaF in the treatment increased.

#### At post-flowering stage (pot experiment and field experiment)

Fluoride concentration in plants of red chilli was estimated 0.178mg/kg in root, 0.12mg/kg in shoot, 0.104mg/kg in leaves and 0.138mg/kg in fruit samples of plants grown under (distilled water) condition and treatment level 14ppm, fluoride

concentration was estimated 9.948mg/kg in root, 7.872mg/kg in shoot, 6.302mg/kg in leaves and 8.27mg/kg in fruit. While in field experiment Site<sub>1</sub> (below in 2ppm) was 2.9mg/kg in root, 1.932mg/kg in shoot, 1.752mg/kg in leaves and 2.232mg/kg in fruit samples of plants grown condition and Site<sub>2</sub> (NaF approximately 14ppm) fluoride concentrations was observed 10.73mg/kg in root, 8.512mg/kg in shoot, 4.356mg/kg in leaves and 10.11mg/kg in fruit. Fluoride concentration increased as the concentration of NaF in the treatment increased.

Bioaccumulation of fluoride was highest in roots and lowest in leaves. In 14ppm NaF treated plants, mean fluoride content in the root and leaves was 9.948mg/kg and 6.302mg/kg respectively and field observation of Site<sub>2</sub> was highest fluoride in roots and lowest fluoride in leaves. In comparison to roots, leaves accumulated least fluoride which was 3.518mg/kg. Owing to its low mobility, fluoride accumulated more in plant roots than in other plant parts. Similar findings have been reported by Gautam and Bhardwaj (2010) and these similar Bhargava and Bhardwaj (2011). Bioaccumulation studies of fluoride in red chilli fruits showed an average fluoride content (10.11mg/kg). This study is significant since fluoride is a part of food web (Murray, 1981).

**Table 3.** Fluoride analysis in different plant parts of *Capsicum annum var. annum* after harvesting at peak-flowering stage (80 days) in pot experiment.

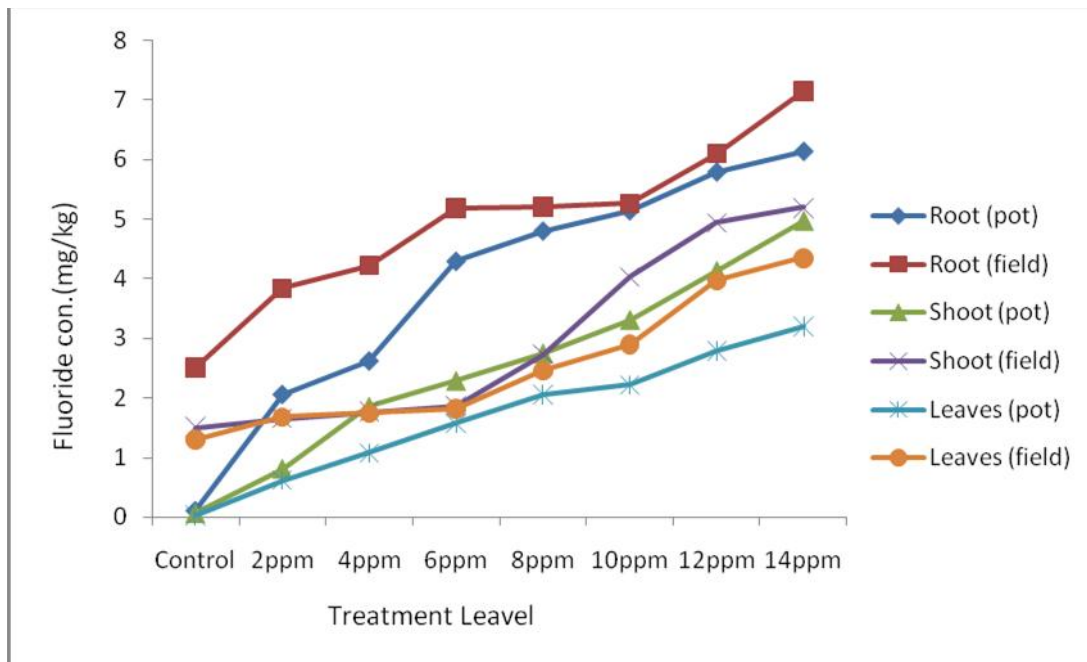
No.	Treatment Levels	Fluoride (mg/kg)		
		Root	Shoot	Leaves
1.	control	0.102±0.004	0.068±0.001	0.02±0.0001
2.	2ppm	2.05±0.011 (20.09)	0.812±0.004 (11.94)	0.614±0.009 (15.35)
3.	4ppm	2.612±0.003 (25.60)	1.854±0.004 (27.26)	1.074±0.002 (26.85)
4.	6ppm	4.282±0.002 (41.98)	2.284±0.004 (33.58)	1.568±0.001 (39.2)
5.	8ppm	4.79±0.001 (46.96)	2.748±0.007 (40.41)	2.058±0.013 (51.45)
6.	10ppm	5.13±0.010 (50.29)	3.31±0.003 (48.67)	2.218±0.006 (55.45)
7.	12ppm	5.78±0.004 (56.66)	4.13±0.004 (60.73)	2.782±0.005 (69.55)
8.	14ppm	6.126±0.003 (60.05)	4.972±0.286 (73.11)	3.2±0.014 (80.00)

All values of mean ± S.D. and (%)

**Table 4.** Fluoride analysis in different plant parts of *Capsicum annum var. annum* after harvesting at peak-flowering stage (80 days) in field observation.

No.	Site No.	Fluoride (mg/kg)		
		Root	Shoot	Leaves
1.	S <sub>1</sub> (jhilo)	2.508±0.076	1.5±0.053	1.294±0.039
2.	S <sub>2</sub> (Raipur)	3.836±0.061 (1.52)	1.65±0.037 (1.1)	1.674±0.143 (1.29)
3.	S <sub>3</sub> (Puranabas)	4.22±0.134 (1.68)	1.766±0.116 (1.17)	1.742±0.124 (1.34)
4.	S <sub>4</sub> (DhaniAhiran)	5.174±0.017 (2.06)	1.862±0.102 (1.24)	1.818±0.148 (1.40)
5.	S <sub>5</sub> (Naikothi)	5.20±0.010 (2.07)	2.732±0.141 (1.82)	2.458±0.756 (1.89)
6.	S <sub>6</sub> (Dhani Neem kali)	5.256±0.099 (2.09)	4.026±0.038 (2.68)	2.896±0.077 (2.23)
7.	S <sub>7</sub> (Bharala)	6.092±0.036 (2.42)	4.942±0.022 (3.29)	3.972±0.065 (3.06)
8.	S <sub>8</sub> (Thikaria)	7.14±0.044 (2.84)	5.196±0.038 (3.46)	4.356±0.158 (3.36)

All values of mean ± S.D. and (%)

**Figure 2.** Effect of different sodium fluoride concentration on the peak-flowering stage (comparative study of the pot experiment and field observation)**Table 5.** Fluoride analysis in different plant parts of *Capsicum annum var. annum* after harvesting at post-flowering stage (100 days) in pot experiment.

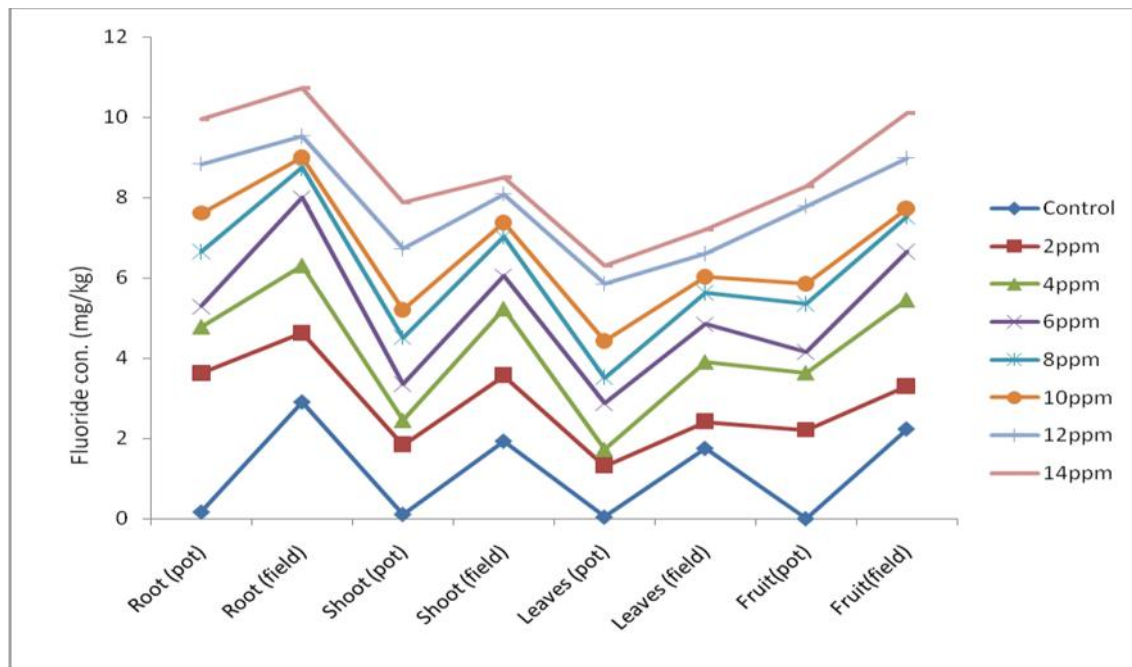
S. No.	Treatment Levels	Fluoride (mg/kg)			
		Root	Shoot	Leaves	Fruit
1.	control	0.178±0.003	0.12±0.001	0.054±0.0005	0.0138±0.003
2.	2ppm	3.636±0.006 (20.42)	1.85±0.003 (15.41)	1.316±0.007 (12.65)	2.212±0.009 (16.02)
3.	4ppm	4.78±0.001 (26.85)	2.448±0.045 (20.4)	1.724±0.089 (16.57)	3.634±0.002 (26.33)
4.	6ppm	5.29±0.004 (29.71)	3.362±0.005 (28.01)	2.876±0.002 (27.65)	4.152±0.008 (30.08)
5.	8ppm	6.662±0.001 (37.42)	4.51±0.002 (37.58)	3.514±0.003 (33.78)	5.352±0.008 (38.78)
6.	10ppm	7.618±0.004 (42.79)	5.216±0.004 (43.46)	4.437±0.004 (42.63)	5.862±0.009 (42.47)
7.	12ppm	8.836±0.007 (49.64)	6.728±0.004 (56.06)	5.852±0.002 (56.26)	7.79±0.006 (56.44)
8.	14ppm	9.948±0.026 (55.88)	7.872±0.003 (65.6)	6.302±0.114 (60.59)	8.27±0.009 (59.92)

All values of mean ± S.D. and (%)

**Table 6.** Fluoride analysis in different plant parts of *Capsicum annum* var. *annuum* after harvesting at peak-flowering stage (100 days) in field observation.

S. No.	Site No.	Fluoride (mg/kg)			
		Root	Shoot	Leaves	Fruit
1.	S <sub>1</sub> (jhilo)	2.9±0.286	1.932±0.016	1.752±0.009	2.232±0.019
2.	S <sub>2</sub> (Raipur)	4.642±0.038 (1.60)	3.576±0.063 (1.85)	2.424±0.022 (1.38)	3.31±0.095 (1.48)
3.	S <sub>3</sub> (Puranabas)	6.3±0.130 (2.17)	5.226±0.163 (2.70)	3.902±0.284 (2.22)	5.448±0.044 (2.44)
4.	S <sub>4</sub> (DhaniAhiran)	7.996±0.047 (2.75)	6.048±0.330 (3.13)	4.842±0.097 (2.76)	6.658±0.036 (2.98)
5.	S <sub>5</sub> (Naikothi)	8.746±0.132 (3.01)	7.022±0.053 (3.63)	5.634±0.021 (2.91)	7.52±0.162 (3.36)
6.	S <sub>6</sub> (Dhani Neem kali)	9.01±0.258 (3.10)	7.384±0.274 (3.82)	6.032±0.037 (3.44)	7.732±0.093 (3.46)
7.	S <sub>7</sub> (Bharala)	9.53±0.234 (3.28)	8.086±0.258 (4.18)	6.61±3.77 (0.184)	8.984±0.055 (4.02)
8.	S <sub>8</sub> (Thikaria)	10.73±0.148 (3.7)	8.512±0.280 (4.40)	7.212±0.259 (4.11)	10.11±0.196 (4.52)

All values of mean ± S.D. and (%)

**Figure 3.** Effect of different sodium fluoride concentration on the post-flowering stage (comparative study of the pot experiment and field observation)

Results reported in this study show that fluoride treatment is detrimental to the absorption of fluoride and yield of red chilli especially at higher concentration (14ppmNaF). Bioaccumulation of fluoride in red chilli generates primary source of fluoride to human population resulting in spices-borne fluorosis. It was observed that concentration of fluoride was higher in field experiment in comparison to pot experiment. It may be due to the use of fluoride contaminated soil and water in field while we are using only fluoride contaminated water in pot.

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